Firebird 4.0 Language Reference

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Chapter 1. About the Firebird 4.0 Language Reference

This Language Reference describes the SQL language supported by Firebird 4.0.

This Firebird 4.0 Language Reference is the third comprehensive manual to cover all aspects of the query language used by developers to communicate, through their applications, with the Firebird relational database management system.

1.1. Subject

The subject of this volume is wholly Firebird's implementation of the SQL relational database language. Firebird conforms closely with international standards for SQL, from data type support, data storage structures, referential integrity mechanisms, to data manipulation capabilities and access privileges. Firebird also implements a robust procedural language — procedural SQL (PSQL) — for stored procedures, stored functions, triggers, and dynamically-executable code blocks. These are the areas addressed in this volume.

This document does not cover configuration of Firebird, Firebird command-line tools, nor its programming APIs.

1.2. Authorship

For the Firebird 4.0 version, the *Firebird 3.0 Language Reference* was taken as the base, and Firebird 4.0 information was added based on the *Firebird 4.0 Release Notes* and feature documentation.

1.2.1. Contributors

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1.3. Reporting Errors or Missing Content

If you find errors, missing content or other problems in this document, please report this in our issue tracker of the firebird-documentation GitHub repository.

Pull requests with changes and fixes are also much appreciated.

1.4. Acknowledgments

Sponsors and Other Donors

See also the Acknowledgements in the Firebird 2.5 Language Reference for the sponsors of the initial Russian version and its translation.

Sponsors of the Russian Language Reference Manual

Moscow Exchange (Russia)

Moscow Exchange is the largest exchange holding in Russia and Eastern Europe, founded on December 19, 2011, through the consolidation of the MICEX (founded in 1992) and RTS (founded in 1995) exchange groups. Moscow Exchange ranks among the world's top 20 exchanges by trading in bonds and by the total capitalization of shares traded, as well as among the 10 largest exchange platforms for trading derivatives.

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1.5. Contributing

There are several ways you can contribute to the documentation of Firebird, or Firebird in general:

- Participate on the mailing lists (see https://www.firebirdsql.org/en/mailing-lists/)
- Report bugs or submit pull requests on GitHub (https://github.com/FirebirdSQL/)
- Become a developer (contact us on firebird-devel)
- Donate to the Firebird Foundation (see https://www.firebirdsql.org/en/donate/)
- Become a paying member or sponsor of the Firebird Foundation (see https://www.firebirdsql.org/en/firebird-foundation/)

Chapter 2. SQL Language Structure

This reference describes the SQL language supported by Firebird.

2.1. Background to Firebird's SQL Language

To begin, a few points about some characteristics that are in the background to Firebird's language implementation.

2.1.1. SQL Flavours

Distinct *subsets of SQL* apply to different sectors of activity. The SQL subsets in Firebird's language implementation are:

- Dynamic SQL (DSQL)
- Procedural SQL (PSQL)
- Embedded SQL (ESQL)
- Interactive SQL (ISQL)

Dynamic SQL is the major part of the language which corresponds to the Part 2 (SQL/Foundation) part of the SQL specification. DSQL represents statements passed by client applications through the public Firebird API and processed by the database engine.

Procedural SQL augments Dynamic SQL to allow compound statements containing local variables, assignments, conditions, loops and other procedural constructs. PSQL corresponds to the Part 4 (SQL/PSM) part of the SQL specifications. Originally, PSQL extensions were available in persistent stored modules (procedures and triggers) only, but in more recent releases they were surfaced in Dynamic SQL as well (see `EXECUTE BLOCK`).

Embedded SQL defines the DSQL subset supported by Firebird *gpre*, the application which allows you to embed SQL constructs into your host programming language (C, C++, Pascal, Cobol, etc.) and preprocess those embedded constructs into the proper Firebird API calls.

Only a portion of the statements and expressions implemented in DSQL are supported in ESQL.

Interactive ISQL refers to the language that can be executed using Firebird *isql*, the command-line application for accessing databases interactively. As a regular client application, its native language is DSQL. It also offers a few additional commands that are not available outside its specific environment.

Both DSQL and PSQL subsets are completely presented in this reference. Neither ESQL nor ISQL flavours are described here unless mentioned explicitly.

2.1.2. SQL Dialects

SQL dialect is a term that defines the specific features of the SQL language that are available when

accessing a database. SQL dialects can be defined at the database level and specified at the connection level. Three dialects are available:

- *Dialect 1* is intended solely to allow backward comptibility with legacy databases from very old InterBase versions, v.5 and below. Dialect 1 databases retain certain language features that differ from Dialect 3, the default for Firebird databases.
  - Date and time information are stored in a `DATE` data type. A `TIMESTAMP` data type is also available, that is identical to this `DATE` implementation.
  - Double quotes may be used as an alternative to apostrophes for delimiting string data. This is contrary to the SQL standard — double quotes are reserved for a distinct syntactic purpose both in standard SQL and in Dialect 3. Double-quoting strings is therefore to be avoided strenuously.
  - The precision for `NUMERIC` and `DECIMAL` data types is smaller than in Dialect 3 and, if the precision of a fixed decimal number is greater than 9, Firebird stores it internally as a long floating point value.
  - The `BIGINT` (64-bit integer) data type is not supported.
  - Identifiers are case-insensitive and must always comply with the rules for regular identifiers — see the section Identifiers below.
  - Although generator values are stored as 64-bit integers, a Dialect 1 client request, `SELECT GEN_ID (MyGen, 1)`, for example, will return the generator value truncated to 32 bits.
- *Dialect 2* is available only on the Firebird client connection and cannot be set in the database. It is intended to assist debugging of possible problems with legacy data when migrating a database from dialect 1 to 3.
- In *Dialect 3* databases,
  - numbers (`DECIMAL` and `NUMERIC` data types) are stored internally as long fixed point values (scaled integers) when the precision is greater than 9.
  - The `TIME` data type is available for storing time-of-day data only.
  - The `DATE` data type stores only date information.
  - The 64-bit integer data type `BIGINT` is available.
  - Double quotes are reserved for delimiting non-regular identifiers, enabling object names that are case-sensitive or that do not meet the requirements for regular identifiers in other ways.
  - All strings must be delimited with single quotes (apostrophes).
  - Generator values are stored as 64-bit integers.

Use of Dialect 3 is strongly recommended for newly developed databases and applications. Both database and connection dialects should match, except under migration conditions with Dialect 2.

This reference describes the semantics of SQL Dialect 3 unless specified otherwise.

2.1.3. Error Conditions

Processing of every SQL statement either completes successfully or fails due to a specific error condition. Error handling can be done as in the client the application and on the server side using PSQL.

2.2. Basic Elements: Statements, Clauses, Keywords

The primary construct in SQL is the *statement*. A statement defines what the database management system should do with a particular data or metadata object. More complex statements contain simpler constructs — *clauses* and *options*.

Clauses

A clause defines a certain type of directive in a statement. For instance, the `WHERE` clause in a `SELECT` statement and in some other data manipulation statements (`UPDATE`, `DELETE`) specifies criteria for searching one or more tables for the rows that are to be selected, updated or deleted. The `ORDER BY` clause specifies how the output data — result set — should be sorted.

Options

Options, being the simplest constructs, are specified in association with specific keywords to provide qualification for clause elements. Where alternative options are available, it is usual for one of them to be the default, used if nothing is specified for that option. For instance, the `SELECT` statement will return all of the rows that match the search criteria unless the `DISTINCT` option restricts the output to non-duplicated rows.

Keywords

All words that are included in the SQL lexicon are keywords. Some keywords are *reserved*, meaning their usage as identifiers for database objects, parameter names or variables is prohibited in some or all contexts. Non-reserved keywords can be used as identifiers, although it is not recommended. From time to time, non-reserved keywords may become reserved when some new language feature is introduced.

For instance, the following statement will be executed without errors because, although `ABS` is a keyword, it is not a reserved word.

```
CREATE TABLE T (ABS INT NOT NULL);
```

On the contrary, the following statement will return an error because `ADD` is both a keyword and a reserved word.

```
CREATE TABLE T (ADD INT NOT NULL);
```

Refer to the list of reserved words and keywords in the chapter Reserved Words and Keywords.

2.3. Identifiers

All database objects have names, often called *identifiers*. The maximum identifier length is 63 characters character set UTF8 (252 bytes).

It is possible to restrict the actual maximum identifier length through configuration. Consult the *Firebird 4.0 Release Notes* for details. In this language reference we assume the default configuration of 63 characters (252 bytes).

Two types of names are valid as identifiers: *regular* names, similar to variable names in regular programming languages, and *delimited* names that are specific to SQL. To be valid, each type of identifier must conform to a set of rules, as follows:

2.3.1. Rules for Regular Object Identifiers

- Length cannot exceed 63 characters
- The name must start with an unaccented, 7-bit ASCII alphabetic character. It may be followed by other 7-bit ASCII letters, digits, underscores or dollar signs. No other characters, including spaces, are valid. The name is case-insensitive, meaning it can be declared and used in either upper or lower case. Thus, from the system's point of view, the following names are the same:

```
fullname
FULLNAME
FuLlNaMe
FullName
```

Regular name syntax

```
<name> ::=
  <letter> | <name><letter> | <name><digit> | <name>_ | <name>$

<letter> ::= <upper letter> | <lower letter>

<upper letter> ::= A | B | C | D | E | F | G | H | I | J | K | L | M |
                   N | O | P | Q | R | S | T | U | V | W | X | Y | Z

<lower letter> ::= a | b | c | d | e | f | g | h | i | j | k | l | m |
                   n | o | p | q | r | s | t | u | v | w | x | y | z

<digit> ::= 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9
```

2.3.2. Rules for Delimited Object Identifiers

- Length cannot exceed 63 characters in character set UTF8 (252 bytes). Identifiers are stored in character set `UTF8`, which means characters outside the ASCII range are stored using 2 to 4 bytes.
- The entire string must be enclosed in double-quotes, e.g. `"anIdentifier"`

- It may contain any character from the UTF8 character set, including accented characters, spaces and special characters
- An identifier can be a reserved word
- Delimited identifiers are case-sensitive in all contexts
- Trailing spaces in delimited names are removed, as with any string constant
- Delimited identifiers are available in Dialect 3 only. For more details on dialects, see SQL Dialects

Delimited name syntax

```
<delimited name> ::= "<permitted_character>[<permitted_character> ...]"
```

A delimited identifier such as "FULLNAME" is the same as the regular identifiers FULLNAME, fullname, FullName, and so on. The reason is that Firebird stores regular identifiers in upper case, regardless of how they were defined or declared. Delimited identifiers are always stored according to the exact case of their definition or declaration. Thus, "FullName" (quoted) is different from FullName (unquoted, i.e. regular) which is stored as FULLNAME in the metadata.

2.4. Literals

Literals are used to directly represent data. Examples of standard types of literals are:

```
integer        - 0, -34, 45, 0X080000000;
fixed-point    - 0.0, -3.14
floating-point - 3.23e-23;
string         - 'text', 'don''t!';
binary string  - x'48656C6C6F20776F726C64'
date           - DATE '2018-01-19';
time           - TIME '15:12:56';
timestamp      - TIMESTAMP '2018-01-19 13:32:02';
boolean        - true, false, unknown
null state     - null
```

Details about literals for each data type are discussed in section Literals (Constants) of chapter Common Language Elements.

2.5. Operators and Special Characters

A set of special characters is reserved for use as operators or separators.

```
<special char> ::=
    <space> | " | % | & | ' | ( | ) | * | + | , | -
  | . | / | : | ; | < | = | > | ? | [ | ] | ^ | { | }
```

Some of these characters, alone or in combinations, may be used as operators (arithmetical, string, logical), as SQL command separators, to quote identifiers and to mark the limits of string literals or comments.

Operator Syntax

```
<operator> ::=
    <string concatenation operator>
  | <arithmetic operator>
  | <comparison operator>
  | <logical operator>

<string concatentation operator> ::= "||"

<arithmetic operator> ::= * | / | + | - |

<comparison operator> ::=
    =  | <> | != | ~= | ^= | > | < | >= | <=
  | !> | ~> | ^> | !< | ~< | ^<

<logical operator> ::= NOT | AND | OR
```

For more details on operators, see Expressions.

2.6. Comments

Comments may be present in SQL scripts, SQL statements and PSQL modules. A comment can be any text specified by the code writer, usually used to document how particular parts of the code work. The parser ignores the text of comments.

Firebird supports two types of comments: *block* and *in-line*.

Syntax

```
<comment> ::= <block comment> | <single-line comment>

<block comment> ::=
  /* <character>[<character> ⋯] */

<single-line comment> ::=
  -- <character>[<character> ⋯]<end line>
```

Block comments start with the `/*` character pair and end with the `*/` character pair. Text in block comments may be of any length and can occupy multiple lines.

In-line comments start with a pair of hyphen characters, `--` and continue up to the end of the current line.

Example

```
CREATE PROCEDURE P(APARAM INT)
  RETURNS (B INT)
AS
BEGIN
  /* This text will be ignored during the execution of the statement
     since it is a comment
  */
  B = A + 1; -- In-line comment
  SUSPEND;
END
```

Chapter 3. Data Types and Subtypes

Data of various types are used to:

- define columns in a database table in the `CREATE TABLE` statement or change columns using `ALTER TABLE`
- declare or change a *domain* using the `CREATE DOMAIN` or `ALTER DOMAIN` statements
- declare local variables in stored procedures, PSQL blocks and triggers and specify parameters in stored procedures
- indirectly specify arguments and return values when declaring external functions (UDFs — user-defined functions)
- provide arguments for the `CAST()` function when explicitly converting data from one type to another

Table 1. Overview of Data Types

Name	Size	Precision & Limits	Description
`BIGINT`	64 bits	From -2^{63} to (2^{63} - 1)	Signed 64-bit integer. This data type is available in Dialect 3 only
`BINARY(n)`	*n* bytes	from 1 to 32,767 bytes	A fixed-length binary data type; synonym for `CHAR(n) CHARACTER SET OCTETS` Values shorter than the declared length are padded with NUL up to the declared length. If the number of characters is not specified, 1 is used by default.
`BLOB`	Varying	The size of a `BLOB` segment is limited to 64K. The maximum size of a BLOB field is 4 GB	A data type of variable size for storing large amounts of data, such as images, text, digital sounds. The basic structural unit is a segment. The blob subtype defines its content
`BOOLEAN`	8 bits	false, true, unknown	Boolean data type
`CHAR(n)`, `CHARACTER(n)`	*n* characters. Size in bytes depends on the encoding, the number of bytes in a character	from 1 to 32,767 bytes	A fixed-length character data type. Values shorter than the declared length are padded with spaces (NUL for character set OCTETS) up to the declared length. If the number of characters is not specified, 1 is used by default.

Name	Size	Precision & Limits	Description
`DATE`	32 bits	From 0001-01-01 AD to 9999-12-31 AD	Date only, no time element
`DECFLOAT ( dec_prec)`	64 bits or 128 bits	*dec_prec* = 16 or 34, defines the number of decimal digits	Decimal floating-point type
`DECIMAL ( precision, scale)`	Varying (16, 32, 64 or 128 bits)	*precision* = from 1 to 38, defines the least possible number of digits to store; *scale* = from 0 to 38, defines the number of digits after the decimal point	A number with a decimal point that has *scale* digits after the point. *scale* must be less than or equal to *precision*. Example: `DECIMAL(10,3)` contains a number in exactly the following format: `ppppppp.sss`
`DOUBLE PRECISION`	64 bits	$2.225 * 10^{-308}$ to $1.797 * 10^{308}$	Double-precision IEEE, ~15 digits, reliable size depends on the platform
`FLOAT`	32 bits	$1.175 * 10^{-38}$ to $3.402 * 10^{38}$	Single-precision IEEE, ~7 digits
`FLOAT (bin_prec)`	32 bits or 64 bits	*bin_prec* binary precision	Binary precision 1 - 24: synonym for `FLOAT` (32-bit single precision) 25 - 53: synonym for `DOUBLE PRECISION` (64-bit double precision)
`INTEGER, INT`	32 bits	-2,147,483,648 up to 2,147,483,647	Signed 32-bit integer
`INT128`	128 bits	From -2^{127} to $(2^{127} - 1)$	Signed 128-bit integer
`NUMERIC ( precision, scale)`	Varying (16, 32, 64 or 128 bits)	*precision* = from 1 to 38, defines the exact number of digits to store; *scale* = from 0 to 38, defines the number of digits after the decimal point	A number with a decimal point that has *scale* digits after the point. *scale* must be less than or equal to *precision*. Example: `NUMERIC(10,3)` contains a number in exactly the following format: `ppppppp.sss`
`REAL`	32-bits		Synonym for `FLOAT`
`SMALLINT`	16 bits	-32,768 to 32,767	Signed short (word)

Name	Size	Precision & Limits	Description
`TIME [WITHOUT TIME ZONE]`	4 bytes	0:00 to 23:59:59.9999	Time of day. It cannot be used to store an interval of time.
`TIME WITH TIME ZONE`	6 bytes	0:00 to 23:59:59.9999	Time of day with either a time zone offset or named zone. It cannot be used to store an interval of time.
`TIMESTAMP [WITHOUT TIME ZONE]`	8 bytes	From start of day 0001-01-01 AD to end of day 9999-12-31 AD	Date and time of day
`TIMESTAMP WITH TIME ZONE`	10 bytes	From start of day 0001-01-01 AD to end of day 9999-12-31 AD	Date and time of day with either a time zone offset or named zone.
`VARBINARY(n)`, `BINARY VARYING(n)`	*n* bytes	from 1 to 32,765 bytes	Variable length string type; synonym for `VARCHAR(n) CHARACTER SET OCTETS`. The total size cannot be larger than (32KB-3). The two leading bytes store the declared length. There is no default size: the *n* argument is mandatory. Leading and trailing NUL characters are stored, and they are not trimmed, except for those trailing characters that are past the declared length.
`VARCHAR(n)`, `CHAR VARYING(n)`, `CHARACTER VARYING(n)`	*n* characters. Size in bytes depends on the encoding, the number of bytes in a character	from 1 to 32,765 bytes	Variable length string type. The total size of characters in bytes cannot be larger than (32KB-3), taking into account their encoding. The two leading bytes store the declared length. There is no default size: the *n* argument is mandatory. Leading and trailing spaces are stored, and they are not trimmed, except for those trailing characters that are past the declared length.

Note About Dates

Bear in mind that a time series consisting of dates in past centuries is processed without taking into account the actual historical facts, as though the Gregorian calendar were applicable throughout the entire series.

3.1. Integer Data Types

The SMALLINT, INTEGER, BIGINT and INT128 data types are used for integers of various precision in Dialect 3. Firebird does not support an unsigned integer data type.

3.1.1. SMALLINT

The 16-bit SMALLINT data type is for compact data storage of integer data for which only a narrow range of possible values is required. Numbers of the SMALLINT type are within the range from -2^{16} to $2^{16} - 1$, that is, from -32,768 to 32,767.

SMALLINT *Examples*

```
CREATE DOMAIN DFLAG AS SMALLINT DEFAULT 0 NOT NULL
  CHECK (VALUE=-1 OR VALUE=0 OR VALUE=1);

CREATE DOMAIN RGB_VALUE AS SMALLINT;
```

3.1.2. INTEGER

The INTEGER data type is a 32-bit integer. The shorthand name of the data type is INT. Numbers of the INTEGER type are within the range from -2^{32} to $2^{32} - 1$, that is, from -2,147,483,648 to 2,147,483,647.

INTEGER *Example*

```
CREATE TABLE CUSTOMER (
  CUST_NO INTEGER NOT NULL,
  CUSTOMER VARCHAR(25) NOT NULL,
  CONTACT_FIRST VARCHAR(15),
  CONTACT_LAST VARCHAR(20),
  ...
    PRIMARY KEY (CUST_NO) )
```

3.1.3. BIGINT

BIGINT is an SQL:99-compliant 64-bit integer data type, available only in Dialect 3.

Numbers of the BIGINT type are within the range from -2^{63} to $2^{63} - 1$, or from -9,223,372,036,854,775,808 to 9,223,372,036,854,775,807.

3.1.4. INT128

INT128 is a 128-bit integer data type. This type is not defined in the SQL standard.

Numbers of the INT128 type are within the range from -2^{127} to $2^{127} - 1$.

3.1.5. Hexadecimal Format for Integer Numbers

Constants of integer types can be specified in a hexadecimal format by means of 1 to 8 digits for INTEGER, 9 to 16 hexadecimal digits for BIGINT, and — since Firebird 4.0.1 — 10 to 32 hexadecimal digits for INT128. Hex representation for writing to SMALLINT is not explicitly supported, but Firebird will transparently convert a hex number to SMALLINT if necessary, provided it falls within the ranges of negative and positive SMALLINT.

The usage and numerical value ranges of hexadecimal notation are described in more detail in the discussion of number constants in the chapter entitled *Common Language Elements*.

Examples Using Integer Types

```
CREATE TABLE WHOLELOTTARECORDS (
  ID BIGINT NOT NULL PRIMARY KEY,
  DESCRIPTION VARCHAR(32)
);

INSERT INTO MYBIGINTS VALUES (
  -236453287458723,
  328832607832,
  22,
  -56786237632476,
  0X6F55A09D42,       -- 478177959234
  0X7FFFFFFFFFFFFFFF, -- 9223372036854775807
  0XFFFFFFFFFFFFFFFF, -- -1
  0X80000000,         -- -2147483648, an INTEGER
  0X080000000,        -- 2147483648, a BIGINT
  0XFFFFFFFF,         -- -1, an INTEGER
  0X0FFFFFFFF         -- 4294967295, a BIGINT
);
```

The hexadecimal INTEGERs in the above example are automatically cast to BIGINT before being inserted into the table. However, this happens *after* the numerical value is determined, so 0x80000000 (8 digits) and 0x080000000 (9 digits) will be saved as different BIGINT values.

3.2. Floating-Point Data Types

Firebird supports two types of floating-point data types: approximate or binary floating-point data types (FLOAT and DOUBLE PRECISION), and decimal floating-point types (DECFLOAT).

3.2.1. Approximate Floating-Point Data Types

Approximate floating-point data types are stored in an IEEE 754 binary format that comprises sign, exponent and mantissa. Precision is dynamic, corresponding to the physical storage format of the value, which is exactly 4 bytes for the FLOAT type and 8 bytes for DOUBLE PRECISION.

Considering the peculiarities of storing floating-point numbers in a database, these data types are not recommended for storing monetary data. For the same reasons, columns with floating-point

data are not recommended for use as keys or to have uniqueness constraints applied to them.

For testing data in columns with floating-point data types, expressions should check using a range, for instance, BETWEEN, rather than searching for exact matches.

When using these data types in expressions, extreme care is advised regarding the rounding of evaluation results.

FLOAT

Data Type Declaration Format

```
FLOAT [(bin_prec)]
```

Table 2. FLOAT *Type Parameters*

Parameter	Description
bin_prec	Precision in binary digits, default is 24 1 - 24: 32-bit single precision 25 - 53: 64-bit double precision

The FLOAT data type defaults to a 32-bit single precision floating-point type with an approximate precision of 7 decimal digits after the decimal point (24 binary digits). To ensure the safety of storage, rely on 6 decimal digits of precision.

The syntax FLOAT(bin_prec) was introduced in Firebird 4.0, and behaves as follows:

- 1 <= _bin_prec <= 23: 32-bit single precision (synonym for FLOAT)
- 25 <= _bin_prec <= 53: 64-bit double precision (synonym for DOUBLE PRECISION)

The behaviour of FLOAT (without explicit precision) behaves as the SQL standard type REAL.

Compatibility Notes

- Firebird 3.0 and earlier supported FLOAT(dec_prec) where *dec_prec* was the approximate precision in decimal digits, with 0 <= *dec_prec* <= 7 mapped to 32-bit single precision and *P* > 7 mapped to 64-bit double precision. This syntax was never documented.
- For *bin_prec* in FLOAT(bin_prec), the values 1 <= *bin_prec* <= 24 are all treated as *bin_prec* = 24, values 25 <= *bin_prec* <= 53 are all handled as *bin_prec* = 53.
- Most Firebird tools will report FLOAT(1) - FLOAT(24) as FLOAT, and FLOAT(25) - FLOAT(53) as DOUBLE PRECISION.

REAL

Data Type Declaration Format

```
REAL
```

The data type REAL is a synonym for FLOAT, and is provided for syntax compatibility. When used to define a column or parameter, it's indistinguishable from using FLOAT or FLOAT(1) - FLOAT(24).

Compatibility Note

- REAL has been available as a synonym for FLOAT since Firebird 1.0 and even earlier, but was never documented.
- Most Firebird tools will report FLOAT for REAL.

DOUBLE PRECISION

Data Type Declaration Format

```
DOUBLE PRECISION
```

The DOUBLE PRECISION data type is stored with an approximate precision of 15 digits.

Compatibility Notes

- Firebird also has the — previously undocumented — synonyms for DOUBLE PRECISION: LONG FLOAT and LONG FLOAT(bin_prec), with 1 <= *bin_prec* <= 53.

  These non-standard type names are deprecated and may be removed in a future Firebird version.

- Firebird 3.0 and earlier supported LONG FLOAT(dec_prec) where *dec_prec* was the approximate precision in decimal digits, where any value for *dec_prec* mapped to 64-bit double precision.

3.2.2. Decimal Floating-Point Types

Decimal floating-point are stored in an IEEE 754 decimal format that comprises sign, exponent and coefficient. Contrary to the approximate floating-point data types, precision is either 16 or 34 decimal digits.

DECFLOAT

Data Type Declaration Format

```
DECFLOAT [(precision)]
```

Table 3. DECFLOAT *Type Parameters*

Parameter	Description
precision	Precision in decimal digits, either 16 or 34. Default is 34.

DECFLOAT is a SQL:2016 standard-complient numeric type that stores floating-point number precisely (decimal floating-point type), unlike FLOAT or DOUBLE PRECISION that provide a binary approximation of the purported precision.

The type is stored and transmitted as IEEE 754 standard types `Decimal64` (`DECFLOAT(16)`) or `Decimal128` (`DECFLOAT(34)`).

All intermediate calculations are performed with 34-digit values.

16-digit and 34-digit

The "16" and "34" refer to the maximum precision in Base-10 digits. See https://en/wikipedia.org/wiki/iEEE_754#Basic_and_interchange_formats for a comprehensive table.

Table 4. Range of Values

Type	Maximum precision	Minimum Exponent	Maximum Exponent	Smallest value	Largest value
`DECFLOAT(16)`	16	-383	+384	1E-398	9.9..9E+384
`DECFLOAT(34)`	34	-6143	+6144	1E-6176	9.9..9E+6144

Observe that although the smallest exponent for `DECFLOAT(16)` is -383, the smallest value has an exponent of -398, but 15 fewer digits. And similar for `DECFLOAT(34)`, smallest exponent is -6143, but the smalles value has an exponent of -6176, but 33 fewer digits. The reason is that precision was "sacrificed" to be able to store a smaller value.

This is a result of how the value is stored: as a decimal value of 16 or 34 digits and an exponent. For example `1.234567890123456e-383` is actually stored as coefficient `1234567890123456` and exponent `-398`, while `1E-398` is stored as coefficient 1, exponent `-398`.

Behaviour of `DECFLOAT` Operations

The behaviour of `DECFLOAT` operations in a session, specifically rounding and error behaviour, can be configured using the `SET DECFLOAT` management statement.

Length of `DECFLOAT` Literals

It is possible to express `DECFLOAT(34)` values in approximate numeric literals, but only for values with a mantissa of 20 or more digits, or an absolute exponent larger than 308. Scientific notation literals with fewer digits or a smaller absolute exponent are `DOUBLE PRECISION` literals. Exact numeric literals with 40 or more digits — actually 39 digits, when larger than the maximum `INT128` value — are also handled as `DECFLOAT(34)`.

Alternatively, use a string literal and explicitly cast to the desired `DECFLOAT` type.

The length of `DECFLOAT` literals cannot exceed 1024 characters. Scientific notation is required for greater values. For example, `0.0<1020 zeroes>11` cannot be used as a literal, the equivalent in scientific notation, `1.1E-1022` is valid. Similarly, `10<1022 zeroes>0` can be presented as `1.0E1024`. Literals with more than 34 significant digits are rounded using the `DECFLOAT` rounding mode of the session.

DECFLOAT and Functions

Use with Standard Functions

A number of standard scalar functions can be used with expressions and values of the DECFLOAT type. They are:

ABS	CEILING	EXP	FLOOR	LN
LOG	LOG10	POWER	SIGN	SQRT

The aggregate functions SUM, AVG, MAX and MIN work with DECFLOAT data, as do all the statistics aggregates (including but not limited to STDDEV or CORR).

Special Functions for DECFLOAT

Firebird supports four functions, designed to support DECFLOAT data specifically:

COMPARE_DECFLOAT
: compares two DECFLOAT values to be equal, different or unordered

NORMALIZE_DECFLOAT
: takes a single DECFLOAT argument and returns it in its simplest form

QUANTIZE
: takes two DECFLOAT arguments and returns the first argument scaled using the second value as a pattern

TOTALORDER
: performs an exact comparison on two DECFLOAT values

Detailed descriptions are available in the Special Functions for DECFLOAT section of the *Built-in Scalar Functions* chapter.

3.3. Fixed-Point Data Types

Fixed-point data types ensure the predictability of multiplication and division operations, making them the choice for storing monetary values. Firebird implements two fixed-point data types: NUMERIC and DECIMAL. According to the standard, both types limit the stored number to the declared scale (the number of digits after the decimal point).

Different treatments limit precision for each type: precision for NUMERIC columns is exactly “as declared”, while DECIMAL columns accepts numbers whose precision is at least equal to what was declared.

The behaviour of NUMERIC and DECIMAL in Firebird is like the SQL-standard DECIMAL; the precision is at least equal to what was declared.

For instance, NUMERIC(4, 2) defines a number consisting altogether of four digits, including two digits after the decimal point; that is, it can have up to two digits before the point and no more than

two digits after the point. If the number 3.1415 is written to a column with this data type definition, the value of 3.14 will be saved in the `NUMERIC(4, 2)` column.

The form of declaration for fixed-point data, for instance, `NUMERIC(p, s)`, is common to both types. It is important to realise that the `s` argument in this template is *scale*, rather than "a count of digits after the decimal point". Understanding the mechanism for storing and retrieving fixed-point data should help to visualise why: for storage, the number is multiplied by 10^s (10 to the power of `s`), converting it to an integer; when read, the integer is converted back.

The method of storing fixed-point data in the database depends on several factors: declared precision, database dialect, declaration type.

Table 5. Method of Physical Storage for Fixed-Point Numbers

Precision	Data type	Dialect 1	Dialect 3
1 - 4	NUMERIC	SMALLINT	SMALLINT
1 - 4	DECIMAL	INTEGER	INTEGER
5 - 9	NUMERIC or DECIMAL	INTEGER	INTEGER
10 - 18	NUMERIC or DECIMAL	DOUBLE PRECISION	BIGINT
19 - 38	NUMERIC or DECIMAL	INT128	INT128

Numerics with precision less than 19 digits use `SMALLINT`, `INTEGER`, `BIGINT` or `DOUBLE PRECISION` as the base datatype, depending on the number of digits and SQL dialect. When precision is between 19 and 38 digits a 128-bit integer is used for internal storage, and the actual precision is always extended to the full 38 digits.

For complex calculations, those digits are cast internally to DECFLOAT(34). The result of various mathematical operations, such as `LOG()`, `EXP()` and so on, and aggregate functions using a high precision numeric argument, will be `DECFLOAT(34)`.

3.3.1. NUMERIC

Data Type Declaration Format

```
NUMERIC [(precision [, scale])]
```

Table 6. `NUMERIC` Type Parameters

Parameter	Description
precision	Precision, between 1 and 38. Defaults to 9.
scale	Scale, between 0 and *precision*. Defaults to 0.

Storage Examples

Further to the explanation above, Firebird will store `NUMERIC` data according the declared *precision* and *scale*. Some more examples are:

```
NUMERIC(4) stored as      SMALLINT (exact data)
NUMERIC(4,2)              SMALLINT (data * 10²)
NUMERIC(10,4) (Dialect 1) DOUBLE PRECISION
              (Dialect 3) BIGINT (data * 10⁴)
NUMERIC(38,6)             INT128 (data * 10⁶)
```

Always keep in mind that the storage format depends on the precision. For instance, you define the column type as `NUMERIC(2,2)` presuming that its range of values will be -0.99…0.99. However, the actual range of values for the column will be -327.68…327.67, which is due to storing the `NUMERIC(2,2)` data type in the `SMALLINT` format. In storage, the `NUMERIC(4,2)`, `NUMERIC(3,2)` and `NUMERIC(2,2)` data types are the same, in fact. It means that if you really want to store data in a column with the `NUMERIC(2,2)` data type and limit the range to -0.99…0.99, you will have to create a constraint for it.

3.3.2. DECIMAL

Data Type Declaration Format

```
DECIMAL [(precision [, scale])]
```

Table 7. `DECIMAL` *Type Parameters*

Parameter	Description
precision	Precision, between 1 and 38. Defaults to 9.
scale	Scale, between 0 and *precision*. Defaults to 0.

Storage Examples

The storage format in the database for `DECIMAL` is very similar to `NUMERIC`, with some differences that are easier to observe with the help of some more examples:

```
DECIMAL(4) stored as      INTEGER (exact data)
DECIMAL(4,2)              INTEGER (data * 10²)
DECIMAL(10,4) (Dialect 1) DOUBLE PRECISION
              (Dialect 3) BIGINT (data * 10⁴)
DECIMAL(38,6)             INT128 (data * 10⁶)
```

3.4. Data Types for Dates and Times

The `DATE`, `TIME` and `TIMESTAMP` data types are used to work with data containing dates and times.

Firebird 4.0 introduces time zone support, using the types `TIME WITH TIME ZONE` and `TIMESTAMP WITH TIME ZONE`. In this language reference, we'll use `TIME` and `TIMESTAMP` to refer both to the specific types without time zone — `TIME [WITHOUT TIME ZONE]` and `TIMESTAMP [WITHOUT TIME ZONE]` — and aspects of both the without time zone and with time zone types, which one we mean is usually clear from the

context.

The data types `TIME WITHOUT TIME ZONE`, `TIMESTAMP WITHOUT TIME ZONE` and `DATE` are defined to use the *session time zone* when converting from or to a `TIME WITH TIME ZONE` or `TIMESTAMP WITH TIME ZONE`. `TIME` and `TIMESTAMP` are synonymous to their respective `WITHOUT TIME ZONE` data types.

Dialect 3 supports all the five types, while Dialect 1 has only `DATE`. The `DATE` type in Dialect 3 is "date-only", whereas the Dialect 1 `DATE` type stores both date and time-of-day, equivalent to `TIMESTAMP` in Dialect 3. Dialect 1 has no "date-only" type.

Dialect 1 `DATE` data can be defined alternatively as `TIMESTAMP` and this is recommended for new definitions in Dialect 1 databases.

Fractions of Seconds

If fractions of seconds are stored in date and time data types, Firebird stores them to ten-thousandths of a second. If a lower granularity is preferred, the fraction can be specified explicitly as thousandths, hundredths or tenths of a second, or second, in Dialect 3 databases of ODS 11 or higher.

Some Useful Knowledge about Subseconds Precision

The time-part of a `TIME` or `TIMESTAMP` is a 4-byte WORD, with room for deci-milliseconds (or 100 microseconds) precision and time values are stored as the number of deci-milliseconds elapsed since midnight. The actual precision of values stored in or read from time(stamp) functions and variables is:

- `CURRENT_TIME` and `LOCALTIME` default to seconds precision and can be specified up to milliseconds precision with `CURRENT_TIME (0|1|2|3)` or `LOCALTIME (0|1|2|3)`
- `CURRENT_TIMESTAMP` and `LOCALTIMESTAMP` default to milliseconds precision. Precision from seconds to milliseconds can be specified with `CURRENT_TIMESTAMP (0|1|2|3)` or `LOCALTIMESTAMP (0|1|2|3)`
- Literal `'NOW'` defaults to milliseconds precision
- Functions `DATEADD()` and — since Firebird 4.0.1 — `DATEDIFF()` support up to deci-milliseconds precision with `MILLISECOND`
- The `EXTRACT()` function returns up to deci-milliseconds precision with the `SECOND` and `MILLISECOND` arguments
- the '+' and '-' operators work with deci-milliseconds precision.

Deci-milliseconds precision is rare and is not supported by all drivers and access components. The best assumption to make from all this is that, although Firebird stores `TIME` and the `TIMESTAMP` time-part values as the number of deci-milliseconds (10^{-4} seconds) elapsed since midnight, the actual precision could vary from seconds to milliseconds.

Storage of Time Zone Types

The time zone types are stored as values at UTC (offset 0), using the structure of `TIME` or `TIMESTAMP` + two extra bytes for time zone information (either an offset in minutes, or the id of a named time zone). Storing as UTC allows Firebird to index and compare two values in different time zones.

Storing at UTC has some caveats:

- When you use named zones, and the time zone rules for that zone change, the UTC time stays the same, but the local time in the named zone may change.
- For `TIME WITH TIME ZONE`, calculating a time zone offset for a named zone to get the local time in the zone applies the rules valid at the 1st of January 2020 to ensure a stable value. This may result in unexpected or confusing results.
- When the rules of a named time zone changes, a value in the affected date range may no longer match the intended value if the actual offset in that named zone changes.

3.4.1. DATE

Syntax

```
DATE
```

The `DATE` data type in Dialect 3 stores only date without time. The available range for storing data is from January 01, 1 to December 31, 9999.

Dialect 1 has no “date-only” type.

In Dialect 1, date literals without a time part, as well as casts of date mnemonics `'TODAY'`, `'YESTERDAY'` and `'TOMORROW'` automatically get a zero time part.

If, for some reason, it is important to you to store a Dialect 1 timestamp literal with an explicit zero time-part, the engine will accept a literal like `'2016-12-25 00:00:00.0000'`. However, `'2016-12-25'` would have precisely the same effect, with fewer keystrokes!

3.4.2. TIME

Syntax

```
TIME [{ WITHOUT | WITH } TIME ZONE]
```

For a bare `TIME`, `WITHOUT TIME ZONE` is assumed.

The `TIME` data type is available in Dialect 3 only. It stores the time of day within the range from 00:00:00.0000 to 23:59:59.9999.

If you need to get the time-part from DATE in Dialect 1, you can use the EXTRACT function.

Examples Using EXTRACT()

```
EXTRACT (HOUR FROM DATE_FIELD)
EXTRACT (MINUTE FROM DATE_FIELD)
EXTRACT (SECOND FROM DATE_FIELD)
```

See also the EXTRACT() function in the chapter entitled *Built-in Functions*.

TIME [WITHOUT TIME ZONE]

The TIME (or synonym TIME WITHOUT TIME ZONE) represents a time without time zone information.

TIME WITH TIME ZONE

The TIME WITH TIME ZONE represents a time with time zone information (either an offset or a named zone).

Firebird uses the ICU implementation of the IANA Time Zone Database for named zones.

Examples Using EXTRACT()

```
EXTRACT (TIMEZONE_HOUR FROM TIME_TZ_FIELD)
EXTRACT (TIMEZONE_MINUTE FROM TIME_TZ_FIELD)
```

3.4.3. TIMESTAMP

Syntax

```
TIMESTAMP [{ WITHOUT | WITH } TIME ZONE]
```

For a bare TIMESTAMP, WITHOUT TIME ZONE is assumed.

The TIMESTAMP data type is available in Dialect 3 and Dialect 1. It comprises two 32-bit words — a date-part and a time-part — to form a structure that stores both date and time-of-day. It is the same as the DATE type in Dialect 1.

The EXTRACT function works equally well with TIMESTAMP as with the Dialect 1 DATE type.

TIMESTAMP [WITHOUT TIME ZONE]

The TIMESTAMP (or synonym TIMESTAMP WITHOUT TIME ZONE) represents a time and date without time zone information.

TIMESTAMP WITH TIME ZONE

The TIMESTAMP WITH TIME ZONE represents a time with time zone information (either an offset or a named zone).

3.4.4. Session Time Zone

As the name implies, the session time zone, can be different for each database attachment. It can be set explicitly in the DPB with the item `isc_dpb_session_time_zone`; otherwise, by default, it uses the same time zone as the operating system of the Firebird server process. This default can be overridden in `firebird.conf`, setting `DefaultTimeZone`.

Drivers may apply different defaults, for example specifying the client time zone as the default session time zone. Check your driver documentation for details.

Subsequently, the time zone can be changed to a given time zone using a `SET TIME ZONE` statement or reset to its original value with `SET TIME ZONE LOCAL`.

3.4.5. Time Zone Format

A time zone is specified as a string, either a time zone region (for example, `'America/Sao_Paulo'`) or a displacement from GMT in hours:minutes (for example, `'-03:00'`).

Supported time zone region names can be found in the system table `RDB$TIME_ZONES`.

A time/timestamp with time zone is considered equal to another time/timestamp with time zone if their conversions to UTC are equivalent. For example, `time '10:00 -02:00'` and `time '09:00 -03:00'` are equivalent, since both are the same as `time '12:00 GMT'`.

The same equivalence applies in `UNIQUE` constraints and for sorting purposes.

3.4.6. Operations Using Date and Time Values

The method of storing date and time values makes it possible to involve them as operands in some arithmetic operations. In storage, a date value or date-part of a timestamp is represented as the number of days elapsed since “date zero” — November 17, 1898 — whilst a time value or the time-part of a timestamp is represented as the number of seconds (with fractions of seconds taken into account) since midnight.

An example is to subtract an earlier date, time or timestamp from a later one, resulting in an interval of time, in days and fractions of days.

Table 8. Arithmetic Operations for Date and Time Data Types

Operand 1	Operation	Operand 2	Result
`DATE`	+	`TIME`	`TIMESTAMP`
`DATE`	+	`TIME WITH TIME ZONE`	`TIMESTAMP WITH TIME ZONE`
`DATE`	+	Numeric value `n`	`DATE` increased by *n* whole days. Broken values are rounded (not floored) to the nearest integer
`TIME`	+	`DATE`	`TIMESTAMP`

Operand 1	Operation	Operand 2	Result
`TIME WITH TIME ZONE`	+	`DATE`	`TIMESTAMP WITH TIME ZONE`
`TIME`	+	Numeric value `n`	`TIME` increased by *n* seconds. The fractional part is taken into account
`TIME WITH TIME ZONE`	+	Numeric value `n`	`TIME WITH TIME ZONE` increased by *n* seconds. The fractional part is taken into account
`TIMESTAMP`	+	Numeric value `n`	`TIMESTAMP`, where the date will advance by the number of days and part of a day represented by number *n* — so "`+ 2.75`" will push the date forward by 2 days and 18 hours
`TIMESTAMP WITH TIME ZONE`	+	Numeric value `n`	`TIMESTAMP WITH TIME ZONE`, where the date will advance by the number of days and part of a day represented by number *n* — so "`+ 2.75`" will push the date forward by 2 days and 18 hours
`DATE`	-	`DATE`	Number of days elapsed, within the range `DECIMAL(9, 0)`
`DATE`	-	Numeric value `n`	`DATE` reduced by *n* whole days. Broken values are rounded (not floored) to the nearest integer
`TIME`	-	`TIME`	Number of seconds elapsed, within the range `DECIMAL(9, 4)`
`TIME`	-	`TIME WITH TIME ZONE`	The without time zone value is converted to WITH TIME ZONE in the current session time zone. Number of seconds elapsed between the UTC values, within the range `DECIMAL(9, 4)`. Also applies when swapping types.
`TIME WITH TIME ZONE`	-	`TIME WITH TIME ZONE`	Number of seconds elapsed between the UTC values, within the range `DECIMAL(9, 4)`
`TIME`	-	Numeric value `n`	`TIME` reduced by *n* seconds. The fractional part is taken into account
`TIMESTAMP`	-	`TIMESTAMP`	Number of days and part-day, within the range `DECIMAL(18, 9)`

Operand 1	Operation	Operand 2	Result
`TIMESTAMP`	-	`TIMESTAMP WITH TIME ZONE`	The without time zone value is converted to WITH TIME ZONE in the current session time zone. Number of days and part-day between UTC values, within the range `DECIMAL(18, 9)`. Also applies when swapping types.
`TIMESTAMP WITH TIME ZONE`	-	`TIMESTAMP WITH TIME ZONE`	Number of days and part-day between UTC values, within the range `DECIMAL(18, 9)`
`TIMESTAMP`	-	Numeric value `n`	`TIMESTAMP` where the date will decrease by the number of days and part of a day represented by number *n* — so "`-2.25`" will decrease the date by 2 days and 6 hours

Notes

The `DATE` type is considered as `TIMESTAMP` in Dialect 1.

See also

`DATEADD`, `DATEDIFF`

3.4.7. Supplemental Time Zone Features

Firebird 4.0 provides a number of features to discover time zone information.

Virtual table `RDB$TIME_ZONES`

A virtual table listing time zones supported in the engine.

See also `RDB$TIME_ZONES` in *System Tables*.

Package `RDB$TIME_ZONE_UTIL`

A package of time zone utility functions and procedures:

Function `DATABASE_VERSION`

`RDB$TIME_ZONE_UTIL.DATABASE_VERSION` returns the version of the time zone database as a `VARCHAR(10) CHARACTER SET ASCII`.

Example

```
select rdb$time_zone_util.database_version() from rdb$database;
```

Returns:

```
DATABASE_VERSION
================
2021a
```

Procedure TRANSITIONS

RDB$TIME_ZONE_UTIL.TRANSITIONS returns the set of rules between the start and end timestamps for a named time zone.

The input parameters are:

- RDB$TIME_ZONE_NAME type CHAR(63)
- RDB$FROM_TIMESTAMP type TIMESTAMP WITH TIME ZONE
- RDB$TO_TIMESTAMP type TIMESTAMP WITH TIME ZONE

Output parameters:

RDB$START_TIMESTAMP
: type TIMESTAMP WITH TIME ZONE — The start timestamp of the transition

RDB$END_TIMESTAMP
: type TIMESTAMP WITH TIME ZONE — The end timestamp of the transition

RDB$ZONE_OFFSET
: type SMALLINT — The zone's offset, in minutes

RDB$DST_OFFSET
: type SMALLINT — The zone's DST offset, in minutes

RDB$EFFECTIVE_OFFSET
: type SMALLINT — Effective offset (ZONE_OFFSET + DST_OFFSET)

Example

```
select *
  from rdb$time_zone_util.transitions(
    'America/Sao_Paulo',
    timestamp '2017-01-01',
    timestamp '2019-01-01');
```

Returns (RDB$ prefix left off for brevity):

```
             START_TIMESTAMP                END_TIMESTAMP ZONE_OFFSET DST_OFFSET
EFFECTIVE_OFFSET
============================ ============================ =========== ==========
================
2016-10-16 03:00:00.0000 GMT 2017-02-19 01:59:59.9999 GMT        -180         60
```

```
-120
2017-02-19 02:00:00.0000 GMT 2017-10-15 02:59:59.9999 GMT       -180         0
-180
2017-10-15 03:00:00.0000 GMT 2018-02-18 01:59:59.9999 GMT       -180        60
-120
2018-02-18 02:00:00.0000 GMT 2018-10-21 02:59:59.9999 GMT       -180         0
-180
2018-10-21 03:00:00.0000 GMT 2019-02-17 01:59:59.9999 GMT       -180        60
-120
```

Updating the Time Zone Database

Time zones are often changed: of course, when it happens, it is desirable to update the time zone database as soon as possible.

Firebird stores `WITH TIME ZONE` values translated to UTC time. Suppose a value is created with one time zone database, and a later update of that database changes the information in the range of our stored value. When that value is read, it will be returned as different to the value that was stored initially.

Firebird uses the IANA time zone database through the ICU library. The ICU library presented in the Firebird kit (Windows), or installed in a POSIX operating system, can sometimes have an outdated time zone database.

An updated database can be found on this page on the FirebirdSQL GitHub. Filename `le.zip` stands for little-endian and is the necessary file for most computer architectures (Intel/AMD compatible x86 or x64), while `be.zip` stands for big-endian architectures and is necessary mostly for RISC computer architectures. The content of the zip file must be extracted in the `/tzdata` sub-directory of the Firebird installation, overwriting existing `*.res` files belonging to the database.

`/tzdata` is the default directory where Firebird looks for the time zone database. It can be overridden with the `ICU_TIMEZONE_FILES_DIR` environment variable.

3.5. Character Data Types

For working with character data, Firebird has the fixed-length `CHAR` and the variable-length `VARCHAR` data types. The maximum size of text data stored in these data types is 32,767 bytes for `CHAR` and 32,765 bytes for `VARCHAR`. The maximum number of *characters* that will fit within these limits depends on the `CHARACTER SET` being used for the data under consideration. The collation sequence does not affect this maximum, although it may affect the maximum size of any index that involves the column.

If no character set is explicitly specified when defining a character object, the default character set specified when the database was created will be used. If the database does not have a default character set defined, the field gets the character set `NONE`.

3.5.1. Unicode

Most current development tools support Unicode, implemented in Firebird with the character sets UTF8 and UNICODE_FSS. UTF8 comes with collations for many languages. UNICODE_FSS is more limited and is used mainly by Firebird internally for storing metadata. Keep in mind that one UTF8 character occupies up to 4 bytes, thus limiting the size of CHAR fields to 8,191 characters (32,767/4).

The actual “bytes per character” value depends on the range the character belongs to. Non-accented Latin letters occupy 1 byte, Cyrillic letters from the WIN1251 encoding occupy 2 bytes in UTF8, characters from other encodings may occupy up to 4 bytes.

The UTF8 character set implemented in Firebird supports the latest version of the Unicode standard, thus recommending its use for international databases.

3.5.2. Client Character Set

While working with strings, it is essential to keep the character set of the client connection in mind. If there is a mismatch between the character sets of the stored data and that of the client connection, the output results for string columns are automatically re-encoded, both when data are sent from the client to the server and when they are sent back from the server to the client. For example, if the database was created in the WIN1251 encoding but KOI8R or UTF8 is specified in the client’s connection parameters, the mismatch will be transparent.

3.5.3. Special Character Sets

Character set NONE

The character set NONE is a *special character set* in Firebird. It can be characterized such that each byte is a part of a string, but the string is stored in the system without any clues about what constitutes any character: character encoding, collation, case, etc. are simply unknown. It is the responsibility of the client application to deal with the data and provide the means to interpret the string of bytes in some way that is meaningful to the application and the human user.

Character set OCTETS

Data in OCTETS encoding are treated as bytes that may not actually be interpreted as characters. OCTETS provides a way to store binary data, which could be the results of some Firebird functions. The database engine has no concept of what it is meant to do with a string of bits in OCTETS, other than just store it and retrieve it. Again, the client side is responsible for validating the data, presenting them in formats that are meaningful to the application and its users and handling any exceptions arising from decoding and encoding them. Since Firebird 4.0 CHAR and VARCHAR with character set OCTETS have synonyms BINARY and VARBINARY.

3.5.4. Collation Sequence

Each character set has a default collation sequence (COLLATE) that specifies the collation order. Usually, it provides nothing more than ordering based on the numeric code of the characters and a basic mapping of upper- and lower-case characters. If some behaviour is needed for strings that is not provided by the default collation sequence and a suitable alternative collation is supported for

that character set, a COLLATE collation clause can be specified in the column definition.

A COLLATE collation clause can be applied in other contexts besides the column definition. For greater-than/less-than comparison operations, it can be added in the WHERE clause of a SELECT statement. If output needs to be sorted in a special alphabetic sequence, or case-insensitively, and the appropriate collation exists, then a COLLATE clause can be included with the ORDER BY clause when rows are being sorted on a character field and with the GROUP BY clause in case of grouping operations.

Case-Insensitive Searching

For a case-insensitive search, the UPPER function could be used to convert both the search argument and the searched strings to upper-case before attempting a match:

```
...
where upper(name) = upper(:flt_name)
```

For strings in a character set that has a case-insensitive collation available, you can simply apply the collation, to compare the search argument and the searched strings directly. For example, using the WIN1251 character set, the collation PXW_CYRL is case-insensitive for this purpose:

```
...
WHERE FIRST_NAME COLLATE PXW_CYRL >= :FLT_NAME
...
ORDER BY NAME COLLATE PXW_CYRL
```

See also
CONTAINING

UTF8 Collation Sequences

The following table shows the possible collation sequences for the UTF8 character set.

Table 9. Collation Sequences for Character Set UTF8

Collation	Characteristics
UCS_BASIC	Collation works according to the position of the character in the table (binary). Added in Firebird 2.0
UNICODE	Collation works according to the UCA algorithm (Unicode Collation Algorithm) (alphabetical). Added in Firebird 2.0
UTF8	The default, binary collation, identical to UCS_BASIC, which was added for SQL compatibility
UNICODE_CI	Case-insensitive collation, works without taking character case into account. Added in Firebird 2.1

Collation	Characteristics
UNICODE_CI_AI	Case-insensitive, accent-insensitive collation, works alphabetically without taking character case or accents into account. Added in Firebird 2.5

Example

An example of collation for the UTF8 character set without taking into account the case or accentuation of characters (similar to COLLATE PXW_CYRL).

```
...
ORDER BY NAME COLLATE UNICODE_CI_AI
```

3.5.5. Character Indexes

In Firebird earlier than version 2.0, a problem can occur with building an index for character columns that use a non-standard collation sequence: the length of an indexed field is limited to 252 bytes with no COLLATE specified or 84 bytes if COLLATE is specified. Multi-byte character sets and compound indexes limit the size even further.

Starting from Firebird 2.0, the maximum length for an index equals one quarter of the page size, i.e. from 1,024 — for page size 4,096 — to 8,192 bytes — for page size 32,768. The maximum length of an indexed string is 9 bytes less than that quarter-page limit.

Calculating Maximum Length of an Indexed String Field

The following formula calculates the maximum length of an indexed string (in characters):

```
max_char_length = FLOOR((page_size / 4 - 9) / N)
```

where *N* is the number of bytes per character in the character set.

The table below shows the maximum length of an indexed string (in characters), according to page size and character set, calculated using this formula.

Table 10. Maximum Index Lengths by Page Size and Character Size

Page Size	Bytes per character				
	1	2	3	4	6
4,096	1,015	507	338	253	169
8,192	2,039	1,019	679	509	339
16,384	4,087	2,043	1,362	1,021	681
32,768	8,183	4,091	2,727	2,045	1,363

With case-insensitive collations ("_CI"), one character in the *index* will occupy not 4, but 6 (six) bytes, so the maximum key length for a page of — for example — 4,096 bytes, will be 169 characters.

See also

`CREATE DATABASE`, Collation sequence, `SELECT`, `WHERE`, `GROUP BY`, `ORDER BY`

3.5.6. Character Types in Detail

`BINARY`

Data Type Declaration Format

```
BINARY [(length)]
```

Table 11. `BINARY` Type Parameters

Parameter	Description
length	Length in bytes between 1 and 32,767; defaults to 1.

`BINARY` is a fixed-length data type, and is an SQL standard-compliant alias for `CHAR(length) CHARACTER SET OCTETS`. Values shorter than the declared length are padded with NUL up to the declared length.

Some tools may report the type as `CHAR CHARACTER SET OCTETS` instead of `BINARY`.

See also

`CHAR`, `VARBINARY`

`CHAR`

Data Type Declaration Format

```
{CHAR | CHARACTER} [(length)]
  [CHARACTER SET <set>] [COLLATE <name>]
```

Table 12. `CHAR` Type Parameters

Parameter	Description
length	Length in characters, defaults to 1. A valid *length* is from 1 to the maximum number of characters that can be accommodated within 32,767 bytes.
set	Character set name
name	Collation name

`CHAR` is a fixed-length data type. Values shorter than the declared length are padded with spaces up to the declared length. Generally, the pad character does not have to be a space: it depends on the

character set. For example, the pad character for the OCTETS character set is NUL.

The full name of this data type is CHARACTER, but there is no requirement to use full names and people rarely do so.

Fixed-length character data can be used to store codes whose length is standard and has a definite "width" in directories. An example of such a code is an EAN13 barcode — 13 characters, all filled.

- Since Firebird 4.0, CHAR CHARACTER SET OCTETS has the alias BINARY
- Formally, the COLLATE clause is not part of the data type declaration, and its position depends on the syntax of the statement.

See also

BINARY, VARCHAR

VARBINARY

Data Type Declaration Format

```
{VARBINARY | BINARY VARYING} (length)
```

Table 13. VARBINARY *Type Parameters*

Parameter	Description
length	Length in bytes between 1 and 32,765

VARBINARY is variable length binary type, and is an SQL standard-compliant alias for VARCHAR(length) CHARACTER SET OCTETS.

Some tools may report the type as VARCHAR CHARACTER SET OCTETS instead of VARBINARY.

See also

VARCHAR, BINARY

VARCHAR

Data Type Declaration Format

```
{VARCHAR | {CHAR | CHARACTER} VARYING} (length)
  [CHARACTER SET <set>] [COLLATE <name>]
```

Table 14. VARCHAR *Type Parameters*

Parameter	Description
length	Length in characters. A valid *length* is from 1 to the maximum number of characters that can be accommodated within 32,765 bytes.
set	Character set name

Parameter	Description
name	Collation name

VARCHAR is the basic string type for storing texts of variable length, up to a maximum of 32,765 bytes. The stored structure is equal to the actual size of the data plus 2 bytes where the length of the data is recorded.

All characters that are sent from the client application to the database are considered meaningful, including the leading and trailing spaces.

The full name of this type is CHARACTER VARYING. Another variant of the name is written as CHAR VARYING.

- Since Firebird 4.0, VARCHAR CHARACTER SET OCTETS has the alias VARBINARY
- Formally, the COLLATE clause is not part of the data type declaration, and its position depends on the syntax of the statement.

See also

VARBINARY, CHAR

NCHAR

Data Type Declaration Format

```
{NCHAR | NATIONAL {CHAR | CHARACTER}} [(length)]
```

NCHAR is a fixed-length character data type with the ISO8859_1 character set predefined. In all other respects it is the same as CHAR.

If no *length* is specified, it is taken to be 1.

A similar data type is available for the variable-length string type: NATIONAL {CHAR | CHARACTER} VARYING.

See also

CHAR, VARCHAR

3.6. Boolean Data Type

3.6.1. BOOLEAN

Data Type Declaration Format

```
BOOLEAN
```

The SQL:2008 compliant BOOLEAN data type (8 bits) comprises the distinct truth values TRUE and FALSE. Unless prohibited by a NOT NULL constraint, the BOOLEAN data type also supports the truth value

UNKNOWN as the null value. The specification does not make a distinction between the NULL value of this data type, and the truth value UNKNOWN that is the result of an SQL predicate, search condition, or Boolean value expression: they may be used interchangeably to mean exactly the same thing.

As with many programming languages, the SQL BOOLEAN values can be tested with implicit truth values. For example, `field1 OR field2` and `NOT field1` are valid expressions.

The IS Operator

Predicates can use the operator Boolean `IS [NOT]` for matching. For example, `field1 IS FALSE`, or `field1 IS NOT TRUE`.

- Equivalence operators (“=”, “!=”, “<>” and so on) are valid in all comparisons.

BOOLEAN Examples

1. Inserting and selecting

```
CREATE TABLE TBOOL (ID INT, BVAL BOOLEAN);
COMMIT;

INSERT INTO TBOOL VALUES (1, TRUE);
INSERT INTO TBOOL VALUES (2, 2 = 4);
INSERT INTO TBOOL VALUES (3, NULL = 1);
COMMIT;

SELECT * FROM TBOOL;
          ID    BVAL
============ =======
           1 <true>
           2 <false>
           3 <null>
```

2. Test for TRUE value

```
SELECT * FROM TBOOL WHERE BVAL;
          ID    BVAL
============ =======
           1 <true>
```

3. Test for FALSE value

```
SELECT * FROM TBOOL WHERE BVAL IS FALSE;
          ID    BVAL
============ =======
           2 <false>
```

4. Test for UNKNOWN value

```
SELECT * FROM TBOOL WHERE BVAL IS UNKNOWN;
          ID    BVAL
============ =======
           3 <null>
```

5. Boolean values in SELECT list

```
SELECT ID, BVAL, BVAL AND ID < 2
  FROM TBOOL;
          ID    BVAL    =======
============ ======= =======
           1 <true>  <true>
           2 <false> <false>
           3 <null>  <false>
```

6. PSQL declaration with start value

```
DECLARE VARIABLE VAR1 BOOLEAN = TRUE;
```

7. Valid syntax, but as with a comparison with NULL, will never return any record

```
SELECT * FROM TBOOL WHERE BVAL = UNKNOWN;
SELECT * FROM TBOOL WHERE BVAL <> UNKNOWN;
```

Use of Boolean against other data types

Although BOOLEAN is not inherently convertible to any other data type, from version 3.0.1 the strings 'true' and 'false' (case-insensitive) will be implicitly cast to BOOLEAN in value expressions, e.g.

```
if (true > 'false') then ...
```

'false' is converted to BOOLEAN. Any attempt to use the Boolean operators AND, NOT, OR and IS will fail. NOT 'False', for example, is invalid.

A BOOLEAN can be explicitly converted to and from string with CAST. UNKNOWN is not available for any form of casting.

Other Notes

- The type is represented in the API with the FB_BOOLEAN type and FB_TRUE and FB_FALSE constants.
- The value TRUE is greater than the value FALSE.

3.7. Binary Data Types

The types `BINARY` and `VARBINARY` are covered earlier in section Character Data Types.

`BLOB`s (Binary Large Objects) are complex structures used to store text and binary data of an undefined length, often very large.

Syntax

```
BLOB [SUB_TYPE <subtype>]
  [SEGMENT SIZE <segment size>]
  [CHARACTER SET <character set>]
  [COLLATE <collation name>]
```

Shortened syntax

```
BLOB (<segment size>)
BLOB (<segment size>, <subtype>)
BLOB (, <subtype>)
```

Formally, the `COLLATE` clause is not part of the data type declaration, and its position depends on the syntax of the statement.

Segment Size

Specifying the BLOB segment size is throwback to times past, when applications for working with BLOB data were written in C (Embedded SQL) with the help of the *gpre* pre-compiler. Nowadays, it is effectively irrelevant. The segment size for BLOB data is determined by the client side and is usually larger than the data page size, in any case.

3.7.1. `BLOB` Subtypes

The optional `SUB_TYPE` parameter specifies the nature of data written to the column. Firebird provides two pre-defined subtypes for storing user data:

Subtype 0: `BINARY`

If a subtype is not specified, the specification is assumed to be for untyped data and the default `SUB_TYPE 0` is applied. The alias for subtype zero is `BINARY`. This is the subtype to specify when the data are any form of binary file or stream: images, audio, word-processor files, PDFs and so on.

Subtype 1: `TEXT`

Subtype 1 has an alias, `TEXT`, which can be used in declarations and definitions. For instance, `BLOB SUB_TYPE TEXT`. It is a specialized subtype used to store plain text data that is too large to fit into a string type. A `CHARACTER SET` may be specified, if the field is to store text with a different encoding to that specified for the database. From Firebird 2.0, a `COLLATE` clause is also supported.

Specifying a `CHARACTER SET` without `SUB_TYPE` implies `SUB_TYPE TEXT`.

Custom Subtypes

It is also possible to add custom data subtypes, for which the range of enumeration from -1 to -32,768 is reserved. Custom subtypes enumerated with positive numbers are not allowed, as the Firebird engine uses the numbers from 2-upward for some internal subtypes in metadata.

3.7.2. `BLOB` Specifics

Size

The maximum size of a `BLOB` field is limited to 4GB, regardless of whether the server is 32-bit or 64-bit. (The internal structures related to `BLOB`s maintain their own 4-byte counters.) For a page size of 4 KB (4096 bytes) the maximum size is lower — slightly less than 2GB.

Operations and Expressions

Text BLOBs of any length and any character set — including multi-byte — can be operands for practically any statement or internal functions. The following operators are supported completely:

`=`	(assignment)
`=, <>, <, <=, >, >=`	(comparison)
`||`	(concatenation)
`BETWEEN,`	`IS [NOT] DISTINCT FROM,`
`IN,`	`ANY | SOME,`
`ALL`	

As an efficient alternative to concatenation, you can also use `BLOB_APPEND()`.

Partial support:

- An error occurs with these if the search argument is larger than or equal to 32 KB:

  `STARTING [WITH], LIKE,`
  `CONTAINING`

- Aggregation clauses work not on the contents of the field itself, but on the BLOB ID. Aside from that, there are some quirks:

`SELECT DISTINCT`	returns several NULL values by mistake if they are present
`ORDER BY`	—
`GROUP BY`	concatenates the same strings if they are adjacent to each other, but does not do it if they are remote from each other

`BLOB` *Storage*

- By default, a regular record is created for each BLOB and it is stored on a data page that is

allocated for it. If the entire BLOB fits onto this page, it is called a *level 0 BLOB*. The number of this special record is stored in the table record and occupies 8 bytes.

- If a BLOB does not fit onto one data page, its contents are put onto separate pages allocated exclusively to it (blob pages), while the numbers of these pages are stored into the BLOB record. This is a *level 1 BLOB*.
- If the array of page numbers containing the BLOB data does not fit onto a data page, the array is put on separate blob pages, while the numbers of these pages are put into the BLOB record. This is a *level 2 BLOB*.
- Levels higher than 2 are not supported.

See also

FILTER, DECLARE FILTER, BLOB_APPEND()

3.8. Array Types

Firebird does not offer much in the way of language or tools for working with the contents of arrays, and there are no plans to improve this. This limits the usefulness and accessibility of array types. Therefore, the general advice is: do not use arrays.

The support of arrays in the Firebird DBMS is a departure from the traditional relational model. Supporting arrays in the DBMS could make it easier to solve some data-processing tasks involving large sets of similar data.

Arrays in Firebird are stored in BLOB of a specialized type. Arrays can be one-dimensional and multi-dimensional and of any data type except BLOB and ARRAY.

Example

```
CREATE TABLE SAMPLE_ARR (
  ID INTEGER NOT NULL PRIMARY KEY,
  ARR_INT INTEGER [4]
);
```

This example will create a table with a field of the array type consisting of four integers. The subscripts of this array are from 1 to 4.

3.8.1. Specifying Explicit Boundaries for Dimensions

By default, dimensions are 1-based — subscripts are numbered from 1. To specify explicit upper and lower bounds of the subscript values, use the following syntax:

```
'[' <lower>:<upper> ']'
```

3.8.2. Adding More Dimensions

A new dimension is added using a comma in the syntax. In this example we create a table with a two-dimensional array, with the lower bound of subscripts in both dimensions starting from zero:

```
CREATE TABLE SAMPLE_ARR2 (
  ID INTEGER NOT NULL PRIMARY KEY,
  ARR_INT INTEGER [0:3, 0:3]
);
```

The database `employee.fdb`, found in the `../examples/empbuild` directory of any Firebird distribution package, contains a sample stored procedure showing some simple work with arrays:

3.8.3. PSQL Source for `SHOW_LANGS`, a procedure involving an array

```
CREATE OR ALTER PROCEDURE SHOW_LANGS (
  CODE VARCHAR(5),
  GRADE SMALLINT,
  CTY VARCHAR(15))
RETURNS (LANGUAGES VARCHAR(15))
AS
  DECLARE VARIABLE I INTEGER;
BEGIN
  I = 1;
  WHILE (I <= 5) DO
  BEGIN
    SELECT LANGUAGE_REQ[:I]
    FROM JOB
    WHERE (JOB_CODE = :CODE)
      AND (JOB_GRADE = :GRADE)
      AND (JOB_COUNTRY = :CTY)
      AND (LANGUAGE_REQ IS NOT NULL))
    INTO :LANGUAGES;

    IF (LANGUAGES = '') THEN
    /* PRINTS 'NULL' INSTEAD OF BLANKS */
      LANGUAGES = 'NULL';
    I = I +1;
    SUSPEND;
  END
END
```

If the features described are enough for your tasks, you might consider using arrays in your projects. Currently, no improvements are planned to enhance support for arrays in Firebird.

3.9. Special Data Types

“Special” data types …

3.9.1. SQL_NULL Data Type

The SQL_NULL type holds no data, but only a state: NULL or NOT NULL. It is not available as a data type for declaring table fields, PSQL variables or parameter descriptions. It was added to support the use of untyped parameters in expressions involving the IS NULL predicate.

An evaluation problem occurs when optional filters are used to write queries of the following type:

```
WHERE col1 = :param1 OR :param1 IS NULL
```

After processing, at the API level, the query will look like this:

```
WHERE col1 = ? OR ? IS NULL
```

This is a case where the developer writes an SQL query and considers :param1 as though it were a *variable* that he can refer to twice. However, at the API level, the query contains two separate and independent parameters. The server cannot determine the type of the second parameter since it comes in association with IS NULL.

The SQL_NULL data type solves this problem. Whenever the engine encounters an “? IS NULL” predicate in a query, it assigns the SQL_NULL type to the parameter, which will indicate that parameter is only about “nullness” and the data type or the value need not be addressed.

The following example demonstrates its use in practice. It assumes two named parameters — say, :size and :colour — which might, for example, get values from on-screen text fields or drop-down lists. Each named parameter corresponds with two positional parameters in the query.

```
SELECT
  SH.SIZE, SH.COLOUR, SH.PRICE
FROM SHIRTS SH
WHERE (SH.SIZE = ? OR ? IS NULL)
  AND (SH.COLOUR = ? OR ? IS NULL)
```

Explaining what happens here assumes the reader is familiar with the Firebird API and the passing of parameters in XSQLVAR structures — what happens under the surface will not be of interest to those who are not writing drivers or applications that communicate using the “naked” API.

The application passes the parameterized query to the server in the usual positional ?-form. Pairs of “identical” parameters cannot be merged into one so, for two optional filters, for example, four positional parameters are needed: one for each ? in our example.

After the call to isc_dsql_describe_bind(), the SQLTYPE of the second and fourth parameters will be

set to SQL_NULL. Firebird has no knowledge of their special relation with the first and third parameters: that responsibility lies entirely on the application side.

Once the values for size and colour have been set (or left unset) by the user and the query is about to be executed, each pair of XSQLVARs must be filled as follows:

User has supplied a value

First parameter (value compare): set *sqldata to the supplied value and *sqlind to 0 (for NOT NULL)

Second parameter (NULL test): set sqldata to null (null pointer, not SQL NULL) and *sqlind to 0 (for NOT NULL)

User has left the field blank

Both parameters: set sqldata to null (null pointer, not SQL NULL) and *sqlind to -1 (indicating NULL)

In other words: The value compare parameter is always set as usual. The SQL_NULL parameter is set the same, except that sqldata remains null at all times.

3.10. Conversion of Data Types

When composing an expression or specifying an operation, the aim should be to use compatible data types for the operands. When a need arises to use a mixture of data types, it should prompt you to look for a way to convert incompatible operands before subjecting them to the operation. The ability to convert data may well be an issue if you are working with Dialect 1 data.

3.10.1. Explicit Data Type Conversion

The CAST function enables explicit conversion between many pairs of data types.

Syntax

```
CAST (<expression> AS <target_type>)

<target_type> ::= <domain_or_non_array_type> | <array_datatype>

<domain_or_non_array_type> ::=
  !! See Scalar Data Types Syntax !!

<array_datatype> ::=
  !! See Array Data Types Syntax !!
```

See also CAST() in Chapter *Built-in Scalar Functions*.

Casting to a Domain

When you cast to a domain, any constraints declared for it are taken into account, i.e., NOT NULL or CHECK constraints. If the *value* does not pass the check, the cast will fail.

If TYPE OF is additionally specified — casting to its base type — any domain constraints are ignored during the cast. If TYPE OF is used with a character type (CHAR/VARCHAR), the character set and collation are retained.

Casting to TYPE OF COLUMN

When operands are cast to the type of a column, the specified column may be from a table or a view.

Only the type of the column itself is used. For character types, the cast includes the character set, but not the collation. The constraints and default values of the source column are not applied.

Example

```
CREATE TABLE TTT (
  S VARCHAR (40)
  CHARACTER SET UTF8 COLLATE UNICODE_CI_AI
);
COMMIT;

SELECT
  CAST ('I have many friends' AS TYPE OF COLUMN TTT.S)
FROM RDB$DATABASE;
```

Conversions Possible for the CAST Function

Table 15. Conversions with CAST

From Data Type	To Data Type
Numeric types	Numeric types, [VAR]CHAR, BLOB
[VAR]CHAR	[VAR]CHAR, BLOB, Numeric types, DATE, TIME, TIMESTAMP, BOOLEAN
BLOB	[VAR]CHAR, BLOB, Numeric types, DATE, TIME, TIMESTAMP, BOOLEAN
DATE, TIME	[VAR]CHAR, BLOB, TIMESTAMP
TIMESTAMP	[VAR]CHAR, BLOB, DATE, TIME
BOOLEAN	BOOLEAN, [VAR]CHAR, BLOB

To convert string data types to the BOOLEAN type, the value must be (case-insensitive) 'true' or 'false', or NULL.

Keep in mind that partial information loss is possible. For instance, when you cast the TIMESTAMP data type to the DATE data type, the time-part is lost.

Datetime Formats

To cast string data types to the DATE, TIME or TIMESTAMP data types, you need the string argument to be one of the predefined datetime mnemonics (see Table 16) or a representation of the date in one of the allowed *datetime* formats (see Datetime Format Syntax),

Table 16. Predefined Datetime Mnemonics

Literal	Description
`'NOW'`	Current date and time
`'TODAY'`	Current date
`'TOMORROW'`	Current date + 1 (day)
`'YESTERDAY'`	Current date - 1 (day)

Casting the date mnemonics `'TODAY'`, `'TOMORROW'` or `'YESTERDAY'` to a `TIMESTAMP WITH TIME ZONE` will produce a value at 00:00:00 UTC rebased to the session time zone.

For example `cast('TODAY' as timestamp with time zone)` on 2021-05-02 20:00 - 2021-05-03 19:59 New York (or 2021-05-03 00:00 - 2021-05-03 23:59 UTC) with session time zone America/New_York will produce a value `TIMESTAMP '2021-05-02 20:00:00.0000 America/New_York'`, while `cast('TODAY' as date)` or `CURRENT_DATE` will produce either `DATE '2021-05-02'` or `DATE '2021-05-03'` depending on the actual date.

Sample Date Literal Interpretations

```
select
  cast('04.12.2014' as date) as d1, -- DD.MM.YYYY
  cast('04 12 2014' as date) as d2, -- MM DD YYYY
  cast('4-12-2014' as date) as d3,  -- MM-DD-YYYY
  cast('04/12/2014' as date) as d4, -- MM/DD/YYYY
  cast('04.12.14' as date) as d5,   -- DD.MM.YY
  -- DD.MM with current year
  cast('04.12' as date) as d6,
  -- MM/DD with current year
  cast('04/12' as date) as d7,
  cast('2014/12/04' as date) as d8, -- YYYY/MM/DD
  cast('2014 12 04' as date) as d9, -- YYYY MM DD
  cast('2014.12.04' as date) as d10, -- YYYY.MM.DD
  cast('2014-12-04' as date) as d11, -- YYYY-MM-DD
  cast('4 Jan 2014' as date) as d12, -- DD MM YYYY
  cast('2014 Jan 4' as date) as dt13, -- YYYY MM DD
  cast('Jan 4 2014' as date) as dt14, -- MM DD YYYY
  cast('11:37' as time) as t1, -- HH:mm
  cast('11:37:12' as time) as t2, -- HH:mm:ss
  cast('11:31:12.1234' as time) as t3, -- HH:mm:ss.nnnn
  -- DD.MM.YYYY HH:mm
  cast('04.12.2014 11:37' as timestamp) as dt1,
  -- MM/DD/YYYY HH:mm:ss
  cast('04/12/2014 11:37:12' as timestamp) as dt2,
  -- DD.MM.YYYY HH:mm:ss.nnnn
  cast('04.12.2014 11:31:12.1234' as timestamp) as dt3,
  cast('now' as timestamp) as m1,
  cast('today' as date) as m2,
  cast('yesterday' as date) as m3,
```

```
  cast('tomorrow' as date) as m4
from rdb$database
```

Shorthand Casts for Datetime Data Types

Firebird allows the use of a shorthand "C-style" type syntax for casts from string to the types DATE, TIME and TIMESTAMP. The SQL standard calls these datetime literals.

Syntax

```
<data_type> 'date_format_string'
```

See also Datetime Literals.

These literal expressions are evaluated directly during parsing, as though the statement were already prepared for execution. As this produced unexpected or confusing results when using the datetime mnemonics like 'NOW', especially in PSQL code, the datetime mnemonics are no longer allowed in datetime literals since Firebird 4.0.

To use datetime mnemonics, use the full CAST syntax. An example of using such an expression in a trigger:

```
NEW.CHANGE_DATE = CAST('now' AS TIMESTAMP);
```

3.10.2. Implicit Data Type Conversion

Implicit data conversion in expressions — except string concatenation — is not possible in Dialect 3; the CAST function is almost always required to specify the correct type. In predicates (comparison expressions), Dialect 3 will perform implicit data conversion from string to the type of the other operand of the comparison.

In Dialect 1, in many expressions, one type is implicitly converted to another without the need to use the CAST function. For instance, the following statement in Dialect 1 is valid:

```
UPDATE ATABLE
  SET ADATE = '25.12.2016' + 1
```

The string literal is converted to the DATE type implicitly.

In Dialect 3, this statement will throw error 35544569, *"Dynamic SQL Error: expression evaluation not supported, Strings cannot be added or subtracted in dialect 3"*, and a cast will be needed:

```
UPDATE ATABLE
  SET ADATE = CAST ('25.12.2016' AS DATE) + 1
```

Or, with a datetime literal:

```
UPDATE ATABLE
  SET ADATE = DATE '25.12.2016' + 1
```

In Dialect 1, mixing integer data and numeric strings is usually possible because the parser will try to cast the string implicitly. For example,

```
2 + '1'
```

will be executed correctly.

In Dialect 3, an expression like this will raise an error, so you will need to write it as a `CAST` expression:

```
2 + CAST('1' AS SMALLINT)
```

The exception to the rule is during *string concatenation*.

Implicit Conversion During String Concatenation

When multiple data elements are being concatenated, all non-string data will undergo implicit conversion to string, if possible.

Example

```
SELECT 30||' days hath September, April, June and November' CONCAT$
  FROM RDB$DATABASE;

CONCAT$
================================================
30 days hath September, April, June and November
```

3.11. Custom Data Types — Domains

In Firebird, the concept of a “user-defined data type” is implemented in the form of the *domain*. Creating a domain does not truly create a new data type, of course. A domain provides the means to encapsulate an existing data type with a set of attributes and make this “capsule” available for multiple usage across the whole database. If several tables need columns defined with identical or nearly identical attributes, a domain makes sense.

Domain usage is not limited to column definitions for tables and views. Domains can be used to declare input and output parameters and variables in PSQL code.

3.11.1. Domain Attributes

A domain definition contains required and optional attributes. The *data type* is a required attribute. Optional attributes include:

- a default value
- to allow or forbid `NULL`
- `CHECK` constraints
- character set (for character data types and text BLOB fields)
- collation (for character data types)

Sample domain definition

```
CREATE DOMAIN BOOL3 AS SMALLINT
  CHECK (VALUE IS NULL OR VALUE IN (0, 1));
```

See also

Explicit Data Type Conversion for the description of differences in the data conversion mechanism when domains are specified for the `TYPE OF` and `TYPE OF COLUMN` modifiers.

3.11.2. Domain Override

While defining a column using a domain, it is possible to override some of the attributes inherited from the domain. Table 3.9 summarises the rules for domain override.

Table 17. Rules for Overriding Domain Attributes in Column Definition

Attribute	Override?	Comments
Data type	No	
Default value	Yes	
Text character set	Yes	It can be also used to restore the default database values for the column
Text collation sequence	Yes	
`CHECK` constraints	Yes	To add new conditions to the check, you can use the corresponding `CHECK` clauses in the CREATE and ALTER statements at the table level.
`NOT NULL`	No	Often it is better to leave domain nullable in its definition and decide whether to make it `NOT NULL` when using the domain to define columns.

3.11.3. Creating and Administering Domains

A domain is created with the DDL statement `CREATE DOMAIN`.

Short Syntax

```
CREATE DOMAIN name [AS] <type>
  [DEFAULT {<const> | <literal> | NULL | <context_var>}]
  [NOT NULL] [CHECK (<condition>)]
  [COLLATE <collation>]
```

See also

`CREATE DOMAIN` in the Data Definition Language (DDL) section.

Altering a Domain

To change the attributes of a domain, use the DDL statement `ALTER DOMAIN`. With this statement you can:

- rename the domain
- change the data type
- drop the current default value
- set a new default value
- drop the `NOT NULL` constraint
- set the `NOT NULL` constraint
- drop an existing `CHECK` constraint
- add a new `CHECK` constraint

Short Syntax

```
ALTER DOMAIN name
  [{TO new_name}]
  [{SET DEFAULT { <literal> | NULL | <context_var> } |
    DROP DEFAULT}]
  [{SET | DROP} NOT NULL ]
  [{ADD [CONSTRAINT] CHECK (<dom_condition>) |
    DROP CONSTRAINT}]
  [{TYPE <datatype>}]
```

Example

```
ALTER DOMAIN STORE_GRP SET DEFAULT -1;
```

When changing a domain, its dependencies must be taken into account: whether there are table columns, any variables, input and/or output parameters with the type of this domain declared in the PSQL code. If you change domains in haste, without carefully checking them, your code may stop working!

When you convert data types in a domain, you must not perform any conversions

> that may result in data loss. Also, for example, if you convert `VARCHAR` to `INTEGER`, check carefully that all data using this domain can be successfully converted.

See also

`ALTER DOMAIN` in the Data Definition Language (DDL) section.

Deleting (Dropping) a Domain

The DDL statement `DROP DOMAIN` deletes a domain from the database, provided it is not in use by any other database objects.

Syntax

```
DROP DOMAIN name
```

Example

```
DROP DOMAIN Test_Domain
```

See also

`DROP DOMAIN` in the Data Definition Language (DDL) section.

3.12. Data Type Declaration Syntax

This section documents the syntax of declaring data types. Data type declaration commonly occurs in DDL statements, but also in `CAST` and `EXECUTE BLOCK`.

The syntax documented below is referenced from other parts of this language reference.

3.12.1. Scalar Data Types Syntax

The scalar data types are simple data types that hold a single value. For reasons of organisation, the syntax of BLOB types are defined separately in BLOB Data Types Syntax.

Scalar Data Types Syntax

```
<domain_or_non_array_type> ::=
    <scalar_datatype>
  | <blob_datatype>
  | [TYPE OF] domain
  | TYPE OF COLUMN rel.col

<scalar_datatype> ::=
    SMALLINT | INT[EGER] | BIGINT | INT128
  | REAL | FLOAT [(bin_prec)] | DOUBLE PRECISION
  | DECFLOAT [(dec_prec)]
  | BOOLEAN
  | DATE
```

```
    | TIME [{WITHOUT | WITH} TIME ZONE]
    | TIMESTAMP [{WITHOUT | WITH} TIME ZONE]
    | {DECIMAL | NUMERIC} [(precision [, scale])]
    | {VARCHAR | {CHAR | CHARACTER} VARYING} (length)
      [CHARACTER SET charset]
    | {CHAR | CHARACTER} [(length)] [CHARACTER SET charset]
    | {NCHAR | NATIONAL {CHARACTER | CHAR}} VARYING (length)
    | {NCHAR | NATIONAL {CHARACTER | CHAR}} [(length)]
    | BINARY [(length)]
    | {VARBINARY | BINARY VARYING} (length)
```

Table 18. Arguments for the Scalar Data Types Syntax

Argument	Description
domain	Domain (only non-array domains)
rel	Name of a table or view
col	Name of a column in a table or view (only columns of a non-array type)
bin_prec	Binary precision, default is 24. 1 - 24: 32-bit single precision 25 - 53: 64-bit double precision (synonym of `DOUBLE PRECISION`)
dec_prec	Decimal precision of `DECFLOAT`, either 16 or 34; Default is 34
precision	Numeric precision in decimal digits. From 1 to 38
scale	Scale, or number of decimals. From 0 to 38. It must be less than or equal to *precision*
length	The maximum length of a string, in characters, or — for `BINARY` and `VARBINARY` — bytes; optional for fixed-width character types, defaults to 1
charset	Character set
domain_or_non_array_type	Non-array types that can be used in PSQL code and casts

Use of Domains in Declarations

A domain name can be specified as the type of a PSQL parameter or local variable. The parameter or variable will inherit all domain attributes. If a default value is specified for the parameter or variable, it overrides the default value specified in the domain definition.

If the `TYPE OF` clause is added before the domain name, only the data type of the domain is used: any of the other attributes of the domain — `NOT NULL` constraint, `CHECK` constraints, default value — are neither checked nor used. However, if the domain is of a text type, its character set and collation sequence are always used.

Use of Column Type in Declarations

Input and output parameters or local variables can also be declared using the data type of columns

in existing tables and views. The `TYPE OF COLUMN` clause is used for that, specifying *relationname .columnname* as its argument.

When `TYPE OF COLUMN` is used, the parameter or variable inherits only the data type and — for string types — the character set and collation sequence. The constraints and default value of the column are ignored.

3.12.2. BLOB Data Types Syntax

The BLOB data types hold binary, character or custom format data of unspecified size. For more information, see Binary Data Types.

BLOB Data Types Syntax

```
<blob_datatype> ::=
    BLOB [SUB_TYPE {subtype_num | subtype_name}]
    [SEGMENT SIZE seglen] [CHARACTER SET charset]
  | BLOB [(seglen [, subtype_num])]
```

Table 19. Arguments for the Blob Data Types Syntax

Argument	Description
charset	Character set (ignored for sub-types other than `TEXT`/1)
subtype_num	`BLOB` subtype number
subtype_name	`BLOB` subtype mnemonic name; this can be `TEXT`, `BINARY`, or one of the (other) standard or custom names defined in `RDB$TYPES` for `RDB$FIELD_NAME = 'RDB$FIELD_SUB_TYPE'`.
seglen	Segment size, cannot be greater than 65,535, defaults to 80 when not specified. See also Segment Size

3.12.3. Array Data Types Syntax

The array data types hold multiple scalar values in a single or multi-dimensional array. For more information, see Array Types

Array Data Types Syntax

```
<array_datatype> ::=
    {SMALLINT | INT[EGER] | BIGINT | INT128} <array_dim>
  | {REAL | FLOAT [(bin_prec)] | DOUBLE PRECISION} <array_dim>
  | DECFLOAT [(dec_prec)] <array_dim>
  | BOOLEAN <array_dim>
  | DATE <array_dim>
  | TIME [{WITHOUT | WITH} TIME ZONE] <array_dim>
  | TIMESTAMP [{WITHOUT | WITH} TIME ZONE] <array_dim>
  | {DECIMAL | NUMERIC} [(precision [, scale])] <array_dim>
  | {VARCHAR | {CHAR | CHARACTER} VARYING} (length)
    <array_dim> [CHARACTER SET charset]
```

```
  | {CHAR | CHARACTER} [(length)] <array_dim>
    [CHARACTER SET charset]
  | {NCHAR | NATIONAL {CHARACTER | CHAR}} VARYING (length)
    <array_dim>
  | {NCHAR | NATIONAL {CHARACTER | CHAR}}
    [(length)] <array_dim>
  | BINARY [(length)] <array_dim>
  | {VARBINARY | BINARY VARYING} (length) <array_dim>

<array_dim> ::= '[' [m:]n [,[m:]n ...] ']'
```

Table 20. Arguments for the Array Data Types Syntax

Argument	Description
array_dim	Array dimensions
bin_prec	Binary precision, default is 24. 1 - 24: 32-bit single precision 25 - 53: 64-bit double precision (synonym of `DOUBLE PRECISION`)
dec_prec	Decimal precision of `DECFLOAT`, either 16 or 34; default is 34
precision	Numeric precision in decimal digits. From 1 to 38
scale	Scale, or number of decimals. From 0 to 38. It must be less than or equal to *precision*
length	The maximum length of a string, in characters, or — for `BINARY` and `VARBINARY` — bytes; optional for fixed-width character types, defaults to 1
charset	Character set
m, n	Integer numbers defining the index range of an array dimension

Chapter 4. Common Language Elements

This chapter covers the elements that are common throughout the implementation of the SQL language — the *expressions* that are used to extract and operate on conditions about data and the *predicates* that test the truth of those assertions.

4.1. Expressions

SQL expressions provide formal methods for evaluating, transforming and comparing values. SQL expressions may include table columns, variables, constants, literals, various statements and predicates and also other expressions. The complete list of possible tokens in expressions follows.

Description of Expression Elements

Column name

Identifier of a column from a specified table used in evaluations or as a search condition. A column of the array type cannot be an element in an expression except when used with the `IS [NOT] NULL` predicate.

Array element

An expression may contain a reference to an array member i.e., `<array_name>[s]`, where `s` is the subscript of the member in the array `<array_name>`

Arithmetic operators

The +, -, *, / characters used to calculate values

Concatenation operator

The || (“double-pipe”) operator used to concatenate strings

Logical operators

The reserved words `NOT`, `AND` and `OR`, used to combine simple search conditions in order to create complex conditions

Comparison operators

The symbols =, <>, !=, ~=, ^=, <, <=, >, >=, !<, ~<, ^<, !>, ~> and ^>

Comparison predicates

`LIKE`, `STARTING WITH`, `CONTAINING`, `SIMILAR TO`, `BETWEEN`, `IS [NOT] NULL`, `IS [NOT] {TRUE | FALSE | UNKNOWN}` and `IS [NOT] DISTINCT FROM`

Existential predicates

Predicates used to check the existence of values in a set. The `IN` predicate can be used both with sets of comma-separated constants and with subqueries that return a single column. The `EXISTS`, `SINGULAR`, `ALL`, `ANY` and `SOME` predicates can be used only with subqueries.

Constant or Literal

Numbers, or string literals enclosed in apostrophes, Boolean values `TRUE`, `FALSE` and `UNKOWN`, `NULL`

Datetime literal

An expression, similar to a string literal enclosed in apostrophes, that can be interpreted as a date, time or timestamp value. Datetime literals can be strings of characters and numerals, such as `TIMESTAMP '25.12.2016 15:30:35'`, that can be resolved as datetime value, also used for string literals that can be cast to a datetime type.

Datetime mnemonics

A string literal with a description of a desired datetime value that can be cast to a datetime type. For example `'TODAY'`, `'NOW'`.

Context variable

An internally-defined context variable

Local variable

Declared local variable, input or output parameter of a PSQL module (stored procedure, trigger, unnamed PSQL block in DSQL)

Positional parameter

A member of in an ordered group of one or more unnamed parameters passed to a stored procedure or prepared query

Subquery

A `SELECT` statement enclosed in parentheses that returns a single (scalar) value or, when used in existential predicates, a set of values

Function identifier

The identifier of an internal or external function in a function expression

Type cast

An expression explicitly converting data of one data type to another using the `CAST` function (`CAST (<value> AS <datatype>)`). For date/time literals only, the shorthand syntax <datatype> <value> is also supported (`DATE '2016-12-25'`).

Conditional expression

Expressions using CASE and related internal functions

Parentheses

Bracket pairs (⋯) used to group expressions. Operations inside the parentheses are performed before operations outside them. When nested parentheses are used, the most deeply nested expressions are evaluated first and then the evaluations move outward through the levels of nesting.

`COLLATE` clause

Clause applied to CHAR and VARCHAR types to specify the character-set-specific collation sequence to use in string comparisons

`NEXT VALUE FOR` sequence

Expression for obtaining the next value of a specified generator (sequence). The internal

`GEN_ID()` function does the same.

`AT` expression

Expression to change the time zone of a datetime.

4.1.1. Literals (Constants)

A literal — or constant — is a value that is supplied directly in an SQL statement, not derived from an expression, a parameter, a column reference nor a variable. It can be a string or a number.

String Literals

A string literal is a series of characters enclosed between a pair of apostrophes ("single quotes"). The maximum length of a string literal is 32,765 for `CHAR`/`VARCHAR`, or 65,533 bytes for `BLOB`; the maximum character count will be determined by the number of bytes used to encode each character.

- Double quotes are *NOT VALID* for quoting strings. The SQL standard reserves double quotes for a different purpose: quoting identifiers.
- If a literal apostrophe is required within a string constant, it is "escaped" by prefixing it with another apostrophe. For example, `'Mother O''Reilly''s home-made hooch'`. Or use the alternative quote literal: `q'{Mother O'Reilly's home-made hooch}'`
- Care should be taken with the string length if the value is to be written to a `CHAR` or `VARCHAR` column. The maximum length for a `CHAR` or VARCHAR` literal is 32,765 bytes.

The character set of a string constant is assumed to be the same as the character set of its destined storage.

String Literals in Hexadecimal Notation

From Firebird 2.5 forward, string literals can be entered in hexadecimal notation, so-called "binary strings". Each pair of hex digits defines one byte in the string. Strings entered this way will be type `BINARY` (or character set `OCTETS`) by default, unless the *introducer syntax* is used to force a string to be interpreted as another character set.

Syntax

```
{x|X}'<hexstring>'

<hexstring>  ::=  an even number of <hexdigit>
<hexdigit>   ::=  one of 0..9, A..F, a..f
```

Examples

```
select x'4E657276656E' from rdb$database
-- returns 4E657276656E, a 6-byte 'binary' string
```

```
select _ascii x'4E657276656E' from rdb$database
-- returns 'Nerven' (same string, now interpreted as ASCII text)

select _iso8859_1 x'53E46765' from rdb$database
-- returns 'Säge' (4 chars, 4 bytes)

select _utf8 x'53C3A46765' from rdb$database
-- returns 'Säge' (4 chars, 5 bytes)
```

Notes

The client interface determines how binary strings are displayed to the user. The *isql* utility, for example, uses upper case letters A-F, while FlameRobin uses lower case letters. Other client programs may use other conventions, such as displaying spaces between the byte pairs: `'4E 65 72 76 65 6E'`.

The hexadecimal notation allows any byte value (including 00) to be inserted at any position in the string. However, if you want to coerce it to anything other than OCTETS, it is your responsibility to supply the bytes in a sequence that is valid for the target character set.

Alternative String Literals

Since Firebird 3.0, it is possible to use a character, or character pair, other than the doubled (escaped) apostrophe, to embed a quoted string inside another string without the need to escape the quote. The keyword `q` or `Q` preceding a quoted string informs the parser that certain left-right pairs or pairs of identical characters within the string are the delimiters of the embedded string literal.

Syntax

```
<alternative string literal> ::=
    { q | Q } <quote> <start char> [<char> ...] <end char> <quote>
```

Rules

When `<start char>` is '(', '{', '[' or '<', `<end char>` is paired up with its respective "partner", viz. ')', '}', ']' and '>'. In other cases, `<end char>` is the same as `<start char>`.

Inside the string, i.e. `<char>` items, single (not escaped) quotes can be used. Each quote will be part of the result string.

Examples

```
select q'{abc{def}ghi}' from rdb$database;        -- result: abc{def}ghi
select q'!That's a string!' from rdb$database;    -- result: That's a string
```

Introducer Syntax for String Literals

If necessary, a string literal may be preceded by a character set name, itself prefixed with an underscore "_". This is known as *introducer syntax*. Its purpose is to inform the engine about how to interpret and store the incoming string.

Example

```
INSERT INTO People
VALUES (_ISO8859_1 'Hans-Jörg Schäfer')
```

Number Literals

A number literal is any valid number in a supported notation:

- In SQL, for numbers in the standard decimal notation, the decimal point is always represented by period character ('.', full-stop, dot); thousands are not separated. Inclusion of commas, blanks, etc. will cause errors.
- Exponential notation is supported. For example, 0.0000234 can be expressed as `2.34e-5`.
- Hexadecimal notation is supported by Firebird 2.5 and higher versions — see below.

The format of the literal decides the type (<d> for a decimal digit, <h> for a hexadecimal digit):

Format	Type
<d>[<d> ⋯]	`INTEGER`, `BIGINT`, `INT128` or `DECFLOAT(34)` (depends on if value fits in the type). `DECFLOAT(34)` is used for values that do not fit in `INT128`.
0{x|X} <h><h>[<h><h> ⋯]	`INTEGER` for 1-4 <h><h> pairs or `BIGINT` for 5-8 pairs
<d>[<d> ⋯] "." [<d> ⋯]	`NUMERIC(18, n)`, `NUMERIC(38, n)` or `DECFLOAT(34)` where *n* depends on the number of digits after the decimal point, and precision on the total number of digits. For backwards compatibility, some values of 19 digits are mapped to `NUMERIC(18,2)`. `DECFLOAT(34)` is used when the unscaled value does not fit in `INT128`.
<d>[<d> ⋯]["." [<d> ⋯]] E <d>[<d> ⋯]	`DOUBLE PRECISION` or `DECFLOAT(34)`, where `DECFLOAT` is used only if number of digits is 20 or higher, or the absolute exponent is 309 or greater.

Hexadecimal Notation for Numbers

From Firebird 2.5 forward, integer values can be entered in hexadecimal notation. Numbers with 1-

8 hex digits will be interpreted as type INTEGER; numbers with 9-16 hex digits as type BIGINT; numbers with 17-32 hex digits as type INT128.

Syntax

```
0{x|X}<hexdigits>

<hexdigits>  ::=  1-32 of <hexdigit>
<hexdigit>   ::=  one of 0..9, A..F, a..f
```

Examples

```
select 0x6FAA0D3 from rdb$database           -- returns 117088467
select 0x4F9 from rdb$database               -- returns 1273
select 0x6E44F9A8 from rdb$database          -- returns 1850014120
select 0x9E44F9A8 from rdb$database          -- returns -1639646808 (an INTEGER)
select 0x09E44F9A8 from rdb$database         -- returns 2655320488 (a BIGINT)
select 0x28ED678A4C987 from rdb$database     -- returns 720001751632263
select 0xFFFFFFFFFFFFFFFF from rdb$database  -- returns -1
```

Hexadecimal Value Ranges

- Hex numbers in the range 0 .. 7FFF FFFF are positive INTEGERs with values between 0 .. 2147483647 decimal. To coerce a number to BIGINT, prepend enough zeroes to bring the total number of hex digits to nine or above. That changes the type but not the value.
- Hex numbers between 8000 0000 .. FFFF FFFF require some attention:
  - When written with eight hex digits, as in 0x9E44F9A8, a value is interpreted as 32-bit INTEGER. Since the leftmost bit (sign bit) is set, it maps to the negative range -2147483648 .. -1 decimal.
  - With one or more zeroes prepended, as in 0x09E44F9A8, a value is interpreted as 64-bit BIGINT in the range 0000 0000 8000 0000 .. 0000 0000 FFFF FFFF. The sign bit is not set now, so they map to the positive range 2147483648 .. 4294967295 decimal.

  Thus, in this range — and only in this range — prepending a mathematically insignificant 0 results in a totally different value. This is something to be aware of.
- Hex numbers between 1 0000 0000 .. 7FFF FFFF FFFF FFFF are all positive BIGINT.
- Hex numbers between 8000 0000 0000 0000 .. FFFF FFFF FFFF FFFF are all negative BIGINT.
- A SMALLINT cannot be written in hex, strictly speaking, since even 0x1 is evaluated as INTEGER. However, if you write a positive integer within the 16-bit range 0x0000 (decimal zero) to 0x7FFF (decimal 32767) it will be converted to SMALLINT transparently.

  It is possible to write to a negative SMALLINT in hex, using a 4-byte hex number within the range 0xFFFF8000 (decimal -32768) to 0xFFFFFFFF (decimal -1).

Boolean Literals

A Boolean literal is one of TRUE, FALSE or UNKNOWN.

Datetime Literals

Formally, the SQL standard defines datetime literals as a prefix `DATE`, `TIME` and `TIMESTAMP` followed by a string literal with a datetime format. Historically, Firebird documentation has referred to these datetime literals as "`shorthand casts`".

In Firebird 4.0, the use of datetime mnemonics in datetime literals (e.g. `DATE 'TODAY'`) is no longer allowed.

The format of datetime literals and strings in Firebird 4.0 is more strict compared to earlier Firebird versions.

Datetime Literal Syntax

```
<datetime_literal> ::=
    DATE '<date_format>'
  | TIME { '<time_format>' | '<time_tz_format>' }
  | TIMESTAMP { '<timestamp_format>' | '<timestamp_tz_format>' }
```

Datetime Format Syntax

```
<date_format> ::=
      [YYYY<p>]MM<p>DD
    | MM<p>DD[<p>{ YYYY | YY }]
    | DD<p>MM[<p>{ YYYY | YY }]

<time_format> ::= HH[:mm[:SS[<f>NNNN]]]

<timestamp_format> ::= <date_format> [<space> <time_format>]

<time_zone> ::=
    { + | - }HH:MM
  | time zone name (e.g. Europe/Berlin)

<time_tz_format> ::= <time_format> [<space>] <time_zone>

<timestamp_tz_format> ::= <timestamp_format> [<space>] <time_zone>

<p> ::= whitespace | . | - | /
<f> ::= : | .
```

Table 21. Date and Time Literal Format Arguments

Argument	Description
datetime_literal	Datetime literal
date_format	Format of date
time_format	Format of time
timestamp_format	Format of timestamp

Argument	Description
time_zone	Format of time zone
time_tz_format	Format of time with time zone
timestamp_tz_format	Format of timestamp with time zone
YYYY	Four-digit year
YY	Two-digit year
MM	Month It may contain 1 or 2 digits (1-12 or 01-12). You can also specify the three-letter shorthand name or the full name of a month in English. Case-insensitive
DD	Day. It may contain 1 or 2 digits (1-31 or 01-31)
HH	Hour. It may contain 1 or 2 digits (0-23 or 00-23)
mm	Minutes. It may contain 1 or 2 digits (0-59 or 00-59)
SS	Seconds. It may contain 1 or 2 digits (0-59 or 00-59)
NNNN	Ten-thousandths of a second. It may contain from 1 to 4 digits (0-9999)
p	A date separator, any of permitted characters. Leading and trailing spaces are ignored. The choice of separator in a date decides whether the parser reads MM<p>DD or DD<p>MM.
f	Fractional seconds separator

Use of the complete specification of the year in the four-digit form — YYYY — is strongly recommended, to avoid confusion in date calculations and aggregations.

Example

```
-- 1
  UPDATE PEOPLE
  SET AGECAT = 'SENIOR'
  WHERE BIRTHDATE < DATE '1-Jan-1943';
-- 2
  INSERT INTO APPOINTMENTS
  (EMPLOYEE_ID, CLIENT_ID, APP_DATE, APP_TIME)
  VALUES (973, 8804, DATE '1-Jan-2021' + 2, TIME '16:00');
-- 3
  NEW.LASTMOD = TIMESTAMP '1-Jan-2021 16:00';
```

Although the Firebird datetime syntax is very flexible, to avoid ambiguity we recommend using the ISO-8601 order (year-month-day), '-' as the date separator, 4 digits for year, 2 digits for month, day, minute and second, and '.' as second.fractions separator. This format is also the only one defined in the SQL standard.

> In short, use `TIMESTAMP '2021-05-03 04:05:00.1 +02:00'`, not `TIMESTAMP '3.5.21 4:5:0:1 +2:0'`.

4.1.2. SQL Operators

SQL operators comprise operators for comparing, calculating, evaluating and concatenating values.

Operator Precedence

SQL Operators are divided into four types. Each operator type has a *precedence*, a ranking that determines the order in which operators and the values obtained with their help are evaluated in an expression. The higher the precedence of the operator type is, the earlier it will be evaluated. Each operator has its own precedence within its type, that determines the order in which they are evaluated in an expression.

Operators with the same precedence are evaluated from left to right. To force a different evaluation order, operations can be grouped by means of parentheses.

Table 22. Operator Type Precedence

Operator Type	Precedence	Explanation
Concatenation	1	Strings are concatenated before any other operations take place
Arithmetic	2	Arithmetic operations are performed after strings are concatenated, but before comparison and logical operations
Comparison	3	Comparison operations take place after string concatenation and arithmetic operations, but before logical operations
Logical	4	Logical operators are executed after all other types of operators

Concatenation Operator

The concatenation operator, two pipe characters known as “double pipe” — ‘||’ — concatenates (connects together) two character strings to form a single string. Character strings can be constants or values obtained from columns or other expressions.

Example

```
SELECT LAST_NAME || ', ' || FIRST_NAME AS FULL_NAME
FROM EMPLOYEE
```

See also

`BLOB_APPEND()`

Arithmetic Operators

Table 23. Arithmetic Operator Precedence

Operator	Purpose	Precedence
`+signed_number`	Unary plus	1
`-signed_number`	Unary minus	1
*	Multiplication	2
/	Division	2
+	Addition	3
-	Subtraction	3

Example

```
UPDATE T
    SET A = 4 + 1/(B-C)*D
```

Where operators have the same precedence, they are evaluated in left-to-right sequence.

Comparison Operators

Table 24. Comparison Operator Precedence

Operator	Purpose	Precedence
`IS`	Checks that the expression on the left is (not) `NULL` or the Boolean value on the right	1
=	Is equal to, is identical to	2
<>, !=, ~=, ^=	Is not equal to	2
>	Is greater than	2
<	Is less than	2
>=	Is greater than or equal to	2
<=	Is less than or equal to	2
!>, ~>, ^>	Is not greater than	2
!<, ~<, ^<	Is not less than	2

This group also includes comparison predicates `BETWEEN`, `LIKE`, `CONTAINING`, `SIMILAR TO` and others.

Example

```
IF (SALARY > 1400) THEN
...
```

See also

Other Comparison Predicates.

Logical Operators

Table 25. Logical Operator Precedence

Operator	Purpose	Precedence
`NOT`	Negation of a search condition	1
`AND`	Combines two or more predicates, each of which must be true for the entire predicate to be true	2
`OR`	Combines two or more predicates, of which at least one predicate must be true for the entire predicate to be true	3

Example

```
IF (A < B OR (A > C AND A > D) AND NOT (C = D)) THEN ⋯
```

`NEXT VALUE FOR`

Available in

DSQL, PSQL

Result type

`BIGINT` — dialect 2 and 3
`INTEGER` — dialect 1

Syntax

```
NEXT VALUE FOR sequence-name
```

`NEXT VALUE FOR` returns the next value of a sequence. `SEQUENCE` is the SQL-standard term for what is historically called a *generator* in Firebird and its ancestor, InterBase. The `NEXT VALUE FOR` operator is equivalent to the legacy `GEN_ID (⋯, increment)` function with *increment* the increment stored in the metadata of the sequence. It is the recommended syntax for retrieving the next sequence value.

Unlike the `GEN_ID` function, the `NEXT VALUE FOR` expression does not take any parameters and thus, provides no way to retrieve the *current value* of a sequence, nor to step the next value by a different value than the *increment* configured for the sequence. `GEN_ID (⋯, <step value>)` is still needed for these tasks. A *step value* of 0 returns the current sequence value.

The *increment* of a sequence can be configured with the `INCREMENT` clause of `CREATE SEQUENCE` or `ALTER SEQUENCE`.

In dialect 1, the result type is `INTEGER`, in dialect 2 and 3 it is `BIGINT`.

Example

```
NEW.CUST_ID = NEXT VALUE FOR CUSTSEQ;
```

See also

SEQUENCE (GENERATOR), GEN_ID()

AT Time Zone Expression

Available in

DSQL, PSQL

Syntax

```
<at expr> ::= <expr> AT { TIME ZONE <time zone string> | LOCAL }
```

The AT expression expresses a datetime value in a different time zone, while keeping the same UTC instant.

AT translates a time/timestamp value to its corresponding value in another time zone. If LOCAL is used, the value is converted to the session time zone.

When *expr* is a WITHOUT TIME ZONE type, *expr* is first converted to a WITH TIME ZONE in the session time zone and then transformed to the specified time zone.

Examples

```
select time '12:00 GMT' at time zone '-03:00' from rdb$database;
select current_timestamp at time zone 'America/Sao_Paulo' from rdb$database;
select timestamp '2018-01-01 12:00 GMT' at local from rdb$database;
```

4.1.3. Conditional Expressions

A conditional expression is one that returns different values according to how a certain condition is met. It is composed by applying a conditional function construct, of which Firebird supports several. This section describes only one conditional expression construct: CASE. All other conditional expressions apply internal functions derived from CASE and are described in Conditional Functions.

CASE

Available in

DSQL, PSQL

The CASE construct returns a single value from a number of possible values. Two syntactic variants are supported:

- The *simple* CASE, comparable to a *case construct* in Pascal or a *switch* in C
- The *searched* CASE, which works like a series of "if ⋯ else if ⋯ else if" clauses.

Simple CASE

Syntax

```
...
CASE <test-expr>
  WHEN <expr> THEN <result>
  [WHEN <expr> THEN <result> ...]
  [ELSE <defaultresult>]
END
...
```

When this variant is used, *test-expr* is compared to the first *expr*, second *expr* and so on, until a match is found, and the corresponding result is returned. If no match is found, *defaultresult* from the optional ELSE clause is returned. If there are no matches and no ELSE clause, NULL is returned.

The matching works identically to the "=" operator. That is, if *test-expr* is NULL, it does not match any *expr*, not even an expression that resolves to NULL.

The returned result does not have to be a literal value: it might be a field or variable name, compound expression or NULL literal.

Example

```
SELECT
  NAME,
  AGE,
  CASE UPPER(SEX)
    WHEN 'M' THEN 'Male'
    WHEN 'F' THEN 'Female'
    ELSE 'Unknown'
  END GENDER,
RELIGION
    FROM PEOPLE
```

A short form of the simple CASE construct is the DECODE function.

Searched CASE

Syntax

```
CASE
  WHEN <bool_expr> THEN <result>
  [WHEN <bool_expr> THEN <result> ⋯]
  [ELSE <defaultresult>]
END
```

The *bool_expr* expression is one that gives a ternary logical result: TRUE, FALSE or NULL. The first expression to return TRUE determines the result. If no expressions return TRUE, *defaultresult* from the optional ELSE clause is returned as the result. If no expressions return TRUE and there is no ELSE

clause, the result will be NULL.

As with the simple CASE construct, the result need not be a literal value: it might be a field or variable name, a compound expression, or be NULL.

Example

```
CANVOTE = CASE
  WHEN AGE >= 18 THEN 'Yes'
  WHEN AGE < 18 THEN 'No'
  ELSE 'Unsure'
END
```

4.1.4. NULL in Expressions

NULL is not a value in SQL, but a *state* indicating that the value of the element either is *unknown* or it does not exist. It is not a zero, nor a void, nor an "empty string", and it does not act like any value.

When you use NULL in numeric, string or date/time expressions, the result will always be NULL. When you use NULL in logical (Boolean) expressions, the result will depend on the type of the operation and on other participating values. When you compare a value to NULL, the result will be *unknown*.

NULL means NULL but, in Firebird, the logical result *unknown* is also *represented by* NULL.

Expressions Returning NULL

Expressions in this list will always return NULL:

```
1 + 2 + 3 + NULL
'Home ' || 'sweet ' || NULL
MyField = NULL
MyField <> NULL
NULL = NULL
not (NULL)
```

If it seems difficult to understand why, remember that NULL is a state that stands for "unknown".

NULL in Logical Expressions

It has already been shown that NOT (NULL) results in NULL. The interaction is a bit more complicated for the logical AND and logical OR operators:

```
NULL or false  → NULL
NULL or true   → true
NULL or NULL   → NULL
NULL and false → false
NULL and true  → NULL
```

```
NULL and NULL  → NULL
```

As a basic rule-of-thumb, if applying `TRUE` instead of `NULL` produces a different result than applying `FALSE`, then the outcome of the original expression is *unknown*, or `NULL`.

Examples

```
(1 = NULL) or (1 <> 1)    -- returns NULL
(1 = NULL) or FALSE       -- returns NULL
(1 = NULL) or (1 = 1)     -- returns TRUE
(1 = NULL) or TRUE        -- returns TRUE
(1 = NULL) or (1 = NULL)  -- returns NULL
(1 = NULL) or UNKNOWN     -- returns NULL
(1 = NULL) and (1 <> 1)   -- returns FALSE
(1 = NULL) and FALSE      -- returns FALSE
(1 = NULL) and (1 = 1)    -- returns NULL
(1 = NULL) and TRUE       -- returns NULL
(1 = NULL) and (1 = NULL) -- returns NULL
(1 = NULL) and UNKNOWN    -- returns NULL
```

4.1.5. Subqueries

A subquery is a special form of expression that is actually a query embedded within another query. Subqueries are written in the same way as regular `SELECT` queries, but they must be enclosed in parentheses. Subquery expressions can be used in the following ways:

- To specify an output column in the SELECT list
- To obtain values or conditions for search predicates (the `WHERE`, `HAVING` clauses).
- To produce a set that the enclosing query can select from, as though were a regular table or view. Subqueries like this appear in the `FROM` clause (derived tables) or in a Common Table Expression (CTE)

Correlated Subqueries

A subquery can be *correlated*. A query is correlated when the subquery and the main query are interdependent. To process each record in the subquery, it is necessary to fetch a record in the main query; i.e. the subquery fully depends on the main query.

Sample Correlated Subquery

```
SELECT *
FROM Customers C
WHERE EXISTS
  (SELECT *
   FROM Orders O
   WHERE C.cnum = O.cnum
```

```
    AND O.adate = DATE '10.03.1990');
```

When subqueries are used to get the values of the output column in the `SELECT` list, a subquery must return a *scalar* result (see below).

Scalar Results

Subqueries used in search predicates, other than existential and quantified predicates, must return a *scalar* result; that is, not more than one column from not more than one matching row or aggregation. If the result would return more, a run-time error will occur ("Multiple rows in a singleton select...").

Although it is reporting a genuine error, the message can be slightly misleading. A "singleton SELECT" is a query that must not be capable of returning more than one row. However, "singleton" and "scalar" are not synonymous: not all singleton SELECTS are required to be scalar; and single-column selects can return multiple rows for existential and quantified predicates.

Subquery Examples

1. A subquery as the output column in a `SELECT` list:

```
SELECT
  e.first_name,
  e.last_name,
  (SELECT
       sh.new_salary
   FROM
       salary_history sh
   WHERE
       sh.emp_no = e.emp_no
   ORDER BY sh.change_date DESC ROWS 1) AS last_salary
FROM
  employee e
```

2. A subquery in the `WHERE` clause for obtaining the employee's maximum salary and filtering by it:

```
SELECT
  e.first_name,
  e.last_name,
  e.salary
FROM employee e
WHERE
  e.salary = (
    SELECT MAX(ie.salary)
    FROM employee ie
  )
```

4.2. Predicates

A predicate is a simple expression asserting some fact, let's call it P. If P resolves as TRUE, it succeeds. If it resolves to FALSE or NULL (UNKNOWN), it fails. A trap lies here, though: suppose the predicate, P, returns FALSE. In this case NOT(P) will return TRUE. On the other hand, if P returns NULL (unknown), then NOT(P) returns NULL as well.

In SQL, predicates can appear in CHECK constraints, WHERE and HAVING clauses, CASE expressions, the IIF() function and in the ON condition of JOIN clauses, and anywhere a normal expression can occur.

4.2.1. Conditions

A condition — or Boolean expression — is a statement about the data that, like a predicate, can resolve to TRUE, FALSE or NULL. Conditions consist of one or more predicates, possibly negated using NOT and connected by AND and OR operators. Parentheses may be used for grouping predicates and controlling evaluation order.

A predicate may embed other predicates. Evaluation sequence is in the outward direction, i.e., the innermost predicates are evaluated first. Each "level" is evaluated in precedence order until the truth value of the ultimate condition is resolved.

4.2.2. Comparison Predicates

A comparison predicate consists of two expressions connected with a comparison operator. There are six traditional comparison operators:

```
=, >, <, >=, <=, <>
```

For the complete list of comparison operators with their variant forms, see Comparison Operators.

If one of the sides (left or right) of a comparison predicate has NULL in it, the value of the predicate will be UNKNOWN.

Examples

1. Retrieve information about computers with the CPU frequency not less than 500 MHz and the price lower than $800:

```
SELECT *
FROM Pc
WHERE speed >= 500 AND price < 800;
```

2. Retrieve information about all dot matrix printers that cost less than $300:

```
SELECT *
FROM Printer
```

```
WHERE ptrtype = 'matrix' AND price < 300;
```

3. The following query will return no data, even if there are printers with no type specified for them, because a predicate that compares NULL with NULL returns NULL:

```
SELECT *
FROM Printer
WHERE ptrtype = NULL AND price < 300;
```

On the other hand, ptrtype can be tested for NULL and return a result: it is just that it is not a *comparison* test:

```
SELECT *
FROM Printer
WHERE ptrtype IS NULL AND price < 300;
```

— see IS [NOT] NULL.

Note about String Comparison

When CHAR and VARCHAR fields are compared for equality, trailing spaces are ignored in all cases.

Other Comparison Predicates

Other comparison predicates are marked by keyword symbols.

BETWEEN

Available in

DSQL, PSQL, ESQL

Syntax

```
<value> [NOT] BETWEEN <value_1> AND <value_2>
```

The BETWEEN predicate tests whether a value falls within a specified range of two values. (NOT BETWEEN tests whether the value does not fall within that range.)

The operands for BETWEEN predicate are two arguments of compatible data types. Unlike in some other DBMS, the BETWEEN predicate in Firebird is not symmetrical — if the lower value is not the first argument, the BETWEEN predicate will always return FALSE. The search is inclusive (the values represented by both arguments are included in the search). In other words, the BETWEEN predicate could be rewritten:

```
<value> >= <value_1> AND <value> <= <value_2>
```

When BETWEEN is used in the search conditions of DML queries, the Firebird optimizer can use an index on the searched column, if it is available.

Example

```
SELECT *
FROM EMPLOYEE
WHERE HIRE_DATE BETWEEN date '1992-01-01' AND CURRENT_DATE
```

LIKE

Available in

DSQL, PSQL, ESQL

Syntax

```
<match_value> [NOT] LIKE <pattern>
   [ESCAPE <escape character>]

<match_value>      ::= character-type expression
<pattern>          ::= search pattern
<escape character> ::= escape character
```

The LIKE predicate compares the character-type expression with the pattern defined in the second expression. Case- or accent-sensitivity for the comparison is determined by the collation that is in use. A collation can be specified for either operand, if required.

Wildcards

Two wildcard symbols are available for use in the search pattern:

- the percentage symbol (%) will match any sequence of zero or more characters in the tested value
- the underscore character (_) will match any single character in the tested value

If the tested value matches the pattern, taking into account wildcard symbols, the predicate is TRUE.

Using the ESCAPE Character Option

If the search string contains either of the wildcard symbols, the ESCAPE clause can be used to specify an escape character. The escape character must precede the '%' or '_' symbol in the search string, to indicate that the symbol is to be interpreted as a literal character.

Examples using LIKE

1. Find the numbers of departments whose names start with the word "Software":

```
SELECT DEPT_NO
```

```
FROM DEPT
WHERE DEPT_NAME LIKE 'Software%';
```

It is possible to use an index on the DEPT_NAME field if it exists.

About `LIKE` and the Optimizer

Actually, the `LIKE` predicate does not use an index. However, if the predicate takes the form of `LIKE 'string%'`, it will be converted to the `STARTING WITH` predicate, which will use an index. This optimization only works for literal patterns, not for parameters.

So, if you need to search for the beginning of a string, it is recommended to use the `STARTING WITH` predicate instead of the `LIKE` predicate.

2. Search for employees whose names consist of 5 letters, start with the letters “Sm” and end with “th”. The predicate will be true for such names as “Smith” and “Smyth”.

```
SELECT
  first_name
FROM
  employee
WHERE first_name LIKE 'Sm_th'
```

3. Search for all clients whose address contains the string “Rostov”:

```
SELECT *
FROM CUSTOMER
WHERE ADDRESS LIKE '%Rostov%'
```

If you need to do a case-insensitive search for something *enclosed inside* a string (`LIKE '%Abc%'`), use of the `CONTAINING` predicate is recommended, in preference to the `LIKE` predicate.

4. Search for tables containing the underscore character in their names. The ‘#’ character is used as the escape character:

```
SELECT
  RDB$RELATION_NAME
FROM RDB$RELATIONS
WHERE RDB$RELATION_NAME LIKE '%#_%' ESCAPE '#'
```

See also

`STARTING WITH`, `CONTAINING`, `SIMILAR TO`

STARTING WITH

Available in

DSQL, PSQL, ESQL

Syntax

```
<value> [NOT] STARTING WITH <value>
```

The `STARTING WITH` predicate searches for a string or a string-like type that starts with the characters in its *value* argument. The case- and accent-sensitivity of `STARTING WITH` depends on the collation of the first *value*.

When `STARTING WITH` is used in the search conditions of DML queries, the Firebird optimizer can use an index on the searched column, if it exists.

Example

Search for employees whose last names start with “Jo”:

```
SELECT LAST_NAME, FIRST_NAME
FROM EMPLOYEE
WHERE LAST_NAME STARTING WITH 'Jo'
```

See also

`LIKE`

CONTAINING

Available in

DSQL, PSQL, ESQL

Syntax

```
<value> [NOT] CONTAINING <value>
```

The `CONTAINING` predicate searches for a string or a string-like type looking for the sequence of characters that matches its argument. It can be used for an alphanumeric (string-like) search on numbers and dates. A `CONTAINING` search is not case-sensitive. However, if an accent-sensitive collation is in use then the search will be accent-sensitive.

Examples

1. Search for projects whose names contain the substring “Map”:

```
SELECT *
FROM PROJECT
WHERE PROJ_NAME CONTAINING 'Map';
```

Two rows with the names “AutoMap” and “MapBrowser port” are returned.

2. Search for changes in salaries with the date containing number 84 (in this case, it means changes that took place in 1984):

```
SELECT *
FROM SALARY_HISTORY
WHERE CHANGE_DATE CONTAINING 84;
```

See also

LIKE

SIMILAR TO

Available in

DSQL, PSQL

Syntax

```
string-expression [NOT] SIMILAR TO <pattern> [ESCAPE <escape-char>]

<pattern>     ::= an SQL regular expression
<escape-char> ::= a single character
```

SIMILAR TO matches a string against an SQL regular expression pattern. Unlike in some other languages, the pattern must match the entire string in order to succeed — matching a substring is not enough. If any operand is NULL, the result is NULL. Otherwise, the result is TRUE or FALSE.

Syntax: SQL Regular Expressions

The following syntax defines the SQL regular expression format. It is a complete and correct top-down definition. It is also highly formal, rather long and probably perfectly fit to discourage everybody who hasn’t already some experience with regular expressions (or with highly formal, rather long top-down definitions). Feel free to skip it and read the next section, Building Regular Expressions, which uses a bottom-up approach, aimed at the rest of us.

```
<regular expression> ::= <regular term> ['|' <regular term> ...]

<regular term> ::= <regular factor> ...

<regular factor> ::= <regular primary> [<quantifier>]

<quantifier> ::= ? | * | + | '{' <m> [,[<n>]] '}'

<m>, <n> ::= unsigned int, with <m> <= <n> if both present

<regular primary> ::=
    <character> | <character class> | %
  | (<regular expression>)
```

```
<character> ::= <escaped character> | <non-escaped character>

<escaped character> ::=
  <escape-char> <special character> | <escape-char> <escape-char>

<special character> ::= any of the characters []()|^-+*%_?{}

<non-escaped character> ::=
  any character that is not a <special character>
  and not equal to <escape-char> (if defined)

<character class> ::=
    '_' | '[' <member> ... ']' | '[^' <non-member> ... ']'
  | '[' <member> ... '^' <non-member> ... ']'

<member>, <non-member> ::= <character> | <range> | <predefined class>

<range> ::= <character>-<character>

<predefined class> ::= '[:' <predefined class name> ':]'

<predefined class name> ::=
  ALPHA | UPPER | LOWER | DIGIT | ALNUM | SPACE | WHITESPACE
```

Building Regular Expressions

In this section are the elements and rules for building SQL regular expressions.

Characters

Within regular expressions, most characters represent themselves. The only exceptions are the special characters below:

```
[ ] ( ) | ^ - + * % _ ? { }
```

... and the *escape character*, if it is defined.

A regular expression that contains no special character or escape characters matches only strings that are identical to itself (subject to the collation in use). That is, it functions just like the '=' operator:

```
'Apple' similar to 'Apple'  -- true
'Apples' similar to 'Apple' -- false
'Apple' similar to 'Apples' -- false
'APPLE' similar to 'Apple'  -- depends on collation
```

Wildcards

The known SQL wildcards '_' and '%' match any single character and a string of any length, respectively:

```
'Birne' similar to 'B_rne'   -- true
'Birne' similar to 'B_ne'    -- false
'Birne' similar to 'B%ne'    -- true
'Birne' similar to 'Bir%ne%' -- true
'Birne' similar to 'Birr%ne' -- false
```

Notice how '%' also matches the empty string.

Character Classes

A bunch of characters enclosed in brackets define a character class. A character in the string matches a class in the pattern if the character is a member of the class:

```
'Citroen' similar to 'Cit[arju]oen'     -- true
'Citroen' similar to 'Ci[tr]oen'        -- false
'Citroen' similar to 'Ci[tr][tr]oen'    -- true
```

As can be seen from the second line, the class only matches a single character, not a sequence.

Within a class definition, two characters connected by a hyphen define a range. A range comprises the two endpoints and all the characters that lie between them in the active collation. Ranges can be placed anywhere in the class definition without special delimiters to keep them apart from the other elements.

```
'Datte' similar to 'Dat[q-u]e'          -- true
'Datte' similar to 'Dat[abq-uy]e'       -- true
'Datte' similar to 'Dat[bcg-km-pwz]e'   -- false
```

Predefined Character Classes

The following predefined character classes can also be used in a class definition:

`[:ALPHA:]`

Latin letters a..z and A..Z. With an accent-insensitive collation, this class also matches accented forms of these characters.

`[:DIGIT:]`

Decimal digits 0..9.

`[:ALNUM:]`

Union of `[:ALPHA:]` and `[:DIGIT:]`.

`[:UPPER:]`

Uppercase Latin letters A..Z. Also matches lowercase with case-insensitive collation and accented forms with accent-insensitive collation.

`[:LOWER:]`

Lowercase Latin letters a..z. Also matches uppercase with case-insensitive collation and accented forms with accent-insensitive collation.

`[:SPACE:]`

Matches the space character (ASCII 32).

`[:WHITESPACE:]`

Matches horizontal tab (ASCII 9), linefeed (ASCII 10), vertical tab (ASCII 11), formfeed (ASCII 12), carriage return (ASCII 13) and space (ASCII 32).

Including a predefined class has the same effect as including all its members. Predefined classes are only allowed within class definitions. If you need to match against a predefined class and nothing more, place an extra pair of brackets around it.

```
'Erdbeere' similar to 'Erd[[:ALNUM:]]eere'     -- true
'Erdbeere' similar to 'Erd[[:DIGIT:]]eere'     -- false
'Erdbeere' similar to 'Erd[a[:SPACE:]b]eere'   -- true
'Erdbeere' similar to [[:ALPHA:]]              -- false
'E'        similar to [[:ALPHA:]]              -- true
```

If a class definition starts with a caret, everything that follows is excluded from the class. All other characters match:

```
'Framboise' similar to 'Fra[^ck-p]boise'       -- false
'Framboise' similar to 'Fr[^a][^a]boise'       -- false
'Framboise' similar to 'Fra[^[:DIGIT:]]boise'  -- true
```

If the caret is not placed at the start of the sequence, the class contains everything before the caret, except for the elements that also occur after the caret:

```
'Grapefruit' similar to 'Grap[a-m^f-i]fruit'   -- true
'Grapefruit' similar to 'Grap[abc^xyz]fruit'   -- false
'Grapefruit' similar to 'Grap[abc^de]fruit'    -- false
'Grapefruit' similar to 'Grap[abe^de]fruit'    -- false

'3' similar to '[[:DIGIT:]^4-8]'               -- true
'6' similar to '[[:DIGIT:]^4-8]'               -- false
```

Lastly, the already mentioned wildcard ‘_’ is a character class of its own, matching any single character.

Quantifiers

A question mark (‘?’) immediately following a character or class indicates that the preceding item may occur 0 or 1 times in order to match:

```
'Hallon' similar to 'Hal?on'                  -- false
'Hallon' similar to 'Hal?lon'                 -- true
'Hallon' similar to 'Halll?on'                -- true
'Hallon' similar to 'Hallll?on'               -- false
'Hallon' similar to 'Halx?lon'                -- true
'Hallon' similar to 'H[a-c]?llon[x-z]?'       -- true
```

An asterisk (‘*’) immediately following a character or class indicates that the preceding item may occur 0 or more times in order to match:

```
'Icaque' similar to 'Ica*que'                 -- true
'Icaque' similar to 'Icar*que'                -- true
'Icaque' similar to 'I[a-c]*que'              -- true
'Icaque' similar to '_*'                      -- true
'Icaque' similar to '[[:ALPHA:]]*'            -- true
'Icaque' similar to 'Ica[xyz]*e'              -- false
```

A plus sign (‘+’) immediately following a character or class indicates that the preceding item must occur 1 or more times in order to match:

```
'Jujube' similar to 'Ju_+'                    -- true
'Jujube' similar to 'Ju+jube'                 -- true
'Jujube' similar to 'Jujuber+'                -- false
'Jujube' similar to 'J[jux]+be'               -- true
'Jujube' sililar to 'J[[:DIGIT:]]+ujube'      -- false
```

If a character or class is followed by a number enclosed in braces (‘{’ and ‘}’), it must be repeated exactly that number of times in order to match:

```
'Kiwi' similar to 'Ki{2}wi'                   -- false
'Kiwi' similar to 'K[ipw]{2}i'                -- true
'Kiwi' similar to 'K[ipw]{2}'                 -- false
'Kiwi' similar to 'K[ipw]{3}'                 -- true
```

If the number is followed by a comma (‘,’), the item must be repeated at least that number of times in order to match:

```
'Limone' similar to 'Li{2,}mone'              -- false
'Limone' similar to 'Li{1,}mone'              -- true
'Limone' similar to 'Li[nezom]{2,}'           -- true
```

If the braces contain two numbers separated by a comma, the second number not smaller than the first, then the item must be repeated at least the first number and at most the second number of times in order to match:

```
'Mandarijn' similar to 'M[a-p]{2,5}rijn'       -- true
'Mandarijn' similar to 'M[a-p]{2,3}rijn'       -- false
'Mandarijn' similar to 'M[a-p]{2,3}arijn'      -- true
```

The quantifiers '?', '*' and '+' are shorthand for `{0,1}`, `{0,}` and `{1,}`, respectively.

OR-ing Terms

Regular expression terms can be OR'ed with the '|' operator. A match is made when the argument string matches at least one of the terms:

```
'Nektarin' similar to 'Nek|tarin'              -- false
'Nektarin' similar to 'Nektarin|Persika'       -- true
'Nektarin' similar to 'M_+|N_+|P_+'            -- true
```

Subexpressions

One or more parts of the regular expression can be grouped into subexpressions (also called subpatterns) by placing them between parentheses ('(' and ')'). A subexpression is a regular expression in its own right. It can contain all the elements allowed in a regular expression, and can also have quantifiers added to it.

```
'Orange' similar to 'O(ra|ri|ro)nge'           -- true
'Orange' similar to 'O(r[a-e])+nge'            -- true
'Orange' similar to 'O(ra){2,4}nge'            -- false
'Orange' similar to 'O(r(an|in)g|rong)?e'      -- true
```

Escaping Special Characters

In order to match against a character that is special in regular expressions, that character has to be escaped. There is no default escape character; rather, the user specifies one when needed:

```
'Peer (Poire)' similar to 'P[^ ]+ \(P[^ ]+\)' escape '\'    -- true
'Pera [Pear]'  similar to 'P[^ ]+ #[P[^ ]+#]' escape '#'    -- true
'Päron-äppledryck' similar to 'P%$-ä%' escape '$'           -- true
'Pärondryck' similar to 'P%--ä%' escape '-'                 -- false
```

The last line demonstrates that the escape character can also escape itself, if needed.

`IS [NOT] DISTINCT FROM`

Available in

DSQL, PSQL

Syntax

```
<operand1> IS [NOT] DISTINCT FROM <operand2>
```

Two operands are considered *DISTINCT* (different) if they have a different value or if one of them is NULL and the other non-null. They are considered *NOT DISTINCT* (equal) if they have the same value or if both of them are NULL.

IS [NOT] DISTINCT FROM always returns TRUE or FALSE and never UNKNOWN (NULL) (unknown value). Operators '=' and '<>', conversely, will return UNKNOWN (NULL) if one or both operands are NULL.

Table 26. Results of Various Comparison Predicates

Operand values	**Result of various predicates**			
	=	IS NOT DISTINCT FROM	<>	IS DISTINCT FROM
Same value	TRUE	TRUE	FALSE	FALSE
Different values	FALSE	FALSE	TRUE	TRUE
Both NULL	UNKNOWN	TRUE	UNKNOWN	FALSE
One NULL, one non-NULL	UNKNOWN	FALSE	UNKNOWN	TRUE

Examples

```
SELECT ID, NAME, TEACHER
FROM COURSES
WHERE START_DAY IS NOT DISTINCT FROM END_DAY;

-- PSQL fragment
IF (NEW.JOB IS DISTINCT FROM OLD.JOB)
THEN POST_EVENT 'JOB_CHANGED';
```

See also

IS [NOT] NULL, Boolean IS [NOT]

Boolean IS [NOT]

Available in

DSQL, PSQL

Syntax

```
<value> IS [NOT] { TRUE | FALSE | UNKNOWN }
```

The IS predicate with Boolean literal values checks if the expression on the left side matches the

Boolean value on the right side. The expression on the left side must be of type BOOLEAN, otherwise an exception is raised.

The IS [NOT] UNKNOWN is equivalent to IS [NOT] NULL.

The right side of the predicate only accepts the literals TRUE, FALSE and UNKNOWN (and NULL). It does not accept expressions.

Using the IS predicate with a Boolean data type

```
-- Checking FALSE value
SELECT * FROM TBOOL WHERE BVAL IS FALSE;

ID            BVAL
============= =======
2             <false>

-- Checking UNKNOWN value
SELECT * FROM TBOOL WHERE BVAL IS UNKNOWN;

ID            BVAL
============= =======
3             <null>
```

See also

IS [NOT] NULL

IS [NOT] NULL

Available in

DSQL, PSQL, ESQL

Syntax

```
<value> IS [NOT] NULL
```

Since NULL is not a value, these operators are not comparison operators. The IS [NOT] NULL predicate tests that the expression on the left side has a value (*IS NOT NULL*) or has no value (*IS NULL*).

Example

Search for sales entries that have no shipment date set for them:

```
SELECT * FROM SALES
WHERE SHIP_DATE IS NULL;
```

Note regarding the IS predicates

Up to and including Firebird 2.5, the IS predicates, like the other comparison predicates, do not have precedence over the others. In Firebird 3.0 and higher,

these predicates take precedence above the others.

4.2.3. Existential Predicates

This group of predicates includes those that use subqueries to submit values for all kinds of assertions in search conditions. Existential predicates are so called because they use various methods to test for the *existence* or *non-existence* of some condition, returning `TRUE` if the existence or non-existence is confirmed or `FALSE` otherwise.

`EXISTS`

Available in

DSQL, PSQL, ESQL

Syntax

```
[NOT] EXISTS (<select_stmt>)
```

The `EXISTS` predicate uses a subquery expression as its argument. It returns `TRUE` if the subquery result would contain at least one row; otherwise it returns `FALSE`.

`NOT EXISTS` returns `FALSE` if the subquery result would contain at least one row; it returns `TRUE` otherwise.

The subquery can specify multiple columns, or `SELECT *`, because the evaluation is made on the number of rows that match its criteria, not on the data.

Examples

1. Find those employees who have projects.

```
SELECT *
FROM employee
WHERE EXISTS(SELECT *
             FROM  employee_project ep
             WHERE ep.emp_no = employee.emp_no)
```

2. Find those employees who have no projects.

```
SELECT *
FROM employee
WHERE NOT EXISTS(SELECT *
                 FROM employee_project ep
                 WHERE ep.emp_no = employee.emp_no)
```

`IN`

Available in

DSQL, PSQL, ESQL

Syntax

```
<value> [NOT] IN (<select_stmt> | <value_list>)

<value_list> ::= <value_1> [, <value_2> ⋯]
```

The `IN` predicate tests whether the value of the expression on the left side is present in the set of values specified on the right side. The set of values cannot have more than 1500 items. The `IN` predicate can be replaced with the following equivalent forms:

```
(<value> = <value_1> [OR <value> = <value_2> ⋯])

<value> = { ANY | SOME } (<select_stmt>)
```

When the `IN` predicate is used in the search conditions of DML queries, the Firebird optimizer can use an index on the searched column, if a suitable one exists.

In its second form, the `IN` predicate tests whether the value of the expression on the left side is present — or not present, if `NOT IN` is used — in the result of the executed subquery on the right side.

The subquery must be specified to result in only one column, otherwise the error "*count of column list and variable list do not match*" will occur.

Queries specified using the `IN` predicate with a subquery can be replaced with a similar query using the `EXISTS` predicate. For instance, the following query:

```
SELECT
  model, speed, hd
FROM PC
WHERE
model IN (SELECT model
          FROM product
          WHERE maker = 'A');
```

can be replaced with a similar one using the EXISTS predicate:

```
SELECT
  model, speed, hd
FROM PC
WHERE
 EXISTS (SELECT *
         FROM product
         WHERE maker = 'A'
           AND product.model = PC.model);
```

However, a query using NOT IN with a subquery does not always give the same result as its NOT EXISTS counterpart. The reason is that EXISTS always returns TRUE or FALSE, whereas IN returns NULL in one of these two cases:

a. when the test value is NULL and the IN () list is not empty
b. when the test value has no match in the IN () list and at least one list element is NULL

It is in only these two cases that IN () will return NULL while the corresponding EXISTS predicate will return FALSE ('no matching row found'). In a search or, for example, an IF (…) statement, both results mean “failure” and it makes no difference to the outcome.

But, for the same data, NOT IN () will return NULL, while NOT EXISTS will return TRUE, leading to opposite results.

As an example, suppose you have the following query:

```
-- Looking for people who were not born
-- on the same day as any famous New York citizen
SELECT P1.name AS NAME
FROM Personnel P1
WHERE P1.birthday NOT IN (SELECT C1.birthday
                          FROM Celebrities C1
                          WHERE C1.birthcity = 'New York');
```

Now, assume that the NY celebrities list is not empty and contains at least one NULL birthday. Then for every citizen who does not share his birthday with a NY celebrity, NOT IN will return NULL, because that is what IN does. The search condition is thereby not satisfied and the citizen will be left out of the SELECT result, which is wrong.

For citizens whose birthday does match with a celebrity’s birthday, NOT IN will correctly return FALSE, so they will be left out too, and no rows will be returned.

If the NOT EXISTS form is used:

```
-- Looking for people who were not born
-- on the same day as any famous New York citizen
SELECT P1.name AS NAME
FROM Personnel P1
WHERE NOT EXISTS (SELECT *
                  FROM Celebrities C1
                  WHERE C1.birthcity = 'New York'
                    AND C1.birthday = P1.birthday);
```

non-matches will have a NOT EXISTS result of TRUE and their records will be in the result set.

If there is any chance of NULLs being encountered when searching for a non-match, you will want to use NOT EXISTS.

Examples of use

1. Find employees with the names “Pete”, “Ann” and “Roger”:

```
SELECT *
FROM EMPLOYEE
WHERE FIRST_NAME IN ('Pete', 'Ann', 'Roger');
```

2. Find all computers that have models whose manufacturer starts with the letter “A”:

```
SELECT
  model, speed, hd
FROM PC
WHERE
  model IN (SELECT model
            FROM product
            WHERE maker STARTING WITH 'A');
```

See also

EXISTS

SINGULAR

Available in

DSQL, PSQL, ESQL

Syntax

```
[NOT] SINGULAR (<select_stmt>)
```

The `SINGULAR` predicate takes a subquery as its argument and evaluates it as TRUE if the subquery returns exactly one result row; otherwise the predicate is evaluated as FALSE. The subquery may list several output columns since the rows are not returned anyway. They are only tested for (singular) existence. For brevity, people usually specify ‘`SELECT *`’. The `SINGULAR` predicate can return only two values: `TRUE` or `FALSE`.

Example

Find those employees who have only one project.

```
SELECT *
FROM employee
WHERE SINGULAR(SELECT *
               FROM employee_project ep
               WHERE ep.emp_no = employee.emp_no)
```

4.2.4. Quantified Subquery Predicates

A quantifier is a logical operator that sets the number of objects for which this condition is true. It is not a numeric quantity, but a logical one that connects the condition with the full set of possible objects. Such predicates are based on logical universal and existential quantifiers that are recognised in formal logic.

In subquery expressions, quantified predicates make it possible to compare separate values with the results of subqueries; they have the following common form:

```
<value expression> <comparison operator> <quantifier> <subquery>
```

ALL

Available in

DSQL, PSQL, ESQL

Syntax

```
<value> <op> ALL (<select_stmt>)
```

When the ALL quantifier is used, the predicate is TRUE if every value returned by the subquery satisfies the condition in the predicate of the main query.

Example

Show only those clients whose ratings are higher than the rating of every client in Paris.

```
SELECT c1.*
FROM Customers c1
WHERE c1.rating > ALL
      (SELECT c2.rating
       FROM Customers c2
       WHERE c2.city = 'Paris')
```

If the subquery returns an empty set, the predicate is TRUE for every left-side value, regardless of the operator. This may appear to be contradictory, because every left-side value will thus be considered both smaller and greater than, both equal to and unequal to, every element of the right-side stream.

Nevertheless, it aligns perfectly with formal logic: if the set is empty, the predicate is true 0 times, i.e. for every row in the set.

ANY and SOME

Available in

DSQL, PSQL, ESQL

Syntax

```
<value> <op> {ANY | SOME} (<select_stmt>)
```

The quantifiers `ANY` and `SOME` are identical in their behaviour. Apparently, both are present in the SQL standard so that they could be used interchangeably in order to improve the readability of operators. When the `ANY` or the `SOME` quantifier is used, the predicate is TRUE if any of the values returned by the subquery satisfies the condition in the predicate of the main query. If the subquery would return no rows at all, the predicate is automatically considered as FALSE.

Example

Show only those clients whose ratings are higher than those of one or more clients in Rome.

```
SELECT *
FROM Customers
WHERE rating > ANY
      (SELECT rating
       FROM Customers
       WHERE city = 'Rome')
```

Chapter 5. Data Definition (DDL) Statements

DDL is the data definition language subset of Firebird's SQL language. DDL statements are used to create, modify and delete database objects that have been created by users. When a DDL statement is committed, the metadata for the object are created, changed or deleted.

5.1. DATABASE

This section describes how to create a database, connect to an existing database, alter the file structure of a database and how to delete one. It also explains how to back up a database in two quite different ways and how to switch the database to the "copy-safe" mode for performing an external backup safely.

5.1.1. CREATE DATABASE

Used for

Creating a new database

Available in

DSQL, ESQL

Syntax

```
CREATE {DATABASE | SCHEMA} <filespec>
  [<db_initial_option> [<db_initial_option> ...]]
  [<db_config_option> [<db_config_option> ...]]

<db_initial_option> ::=
    USER username
  | PASSWORD 'password'
  | ROLE rolename
  | PAGE_SIZE [=] size
  | LENGTH [=] num [PAGE[S]]
  | SET NAMES 'charset'

<db_config_option> ::=
    DEFAULT CHARACTER SET default_charset
      [COLLATION collation] -- not supported in ESQL
  | <sec_file>
  | DIFFERENCE FILE 'diff_file' -- not supported in ESQL

<filespec> ::= "'" [server_spec]{filepath | db_alias} "'"

<server_spec> ::=
    host[/{port | service}]:
  | \\host\
  | <protocol>://[host[:{port | service}]/]

<protocol> ::= inet | inet4 | inet6 | wnet | xnet
```

```
<sec_file> ::=
  FILE 'filepath'
  [LENGTH [=] num [PAGE[S]]
  [STARTING [AT [PAGE]] pagenum]
```

Each *db_initial_option* and *db_config_option* can occur at most once, except *sec_file*, which can occur zero or more times.

Table 27. CREATE DATABASE Statement Parameters

Parameter	Description
filespec	File specification for primary database file
server_spec	Remote server specification. Some protocols require specifying a hostname. Optionally includes a port number or service name. Required if the database is created on a remote server.
filepath	Full path and file name including its extension. The file name must be specified according to the rules of the platform file system being used.
db_alias	Database alias previously created in the `databases.conf` file
host	Host name or IP address of the server where the database is to be created
port	The port number where the remote server is listening (parameter *RemoteServicePort* in `firebird.conf` file)
service	Service name. Must match the parameter value of *RemoteServiceName* in `firebird.conf` file)
username	Username of the owner of the new database. The maximum length is 63 characters. The username can optionally be enclosed in single or double quotes. When a username is enclosed in double quotes, it is case-sensitive following the rules for quoted identifiers. When enclosed in single quotes, it behaves as if the value was specified without quotes. The user must be an administrator or have the `CREATE DATABASE` privilege.
password	Password of the user as the database owner. When using the `Legacy_Auth` authentication plugin, only the first 8 characters are used. Case-sensitive
rolename	The name of the role whose rights should be taken into account when creating a database. The role name can be enclosed in single or double quotes. When the role name is enclosed in double quotes, it is case-sensitive following the rules for quoted identifiers. When enclosed in single quotes, it behaves as if the value was specified without quotes.
size	Page size for the database, in bytes. Possible values are 4096, 8192, 16384 and 32768. The default page size is 8192.
num	Maximum size of the primary database file, or a secondary file, in pages
charset	Specifies the character set of the connection available to a client connecting after the database is successfully created. Single quotes are required.

Parameter	Description
default_charset	Specifies the default character set for string data types
collation	Default collation for the default character set
sec_file	File specification for a secondary file
pagenum	Starting page number for a secondary database file
diff_file	File path and name for DIFFERENCE files (.delta files) for backup mode

The `CREATE DATABASE` statement creates a new database. You can use `CREATE DATABASE` or `CREATE SCHEMA`. They are synonymous, but we recommend to always use `CREATE DATABASE` as this may change in a future version of Firebird.

A database may consist of one or several files. The first (main) file is called the *primary file*, subsequent files are called *secondary file(s)*.

Multi-file Databases

Nowadays, multi-file databases are considered an anachronism. It made sense to use multi-file databases on old file systems where the size of any file is limited. For instance, you could not create a file larger than 4 GB on FAT32.

The primary file specification is the name of the database file and its extension with the full path to it according to the rules of the OS platform file system being used. The database file must not exist at the moment the database is being created. If it does exist, you will get an error message, and the database will not be created.

If the full path to the database is not specified, the database will be created in one of the system directories. The particular directory depends on the operating system. For this reason, unless you have a strong reason to prefer that situation, always specify either the absolute path or an *alias*, when creating a database.

Using a Database Alias

You can use aliases instead of the full path to the primary database file. Aliases are defined in the `databases.conf` file in the following format:

```
alias = filepath
```

Executing a `CREATE DATABASE` statement requires special consideration in the client application or database driver. As a result, it is not always possible to execute a `CREATE DATABASE` statement. Some drivers provide other ways to create databases. For example, Jaybird provides the class `org.firebirdsql.management.FBManager` to programmatically create a database.

If necessary, you can always fallback to *isql* to create a database.

Creating a Database on a Remote Server

If you create a database on a remote server, you need to specify the remote server specification. The remote server specification depends on the protocol being used. If you use the TCP/IP protocol to create a database, the primary file specification should look like this:

```
host[/{port|service}]:{filepath | db_alias}
```

If you use the Named Pipes protocol to create a database on a Windows server, the primary file specification should look like this:

```
\\host\{filepath | db_alias}
```

Firebird also has a unified URL-like syntax for the remote server specification. In this syntax, the first part specifies the name of the protocol, then a host name or IP address, port number, and path of the primary database file, or an alias.

The following values can be specified as the protocol:

inet

TCP/IP (first tries to connect using the IPv6 protocol, if it fails, then IPv4)

inet4

TCP/IP v4

inet6

TCP/IP v6

wnet

NetBEUI or Named Pipes Protocol

xnet

local protocol (does not include a host, port and service name)

```
<protocol>://[host[:{port | service}]/]{filepath | db_alias}
```

Optional Parameters for `CREATE DATABASE`

`USER` and `PASSWORD`

Clauses for specifying the username and the password, respectively, of an existing user in the security database (`security4.fdb` or whatever is configured in the *SecurityDatabase* configuration). You do not have to specify the username and password if the `ISC_USER` and `ISC_PASSWORD` environment variables are set. The user specified in the process of creating the database will be its owner. This will be important when considering database and object privileges.

`ROLE`

The `ROLE` clause specifies the name of the role (usually `RDB$ADMIN`), which will be taken into account when creating the database. The role must be assigned to the user in the applicable security database.

`PAGE_SIZE`

Clause for specifying the database page size. This size will be set for the primary file and all secondary files of the database. If you specify the database page size less than 4,096, it will be automatically rounded up to 4,096. Other values not equal to either 4,096, 8,192, 16,384 or 32,768 will be changed to the closest smaller supported value. If the database page size is not specified, it is set to the default value of 8,192.

Bigger Isn't Always Better.

Larger page sizes can fit more records on a single page, have wider indexes, and more indexes, but they will also waste more space for blobs (compare the wasted space of a 3KB blob on page size 4096 with one on 32768: +/- 1KB vs +/- 29KB), and increase memory consumption of the page cache.

`LENGTH`

Clause specifying the maximum size of the primary or secondary database file, in pages. When a database is created, its primary and secondary files will occupy the minimum number of pages necessary to store the system data, regardless of the value specified in the `LENGTH` clause. The `LENGTH` value does not affect the size of the only (or last, in a multi-file database) file. The file will keep increasing its size automatically when necessary.

`SET NAMES`

Clause specifying the character set of the connection available after the database is successfully created. The character set `NONE` is used by default. Notice that the character set should be enclosed in a pair of apostrophes (single quotes).

`DEFAULT CHARACTER SET`

Clause specifying the default character set for creating data structures of string data types. Character sets are used for `CHAR`, `VARCHAR` and `BLOB SUB_TYPE TEXT` data types. The character set `NONE` is used by default. It is also possible to specify the default `COLLATION` for the default character set, making that collation sequence the default for the default character set. The default will be used for the entire database except where an alternative character set, with or without a specified collation, is used explicitly for a field, domain, variable, cast expression, etc.

`STARTING AT`

Clause that specifies the database page number at which the next secondary database file should start. When the previous file is completely filled with data according to the specified page number, the system will start adding new data to the next database file.

`DIFFERENCE FILE`

Clause specifying the path and name for the file delta that stores any mutations to the database file after it has been switched to the "copy-safe" mode by the `ALTER DATABASE BEGIN BACKUP` statement. For the detailed description of this clause, see `ALTER DATABASE`.

Specifying the Database Dialect

Databases are created in Dialect 3 by default. For the database to be created in SQL dialect 1, you will need to execute the statement `SET SQL DIALECT 1` from script or the client application, e.g. in *isql*, before the `CREATE DATABASE` statement.

Who Can Create a Database

The `CREATE DATABASE` statement can be executed by:

- Administrators
- Users with the `CREATE DATABASE` privilege

Examples Using `CREATE DATABASE`

1. Creating a database in Windows, located on disk D with a page size of 4,096. The owner of the database will be the user *wizard*. The database will be in Dialect , and will use `WIN1251` as its default character set.

```
SET SQL DIALECT 1;
CREATE DATABASE 'D:\test.fdb'
USER 'wizard' PASSWORD 'player'
PAGE_SIZE = 4096 DEFAULT CHARACTER SET WIN1251;
```

2. Creating a database in the Linux operating system with a page size of 8,192 (default). The owner of the database will be the user *wizard*. The database will be in Dialect 3 and will use `UTF8` as its default character set, with `UNICODE_CI_AI` as the default collation.

```
CREATE DATABASE '/home/firebird/test.fdb'
USER 'wizard' PASSWORD 'player'
DEFAULT CHARACTER SET UTF8 COLLATION UNICODE_CI_AI;
```

3. Creating a database on the remote server “baseserver” with the path specified in the alias “test” that has been defined previously in the file `databases.conf`. The TCP/IP protocol is used. The owner of the database will be the user *wizard*. The database will be in Dialect 3 and will use `UTF8` as its default character set.

```
CREATE DATABASE 'baseserver:test'
USER 'wizard' PASSWORD 'player'
DEFAULT CHARACTER SET UTF8;
```

4. Creating a database in Dialect 3 with `UTF8` as its default character set. The primary file will contain up to 10,000 pages with a page size of 8,192. As soon as the primary file has reached the maximum number of pages, Firebird will start allocating pages to the secondary file `test.fdb2`. If that file is filled up to its maximum as well, `test.fdb3` becomes the recipient of all new page allocations. As the last file, it has no page limit imposed on it by Firebird. New allocations will

continue for as long as the file system allows it or until the storage device runs out of free space. If a LENGTH parameter were supplied for this last file, it would be ignored.

```
SET SQL DIALECT 3;
CREATE DATABASE 'baseserver:D:\test.fdb'
USER 'wizard' PASSWORD 'player'
PAGE_SIZE = 8192
DEFAULT CHARACTER SET UTF8
FILE 'D:\test.fdb2'
STARTING AT PAGE 10001
FILE 'D:\test.fdb3'
STARTING AT PAGE 20001;
```

5. Creating a database in Dialect 3 with UTF8 as its default character set. The primary file will contain up to 10,000 pages with a page size of 8,192. As far as file size and the use of secondary files are concerned, this database will behave exactly like the one in the previous example.

```
SET SQL DIALECT 3;
CREATE DATABASE 'baseserver:D:\test.fdb'
USER 'wizard' PASSWORD 'player'
PAGE_SIZE = 8192
LENGTH 10000 PAGES
DEFAULT CHARACTER SET UTF8
FILE 'D:\test.fdb2'
FILE 'D:\test.fdb3'
STARTING AT PAGE 20001;
```

See also

ALTER DATABASE, DROP DATABASE

5.1.2. ALTER DATABASE

Used for

Altering the file organisation of a database, toggling its “copy-safe” state, managing encryption, and other database-wide configuration

Available in

DSQL, ESQL — limited feature set

Syntax

```
ALTER {DATABASE | SCHEMA} <alter_db_option> [<alter_db_option> ...]

<alter_db_option> :==
    <add_sec_clause>
  | {ADD DIFFERENCE FILE 'diff_file' | DROP DIFFERENCE FILE}
  | {BEGIN | END} BACKUP
  | SET DEFAULT CHARACTER SET charset
```

```
  | {ENCRYPT WITH plugin_name [KEY key_name] | DECRYPT}
  | SET LINGER TO linger_duration
  | DROP LINGER
  | SET DEFAULT SQL SECURITY {INVOKER | DEFINER}
  | {ENABLE | DISABLE} PUBLICATION
  | INCLUDE <pub_table_filter> TO PUBLICATION
  | EXCLUDE <pub_table_filter> FROM PUBLICATION

<add_sec_clause> ::= ADD <sec_file> [<sec_file> ...]

<sec_file> ::=
  FILE 'filepath'
  [STARTING [AT [PAGE]] pagenum]
  [LENGTH [=] num [PAGE[S]]

<pub_table_filter> ::=
    ALL
  | TABLE table_name [, table_name ...]
```

Multiple files can be added in one ADD clause:

```
ALTER DATABASE
  ADD FILE x LENGTH 8000
    FILE y LENGTH 8000
    FILE z
```

Multiple occurrences of *add_sec_clause* (`ADD FILE` clauses) are allowed; an `ADD FILE` clause that adds multiple files (as in the example above) can be mixed with others that add only one file. The statement was documented incorrectly in the old *InterBase 6 Language Reference*.

Table 28. `ALTER DATABASE` *Statement Parameters*

Parameter	Description
add_sec_clause	Adding a secondary database file
sec_file	File specification for secondary file
filepath	Full path and file name of the delta file or secondary database file
pagenum	Page number from which the secondary database file is to start
num	Maximum size of the secondary file in pages
diff_file	File path and name of the .delta file (difference file)
charset	New default character set of the database
linger_duration	Duration of *linger* delay in seconds; must be greater than or equal to 0 (zero)
plugin_name	The name of the encryption plugin

Parameter	Description
key_name	The name of the encryption key
pub_table_filter	Filter of tables to include to or exclude from publication
table_name	Name (identifier) of a table

The ALTER DATABASE statement can:

- add secondary files to a database
- switch a single-file database into and out of the “copy-safe” mode (DSQL only)
- set or unset the path and name of the delta file for physical backups (DSQL only)

SCHEMA is currently a synonym for DATABASE; this may change in a future version, so we recommend to always use DATABASE

Who Can Alter the Database

The ALTER DATABASE statement can be executed by:

- Administrators
- Users with the ALTER DATABASE privilege

Parameters for ALTER DATABASE

ADD (FILE)

Adds secondary files to the database. It is necessary to specify the full path to the file and the name of the secondary file. The description for the secondary file is similar to the one given for the CREATE DATABASE statement.

ADD DIFFERENCE FILE

Specifies the path and name of the delta file that stores any mutations to the database whenever it is switched to the “copy-safe” mode. This clause does not actually add any file. It just overrides the default name and path of the .delta file. To change the existing settings, you should delete the previously specified description of the .delta file using the DROP DIFFERENCE FILE clause before specifying the new description of the delta file. If the path and name of the .delta file are not overridden, the file will have the same path and name as the database, but with the .delta file extension.

If only a file name is specified, the .delta file will be created in the current directory of the server. On Windows, this will be the system directory — a very unwise location to store volatile user files and contrary to Windows file system rules.

DROP DIFFERENCE FILE

Deletes the description (path and name) of the .delta file specified previously in the ADD DIFFERENCE FILE clause. The file is not actually deleted. DROP DIFFERENCE FILE deletes the path and name of the .delta file from the database header. Next time the database is switched to the “copy-

safe" mode, the default values will be used (i.e. the same path and name as those of the database, but with the .delta extension).

`BEGIN BACKUP`

Switches the database to the "copy-safe" mode. `ALTER DATABASE` with this clause freezes the main database file, making it possible to back it up safely using file system tools, even if users are connected and performing operations with data. Until the backup state of the database is reverted to *NORMAL*, all changes made to the database will be written to the .delta (difference) file.

Despite its syntax, a statement with the `BEGIN BACKUP` clause does not start a backup process but just creates the conditions for doing a task that requires the database file to be read-only temporarily.

`END BACKUP`

Switches the database from the "copy-safe" mode to the normal mode. A statement with this clause merges the .delta file with the main database file and restores the normal operation of the database. Once the `END BACKUP` process starts, the conditions no longer exist for creating safe backups by means of file system tools.

Use of `BEGIN BACKUP` and `END BACKUP` and copying the database files with filesystem tools, is *not safe* with multi-file databases! Use this method only on single-file databases.

Making a safe backup with the *gbak* utility remains possible at all times, although it is not recommended running *gbak* while the database is in *LOCKED* or *MERGE* state.

`SET DEFAULT CHARACTER SET`

Changes the default character set of the database. This change does not affect existing data or columns. The new default character set will only be used in subsequent DDL commands.

`ENCRYPT WITH`

See Encrypting a Database in the Security chapter.

`DECRYPT`

See Decrypting a Database in the Security chapter.

`SET LINGER TO`

Sets the *linger*-delay. The *linger*-delay applies only to Firebird SuperServer, and is the number of seconds the server keeps a database file (and its caches) open after the last connection to that database was closed. This can help to improve performance at low cost, when the database is opened and closed frequently, by keeping resources "warm" for the next connection.

This mode can be useful for web applications - without a connection pool - where the connection to the database usually "lives" for a very short time.

The `SET LINGER TO` and `DROP LINGER` clauses can be combined in a single statement, but the last clause "wins". For example, `ALTER DATABASE SET LINGER TO 5 DROP LINGER` will set the *linger*-delay to 0 (no linger), while `ALTER DATABASE DROP LINGER SET LINGER to 5` will set the *linger*-delay to 5 seconds.

DROP LINGER

Drops the *linger*-delay (sets it to zero). Using `DROP LINGER` is equivalent to using `SET LINGER TO 0`.

Dropping `LINGER` is not an ideal solution for the occasional need to turn it off for some once-only condition where the server needs a forced shutdown. The *gfix* utility now has the `-NoLinger` switch, which will close the specified database immediately after the last attachment is gone, regardless of the `LINGER` setting in the database. The `LINGER` setting is retained and works normally the next time.

The same one-off override is also available through the Services API, using the tag `isc_spb_prp_nolinger`, e.g. (in one line):

```
fbsvcmgr host:service_mgr user sysdba password xxx
       action_properties dbname employee prp_nolinger
```

The `DROP LINGER` and `SET LINGER TO` clauses can be combined in a single statement, but the last clause "wins".

SET DEFAULT SQL SECURITY

Specifies the default `SQL SECURITY` option to apply at runtime for objects without the SQL Security property set. See also *SQL Security* in chapter *Security*.

ENABLE PUBLICATION

Enables publication of this database for replication. Replication begins (or continues) with the next transaction started after this transaction commits.

DISABLE PUBLICATION

Enables publication of this database for replication. Replication is disabled immediately after commit.

EXCLUDE ⋯ FROM PUBLICATION

Excludes tables from publication. If `INCLUDE ALL TO PUBLICATION` clause is used, then all tables created afterwards will also be replicated, unless overridden explicitly in the `CREATE TABLE` statement.

INCLUDE ⋯ TO PUBLICATION

Includes tables to publication. If `INCLUDE ALL TO PUBLICATION` clause is used, then all tables created afterwards will also be replicated, unless overridden explicitly in the `CREATE TABLE` statement.

Replication

- Other than the syntax, configuring Firebird for replication is not covered in this language reference.
- All replication management commands are DDL statements and thus effectively executed at the transaction commit time.

Examples of `ALTER DATABASE` Usage

1. Adding a secondary file to the database. As soon as 30000 pages are filled in the previous primary or secondary file, the Firebird engine will start adding data to the secondary file `test4.fdb`.

```
ALTER DATABASE
  ADD FILE 'D:\test4.fdb'
    STARTING AT PAGE 30001;
```

2. Specifying the path and name of the delta file:

```
ALTER DATABASE
  ADD DIFFERENCE FILE 'D:\test.diff';
```

3. Deleting the description of the delta file:

```
ALTER DATABASE
  DROP DIFFERENCE FILE;
```

4. Switching the database to the “copy-safe” mode:

```
ALTER DATABASE
  BEGIN BACKUP;
```

5. Switching the database back from the “copy-safe” mode to the normal operation mode:

```
ALTER DATABASE
  END BACKUP;
```

6. Changing the default character set for a database to `WIN1251`

```
ALTER DATABASE
  SET DEFAULT CHARACTER SET WIN1252;
```

7. Setting a *linger*-delay of 30 seconds

```
ALTER DATABASE
  SET LINGER TO 30;
```

8. Encrypting the database with a plugin called `DbCrypt`

```
ALTER DATABASE
  ENCRYPT WITH DbCrypt;
```

9. Decrypting the database

```
ALTER DATABASE
  DECRYPT;
```

See also

`CREATE DATABASE`, `DROP DATABASE`

5.1.3. DROP DATABASE

Used for

Deleting the database to which you are currently connected

Available in

DSQL, ESQL

Syntax

```
DROP DATABASE
```

The `DROP DATABASE` statement deletes the current database. Before deleting a database, you have to connect to it. The statement deletes the primary file, all secondary files and all shadow files.

Contrary to `CREATE DATABASE` and `ALTER DATABASE`, `DROP SCHEMA` is not a valid alias for `DROP DATABASE`. This is intentional.

Who Can Drop a Database

The `DROP DATABASE` statement can be executed by:

- Administrators
- Users with the `DROP DATABASE` privilege

Example of `DROP DATABASE`

Deleting the current database

```
DROP DATABASE;
```

See also

`CREATE DATABASE`, `ALTER DATABASE`

5.2. SHADOW

A *shadow* is an exact, page-by-page copy of a database. Once a shadow is created, all changes made in the database are immediately reflected in the shadow. If the primary database file becomes unavailable for some reason, the DBMS will switch to the shadow.

This section describes how to create and delete shadow files.

5.2.1. CREATE SHADOW

Used for

Creating a shadow for the current database

Available in

DSQL, ESQL

Syntax

```
CREATE SHADOW <sh_num> [{AUTO | MANUAL}] [CONDITIONAL]
  'filepath' [LENGTH [=] num [PAGE[S]]]
  [<secondary_file> ...]

<secondary_file> ::=
  FILE 'filepath'
  [STARTING [AT [PAGE]] pagenum]
  [LENGTH [=] num [PAGE[S]]]
```

Table 29. `CREATE SHADOW` Statement Parameters

Parameter	Description
sh_num	Shadow number — a positive number identifying the shadow set
filepath	The name of the shadow file and the path to it, in accord with the rules of the operating system
num	Maximum shadow size, in pages
secondary_file	Secondary file specification
page_num	The number of the page at which the secondary shadow file should start

The `CREATE SHADOW` statement creates a new shadow. The shadow starts duplicating the database right at the moment it is created. It is not possible for a user to connect to a shadow.

Like a database, a shadow may be multi-file. The number and size of a shadow's files are not related to the number and size of the files of database it is shadowing.

The page size for shadow files is set to be equal to the database page size and cannot be changed.

If a calamity occurs involving the original database, the system converts the shadow to a copy of the database and switches to it. The shadow is then *unavailable*. What happens next depends on the `MODE` option.

`AUTO | MANUAL` Modes

When a shadow is converted to a database, it becomes unavailable. A shadow might alternatively become unavailable because someone accidentally deletes its file, or the disk space where the shadow files are stored is exhausted or is itself damaged.

- If the AUTO mode is selected (the default value), shadowing ceases automatically, all references to it are deleted from the database header, and the database continues functioning normally.

  If the `CONDITIONAL` option was set, the system will attempt to create a new shadow to replace the lost one. It does not always succeed, however, and a new one may need to be created manually.

- If the MANUAL mode attribute is set when the shadow becomes unavailable, all attempts to connect to the database and to query it will produce error messages. The database will remain inaccessible until either the shadow again becomes available, or the database administrator deletes it using the `DROP SHADOW` statement. `MANUAL` should be selected if continuous shadowing is more important than uninterrupted operation of the database.

Options for `CREATE SHADOW`

`LENGTH`

Specifies the maximum size of the primary or secondary shadow file in pages. The `LENGTH` value does not affect the size of the only shadow file, nor the last if it is a set. The last (or only) file will keep automatically growing as long as it is necessary.

`STARTING AT`

Specifies the shadow page number at which the next shadow file should start. The system will start adding new data to the next shadow file when the previous file is filled with data up to the specified page number.

You can verify the sizes, names and location of the shadow files by connecting to the database using *isql* and running the command `SHOW DATABASE;`

Who Can Create a Shadow

The `CREATE SHADOW` statement can be executed by:

- Administrators
- Users with the `ALTER DATABASE` privilege

Examples Using CREATE SHADOW

1. Creating a shadow for the current database as “shadow number 1”:

```
CREATE SHADOW 1 'g:\data\test.shd';
```

2. Creating a multi-file shadow for the current database as “shadow number 2”:

```
CREATE SHADOW 2 'g:\data\test.sh1'
  LENGTH 8000 PAGES
  FILE 'g:\data\test.sh2';
```

See also

CREATE DATABASE, DROP SHADOW

5.2.2. DROP SHADOW

Used for

Deleting a shadow from the current database

Available in

DSQL, ESQL

Syntax

```
DROP SHADOW sh_num
  [{DELETE | PRESERVE} FILE]
```

Table 30. DROP SHADOW Statement Parameter

Parameter	Description
sh_num	Shadow number — a positive number identifying the shadow set

The DROP SHADOW statement deletes the specified shadow for the current database. When a shadow is dropped, all files related to it are deleted and shadowing to the specified *sh_num* ceases. The optional DELETE FILE clause makes this behaviour explicit. On the contrary, the PRESERVE FILE clause will remove the shadow from the database, but the file itself will not be deleted.

Who Can Drop a Shadow

The DROP SHADOW statement can be executed by:

- Administrators
- Users with the ALTER DATABASE privilege

Example of DROP SHADOW

Deleting "shadow number 1".

```
DROP SHADOW 1;
```

See also

CREATE SHADOW

5.3. DOMAIN

DOMAIN is one of the object types in a relational database. A domain is created as a specific data type with some attributes attached to it. Once it has been defined in the database, it can be reused repeatedly to define table columns, PSQL arguments and PSQL local variables. Those objects inherit all of the attributes of the domain. Some attributes can be overridden when the new object is defined, if required.

This section describes the syntax of statements used to create, modify and delete domains. A detailed description of domains and their usage can be found in Custom Data Types — Domains.

5.3.1. CREATE DOMAIN

Used for

Creating a new domain

Available in

DSQL, ESQL

Syntax

```
CREATE DOMAIN name [AS] <datatype>
  [DEFAULT {<literal> | NULL | <context_var>}]
  [NOT NULL] [CHECK (<dom_condition>)]
  [COLLATE collation_name]

<datatype> ::=
  <scalar_datatype> | <blob_datatype> | <array_datatype>

<scalar_datatype> ::=
  !! See Scalar Data Types Syntax !!

<blob_datatype> ::=
  !! See BLOB Data Types Syntax !!

<array_datatype> ::=
  !! See Array Data Types Syntax !!

<dom_condition> ::=
    <val> <operator> <val>
```

```
  | <val> [NOT] BETWEEN <val> AND <val>
  | <val> [NOT] IN ({<val> [, <val> ...] | <select_list>})
  | <val> IS [NOT] NULL
  | <val> IS [NOT] DISTINCT FROM <val>
  | <val> [NOT] CONTAINING <val>
  | <val> [NOT] STARTING [WITH] <val>
  | <val> [NOT] LIKE <val> [ESCAPE <val>]
  | <val> [NOT] SIMILAR TO <val> [ESCAPE <val>]
  | <val> <operator> {ALL | SOME | ANY} (<select_list>)
  | [NOT] EXISTS (<select_expr>)
  | [NOT] SINGULAR (<select_expr>)
  | (<dom_condition>)
  | NOT <dom_condition>
  | <dom_condition> OR <dom_condition>
  | <dom_condition> AND <dom_condition>

<operator> ::=
    <> | != | ^= | ~= | = | < | > | <= | >=
  | !< | ^< | ~< | !> | ^> | ~>

<val> ::=
    VALUE
  | <literal>
  | <context_var>
  | <expression>
  | NULL
  | NEXT VALUE FOR genname
  | GEN_ID(genname, <val>)
  | CAST(<val> AS <cast_type>)
  | (<select_one>)
  | func([<val> [, <val> ...]])

<cast_type> ::= <domain_or_non_array_type> | <array_datatype>

<domain_or_non_array_type> ::=
  !! See Scalar Data Types Syntax !!
```

Table 31. `CREATE DOMAIN` *Statement Parameters*

Parameter	Description
name	Domain name. The maximum length is 63 characters
datatype	SQL data type
literal	A literal value that is compatible with *datatype*
context_var	Any context variable whose type is compatible with *datatype*
dom_condition	Domain condition
collation_name	Name of a collation sequence that is valid for *charset_name*, if it is supplied with *datatype* or, otherwise, is valid for the default character set of the database

Parameter	Description
select_one	A scalar SELECT statement — selecting one column and returning only one row
select_list	A SELECT statement selecting one column and returning zero or more rows
select_expr	A SELECT statement selecting one or more columns and returning zero or more rows
expression	An expression resolving to a value that is compatible with *datatype*
genname	Sequence (generator) name
func	Internal function or UDF

The CREATE DOMAIN statement creates a new domain.

Any SQL data type can be specified as the domain type.

Type-specific Details

Array Types

- If the domain is to be an array, the base type can be any SQL data type except BLOB and array.
- The dimensions of the array are specified between square brackets. (In the Syntax block, these brackets appear in quotes to distinguish them from the square brackets that identify optional syntax elements.)
- For each array dimension, one or two integer numbers define the lower and upper boundaries of its index range:
  - By default, arrays are 1-based. The lower boundary is implicit and only the upper boundary need be specified. A single number smaller than 1 defines the range *num*..1 and a number greater than 1 defines the range 1..*num*.
  - Two numbers separated by a colon (':') and optional whitespace, the second greater than the first, can be used to define the range explicitly. One or both boundaries can be less than zero, as long as the upper boundary is greater than the lower.
- When the array has multiple dimensions, the range definitions for each dimension must be separated by commas and optional whitespace.
- Subscripts are validated *only* if an array actually exists. It means that no error messages regarding invalid subscripts will be returned if selecting a specific element returns nothing or if an array field is NULL.

String Types

You can use the CHARACTER SET clause to specify the character set for the CHAR, VARCHAR and BLOB (SUB_TYPE TEXT) types. If the character set is not specified, the character set specified as DEFAULT CHARACTER SET of the database will be used. If no character set was specified then, the character set NONE is applied by default when you create a character domain.

With character set NONE, character data are stored and retrieved the way they were submitted. Data in any encoding can be added to a column based on such

a domain, but it is impossible to add this data to a column with a different encoding. Because no transliteration is performed between the source and destination encodings, errors may result.

`DEFAULT` Clause

The optional `DEFAULT` clause allows you to specify a default value for the domain. This value will be added to the table column that inherits this domain when the `INSERT` statement is executed, if no value is specified for it in the DML statement. Local variables and arguments in PSQL modules that reference this domain will be initialized with the default value. For the default value, use a literal of a compatible type or a context variable of a compatible type.

`NOT NULL` Constraint

Columns and variables based on a domain with the `NOT NULL` constraint will be prevented from being written as `NULL`, i.e., a value is *required*.

When creating a domain, take care to avoid specifying limitations that would contradict one another. For instance, `NOT NULL` and `DEFAULT NULL` are contradictory.

`CHECK` Constraint(s)

The optional `CHECK` clause specifies constraints for the domain. A domain constraint specifies conditions that must be satisfied by the values of table columns or variables that inherit from the domain. A condition must be enclosed in parentheses. A condition is a logical expression (also called a predicate) that can return the Boolean results `TRUE`, `FALSE` and `UNKNOWN`. A condition is considered satisfied if the predicate returns the value `TRUE` or "unknown value" (equivalent to `NULL`). If the predicate returns `FALSE`, the condition for acceptance is not met.

`VALUE` Keyword

The keyword `VALUE` in a domain constraint substitutes for the table column that is based on this domain or for a variable in a PSQL module. It contains the value assigned to the variable or the table column. `VALUE` can be used anywhere in the `CHECK` constraint, though it is usually used in the left part of the condition.

`COLLATE`

The optional `COLLATE` clause allows you to specify the collation sequence if the domain is based on one of the string data types, including `BLOB`s with text subtypes. If no collation sequence is specified, the collation sequence will be the one that is default for the specified character set at the time the domain is created.

Who Can Create a Domain

The `CREATE DOMAIN` statement can be executed by:

- Administrators
- Users with the `CREATE DOMAIN` privilege

`CREATE DOMAIN` Examples

1. Creating a domain that can take values greater than 1,000, with a default value of 10,000.

```
CREATE DOMAIN CUSTNO AS
  INTEGER DEFAULT 10000
  CHECK (VALUE > 1000);
```

2. Creating a domain that can take the values 'Yes' and 'No' in the default character set specified during the creation of the database.

```
CREATE DOMAIN D_BOOLEAN AS
  CHAR(3) CHECK (VALUE IN ('Yes', 'No'));
```

3. Creating a domain with the `UTF8` character set and the `UNICODE_CI_AI` collation sequence.

```
CREATE DOMAIN FIRSTNAME AS
  VARCHAR(30) CHARACTER SET UTF8
  COLLATE UNICODE_CI_AI;
```

4. Creating a domain of the `DATE` type that will not accept NULL and uses the current date as the default value.

```
CREATE DOMAIN D_DATE AS
  DATE DEFAULT CURRENT_DATE
  NOT NULL;
```

5. Creating a domain defined as an array of 2 elements of the `NUMERIC(18, 3)` type. The starting array index is 1.

```
CREATE DOMAIN D_POINT AS
  NUMERIC(18, 3) [2];
```

Domains defined over an array type may be used only to define table columns. You cannot use array domains to define local variables in PSQL modules.

6. Creating a domain whose elements can be only country codes defined in the `COUNTRY` table.

```
CREATE DOMAIN D_COUNTRYCODE AS CHAR(3)
  CHECK (EXISTS(SELECT * FROM COUNTRY
         WHERE COUNTRYCODE = VALUE));
```

The example is given only to show the possibility of using predicates with

> queries in the domain test condition. It is not recommended to create this style of domain in practice unless the lookup table contains data that are never deleted.

See also

`ALTER DOMAIN`, `DROP DOMAIN`

5.3.2. ALTER DOMAIN

Used for

Altering the current attributes of a domain or renaming it

Available in

DSQL, ESQL

Syntax

```
ALTER DOMAIN domain_name
  [TO new_name]
  [TYPE <datatype>]
  [{SET DEFAULT {<literal> | NULL | <context_var>} | DROP DEFAULT}]
  [{SET | DROP} NOT NULL]
  [{ADD [CONSTRAINT] CHECK (<dom_condition>) | DROP CONSTRAINT}]

<datatype> ::=
   <scalar_datatype> | <blob_datatype>

<scalar_datatype> ::=
  !! See Scalar Data Types Syntax !!

<blob_datatype> ::=
  !! See BLOB Data Types Syntax !!

!! See also CREATE DOMAIN Syntax !!
```

Table 32. `ALTER DOMAIN` Statement Parameters

Parameter	Description
new_name	New name for domain. The maximum length is 63 characters
literal	A literal value that is compatible with *datatype*
context_var	Any context variable whose type is compatible with *datatype*

The `ALTER DOMAIN` statement enables changes to the current attributes of a domain, including its name. You can make any number of domain alterations in one `ALTER DOMAIN` statement.

`ALTER DOMAIN` clauses

`TO name`

Use the `TO` clause to rename the domain, as long as there are no dependencies on the domain, i.e. table columns, local variables or procedure arguments referencing it.

`SET DEFAULT`

With the `SET DEFAULT` clause you can set a new default value. If the domain already has a default value, there is no need to delete it first — it will be replaced by the new one.

`DROP DEFAULT`

Use this clause to delete a previously specified default value and replace it with `NULL`.

`SET NOT NULL`

Use this class to add a `NOT NULL` constraint to the domain; columns or parameters of this domain will be prevented from being written as `NULL`, i.e., a value is *required*.

Adding a `NOT NULL` constraint to an existing domain will subject all columns using this comain to a full data validation, so ensure that the columns have no nulls before attempting the change.

`DROP NOT NULL`

Drop the `NOT NULL` constraint from the domain.

An explicit `NOT NULL` constraint on a column that depends on a domain prevails over the domain. In this situation, the modification of the domain to make it nullable does not propagate to the column.

`ADD CONSTRAINT CHECK`

Use the `ADD CONSTRAINT CHECK` clause to add a `CHECK` constraint to the domain. If the domain already has a `CHECK` constraint, it will have to be deleted first, using an `ALTER DOMAIN` statement that includes a `DROP CONSTRAINT` clause.

`TYPE`

The `TYPE` clause is used to change the data type of the domain to a different, compatible one. The system will forbid any change to the type that could result in data loss. An example would be if the number of characters in the new type were smaller than in the existing type.

When you alter the attributes of a domain, existing PSQL code may become invalid. For information on how to detect it, read the piece entitled *The RDB$VALID_BLR Field* in Appendix A.

What `ALTER DOMAIN` Cannot Alter

- If the domain was declared as an array, it is not possible to change its type or its dimensions; nor can any other type be changed to an array type.
- There is no way to change the default collation without dropping the domain and recreating it with the desired attributes.

Who Can Alter a Domain

The `ALTER DOMAIN` statement can be executed by:

- Administrators
- The owner of the domain
- Users with the `ALTER ANY DOMAIN` privilege

Domain alterations can be prevented by dependencies from objects to which the user does not have sufficient privileges.

`ALTER DOMAIN` Examples

1. Changing the data type to `INTEGER` and setting or changing the default value to 2,000:

```
ALTER DOMAIN CUSTNO
  TYPE INTEGER
  SET DEFAULT 2000;
```

2. Renaming a domain.

```
ALTER DOMAIN D_BOOLEAN TO D_BOOL;
```

3. Deleting the default value and adding a constraint for the domain:

```
ALTER DOMAIN D_DATE
  DROP DEFAULT
  ADD CONSTRAINT CHECK (VALUE >= date '01.01.2000');
```

4. Changing the `CHECK` constraint:

```
ALTER DOMAIN D_DATE
  DROP CONSTRAINT;

ALTER DOMAIN D_DATE
  ADD CONSTRAINT CHECK
    (VALUE BETWEEN date '01.01.1900' AND date '31.12.2100');
```

5. Changing the data type to increase the permitted number of characters:

```
ALTER DOMAIN FIRSTNAME
  TYPE VARCHAR(50) CHARACTER SET UTF8;
```

6. Adding a `NOT NULL` constraint:

```
ALTER DOMAIN FIRSTNAME
  SET NOT NULL;
```

7. Removing a `NOT NULL` constraint:

```
ALTER DOMAIN FIRSTNAME
  DROP NOT NULL;
```

See also

`CREATE DOMAIN`, `DROP DOMAIN`

5.3.3. DROP DOMAIN

Used for

Deleting an existing domain

Available in

DSQL, ESQL

Syntax

```
DROP DOMAIN domain_name
```

The `DROP DOMAIN` statement deletes a domain that exists in the database. It is not possible to delete a domain if it is referenced by any database table columns or used in any PSQL module. In order to delete a domain that is in use, all columns in all tables that refer to the domain will have to be dropped and all references to the domain will have to be removed from PSQL modules.

Who Can Drop a Domain

The `DROP DOMAIN` statement can be executed by:

- Administrators
- The owner of the domain
- Users with the `DROP ANY DOMAIN` privilege

Example of `DROP DOMAIN`

Deleting the COUNTRYNAME domain

```
DROP DOMAIN COUNTRYNAME;
```

See also

`CREATE DOMAIN`, `ALTER DOMAIN`

5.4. TABLE

As a relational DBMS, Firebird stores data in tables. A table is a flat, two-dimensional structure containing any number of rows. Table rows are often called *records*.

All rows in a table have the same structure and consist of columns. Table columns are often called *fields*. A table must have at least one column. Each column contains a single type of SQL data.

This section describes how to create, alter and delete tables in a database.

5.4.1. CREATE TABLE

Used for

creating a new table (relation)

Available in

DSQL, ESQL

Syntax

```
CREATE [GLOBAL TEMPORARY] TABLE tablename
  [EXTERNAL [FILE] 'filespec']
  (<col_def> [, {<col_def> | <tconstraint>} ...])
  [{<table_attrs> | <gtt_table_attrs>}]

<col_def> ::=
    <regular_col_def>
  | <computed_col_def>
  | <identity_col_def>

<regular_col_def> ::=
  colname {<datatype> | domainname}
  [DEFAULT {<literal> | NULL | <context_var>}]
  [<col_constraint> ...]
  [COLLATE collation_name]

<computed_col_def> ::=
  colname [<datatype>]
  {COMPUTED [BY] | GENERATED ALWAYS AS} (<expression>)

<identity_col_def> ::=
  colname {<datatype> | domainname}
  GENERATED {ALWAYS | BY DEFAULT} AS IDENTITY
  [(<identity_col_option>...)]
  [<col_constraint> ...]

<identity_col_option> ::=
    START WITH start_value
  | INCREMENT [BY] inc_value
```

```
<datatype> ::=
    <scalar_datatype> | <blob_datatype> | <array_datatype>

<scalar_datatype> ::=
  !! See Scalar Data Types Syntax !!

<blob_datatype> ::=
  !! See BLOB Data Types Syntax !!

<array_datatype> ::=
  !! See Array Data Types Syntax !!

<col_constraint> ::=
  [CONSTRAINT constr_name]
    { PRIMARY KEY [<using_index>]
    | UNIQUE      [<using_index>]
    | REFERENCES other_table [(colname)]
        [ON DELETE {NO ACTION | CASCADE | SET DEFAULT | SET NULL}]
        [ON UPDATE {NO ACTION | CASCADE | SET DEFAULT | SET NULL}]
        [<using_index>]
    | CHECK (<check_condition>)
    | NOT NULL }

<tconstraint> ::=
  [CONSTRAINT constr_name]
    { PRIMARY KEY (<col_list>) [<using_index>]
    | UNIQUE      (<col_list>) [<using_index>]
    | FOREIGN KEY (<col_list>)
        REFERENCES other_table [(<col_list>)]
        [ON DELETE {NO ACTION | CASCADE | SET DEFAULT | SET NULL}]
        [ON UPDATE {NO ACTION | CASCADE | SET DEFAULT | SET NULL}]
        [<using_index>]
    | CHECK (<check_condition>) }

<col_list> ::= colname [, colname ...]

<using_index> ::= USING
  [ASC[ENDING] | DESC[ENDING]] INDEX indexname

<check_condition> ::=
    <val> <operator> <val>
  | <val> [NOT] BETWEEN <val> AND <val>
  | <val> [NOT] IN (<val> [, <val> ...] | <select_list>)
  | <val> IS [NOT] NULL
  | <val> IS [NOT] DISTINCT FROM <val>
  | <val> [NOT] CONTAINING <val>
  | <val> [NOT] STARTING [WITH] <val>
  | <val> [NOT] LIKE <val> [ESCAPE <val>]
  | <val> [NOT] SIMILAR TO <val> [ESCAPE <val>]
  | <val> <operator> {ALL | SOME | ANY} (<select_list>)
  | [NOT] EXISTS (<select_expr>)
```

```
  | [NOT] SINGULAR (<select_expr>)
  | (<check_condition>)
  | NOT <check_condition>
  | <check_condition> OR <check_condition>
  | <check_condition> AND <check_condition>

<operator> ::=
    <> | != | ^= | ~= | = | < | > | <= | >=
  | !< | ^< | ~< | !> | ^> | ~>

<val> ::=
    colname ['['array_idx [, array_idx ...]']']
  | <literal>
  | <context_var>
  | <expression>
  | NULL
  | NEXT VALUE FOR genname
  | GEN_ID(genname, <val>)
  | CAST(<val> AS <cast_type>)
  | (<select_one>)
  | func([<val> [, <val> ...]])

<cast_type> ::= <domain_or_non_array_type> | <array_datatype>

<domain_or_non_array_type> ::=
  !! See Scalar Data Types Syntax !!

<table_attrs> ::= <table_attr> [<table_attr> ...]

<table_attr> ::=
    <sql_security>
  | {ENABLE | DISABLE} PUBLICATION

<sql_security> ::= SQL SECURITY {INVOKER | DEFINER}

<gtt_table_attrs> ::= <gtt_table_attr> [gtt_table_attr> ...]

<gtt_table_attr> ::=
    <sql_security>
  | ON COMMIT {DELETE | PRESERVE} ROWS
```

Table 33. `CREATE TABLE` *Statement Parameters*

Parameter	Description
tablename	Name (identifier) for the table. The maximum length is 63 characters and must be unique in the database.
filespec	File specification (only for external tables). Full file name and path, enclosed in single quotes, correct for the local file system and located on a storage device that is physically connected to Firebird's host computer.

Parameter	Description
colname	Name (identifier) for a column in the table. The maximum length is 63 characters and must be unique in the table.
tconstraint	Table constraint
table_attrs	Attributes of a normal table
gtt_table_attrs	Attributes of a global temporary table
datatype	SQL data type
domain_name	Domain name
start_value	The initial value of the identity column
inc_value	The increment (or step) value of the identity column, default is 1; zero (`0`) is not allowed.
col_constraint	Column constraint
constr_name	The name (identifier) of a constraint. The maximum length is 63 characters.
other_table	The name of the table referenced by the foreign key constraint
other_col	The name of the column in *other_table* that is referenced by the foreign key
literal	A literal value that is allowed in the given context
context_var	Any context variable whose data type is allowed in the given context
check_condition	The condition applied to a CHECK constraint, that will resolve as either true, false or `NULL`
collation	Collation
select_one	A scalar `SELECT` statement — selecting one column and returning only one row
select_list	A `SELECT` statement selecting one column and returning zero or more rows
select_expr	A `SELECT` statement selecting one or more columns and returning zero or more rows
expression	An expression resolving to a value that is allowed in the given context
genname	Sequence (generator) name
func	Internal function or UDF

The `CREATE TABLE` statement creates a new table. Any user can create it and its name must be unique among the names of all tables, views and stored procedures in the database.

A table must contain at least one column that is not computed, and the names of columns must be unique in the table.

A column must have either an explicit *SQL data type*, the name of a *domain* whose attributes will be copied for the column, or be defined as `COMPUTED BY` an expression (a *calculated field*).

A table may have any number of table constraints, including none.

Character Columns

You can use the CHARACTER SET clause to specify the character set for the CHAR, VARCHAR and BLOB (text subtype) types. If the character set is not specified, the default character set of the database - at time of the creation of the column - will be used. If the database has no default character set, the NONE character set is applied. In this case, data is stored and retrieved the way it was submitted. Data in any encoding can be added to such a column, but it is not possible to add this data to a column with a different encoding. No transliteration is performed between the source and destination encodings, which may result in errors.

The optional COLLATE clause allows you to specify the collation sequence for character data types, including BLOB SUB_TYPE TEXT. If no collation sequence is specified, the default collation sequence for the specified character set - at time of the creation of the column - is applied.

Setting a DEFAULT Value

The optional DEFAULT clause allows you to specify the default value for the table column. This value will be added to the column when an INSERT statement is executed if no value was specified for it *and* that column was omitted from the INSERT command.

The default value can be a literal of a compatible type, a context variable that is type-compatible with the data type of the column, or NULL, if the column allows it. If no default value is explicitly specified, NULL is implied.

An expression cannot be used as a default value.

Domain-based Columns

To define a column, you can use a previously defined domain. If the definition of a column is based on a domain, it may contain a new default value, additional CHECK constraints, and a COLLATE clause that will override the values specified in the domain definition. The definition of such a column may contain additional column constraints (for instance, NOT NULL), if the domain does not have it.

It is not possible to define a domain-based column that is nullable if the domain was defined with the NOT NULL attribute. If you want to have a domain that might be used for defining both nullable and non-nullable columns and variables, it is better practice defining the domain nullable and apply NOT NULL in the downstream column definitions and variable declarations.

Identity Columns (Autoincrement)

Identity columns are defined using the GENERATED {ALWAYS | BY DEFAULT} AS IDENTITY clause. The identity column is a column associated with an internal sequence generator. Its value is set automatically every time it is not specified in the INSERT statement, or when the column value is specified as DEFAULT.

Rules

- The data type of an identity column must be an exact number type with zero scale. Allowed types are SMALLINT, INTEGER, BIGINT, NUMERIC(p[,0]) and DECIMAL(p[,0]) with *p* <= 18.
  - The INT128 type and numeric types with a precision higher than 18 are not supported.
- An identity column cannot have a DEFAULT or COMPUTED value.
- An identity column can be altered to become a regular column.
- A regular column cannot be altered to become an identity column.
- Identity columns are implicitly NOT NULL (non-nullable), and cannot be made nullable.
- Uniqueness is not enforced automatically. A UNIQUE or PRIMARY KEY constraint is required to guarantee uniqueness.
- The use of other methods of generating key values for identity columns, e.g. by trigger-generator code or by allowing users to change or add them, is discouraged to avoid unexpected key violations.
- The INCREMENT value cannot be zero (0).

GENERATED ALWAYS

An identity column of type GENERATED ALWAYS will always generate a column value on insert. Explicitly inserting a value into a column of this type is not allowed, unless either:

1. the specified value is DEFAULT; this generates the identity value as normal.
2. the OVERRIDING SYSTEM VALUE clause is specified in the INSERT statement; this allows a user value to be inserted.

GENERATED BY DEFAULT

An identity column of type GENERATED BY DEFAULT will generate a value on insert if no value — other than DEFAULT — is specified on insert. When the OVERRIDING USER VALUE clause is specified in the INSERT statement, the user-provided value is ignored, and an identity value is generated (as if the column was not included in the insert, or the value DEFAULT was specified).

START WITH Option

The optional START WITH clause allows you to specify an initial value other than 1.

Previous versions of Firebird instead used the specified value as the initial value of the internal generator backing the identity column, so the first value was 1 higher than the START WITH value.

This has been fixed in Firebird 4.0 and now the first value generated is the START WITH value, see also firebird#6615.

INCREMENT Option

The optional INCREMENT clause allows you to specify another non-zero step value than 1.

The SQL standard specifies that if `INCREMENT` is specified with a negative value, and `START WITH` is not specified, that the first value generated should be the maximum of the column type (e.g. 2^{31} - 1 for `INTEGER`). Instead, Firebird will start at 1.

Calculated Fields

Calculated fields can be defined with the `COMPUTED [BY]` or `GENERATED ALWAYS AS` clause (according to the SQL:2003 standard). They mean the same. Describing the data type is not required (but possible) for calculated fields, as the DBMS calculates and stores the appropriate type as a result of the expression analysis. Appropriate operations for the data types included in an expression must be specified precisely.

If the data type is explicitly specified for a calculated field, the calculation result is converted to the specified type. This means, for instance, that the result of a numeric expression could be rendered as a string.

In a query that selects a `COMPUTED BY` column, the expression is evaluated for each row of the selected data.

Instead of a computed column, in some cases it makes sense to use a regular column whose value is evaluated in triggers for adding and updating data. It may reduce the performance of inserting/updating records, but it will increase the performance of data selection.

Defining an Array Column

- If the column is to be an array, the base type can be any SQL data type except `BLOB` and array.
- The dimensions of the array are specified between square brackets. (In the Syntax block these brackets appear in quotes to distinguish them from the square brackets that identify optional syntax elements.)
- For each array dimension, one or two integer numbers define the lower and upper boundaries of its index range:
  - By default, arrays are 1-based. The lower boundary is implicit and only the upper boundary need be specified. A single number smaller than 1 defines the range *num*..1 and a number greater than 1 defines the range 1..*num*.
  - Two numbers separated by a colon (‘:’) and optional whitespace, the second greater than the first, can be used to define the range explicitly. One or both boundaries can be less than zero, as long as the upper boundary is greater than the lower.
- When the array has multiple dimensions, the range definitions for each dimension must be separated by commas and optional whitespace.
- Subscripts are validated *only* if an array actually exists. It means that no error messages regarding invalid subscripts will be returned if selecting a specific element returns nothing or if an array field is `NULL`.

Constraints

Five types of constraints can be specified. They are:

- Primary key (`PRIMARY KEY`)
- Unique key (`UNIQUE`)
- Foreign key (`REFERENCES`)
- `CHECK` constraint (`CHECK`)
- `NOT NULL` constraint (`NOT NULL`)

Constraints can be specified at column level ("column constraints") or at table level ("table constraints"). Table-level constraints are required when keys (unique constraint, Primary Key, Foreign Key) consist of multiple columns and when a `CHECK` constraint involves other columns in the row besides the column being defined. The `NOT NULL` constraint can only be specified as a column constraint. Syntax for some types of constraint may differ slightly according to whether the constraint is defined at the column or table level.

- A column-level constraint is specified during a column definition, after all column attributes except `COLLATION` are specified, and can involve only the column specified in that definition
- A table-level constraints can only be specified after the definitions of the columns used in the constraint.
- Table-level constraints are a more flexible way to set constraints, since they can cater for constraints involving multiple columns
- You can mix column-level and table-level constraints in the same `CREATE TABLE` statement

The system automatically creates the corresponding index for a primary key (`PRIMARY KEY`), a unique key (`UNIQUE`) and a foreign key (`REFERENCES` for a column-level constraint, `FOREIGN KEY REFERENCES` for one at the table level).

Names for Constraints and Their Indexes

Column-level constraints and their indexes are named automatically:

- The constraint name has the form `INTEG_n`, where *n* represents one or more digits
- The index name has the form `RDB$PRIMARYn` (for a primary key index), `RDB$FOREIGNn` (for a foreign key index) or `RDB$n` (for a unique key index). Again, *n* represents one or more digits.

Automatic naming of table-level constraints and their indexes follows the same pattern, unless the names are supplied explicitly.

Named Constraints

A constraint can be named explicitly if the `CONSTRAINT` clause is used for its definition. While the `CONSTRAINT` clause is optional for defining column-level constraints, it is mandatory for table-level constraints. By default, the constraint index will have the same name as the constraint. If a different name is wanted for the constraint index, a `USING` clause can be included.

The USING Clause

The USING clause allows you to specify a user-defined name for the index that is created automatically and, optionally, to define the direction of the index — either ascending (the default) or descending.

PRIMARY KEY

The PRIMARY KEY constraint is built on one or more *key columns*, where each column has the NOT NULL constraint specified. The values across the key columns in any row must be unique. A table can have only one primary key.

- A single-column Primary Key can be defined as a column level or a table-level constraint
- A multi-column Primary Key must be specified as a table-level constraint

The UNIQUE Constraint

The UNIQUE constraint defines the requirement of content uniqueness for the values in a key throughout the table. A table can contain any number of unique key constraints.

As with the Primary Key, the Unique constraint can be multi-column. If so, it must be specified as a table-level constraint.

NULL in Unique Keys

Firebird's SQL-99-compliant rules for UNIQUE constraints allow one or more NULLs in a column with a UNIQUE constraint. That makes it possible to define a UNIQUE constraint on a column that does not have the NOT NULL constraint.

For UNIQUE keys that span multiple columns, the logic is a little complicated:

- Multiple rows having null in all the columns of the key are allowed
- Multiple rows having keys with different combinations of nulls and non-null values are allowed
- Multiple rows having the same key columns null and the rest filled with non-null values are allowed, provided the values differ in at least one column
- Multiple rows having the same key columns null and the rest filled with non-null values that are the same in every column will violate the constraint

The rules for uniqueness can be summarised thus:

> In principle, all nulls are considered distinct. However, if two rows have exactly the same key columns filled with non-null values, the NULL columns are ignored and the uniqueness is determined on the non-null columns as though they constituted the entire key.

Illustration

```
RECREATE TABLE t( x int, y int, z int, unique(x,y,z));
INSERT INTO t values( NULL, 1, 1 );
```

```
INSERT INTO t values( NULL, NULL, 1 );
INSERT INTO t values( NULL, NULL, NULL );
INSERT INTO t values( NULL, NULL, NULL ); -- Permitted
INSERT INTO t values( NULL, NULL, 1 );    -- Not permitted
```

FOREIGN KEY

A Foreign Key ensures that the participating column(s) can contain only values that also exist in the referenced column(s) in the master table. These referenced columns are often called *target columns*. They must be the primary key or a unique key in the target table. They need not have a NOT NULL constraint defined on them although, if they are the primary key, they will, of course, have that constraint.

The foreign key columns in the referencing table itself do not require a NOT NULL constraint.

A single-column Foreign Key can be defined in the column declaration, using the keyword REFERENCES:

```
... ,
  ARTIFACT_ID INTEGER REFERENCES COLLECTION (ARTIFACT_ID),
```

The column ARTIFACT_ID in the example references a column of the same name in the table COLLECTIONS.

Both single-column and multi-column foreign keys can be defined at the *table level*. For a multi-column Foreign Key, the table-level declaration is the only option. This method also enables the provision of an optional name for the constraint:

```
...
  CONSTRAINT FK_ARTSOURCE FOREIGN KEY(DEALER_ID, COUNTRY)
    REFERENCES DEALER (DEALER_ID, COUNTRY),
```

Notice that the column names in the referenced ("master") table may differ from those in the Foreign Key.

If no target columns are specified, the Foreign Key automatically references the target table's Primary Key.

Foreign Key Actions

With the sub-clauses ON UPDATE and ON DELETE it is possible to specify an action to be taken on the affected foreign key column(s) when referenced values in the master table are changed:

NO ACTION

(the default) - Nothing is done

`CASCADE`

The change in the master table is propagated to the corresponding row(s) in the child table. If a key value changes, the corresponding key in the child records changes to the new value; if the master row is deleted, the child records are deleted.

`SET DEFAULT`

The Foreign Key columns in the affected rows will be set to their default values *as they were when the foreign key constraint was defined*.

`SET NULL`

The Foreign Key columns in the affected rows will be set to `NULL`.

The specified action, or the default `NO ACTION`, could cause a Foreign Key column to become invalid. For example, it could get a value that is not present in the master table, or it could become `NULL` while the column has a `NOT NULL` constraint. Such conditions will cause the operation on the master table to fail with an error message.

Example

```
...
  CONSTRAINT FK_ORDERS_CUST
    FOREIGN KEY (CUSTOMER) REFERENCES CUSTOMERS (ID)
      ON UPDATE CASCADE ON DELETE SET NULL
```

`CHECK` Constraint

The `CHECK` constraint defines the condition the values inserted in this column must satisfy. A condition is a logical expression (also called a predicate) that can return the TRUE, FALSE and UNKNOWN values. A condition is considered satisfied if the predicate returns TRUE or value UNKNOWN (equivalent to `NULL`). If the predicate returns FALSE, the value will not be accepted. This condition is used for inserting a new row into the table (the `INSERT` statement) and for updating the existing value of the table column (the `UPDATE` statement) and also for statements where one of these actions may take place (UPDATE OR INSERT, MERGE).

A `CHECK` constraint on a domain-based column does not replace an existing `CHECK` condition on the domain, but becomes an addition to it. The Firebird engine has no way, during definition, to verify that the extra `CHECK` does not conflict with the existing one.

`CHECK` constraints — whether defined at table level or column level — refer to table columns *by their names*. The use of the keyword `VALUE` as a placeholder — as in domain `CHECK` constraints — is not valid in the context of defining column constraints.

Example

with two column-level constraints and one at table-level:

```
CREATE TABLE PLACES (
  ...
```

```
  LAT DECIMAL(9, 6) CHECK (ABS(LAT) <=  90),
  LON DECIMAL(9, 6) CHECK (ABS(LON) <= 180),
  ...
  CONSTRAINT CHK_POLES CHECK (ABS(LAT) < 90 OR LON = 0)
);
```

`NOT NULL` Constraint

In Firebird, columns are nullable by default. The `NOT NULL` constraint specifies that the column cannot take `NULL` in place of a value.

A `NOT NULL` constraint can only be defined as a column constraint, not as a table constraint.

`SQL SECURITY` Clause

The `SQL SECURITY` clause specifies the security context for executing functions referenced in calculated columns, and check constraints, and the default context used for triggers fired for this table. When SQL Security is not specified, the default value of the database is applied at runtime.

See also *SQL Security* in chapter *Security*.

Replication Management

When the database has been configured using `ALTER DATABASE INCLUDE ALL TO PUBLICATION`, new tables will automatically be added for publication, unless overridden using the `DISABLE PUBLICATION` clause.

If the database has not been configured for `INCLUDE ALL` (or has later been reconfigured using `ALTER DATABASE EXCLUDE ALL FROM PUBLICATION`), new tables will not automatically be added for publication. To include tables for publication, the `ENABLE PUBLICATION` clause must be used.

Who Can Create a Table

The `CREATE TABLE` statement can be executed by:

- Administrators
- Users with the `CREATE TABLE` privilege

The user executing the `CREATE TABLE` statement becomes the owner of the table.

`CREATE TABLE` Examples

1. Creating the `COUNTRY` table with the primary key specified as a column constraint.

```
CREATE TABLE COUNTRY (
  COUNTRY COUNTRYNAME NOT NULL PRIMARY KEY,
  CURRENCY VARCHAR(10) NOT NULL
);
```

2. Creating the `STOCK` table with the named primary key specified at the column level and the named unique key specified at the table level.

```
CREATE TABLE STOCK (
  MODEL     SMALLINT NOT NULL CONSTRAINT PK_STOCK PRIMARY KEY,
  MODELNAME CHAR(10) NOT NULL,
  ITEMID    INTEGER NOT NULL,
  CONSTRAINT MOD_UNIQUE UNIQUE (MODELNAME, ITEMID)
);
```

3. Creating the `JOB` table with a primary key constraint spanning two columns, a foreign key constraint for the `COUNTRY` table and a table-level `CHECK` constraint. The table also contains an array of 5 elements.

```
CREATE TABLE JOB (
  JOB_CODE        JOBCODE NOT NULL,
  JOB_GRADE       JOBGRADE NOT NULL,
  JOB_COUNTRY     COUNTRYNAME,
  JOB_TITLE       VARCHAR(25) NOT NULL,
  MIN_SALARY      NUMERIC(18, 2) DEFAULT 0 NOT NULL,
  MAX_SALARY      NUMERIC(18, 2) NOT NULL,
  JOB_REQUIREMENT BLOB SUB_TYPE 1,
  LANGUAGE_REQ    VARCHAR(15) [1:5],
  PRIMARY KEY (JOB_CODE, JOB_GRADE),
  FOREIGN KEY (JOB_COUNTRY) REFERENCES COUNTRY (COUNTRY)
  ON UPDATE CASCADE
  ON DELETE SET NULL,
  CONSTRAINT CHK_SALARY CHECK (MIN_SALARY < MAX_SALARY)
);
```

4. Creating the `PROJECT` table with primary, foreign and unique key constraints with custom index names specified with the `USING` clause.

```
CREATE TABLE PROJECT (
  PROJ_ID     PROJNO NOT NULL,
  PROJ_NAME   VARCHAR(20) NOT NULL UNIQUE USING DESC INDEX IDX_PROJNAME,
  PROJ_DESC   BLOB SUB_TYPE 1,
  TEAM_LEADER EMPNO,
  PRODUCT     PRODTYPE,
  CONSTRAINT PK_PROJECT PRIMARY KEY (PROJ_ID) USING INDEX IDX_PROJ_ID,
  FOREIGN KEY (TEAM_LEADER) REFERENCES EMPLOYEE (EMP_NO)
    USING INDEX IDX_LEADER
);
```

5. Creating a table with an identity column

```
create table objects (
```

```
  id integer generated by default as identity primary key,
  name varchar(15)
);

insert into objects (name) values ('Table');
insert into objects (id, name) values (10, 'Computer');
insert into objects (name) values ('Book');

select * from objects order by id;

          ID NAME
============ ===============
           1 Table
           2 Book
          10 Computer
```

6. Creating the SALARY_HISTORY table with two computed fields. The first one is declared according to the SQL:2003 standard, while the second one is declared according to the traditional declaration of computed fields in Firebird.

```
CREATE TABLE SALARY_HISTORY (
  EMP_NO         EMPNO NOT NULL,
  CHANGE_DATE    TIMESTAMP DEFAULT 'NOW' NOT NULL,
  UPDATER_ID     VARCHAR(20) NOT NULL,
  OLD_SALARY     SALARY NOT NULL,
  PERCENT_CHANGE DOUBLE PRECISION DEFAULT 0 NOT NULL,
  SALARY_CHANGE  GENERATED ALWAYS AS
    (OLD_SALARY * PERCENT_CHANGE / 100),
  NEW_SALARY     COMPUTED BY
    (OLD_SALARY + OLD_SALARY * PERCENT_CHANGE / 100)
);
```

7. With DEFINER set for table t, user US needs only the SELECT privilege on t. If it were set for INVOKER, the user would also need the EXECUTE privilege on function f.

```
set term ^;
create function f() returns int
as
begin
    return 3;
end^
set term ;^
create table t (i integer, c computed by (i + f())) SQL SECURITY DEFINER;
insert into t values (2);
grant select on table t to user us;

commit;
```

```
connect 'localhost:/tmp/7.fdb' user us password 'pas';
select * from t;
```

8. With DEFINER set for table tr, user US needs only the INSERT privilege on tr. If it were set for INVOKER, either the user or the trigger would also need the INSERT privilege on table t. The result would be the same if SQL SECURITY DEFINER were specified for trigger tr_ins:

```
create table tr (i integer) SQL SECURITY DEFINER;
create table t (i integer);
set term ^;
create trigger tr_ins for tr after insert
as
begin
  insert into t values (NEW.i);
end^
set term ;^
grant insert on table tr to user us;

commit;

connect 'localhost:/tmp/29.fdb' user us password 'pas';
insert into tr values(2);
```

Global Temporary Tables (GTT)

Global temporary tables have persistent metadata, but their contents are transaction-bound (the default) or connection-bound. Every transaction or connection has its own private instance of a GTT, isolated from all the others. Instances are only created if and when the GTT is referenced. They are destroyed when the transaction ends or on disconnection. The metadata of a GTT can be modified or removed using ALTER TABLE and DROP TABLE, respectively.

Syntax

```
CREATE GLOBAL TEMPORARY TABLE tablename
  (<column_def> [, {<column_def> | <table_constraint>} ...])
  [<gtt_table_attrs>]

<gtt_table_attrs> ::= <gtt_table_attr> [gtt_table_attr> ...]

<gtt_table_attr> ::=
    <sql_security>
  | ON COMMIT {DELETE | PRESERVE} ROWS
```

Syntax notes

- ON COMMIT DELETE ROWS creates a transaction-level GTT (the default), ON COMMIT PRESERVE ROWS a connection-level GTT
- An EXTERNAL [FILE] clause is not allowed in the definition of a global temporary

table

GTTs are writable in read-only transactions. The effect is as follows:

Read-only transaction in read-write database

Writable in both `ON COMMIT PRESERVE ROWS` and `ON COMMIT DELETE ROWS`

Read-only transaction in read-only database

Writable in `ON COMMIT DELETE ROWS` only

Restrictions on GTTs

GTTs can be "dressed up" with all the features and paraphernalia of ordinary tables (keys, references, indexes, triggers and so on) but there are a few restrictions:

- GTTs and regular tables cannot reference one another
- A connection-bound ("`PRESERVE ROWS`") GTT cannot reference a transaction-bound ("`DELETE ROWS`") GTT
- Domain constraints cannot reference any GTT
- The destruction of a GTT instance at the end of its life cycle does not cause any `BEFORE/AFTER` delete triggers to fire

In an existing database, it is not always easy to distinguish a regular table from a GTT, or a transaction-level GTT from a connection-level GTT. Use this query to find out what type of table you are looking at:

```
select t.rdb$type_name
from rdb$relations r
join rdb$types t on r.rdb$relation_type = t.rdb$type
where t.rdb$field_name = 'RDB$RELATION_TYPE'
and r.rdb$relation_name = 'TABLENAME'
```

For an overview of the types of all the relations in the database:

```
select r.rdb$relation_name, t.rdb$type_name
from rdb$relations r
join rdb$types t on r.rdb$relation_type = t.rdb$type
where t.rdb$field_name = 'RDB$RELATION_TYPE'
and coalesce (r.rdb$system_flag, 0) = 0
```

The `RDB$TYPE_NAME` field will show `PERSISTENT` for a regular table, `VIEW` for a view, `GLOBAL_TEMPORARY_PRESERVE` for a connection-bound GTT and `GLOBAL_TEMPORARY_DELETE` for a transaction_bound GTT.

Examples of Global Temporary Tables

1. Creating a connection-scoped global temporary table.

```
CREATE GLOBAL TEMPORARY TABLE MYCONNGTT (
  ID  INTEGER NOT NULL PRIMARY KEY,
  TXT VARCHAR(32),
  TS  TIMESTAMP DEFAULT CURRENT_TIMESTAMP)
ON COMMIT PRESERVE ROWS;
```

2. Creating a transaction-scoped global temporary table that uses a foreign key to reference a connection-scoped global temporary table. The `ON COMMIT` sub-clause is optional because `DELETE ROWS` is the default.

```
CREATE GLOBAL TEMPORARY TABLE MYTXGTT (
  ID        INTEGER NOT NULL PRIMARY KEY,
  PARENT_ID INTEGER NOT NULL REFERENCES MYCONNGTT(ID),
  TXT       VARCHAR(32),
  TS        TIMESTAMP DEFAULT CURRENT_TIMESTAMP
) ON COMMIT DELETE ROWS;
```

External Tables

The optional `EXTERNAL [FILE]` clause specifies that the table is stored outside the database in an external text file of fixed-length records. The columns of a table stored in an external file can be of any type except `BLOB` or `ARRAY`, although for most purposes, only columns of `CHAR` types would be useful.

All you can do with a table stored in an external file is insert new rows (`INSERT`) and query the data (`SELECT`). Updating existing data (`UPDATE`) and deleting rows (`DELETE`) are not possible.

A file that is defined as an external table must be located on a storage device that is physically present on the machine where the Firebird server runs and, if the parameter *ExternalFileAccess* in the `firebird.conf` configuration file is `Restrict`, it must be in one of the directories listed there as the argument for `Restrict`. If the file does not exist yet, Firebird will create it on first access.

The ability to use external files for a table depends on the value set for the *ExternalFileAccess* parameter in `firebird.conf`:

- If it is set to `None` (the default), any attempt to access an external file will be denied.
- The `Restrict` setting is recommended, for restricting external file access to directories created explicitly for the purpose by the server administrator. For example:
  - `ExternalFileAccess = Restrict externalfiles` will restrict access to a directory named `externalfiles` directly beneath the Firebird root directory
  - `ExternalFileAccess = d:\databases\outfiles; e:\infiles` will restrict access

to just those two directories on the Windows host server. Note that any path that is a network mapping will not work. Paths enclosed in single or double quotes will not work, either.

- If this parameter is set to `Full`, external files may be accessed anywhere on the host file system. This creates a security vulnerability and is not recommended.

External File Format

The "row" format of the external table is fixed length and binary. There are no field delimiters: both field and row boundaries are determined by maximum sizes, in bytes, of the field definitions. It is important to keep this in mind, both when defining the structure of the external table and when designing an input file for an external table that is to import data from another application. The ubiquitous ".csv" format, for example, is of no use as an input file and cannot be generated directly into an external file.

The most useful data type for the columns of external tables is the fixed-length `CHAR` type, of suitable lengths for the data they are to carry. Date and number types are easily cast to and from strings whereas, unless the files are to be read by another Firebird database, the native data types — binary data — will appear to external applications as unparseable "alphabetti".

Of course, there are ways to manipulate typed data so as to generate output files from Firebird that can be read directly as input files to other applications, using stored procedures, with or without employing external tables. Such techniques are beyond the scope of a language reference. Here, we provide some guidelines and tips for producing and working with simple text files, since the external table feature is often used as an easy way to produce or read transaction-independent logs that can be studied off-line in a text editor or auditing application.

Row Delimiters

Generally, external files are more useful if rows are separated by a delimiter, in the form of a "newline" sequence that is recognised by reader applications on the intended platform. For most contexts on Windows, it is the two-byte 'CRLF' sequence, carriage return (ASCII code decimal 13) and line feed (ASCII code decimal 10). On POSIX, LF on its own is usual; for some MacOSX applications, it may be LFCR. There are various ways to populate this delimiter column. In our example below, it is done by using a `BEFORE INSERT` trigger and the internal function `ASCII_CHAR`.

External Table Example

For our example, we will define an external log table that might be used by an exception handler in a stored procedure or trigger. The external table is chosen because the messages from any handled exceptions will be retained in the log, even if the transaction that launched the process is eventually rolled back because of another, unhandled exception. For demonstration purposes, it has just two data columns, a time stamp and a message. The third column stores the row delimiter:

```
CREATE TABLE ext_log
  EXTERNAL FILE 'd:\externals\log_me.txt' (
  stamp CHAR (24),
  message CHAR(100),
```

```
  crlf CHAR(2) -- for a Windows context
);
COMMIT;
```

Now, a trigger, to write the timestamp and the row delimiter each time a message is written to the file:

```
SET TERM ^;
CREATE TRIGGER bi_ext_log FOR ext_log
ACTIVE BEFORE INSERT
AS
BEGIN
  IF (new.stamp is NULL) then
    new.stamp = CAST (CURRENT_TIMESTAMP as CHAR(24));
  new.crlf = ASCII_CHAR(13) || ASCII_CHAR(10);
END ^
COMMIT ^
SET TERM ;^
```

Inserting some records (which could have been done by an exception handler or a fan of Shakespeare):

```
insert into ext_log (message)
values('Shall I compare thee to a summer''s day?');
insert into ext_log (message)
values('Thou art more lovely and more temperate');
```

The output:

```
2015-10-07 15:19:03.4110Shall I compare thee to a summer's day?
2015-10-07 15:19:58.7600Thou art more lovely and more temperate
```

5.4.2. ALTER TABLE

Used for

Altering the structure of a table.

Available in

DSQL, ESQL

Syntax

```
ALTER TABLE tablename
  <operation> [, <operation> ...]

<operation> ::=
```

```
    ADD <col_def>
  | ADD <tconstraint>
  | DROP colname
  | DROP CONSTRAINT constr_name
  | ALTER [COLUMN] colname <col_mod>
  | ALTER SQL SECURITY {INVOKER | DEFINER}
  | DROP SQL SECURITY
  | {ENABLE | DISABLE} PUBLICATION

<col_mod> ::=
    TO newname
  | POSITION newpos
  | <regular_col_mod>
  | <computed_col_mod>
  | <identity_col_mod>

<regular_col_mod> ::=
    TYPE {<datatype> | domainname}
  | SET DEFAULT {<literal> | NULL | <context_var>}
  | DROP DEFAULT
  | {SET | DROP} NOT NULL

<computed_col_mod> ::=
    [TYPE <datatype>] {COMPUTED [BY] | GENERATED ALWAYS AS} (<expression>)

<identity_col_mod> ::=
    SET GENERATED {ALWAYS | BY DEFAULT} [<identity_mod_option>...]
  | <identity_mod_options>...
  | DROP IDENTITY

<identity_mod_options> ::=
    RESTART [WITH restart_value]
  | SET INCREMENT [BY] inc_value

!! See CREATE TABLE syntax for further rules !!
```

Table 34. ALTER TABLE Statement Parameters

Parameter	Description
tablename	Name (identifier) of the table
operation	One of the available operations altering the structure of the table
colname	Name (identifier) for a column in the table. The maximum length is 63 characters. Must be unique in the table.
domain_name	Domain name
newname	New name (identifier) for the column. The maximum length is 63 characters. Must be unique in the table.

Parameter	Description
newpos	The new column position (an integer between 1 and the number of columns in the table)
other_table	The name of the table referenced by the foreign key constraint
literal	A literal value that is allowed in the given context
context_var	A context variable whose type is allowed in the given context
check_condition	The condition of a `CHECK` constraint that will be satisfied if it evaluates to TRUE or UNKNOWN/NULL
restart_value	The first value of the identity column after restart
inc_value	The increment (or step) value of the identity column; zero (`0`) is not allowed.

The `ALTER TABLE` statement changes the structure of an existing table. With one `ALTER TABLE` statement it is possible to perform multiple operations, adding/dropping columns and constraints and also altering column specifications.

Multiple operations in an `ALTER TABLE` statement are separated with commas.

Version Count Increments

Some changes in the structure of a table increment the metadata change counter ("version count") assigned to every table. The number of metadata changes is limited to 255 for each table, or 32,000 for each view. Once the counter reaches this limit, you will not be able to make any further changes to the structure of the table or view without resetting the counter.

To reset the metadata change counter

You need to back up and restore the database using the *gbak* utility.

The `ADD` Clause

With the `ADD` clause you can add a new column or a new table constraint. The syntax for defining the column and the syntax of defining the table constraint correspond with those described for `CREATE TABLE` statement.

Effect on Version Count

- Each time a new column is added, the metadata change counter is increased by one
- Adding a new table constraint does not increase the metadata change counter

Points to Be Aware of

1. Adding a column with a `NOT NULL` constraint without a `DEFAULT` value will fail if the table has existing rows. When adding a non-nullable column, it is recommended either to set a default value for it, or to create it as nullable, update the column in existing rows with a non-null value, and then add a `NOT`

NULL constraint.

2. When a new CHECK constraint is added, existing data is not tested for compliance. Prior testing of existing data against the new CHECK expression is recommended.
3. Although adding an identity column is supported, this will only succeed if the table is empty. Adding an identity column will fail if the table has one or more rows.

The DROP Clause

The DROP colname clause deletes the specified column from the table. An attempt to drop a column will fail if anything references it. Consider the following items as sources of potential dependencies:

- column or table constraints
- indexes
- stored procedures and triggers
- views

Effect on Version Count

- Each time a column is dropped, the table's metadata change counter is increased by one.

The DROP CONSTRAINT Clause

The DROP CONSTRAINT clause deletes the specified column-level or table-level constraint.

A PRIMARY KEY or UNIQUE key constraint cannot be deleted if it is referenced by a FOREIGN KEY constraint in another table. It will be necessary to drop that FOREIGN KEY constraint before attempting to drop the PRIMARY KEY or UNIQUE key constraint it references.

Effect on Version Count

- Deleting a column constraint or a table constraint does not increase the metadata change counter.

The ALTER [COLUMN] Clause

With the ALTER [COLUMN] clause, attributes of existing columns can be modified without the need to drop and re-add the column. Permitted modifications are:

- change the name (does not affect the metadata change counter)
- change the data type (increases the metadata change counter by one)
- change the column position in the column list of the table (does not affect the metadata change counter)
- delete the default column value (does not affect the metadata change counter)
- set a default column value or change the existing default (does not affect the metadata change counter)

- change the type and expression for a computed column (does not affect the metadata change counter)
- set the NOT NULL constraint (does not affect the metadata change counter)
- drop the NOT NULL constraint (does not affect the metadata change counter)
- change the type of an identity column, or change an identity column to a regular column
- restart an identity column
- change the increment of an identity column

Renaming a Column: the TO Clause

The TO keyword with a new identifier renames an existing column. The table must not have an existing column that has the same identifier.

It will not be possible to change the name of a column that is included in any constraint: PRIMARY KEY, UNIQUE key, FOREIGN KEY, column constraint or the CHECK constraint of the table.

Renaming a column will also be disallowed if the column is used in any trigger, stored procedure or view.

Changing the Data Type of a Column: the TYPE Clause

The keyword TYPE changes the data type of an existing column to another, allowable type. A type change that might result in data loss will be disallowed. As an example, the number of characters in the new type for a CHAR or VARCHAR column cannot be smaller than the existing specification for it.

If the column was declared as an array, no change to its type or its number of dimensions is permitted.

The data type of a column that is involved in a foreign key, primary key or unique constraint cannot be changed at all.

Changing the Position of a Column: the POSITION Clause

The POSITION keyword changes the position of an existing column in the notional "left-to-right" layout of the record.

Numbering of column positions starts at 1.

- If a position less than 1 is specified, an error message will be returned
- If a position number is greater than the number of columns in the table, its new position will be adjusted silently to match the number of columns.

The DROP DEFAULT and SET DEFAULT Clauses

The optional DROP DEFAULT clause deletes the default value for the column if it was put there previously by a CREATE TABLE or ALTER TABLE statement.

- If the column is based on a domain with a default value, the default value will revert to the

domain default

- An execution error will be raised if an attempt is made to delete the default value of a column which has no default value or whose default value is domain-based

The optional SET DEFAULT clause sets a default value for the column. If the column already has a default value, it will be replaced with the new one. The default value applied to a column always overrides one inherited from a domain.

The SET NOT NULL and DROP NOT NULL Clauses

The SET NOT NULL clause adds a NOT NULL constraint on an existing table column. Contrary to definition in CREATE TABLE, it is not possible to specify a constraint name.

The successful addition of the NOT NULL constraint is subject to a full data validation on the table, so ensure that the column has no nulls before attempting the change.

An explicit NOT NULL constraint on domain-based column overrides domain settings. In this scenario, changing the domain to be nullable does not extend to a table column.

Dropping the NOT NULL constraint from the column if its type is a domain that also has a NOT NULL constraint, has no observable effect until the NOT NULL constraint is dropped from the domain as well.

The COMPUTED [BY] or GENERATED ALWAYS AS Clauses

The data type and expression underlying a computed column can be modified using a COMPUTED [BY] or GENERATED ALWAYS AS clause in the ALTER TABLE ALTER [COLUMN] statement. Converting a regular column to a computed one and vice versa are not permitted.

Changing Identity Columns

or identity columns (SET GENERATED {ALWAYS | BY DEFAULT}) it is possible to modify several properties using the following clauses.

Identity Type

The SET GENERATED {ALWAYS | BY DEFAULT} changes an identity column from ALWAYS to BY DEFAULT and vice versa. It is not possible to use this to change a regular column to an identity column.

RESTART

The RESTART clause restarts the sequence used for generating identity values. If only the RESTART clause is specified, then the sequence resets to the initial value specified when the identity column was defined. If the optional WITH restart_value clause is specified, the sequence will restart with the specified value.

In Firebird 3.0, RESTART WITH restart_value would also change the configured initial value to *restart_value*. This was not compliant with the SQL standard, so in Firebird 4.0, RESTART WITH restart_value will only restart the sequence with the

specified value. Subsequent RESTARTs (without WITH) will use the START WITH value specified when the identity column was defined.

It is currently not possible to change the configured start value.

SET INCREMENT

The SET INCREMENT clause changes the increment of the identity column.

DROP IDENTITY

The DROP IDENTITY clause will change an identity column to a regular column.

It is not possible to change a regular column to an identity column.

Changing SQL Security

Using the ALTER SQL SECURITY or DROP SQL SECURITY clauses, it is possible to change or drop the SQL Security property of a table. After dropping SQL Security, the default value of the database is applied at runtime.

If the SQL Security property is changed for a table, triggers that do not have an explicit SQL Security property will not see the effect of the change until the next time the trigger is loaded into the metadata cache.

Replication Management

To stop replicating a table, use the DISABLE PUBLICATION clause. To start replicating a table, use the ENABLE PUBLICATION clause.

The change in publication status takes effect at commit.

Attributes that Cannot Be Altered

The following alterations are not supported:

- Changing the collation of a character type column

Who Can Alter a Table?

The ALTER TABLE statement can be executed by:

- Administrators
- The owner of the table
- Users with the ALTER ANY TABLE privilege

Examples Using ALTER TABLE

1. Adding the CAPITAL column to the COUNTRY table.

```
ALTER TABLE COUNTRY
  ADD CAPITAL VARCHAR(25);
```

2. Adding the `CAPITAL` column with the `NOT NULL` and `UNIQUE` constraint and deleting the `CURRENCY` column.

```
ALTER TABLE COUNTRY
  ADD CAPITAL VARCHAR(25) NOT NULL UNIQUE,
  DROP CURRENCY;
```

3. Adding the `CHK_SALARY` check constraint and a foreign key to the `JOB` table.

```
ALTER TABLE JOB
  ADD CONSTRAINT CHK_SALARY CHECK (MIN_SALARY < MAX_SALARY),
  ADD FOREIGN KEY (JOB_COUNTRY) REFERENCES COUNTRY (COUNTRY);
```

4. Setting default value for the `MODEL` field, changing the type of the `ITEMID` column and renaming the MODELNAME column.

```
ALTER TABLE STOCK
  ALTER COLUMN MODEL SET DEFAULT 1,
  ALTER COLUMN ITEMID TYPE BIGINT,
  ALTER COLUMN MODELNAME TO NAME;
```

5. Restarting the sequence of an identity column.

```
ALTER TABLE objects
  ALTER ID RESTART WITH 100;
```

6. Changing the computed columns `NEW_SALARY` and `SALARY_CHANGE`.

```
ALTER TABLE SALARY_HISTORY
  ALTER NEW_SALARY GENERATED ALWAYS AS
    (OLD_SALARY + OLD_SALARY * PERCENT_CHANGE / 100),
  ALTER SALARY_CHANGE COMPUTED BY
    (OLD_SALARY * PERCENT_CHANGE / 100);
```

See also

`CREATE TABLE`, `DROP TABLE`, `CREATE DOMAIN`

5.4.3. DROP TABLE

Used for

Dropping (deleting) a table

Available in

DSQL, ESQL

Syntax

```
DROP TABLE tablename
```

Table 35. DROP TABLE Statement Parameter

Parameter	Description
tablename	Name (identifier) of the table

The DROP TABLE statement drops (deletes) an existing table. If the table has dependencies, the DROP TABLE statement will fail with an execution error.

When a table is dropped, all its triggers and indexes will be deleted as well.

Who Can Drop a Table?

The DROP TABLE statement can be executed by:

- Administrators
- The owner of the table
- Users with the DROP ANY TABLE privilege

Example of DROP TABLE

Dropping the COUNTRY table.

```
DROP TABLE COUNTRY;
```

See also

CREATE TABLE, ALTER TABLE, RECREATE TABLE

5.4.4. RECREATE TABLE

Used for

Creating a new table (relation) or recreating an existing one

Available in

DSQL

Syntax

```
RECREATE [GLOBAL TEMPORARY] TABLE tablename
  [EXTERNAL [FILE] 'filespec']
```

```
  (<col_def> [, {<col_def> | <tconstraint>} ...])
  [{<table_attrs> | <gtt_table_attrs>}]
```

See the CREATE TABLE section for the full syntax of CREATE TABLE and descriptions of defining tables, columns and constraints.

RECREATE TABLE creates or recreates a table. If a table with this name already exists, the RECREATE TABLE statement will try to drop it and create a new one. Existing dependencies will prevent the statement from executing.

Example of RECREATE TABLE

Creating or recreating the COUNTRY *table.*

```
RECREATE TABLE COUNTRY (
  COUNTRY COUNTRYNAME NOT NULL PRIMARY KEY,
  CURRENCY VARCHAR(10) NOT NULL
);
```

See also

CREATE TABLE, DROP TABLE

5.5. INDEX

An index is a database object used for faster data retrieval from a table or for speeding up the sorting in a query. Indexes are used also to enforce the refererential integrity constraints PRIMARY KEY, FOREIGN KEY and UNIQUE.

This section describes how to create indexes, activate and deactivate them, delete them and collect statistics (recalculate selectivity) for them.

5.5.1. CREATE INDEX

Used for

Creating an index for a table

Available in

DSQL, ESQL

Syntax

```
CREATE [UNIQUE] [ASC[ENDING] | DESC[ENDING]]
  INDEX indexname ON tablename
  {(col [, col …]) | COMPUTED BY (<expression>)}
```

Table 36. CREATE INDEX *Statement Parameters*

Parameter	Description
indexname	Index name. The maximum length is 63 characters
tablename	The name of the table for which the index is to be built
col	Name of a column in the table. Columns of the types BLOB and ARRAY and computed fields cannot be used in an index
expression	The expression that will compute the values for a computed index, also known as an “expression index”

The CREATE INDEX statement creates an index for a table that can be used to speed up searching, sorting and grouping. Indexes are created automatically in the process of defining constraints, such as primary key, foreign key or unique constraints.

An index can be built on the content of columns of any data type except for BLOB and arrays. The name (identifier) of an index must be unique among all index names.

Key Indexes

When a primary key, foreign key or unique constraint is added to a table or column, an index with the same name is created automatically, without an explicit directive from the designer. For example, the PK_COUNTRY index will be created automatically when you execute and commit the following statement:

```
ALTER TABLE COUNTRY ADD CONSTRAINT PK_COUNTRY
  PRIMARY KEY (ID);
```

Who Can Create an Index?

The CREATE INDEX statement can be executed by:

- Administrators
- The owner of the table
- Users with the ALTER ANY TABLE privilege

Unique Indexes

Specifying the keyword UNIQUE in the index creation statement creates an index in which uniqueness will be enforced throughout the table. The index is referred to as a “unique index”. A unique index is not a constraint.

Unique indexes cannot contain duplicate key values (or duplicate key value combinations, in the case of *compound*, or multi-column, or multi-segment) indexes. Duplicated NULLs are permitted, in accordance with the SQL:99 standard, in both single-segment and multi-segment indexes.

Index Direction

All indexes in Firebird are uni-directional. An index may be constructed from the lowest value to

the highest (ascending order) or from the highest value to the lowest (descending order). The keywords `ASC[ENDING]` and `DESC[ENDING]` are used to specify the direction of the index. The default index order is `ASC[ENDING]`. It is quite valid to define both an ascending and a descending index on the same column or key set.

A descending index can be useful on a column that will be subjected to searches on the high values ("newest", maximum, etc.)

Firebird uses B-tree indexes, which are bidirectional. However, due to technical limitations, Firebird uses an index in one direction only.

See also Firebird for the Database Expert: Episode 3 - On disk consistency

Computed (Expression) Indexes

In creating an index, you can use the `COMPUTED BY` clause to specify an expression instead of one or more columns. Computed indexes are used in queries where the condition in a `WHERE`, `ORDER BY` or `GROUP BY` clause exactly matches the expression in the index definition. The expression in a computed index may involve several columns in the table.

Expression indexes can also be used as a workaround for indexing computed columns: use the name of the computed column as the expression.

Limits on Indexes

Certain limits apply to indexes.

- The maximum length of a key in an index is limited to ¼ of the page size
- A compound index can have at most 16 columns

Maximum Indexes per Table

The number of indexes that can be accommodated for each table is limited. The actual maximum for a specific table depends on the page size and the number of columns in the indexes.

Table 37. Maximum Indexes per Table

Page Size	Number of Indexes Depending on Column Count		
	Single	2-Column	3-Column
4096	203	145	113
8192	408	291	227
16384	818	584	454
32768	1637	1169	909

Character Index Limits

The maximum indexed string length is 9 bytes less than the maximum key length. The maximum

indexable string length depends on the page size and the character set.

Table 38. Maximum indexable (VAR)CHAR length

Page Size	Maximum Indexable String Length by Charset Type			
	1 byte/char	2 byte/char	3 byte/char	4 byte/char
4096	1015	507	338	253
8192	2039	1019	679	509
16384	4087	2043	1362	1021
32768	8183	4091	2727	2045

Depending on the collation, the maximum size can be further reduced as case-insensitive and accent-insensitive collations require more bytes per character in an index. See also *Character Indexes* in Chapter *Data Types and Subtypes*.

Examples Using `CREATE INDEX`

1. Creating an index for the `UPDATER_ID` column in the `SALARY_HISTORY` table

```
CREATE INDEX IDX_UPDATER
  ON SALARY_HISTORY (UPDATER_ID);
```

2. Creating an index with keys sorted in the descending order for the `CHANGE_DATE` column in the `SALARY_HISTORY` table

```
CREATE DESCENDING INDEX IDX_CHANGE
  ON SALARY_HISTORY (CHANGE_DATE);
```

3. Creating a multi-segment index for the `ORDER_STATUS`, `PAID` columns in the `SALES` table

```
CREATE INDEX IDX_SALESTAT
  ON SALES (ORDER_STATUS, PAID);
```

4. Creating an index that does not permit duplicate values for the `NAME` column in the `COUNTRY` table

```
CREATE UNIQUE INDEX UNQ_COUNTRY_NAME
  ON COUNTRY (NAME);
```

5. Creating a computed index for the `PERSONS` table

```
CREATE INDEX IDX_NAME_UPPER ON PERSONS
  COMPUTED BY (UPPER (NAME));
```

An index like this can be used for a case-insensitive search:

```
SELECT *
FROM PERSONS
WHERE UPPER(NAME) STARTING WITH UPPER('Iv');
```

See also

`ALTER INDEX`, `DROP INDEX`

5.5.2. ALTER INDEX

Used for

Activating or deactivating an index; rebuilding an index

Available in

DSQL, ESQL

Syntax

```
ALTER INDEX indexname {ACTIVE | INACTIVE}
```

Table 39. `ALTER INDEX` Statement Parameter

Parameter	Description
indexname	Index name

The `ALTER INDEX` statement activates or deactivates an index. There is no facility on this statement for altering any attributes of the index.

`INACTIVE`

With the `INACTIVE` option, the index is switched from the active to inactive state. The effect is similar to the `DROP INDEX` statement except that the index definition remains in the database. Altering a constraint index to the inactive state is not permitted.

An active index can be deactivated if there are no queries prepared using that index; otherwise, an “object in use” error is returned.

Activating an inactive index is also safe. However, if there are active transactions modifying the table, the transaction containing the `ALTER INDEX` statement will fail if it has the `NOWAIT` attribute. If the transaction is in `WAIT` mode, it will wait for completion of concurrent transactions.

On the other side of the coin, if our `ALTER INDEX` succeeds and starts to rebuild the index at `COMMIT`, other transactions modifying that table will fail or wait, according to their `WAIT`/`NO WAIT` attributes. The situation is exactly the same for `CREATE INDEX`.

How is it Useful?

It might be useful to switch an index to the inactive state whilst inserting,

updating or deleting a large batch of records in the table that owns the index.

`ACTIVE`

With the `ACTIVE` option, if the index is in the inactive state, it will be switched to active state and the system rebuilds the index.

How is it Useful?

Even if the index is *active* when `ALTER INDEX ⋯ ACTIVE` is executed, the index will be rebuilt. Rebuilding indexes can be a useful piece of housekeeping to do, occasionally, on the indexes of a large table in a database that has frequent inserts, updates or deletes but is infrequently restored.

Who Can Alter an Index?

The `ALTER INDEX` statement can be executed by:

- Administrators
- The owner of the table
- Users with the `ALTER ANY TABLE` privilege

Use of `ALTER INDEX` on a Constraint Index

Altering the index of a `PRIMARY KEY`, `FOREIGN KEY` or `UNIQUE` constraint to `INACTIVE` is not permitted. However, `ALTER INDEX ⋯ ACTIVE` works just as well with constraint indexes as it does with others, as an index rebuilding tool.

ALTER INDEX Examples

1. Deactivating the `IDX_UPDATER` index

```
ALTER INDEX IDX_UPDATER INACTIVE;
```

2. Switching the `IDX_UPDATER` index back to the active state and rebuilding it

```
ALTER INDEX IDX_UPDATER ACTIVE;
```

See also

`CREATE INDEX`, `DROP INDEX`, `SET STATISTICS`

5.5.3. DROP INDEX

Used for

Dropping (deleting) an index

Available in

DSQL, ESQL

Syntax

```
DROP INDEX indexname
```

Table 40. DROP INDEX Statement Parameter

Parameter	Description
indexname	Index name

The DROP INDEX statement drops (deletes) the named index from the database.

A constraint index cannot dropped using DROP INDEX. Constraint indexes are dropped during the process of executing the command ALTER TABLE … DROP CONSTRAINT ….

Who Can Drop an Index?

The DROP INDEX statement can be executed by:

- Administrators
- The owner of the table
- Users with the ALTER ANY TABLE privilege

DROP INDEX Example

Dropping the IDX_UPDATER index

```
DROP INDEX IDX_UPDATER;
```

See also

CREATE INDEX, ALTER INDEX

5.5.4. SET STATISTICS

Used for

Recalculating the selectivity of an index

Available in

DSQL, ESQL

Syntax

```
SET STATISTICS INDEX indexname
```

Table 41. SET STATISTICS Statement Parameter

Parameter	Description
indexname	Index name

The `SET STATISTICS` statement recalculates the selectivity of the specified index.

Who Can Update Index Statistics?

The `SET STATISTICS` statement can be executed by:

- Administrators
- The owner of the table
- Users with the `ALTER ANY TABLE` privilege

Index Selectivity

The selectivity of an index is the result of evaluating the number of rows that can be selected in a search on every index value. A unique index has the maximum selectivity because it is impossible to select more than one row for each value of an index key if it is used. Keeping the selectivity of an index up to date is important for the optimizer's choices in seeking the most optimal query plan.

Index statistics in Firebird are not automatically recalculated in response to large batches of inserts, updates or deletions. It may be beneficial to recalculate the selectivity of an index after such operations because the selectivity tends to become outdated.

The statements `CREATE INDEX` and `ALTER INDEX ACTIVE` both store index statistics that completely correspond to the contents of the newly-[re]built index.

It can be performed under concurrent load without risk of corruption. However, be aware that, under concurrent load, the newly calculated statistics could become outdated as soon as `SET STATISTICS` finishes.

Example Using SET STATISTICS

Recalculating the selectivity of the index `IDX_UPDATER`

```
SET STATISTICS INDEX IDX_UPDATER;
```

See also

`CREATE INDEX`, `ALTER INDEX`

5.6. VIEW

A view is a virtual table that is actually a stored and named `SELECT` query for retrieving data of any complexity. Data can be retrieved from one or more tables, from other views and also from selectable stored procedures.

Unlike regular tables in relational databases, a view is not an independent data set stored in the

database. The result is dynamically created as a data set when the view is selected.

The metadata of a view are available to the process that generates the binary code for stored procedures and triggers, just as though they were concrete tables storing persistent data.

5.6.1. CREATE VIEW

Used for

Creating a view

Available in

DSQL

Syntax

```
CREATE VIEW viewname [<full_column_list>]
  AS <select_statement>
  [WITH CHECK OPTION]

<full_column_list> ::= (colname [, colname ...])
```

Table 42. CREATE VIEW Statement Parameters

Parameter	Description
viewname	View name. The maximum length is 63 characters
select_statement	SELECT statement
full_column_list	The list of columns in the view
colname	View column name. Duplicate column names are not allowed.

The CREATE VIEW statement creates a new view. The identifier (name) of a view must be unique among the names of all views, tables and stored procedures in the database.

The name of the new view can be followed by the list of column names that should be returned to the caller when the view is invoked. Names in the list do not have to be related to the names of the columns in the base tables from which they derive.

If the view column list is omitted, the system will use the column names and/or aliases from the SELECT statement. If duplicate names or non-aliased expression-derived columns make it impossible to obtain a valid list, creation of the view fails with an error.

The number of columns in the view's list must exactly match the number of columns in the selection list of the underlying SELECT statement in the view definition.

Additional Points

- If the full list of columns is specified, it makes no sense to specify aliases in the SELECT statement because the names in the column list will override them
- The column list is optional if all the columns in the SELECT are explicitly named

and are unique in the selection list

Updatable Views

A view can be updatable or read-only. If a view is updatable, the data retrieved when this view is called can be changed by the DML statements `INSERT`, `UPDATE`, `DELETE`, `UPDATE OR INSERT` or `MERGE`. Changes made in an updatable view are applied to the underlying table(s).

A read-only view can be made updateable with the use of triggers. Once triggers have been defined on a view, changes posted to it will never be written automatically to the underlying table, even if the view was updateable to begin with. It is the responsibility of the programmer to ensure that the triggers update (or delete from, or insert into) the base tables as needed.

A view will be automatically updatable if all the following conditions are met:

- the `SELECT` statement queries only one table or one updatable view
- the `SELECT` statement does not call any stored procedures
- each base table (or base view) column not present in the view definition meets one of the following conditions:
  - it is nullable
  - it has a non-`NULL` default value
  - it has a trigger that supplies a permitted value
- the `SELECT` statement contains no fields derived from subqueries or other expressions
- the `SELECT` statement does not contain fields defined through aggregate functions (`MIN`, `MAX`, `AVG`, `SUM`, `COUNT`, `LIST`, etc.), statistical functions (`CORR`, `COVAR_POP`, `COVAR_SAMP`, etc.), linear regression functions (`REGR_AVGX`, `REGR_AVGY`, etc.) or any type of window function
- the `SELECT` statement contains no `ORDER BY`, `GROUP BY` or `HAVING` clause
- the `SELECT` statement does not include the keyword `DISTINCT` or row-restrictive keywords such as `ROWS`, `FIRST`, `SKIP`, `OFFSET` or `FETCH`

`WITH CHECK OPTION`

The optional `WITH CHECK OPTION` clause requires an updatable view to check whether new or updated data meet the condition specified in the `WHERE` clause of the `SELECT` statement. Every attempt to insert a new record or to update an existing one is checked whether the new or updated record would meet the `WHERE` criteria. If they fail the check, the operation is not performed and an appropriate error message is returned.

`WITH CHECK OPTION` can be specified only in a `CREATE VIEW` statement in which a `WHERE` clause is present to restrict the output of the main `SELECT` statement. An error message is returned otherwise.

Please note:

If `WITH CHECK OPTION` is used, the engine checks the input against the `WHERE` clause before passing anything to the base relation. Therefore, if the check on the input fails, any default clauses or triggers on the base relation that might have been designed to correct the input will never come into action.

> Furthermore, view fields omitted from the INSERT statement are passed as NULLs to the base relation, regardless of their presence or absence in the WHERE clause. As a result, base table defaults defined on such fields will not be applied. Triggers, on the other hand, will fire and work as expected.
>
> For views that do not have WITH CHECK OPTION, fields omitted from the INSERT statement are not passed to the base relation at all, so any defaults will be applied.

Who Can Create a View?

The CREATE VIEW statement can be executed by:

- Administrators
- Users with the CREATE VIEW privilege

The creator of a view becomes its owner.

To create a view, a non-admin user also needs at least SELECT access to the underlying table(s) and/or view(s), and the EXECUTE privilege on any selectable stored procedures involved.

To enable insertions, updates and deletions through the view, the creator/owner must also possess the corresponding INSERT, UPDATE and DELETE rights on the underlying object(s).

Granting other users privileges on the view is only possible if the view owner has these privileges on the underlying objects WITH GRANT OPTION. It will always be the case if the view owner is also the owner of the underlying objects.

Examples of Creating Views

1. Creating view returning the JOB_CODE and JOB_TITLE columns only for those jobs where MAX_SALARY is less than $15,000.

```
CREATE VIEW ENTRY_LEVEL_JOBS AS
SELECT JOB_CODE, JOB_TITLE
FROM JOB
WHERE MAX_SALARY < 15000;
```

2. Creating a view returning the JOB_CODE and JOB_TITLE columns only for those jobs where MAX_SALARY is less than $15,000. Whenever a new record is inserted or an existing record is updated, the MAX_SALARY < 15000 condition will be checked. If the condition is not true, the insert/update operation will be rejected.

```
CREATE VIEW ENTRY_LEVEL_JOBS AS
SELECT JOB_CODE, JOB_TITLE
FROM JOB
WHERE MAX_SALARY < 15000
WITH CHECK OPTION;
```

3. Creating a view with an explicit column list.

```
CREATE VIEW PRICE_WITH_MARKUP (
  CODE_PRICE,
  COST,
  COST_WITH_MARKUP
) AS
SELECT
  CODE_PRICE,
  COST,
  COST * 1.1
FROM PRICE;
```

4. Creating a view with the help of aliases for fields in the `SELECT` statement (the same result as in Example 3).

```
CREATE VIEW PRICE_WITH_MARKUP AS
SELECT
  CODE_PRICE,
  COST,
  COST * 1.1 AS COST_WITH_MARKUP
FROM PRICE;
```

5. Creating a read-only view based on two tables and a stored procedure.

```
CREATE VIEW GOODS_PRICE AS
SELECT
  goods.name AS goodsname,
  price.cost AS cost,
  b.quantity AS quantity
FROM
  goods
  JOIN price ON goods.code_goods = price.code_goods
  LEFT JOIN sp_get_balance(goods.code_goods) b ON 1 = 1;
```

See also

`ALTER VIEW`, `CREATE OR ALTER VIEW`, `RECREATE VIEW`, `DROP VIEW`

5.6.2. ALTER VIEW

Used for

Modifying an existing view

Available in

DSQL

Syntax

```
ALTER VIEW viewname [<full_column_list>]
    AS <select_statement>
    [WITH CHECK OPTION]

<full_column_list> ::= (colname [, colname ...])
```

Table 43. ALTER VIEW Statement Parameters

Parameter	Description
viewname	Name of an existing view
select_statement	SELECT statement
full_column_list	The list of columns in the view
colname	View column name. Duplicate column names are not allowed.

Use the ALTER VIEW statement for changing the definition of an existing view. Privileges for views remain intact and dependencies are not affected.

The syntax of the ALTER VIEW statement corresponds completely with that of CREATE VIEW.

Be careful when you change the number of columns in a view. Existing application code and PSQL modules that access the view may become invalid. For information on how to detect this kind of problem in stored procedures and trigger, see *The RDB$VALID_BLR Field* in the Appendix.

Who Can Alter a View?

The ALTER VIEW statement can be executed by:

- Administrators
- The owner of the view
- Users with the ALTER ANY VIEW privilege

Example using ALTER VIEW

Altering the view PRICE_WITH_MARKUP

```
ALTER VIEW PRICE_WITH_MARKUP (
  CODE_PRICE,
  COST,
  COST_WITH_MARKUP
) AS
SELECT
  CODE_PRICE,
  COST,
  COST * 1.15
```

```
FROM PRICE;
```

See also

`CREATE VIEW`, `CREATE OR ALTER VIEW`, `RECREATE VIEW`

5.6.3. CREATE OR ALTER VIEW

Used for

Creating a new view or altering an existing view.

Available in

DSQL

Syntax

```
CREATE OR ALTER VIEW viewname [<full_column_list>]
  AS <select_statement>
  [WITH CHECK OPTION]

<full_column_list> ::= (colname [, colname ...])
```

Table 44. `CREATE OR ALTER VIEW` *Statement Parameters*

Parameter	Description
viewname	Name of a view which may or may not exist
select_statement	SELECT statement
full_column_list	The list of columns in the view
colname	View column name. Duplicate column names are not allowed.

Use the `CREATE OR ALTER VIEW` statement for changing the definition of an existing view or creating it if it does not exist. Privileges for an existing view remain intact and dependencies are not affected.

The syntax of the `CREATE OR ALTER VIEW` statement corresponds completely with that of `CREATE VIEW`.

Example of `CREATE OR ALTER VIEW`

Creating the new view `PRICE_WITH_MARKUP` *view or altering it if it already exists*

```
CREATE OR ALTER VIEW PRICE_WITH_MARKUP (
  CODE_PRICE,
  COST,
  COST_WITH_MARKUP
) AS
SELECT
  CODE_PRICE,
  COST,
  COST * 1.15
```

```
FROM PRICE;
```

See also

`CREATE VIEW`, `ALTER VIEW`, `RECREATE VIEW`

5.6.4. DROP VIEW

Used for

Deleting (dropping) a view

Available in

DSQL

Syntax

```
DROP VIEW viewname
```

Table 45. `DROP VIEW` Statement Parameter

Parameter	Description
viewname	View name

The `DROP VIEW` statement drops (deletes) an existing view. The statement will fail if the view has dependencies.

Who Can Drop a View?

The `DROP VIEW` statement can be executed by:

- Administrators
- The owner of the view
- Users with the `DROP ANY VIEW` privilege

Example

Deleting the `PRICE_WITH_MARKUP` view

```
DROP VIEW PRICE_WITH_MARKUP;
```

See also

`CREATE VIEW`, `RECREATE VIEW`, `CREATE OR ALTER VIEW`

5.6.5. RECREATE VIEW

Used for

Creating a new view or recreating an existing view

Available in

DSQL

Syntax

```
RECREATE VIEW viewname [<full_column_list>]
  AS <select_statement>
  [WITH CHECK OPTION]

<full_column_list> ::= (colname [, colname ...])
```

Table 46. `RECREATE VIEW` Statement Parameters

Parameter	Description
viewname	View name. The maximum length is 63 characters
select_statement	SELECT statement
full_column_list	The list of columns in the view
colname	View column name. Duplicate column names are not allowed.

Creates or recreates a view. If there is a view with this name already, the engine will try to drop it before creating the new instance. If the existing view cannot be dropped, because of dependencies or insufficient rights, for example, `RECREATE VIEW` fails with an error.

Example of `RECREATE VIEW`

Creating the new view `PRICE_WITH_MARKUP` view or recreating it, if it already exists

```
RECREATE VIEW PRICE_WITH_MARKUP (
  CODE_PRICE,
  COST,
  COST_WITH_MARKUP
) AS
SELECT
  CODE_PRICE,
  COST,
  COST * 1.15
FROM PRICE;
```

See also

`CREATE VIEW`, `DROP VIEW`, `CREATE OR ALTER VIEW`

5.7. TRIGGER

A trigger is a special type of stored procedure that is not called directly, instead being executed when a specified event occurs in the associated table or view. A DML trigger is specific to one and only one relation (table or view) and one phase in the timing of the event (*BEFORE* or *AFTER*). It can be specified to execute for one specific event (insert, update, delete) or for some combination of

two or three of those events.

Two other forms of trigger exist:

1. a “database trigger” can be specified to fire at the start or end of a user session (connection) or a user transaction.
2. a “DDL trigger” can be specified to fire at the before or after execution of one or more types of DDL statements.

5.7.1. CREATE TRIGGER

Used for

Creating a new trigger

Available in

DSQL, ESQL

Syntax

```
CREATE TRIGGER trigname
  { <relation_trigger_legacy>
  | <relation_trigger_sql2003>
  | <database_trigger>
  | <ddl_trigger> }
  {<psql_trigger> | <external-module-body>}

<relation_trigger_legacy> ::=
  FOR {tablename | viewname}
  [ACTIVE | INACTIVE]
  {BEFORE | AFTER} <mutation_list>
  [POSITION number]

<relation_trigger_sql2003> ::=
  [ACTIVE | INACTIVE]
  {BEFORE | AFTER} <mutation_list>
  ON {tablename | viewname}
  [POSITION number]

<database_trigger> ::=
  [ACTIVE | INACTIVE] ON <db_event>
  [POSITION number]

<ddl_trigger> ::=
  [ACTIVE | INACTIVE]
  {BEFORE | AFTER} <ddl_event>
  [POSITION number]

<mutation_list> ::=
  <mutation> [OR <mutation> [OR <mutation>]]
```

```
<mutation> ::= INSERT | UPDATE | DELETE

<db_event> ::=
    CONNECT | DISCONNECT
  | TRANSACTION {START | COMMIT | ROLLBACK}

<ddl_event> ::=
    ANY DDL STATEMENT
  | <ddl_event_item> [{OR <ddl_event_item>} ...]

<ddl_event_item> ::=
    {CREATE | ALTER | DROP} TABLE
  | {CREATE | ALTER | DROP} PROCEDURE
  | {CREATE | ALTER | DROP} FUNCTION
  | {CREATE | ALTER | DROP} TRIGGER
  | {CREATE | ALTER | DROP} EXCEPTION
  | {CREATE | ALTER | DROP} VIEW
  | {CREATE | ALTER | DROP} DOMAIN
  | {CREATE | ALTER | DROP} ROLE
  | {CREATE | ALTER | DROP} SEQUENCE
  | {CREATE | ALTER | DROP} USER
  | {CREATE | ALTER | DROP} INDEX
  | {CREATE | DROP} COLLATION
  | ALTER CHARACTER SET
  | {CREATE | ALTER | DROP} PACKAGE
  | {CREATE | DROP} PACKAGE BODY
  | {CREATE | ALTER | DROP} MAPPING

<psql_trigger> ::=
  [SQL SECURITY {INVOKER | DEFINER}]
  <psql-module-body>

<psql-module-body> ::=
  !! See Syntax of Module Body !!

<external-module-body> ::=
  !! See Syntax of Module Body !!
```

Table 47. `CREATE TRIGGER` *Statement Parameters*

Parameter	Description
trigname	Trigger name. The maximum length is 63 characters. It must be unique among all trigger names in the database.
relation_trigger_legacy	Legacy style of trigger declaration for a relation trigger
relation_trigger_sql2003	Relation trigger declaration compliant with the SQL:2003 standard
database_trigger	Database trigger declaration
tablename	Name of the table with which the relation trigger is associated

Parameter	Description
viewname	Name of the view with which the relation trigger is associated
mutation_list	List of relation (table | view) events
number	Position of the trigger in the firing order. From 0 to 32,767
db_event	Connection or transaction event
ddl_event	List of metadata change events
ddl_event_item	One of the metadata change events

The `CREATE TRIGGER` statement is used for creating a new trigger. A trigger can be created either for a *relation (table | view) event* (or a combination of events), for a *database event*, or for a *DDL event*.

`CREATE TRIGGER`, along with its associates `ALTER TRIGGER`, `CREATE OR ALTER TRIGGER` and `RECREATE TRIGGER`, is a *compound statement*, consisting of a header and a body. The header specifies the name of the trigger, the name of the relation (for a DML trigger), the phase of the trigger, the event(s) it applies to, and the position to determine an order between triggers.

The trigger body consists of optional declarations of local variables and named cursors followed by one or more statements, or blocks of statements, all enclosed in an outer block that begins with the keyword `BEGIN` and ends with the keyword `END`. Declarations and embedded statements are terminated with semi-colons (‘;’).

The name of the trigger must be unique among all trigger names.

Statement Terminators

Some SQL statement editors — specifically the *isql* utility that comes with Firebird and possibly some third-party editors — employ an internal convention that requires all statements to be terminated with a semi-colon. This creates a conflict with PSQL syntax when coding in these environments. If you are unacquainted with this problem and its solution, please study the details in the PSQL chapter in the section entitled Switching the Terminator in *isql*.

SQL Security

The `SQL SECURITY` clause specifies the security context for executing other routines or inserting into other tables.

By default, a trigger applies the SQL Security property defined on its table (or — if the table doesn’t have the SQL Security property set — the database default), but it can be overridden by specifying it explicitly.

If the SQL Security property is changed for the table, triggers that do not have an explicit SQL Security property will not see the effect of the change until the next time the trigger is loaded into the metadata cache.

See also *SQL Security* in chapter *Security*.

The Trigger Body

The trigger body is either a PSQL body, or an external UDR module body.

See The Module Body in the PSQL chapter for details.

DML Triggers (on Tables or Views)

DML — or "relation" — triggers are executed at the row (record) level, every time the row image changes. A trigger can be either `ACTIVE` or `INACTIVE`. Only active triggers are executed. Triggers are created `ACTIVE` by default.

Who Can Create a DML Trigger?

DML triggers can be created by:

- Administrators
- The owner of the table (or view)
- Users with the `ALTER ANY TABLE` or — for a view — `ALTER ANY VIEW` privilege

Forms of Declaration

Firebird supports two forms of declaration for relation triggers:

- The original, legacy syntax
- The SQL:2003 standard-compliant form (recommended)

The SQL:2003 standard-compliant form is the recommended one.

A relation trigger specifies — among other things — a *phase* and one or more *events*.

Phase

Phase concerns the timing of the trigger with regard to the change-of-state event in the row of data:

- A `BEFORE` trigger is fired before the specified database operation (insert, update or delete) is carried out
- An `AFTER` trigger is fired after the database operation has been completed

Row Events

A relation trigger definition specifies at least one of the DML operations `INSERT`, `UPDATE` and `DELETE`, to indicate one or more events on which the trigger should fire. If multiple operations are specified, they must be separated by the keyword `OR`. No operation may occur more than once.

Within the statement block, the Boolean context variables `INSERTING`, `UPDATING` and `DELETING` can be used to test which operation is currently executing.

Firing Order of Triggers

The keyword `POSITION` allows an optional execution order ("firing order") to be specified for a series

of triggers that have the same phase and event as their target. The default position is 0. If multiple triggers have the same position and phase, those triggers will be executed in an undefined order, while respecting the total order by position and phase.

Examples of `CREATE TRIGGER` for Tables and Views

1. Creating a trigger in the "legacy" form, firing before the event of inserting a new record into the `CUSTOMER` table occurs.

```
CREATE TRIGGER SET_CUST_NO FOR CUSTOMER
ACTIVE BEFORE INSERT POSITION 0
AS
BEGIN
  IF (NEW.CUST_NO IS NULL) THEN
    NEW.CUST_NO = GEN_ID(CUST_NO_GEN, 1);
END
```

2. Creating a trigger firing before the event of inserting a new record into the `CUSTOMER` table in the SQL:2003 standard-compliant form.

```
CREATE TRIGGER set_cust_no
ACTIVE BEFORE INSERT ON customer POSITION 0
AS
BEGIN
  IF (NEW.cust_no IS NULL) THEN
    NEW.cust_no = GEN_ID(cust_no_gen, 1);
END
```

3. Creating a trigger that will fire after either inserting, updating or deleting a record in the `CUSTOMER` table.

```
CREATE TRIGGER TR_CUST_LOG
ACTIVE AFTER INSERT OR UPDATE OR DELETE
ON CUSTOMER POSITION 10
AS
BEGIN
  INSERT INTO CHANGE_LOG (LOG_ID,
                          ID_TABLE,
                          TABLE_NAME,
                          MUTATION)
  VALUES (NEXT VALUE FOR SEQ_CHANGE_LOG,
          OLD.CUST_NO,
          'CUSTOMER',
          CASE
            WHEN INSERTING THEN 'INSERT'
            WHEN UPDATING  THEN 'UPDATE'
            WHEN DELETING  THEN 'DELETE'
          END);
```

```
END
```

4. With DEFINER set for trigger tr_ins, user US needs only the INSERT privilege on tr. If it were set for INVOKER, either the user or the trigger would also need the INSERT privilege on table t.

```
create table tr (i integer);
create table t (i integer);
set term ^;
create trigger tr_ins for tr after insert SQL SECURITY DEFINER
as
begin
  insert into t values (NEW.i);
end^
set term ;^
grant insert on table tr to user us;

commit;

connect 'localhost:/tmp/29.fdb' user us password 'pas';
insert into tr values(2);
```

   The result would be the same if SQL SECURITY DEFINER were specified for table TR:

```
create table tr (i integer) SQL SECURITY DEFINER;
create table t (i integer);
set term ^;
create trigger tr_ins for tr after insert
as
begin
  insert into t values (NEW.i);
end^
set term ;^
grant insert on table tr to user us;

commit;

connect 'localhost:/tmp/29.fdb' user us password 'pas';
insert into tr values(2);
```

Database Triggers

Triggers can be defined to fire upon “database events”, which really refers to a mixture of events that act across the scope of a session (connection) and events that act across the scope of an individual transaction:

- CONNECT
- DISCONNECT

- TRANSACTION START
- TRANSACTION COMMIT
- TRANSACTION ROLLBACK

DDL Triggers are a sub-type of database triggers, covered in a separate section.

Who Can Create a Database Trigger?

Database triggers can be created by:

- Administrators
- Users with the ALTER DATABASE privilege

Execution of Database Triggers and Exception Handling

CONNECT and DISCONNECT triggers are executed in a transaction created specifically for this purpose. This transaction uses the default isolation level, i.e. snapshot (concurrency), write and wait. If all goes well, the transaction is committed. Uncaught exceptions cause the transaction to roll back, and

- for a CONNECT trigger, the connection is then broken and the exception is returned to the client
- for a DISCONNECT trigger, exceptions are not reported. The connection is broken as intended

TRANSACTION triggers are executed within the transaction whose start, commit or rollback evokes them. The action taken after an uncaught exception depends on the event:

- In a TRANSACTION START trigger, the exception is reported to the client and the transaction is rolled back
- In a TRANSACTION COMMIT trigger, the exception is reported, the trigger's actions so far are undone and the commit is cancelled
- In a TRANSACTION ROLLBACK trigger, the exception is not reported and the transaction is rolled back as intended.

Traps

Obviously there is no direct way of knowing if a DISCONNECT or TRANSACTION ROLLBACK trigger caused an exception. It also follows that the connection to the database cannot happen if a CONNECT trigger causes an exception and a transaction cannot start if a TRANSACTION START trigger causes one, either. Both phenomena effectively lock you out of your database until you get in there with database triggers suppressed and fix the bad code.

Suppressing Database Triggers

Some Firebird command-line tools have been supplied with switches that an administrator can use to suppress the automatic firing of database triggers. So far, they are:

```
gbak -nodbtriggers
isql -nodbtriggers
```

```
nbackup -T
```

Two-phase Commit

In a two-phase commit scenario, TRANSACTION COMMIT triggers fire in the prepare phase, not at the commit.

Some Caveats

1. The use of the IN AUTONOMOUS TRANSACTION DO statement in the database event triggers related to transactions (TRANSACTION START, TRANSACTION ROLLBACK, TRANSACTION COMMIT) may cause the autonomous transaction to enter an infinite loop
2. The DISCONNECT and TRANSACTION ROLLBACK event triggers will not be executed when clients are disconnected via monitoring tables (DELETE FROM MON$ATTACHMENTS)

Only the database owner and administrators have the authority to create database triggers.

Examples of CREATE TRIGGER for "Database Triggers"

1. Creating a trigger for the event of connecting to the database that logs users logging into the system. The trigger is created as inactive.

```
CREATE TRIGGER tr_log_connect
INACTIVE ON CONNECT POSITION 0
AS
BEGIN
  INSERT INTO LOG_CONNECT (ID,
                           USERNAME,
                           ATIME)
  VALUES (NEXT VALUE FOR SEQ_LOG_CONNECT,
          CURRENT_USER,
          CURRENT_TIMESTAMP);
END
```

2. Creating a trigger for the event of connecting to the database that does not permit any users, except for SYSDBA, to log in during off hours.

```
CREATE EXCEPTION E_INCORRECT_WORKTIME 'The working day has not started yet.';

CREATE TRIGGER TR_LIMIT_WORKTIME ACTIVE
ON CONNECT POSITION 1
AS
BEGIN
  IF ((CURRENT_USER <> 'SYSDBA') AND
      NOT (CURRENT_TIME BETWEEN time '9:00' AND time '17:00')) THEN
    EXCEPTION E_INCORRECT_WORKTIME;
END
```

DDL Triggers

DDL triggers allow restrictions to be placed on users who attempt to create, alter or drop a DDL object. Their other purposes is to keep a metadata change log.

DDL triggers fire on specified metadata changes events in a specified phase. `BEFORE` triggers run before changes to system tables. `AFTER` triggers run after changes in system tables.

The event type `[BEFORE | AFTER]` of a DDL trigger cannot be changed.

In some sense, DDL triggers are a sub-type of database triggers.

Who Can Create a DDL Trigger?

DDL triggers can be created by:

- Administrators
- Users with the `ALTER DATABASE` privilege

Suppressing DDL Triggers

A DDL trigger is a type of database trigger. See Suppressing Database Triggers how to suppress database — and DDL — triggers.

Examples of DDL Triggers

1. Here is how you might use a DDL trigger to enforce a consistent naming scheme, in this case, stored procedure names should begin with the prefix “SP_”:

```
set auto on;
create exception e_invalid_sp_name 'Invalid SP name (should start with SP_)';

set term !;

create trigger trig_ddl_sp before CREATE PROCEDURE
as
begin
  if (rdb$get_context('DDL_TRIGGER', 'OBJECT_NAME') not starting 'SP_') then
    exception e_invalid_sp_name;
end!
```

Test

```
create procedure sp_test
as
begin
end!

create procedure test
```

```
as
begin
end!

-- The last command raises this exception and procedure TEST is not created
-- Statement failed, SQLSTATE = 42000
-- exception 1
-- -E_INVALID_SP_NAME
-- -Invalid SP name (should start with SP_)
-- -At trigger 'TRIG_DDL_SP' line: 4, col: 5

set term ;!
```

2. Implement custom DDL security, in this case restricting the running of DDL commands to certain users:

```
create exception e_access_denied 'Access denied';

set term !;

create trigger trig_ddl before any ddl statement
as
begin
  if (current_user <> 'SUPER_USER') then
    exception e_access_denied;
end!
```

Test

```
create procedure sp_test
as
begin
end!

-- The last command raises this exception and procedure SP_TEST is not created
-- Statement failed, SQLSTATE = 42000
-- exception 1
-- -E_ACCESS_DENIED
-- -Access denied
-- -At trigger 'TRIG_DDL' line: 4, col: 5

set term ;!
```

Firebird has privileges for executing DDL statements, so writing a DDL trigger for this should be a last resort, if the same effect cannot be achieved using privileges.

3. Use a trigger to log DDL actions and attempts:

```
create sequence ddl_seq;

create table ddl_log (
  id bigint not null primary key,
  moment timestamp not null,
  user_name varchar(63) not null,
  event_type varchar(25) not null,
  object_type varchar(25) not null,
  ddl_event varchar(25) not null,
  object_name varchar(63) not null,
  sql_text blob sub_type text not null,
  ok char(1) not null
);

set term !;

create trigger trig_ddl_log_before before any ddl statement
as
  declare id type of column ddl_log.id;
begin
  -- We do the changes in an AUTONOMOUS TRANSACTION, so if an exception happens
  -- and the command didn't run, the log will survive.
  in autonomous transaction do
  begin
    insert into ddl_log (id, moment, user_name, event_type, object_type,
                         ddl_event, object_name, sql_text, ok)
      values (next value for ddl_seq, current_timestamp, current_user,
              rdb$get_context('DDL_TRIGGER', 'EVENT_TYPE'),
              rdb$get_context('DDL_TRIGGER', 'OBJECT_TYPE'),
              rdb$get_context('DDL_TRIGGER', 'DDL_EVENT'),
              rdb$get_context('DDL_TRIGGER', 'OBJECT_NAME'),
              rdb$get_context('DDL_TRIGGER', 'SQL_TEXT'),
              'N')
      returning id into id;
    rdb$set_context('USER_SESSION', 'trig_ddl_log_id', id);
  end
end!
```

The above trigger will fire for this DDL command. It's a good idea to use `-nodbtriggers` when working with them!

```
create trigger trig_ddl_log_after after any ddl statement
as
begin
  -- Here we need an AUTONOMOUS TRANSACTION because the original transaction
  -- will not see the record inserted on the BEFORE trigger autonomous
  -- transaction if user transaction is not READ COMMITTED.
```

```
  in autonomous transaction do
     update ddl_log set ok = 'Y'
     where id = rdb$get_context('USER_SESSION', 'trig_ddl_log_id');
end!

commit!

set term ;!

-- Delete the record about trig_ddl_log_after creation.
delete from ddl_log;
commit;
```

Test

```
-- This will be logged one time
-- (as T1 did not exist, RECREATE acts as CREATE) with OK = Y.
recreate table t1 (
  n1 integer,
  n2 integer
);

-- This will fail as T1 already exists, so OK will be N.
create table t1 (
  n1 integer,
  n2 integer
);

-- T2 does not exist. There will be no log.
drop table t2;

-- This will be logged twice
-- (as T1 exists, RECREATE acts as DROP and CREATE) with OK = Y.
recreate table t1 (
  n integer
);

commit;
```

```
select id, ddl_event, object_name, sql_text, ok
  from ddl_log order by id;

 ID DDL_EVENT                OBJECT_NAME                     SQL_TEXT OK
=== ======================== ======================= ================ ======
  2 CREATE TABLE             T1                                  80:3 Y
=================================================
SQL_TEXT:
recreate table t1 (
```

```
    n1 integer,
    n2 integer
)
==========================================================
  3 CREATE TABLE             T1                                 80:2 N
==========================================================
SQL_TEXT:
create table t1 (
    n1 integer,
    n2 integer
)
==========================================================
  4 DROP TABLE               T1                                 80:6 Y
==========================================================
SQL_TEXT:
recreate table t1 (
    n integer
)
==========================================================
  5 CREATE TABLE             T1                                 80:9 Y
==========================================================
SQL_TEXT:
recreate table t1 (
    n integer
)
==========================================================
```

See also

`ALTER TRIGGER`, `CREATE OR ALTER TRIGGER`, `RECREATE TRIGGER`, `DROP TRIGGER`, DDL Triggers in Chapter *Procedural SQL (PSQL) Statements*

5.7.2. ALTER TRIGGER

Used for

Modifying and deactivating an existing trigger

Available in

DSQL, ESQL

Syntax

```
ALTER TRIGGER trigname
  [ACTIVE | INACTIVE]
  [{BEFORE | AFTER} <mutation_list>]
  [POSITION number]
  [{<psql_trigger> | <external-module-body>}]

<psql_trigger> ::=
  [<sql_security>]
  [<psql-module-body>]
```

```
<sql_security> ::=
    SQL SECURITY {INVOKER | DEFINER}
  | DROP SQL SECURITY

!! See syntax of CREATE TRIGGER for further rules !!
```

The ALTER TRIGGER statement only allows certain changes to the header and body of a trigger.

Permitted Changes to Triggers

- Status (ACTIVE | INACTIVE)
- Phase (BEFORE | AFTER) (of DML triggers)
- Events (of DML triggers)
- Position in the firing order
- Modifications to code in the trigger body

If an element is not specified, it remains unchanged.

A DML trigger cannot be changed to a database (or DDL) trigger.

It is not possible to change the event(s) or phase of a database (or DDL) trigger.

Reminders

The BEFORE keyword directs that the trigger be executed before the associated event occurs; the AFTER keyword directs that it be executed after the event.

More than one DML event — INSERT, UPDATE, DELETE — can be covered in a single trigger. The events should be separated with the keyword OR. No event should be mentioned more than once.

The keyword POSITION allows an optional execution order (“firing order”) to be specified for a series of triggers that have the same phase and event as their target. The default position is 0. If multiple triggers have the same position and phase, those triggers will be executed in an undefined order, while respecting the total order by position and phase.

Who Can Alter a Trigger?

DML triggers can be altered by:

- Administrators
- The owner of the table (or view)
- Users with the ALTER ANY TABLE or — for a view — ALTER ANY VIEW privilege

Database and DDL triggers can be altered by:

- Administrators
- Users with the `ALTER DATABASE` privilege

Examples using ALTER TRIGGER

1. Deactivating the `set_cust_no` trigger (switching it to the inactive status).

```
ALTER TRIGGER set_cust_no INACTIVE;
```

2. Changing the firing order position of the `set_cust_no` trigger.

```
ALTER TRIGGER set_cust_no POSITION 14;
```

3. Switching the `TR_CUST_LOG` trigger to the inactive status and modifying the list of events.

```
ALTER TRIGGER TR_CUST_LOG
INACTIVE AFTER INSERT OR UPDATE;
```

4. Switching the `tr_log_connect trigger` to the active status, changing its position and body.

```
ALTER TRIGGER tr_log_connect
ACTIVE POSITION 1
AS
BEGIN
  INSERT INTO LOG_CONNECT (ID,
                           USERNAME,
                           ROLENAME,
                           ATIME)
  VALUES (NEXT VALUE FOR SEQ_LOG_CONNECT,
          CURRENT_USER,
          CURRENT_ROLE,
          CURRENT_TIMESTAMP);
END
```

See also

`CREATE TRIGGER`, `CREATE OR ALTER TRIGGER`, `RECREATE TRIGGER`, `DROP TRIGGER`

5.7.3. CREATE OR ALTER TRIGGER

Used for

Creating a new trigger or altering an existing trigger

Available in

DSQL

Syntax

```
CREATE OR ALTER TRIGGER trigname
  { <relation_trigger_legacy>
  | <relation_trigger_sql2003>
  | <database_trigger>
  | <ddl_trigger> }
  {<psql_trigger> | <external-module-body>}

!! See syntax of CREATE TRIGGER for further rules !!
```

The `CREATE OR ALTER TRIGGER` statement creates a new trigger if it does not exist; otherwise it alters and recompiles it with the privileges intact and dependencies unaffected.

Example of `CREATE OR ALTER TRIGGER`

Creating a new trigger if it does not exist or altering it if it does exist

```
CREATE OR ALTER TRIGGER set_cust_no
ACTIVE BEFORE INSERT ON customer POSITION 0
AS
BEGIN
  IF (NEW.cust_no IS NULL) THEN
    NEW.cust_no = GEN_ID(cust_no_gen, 1);
END
```

See also

`CREATE TRIGGER`, `ALTER TRIGGER`, `RECREATE TRIGGER`

5.7.4. DROP TRIGGER

Used for

Dropping (deleting) an existing trigger

Available in

DSQL, ESQL

Syntax

```
DROP TRIGGER trigname
```

Table 48. `DROP TRIGGER` Statement Parameter

Parameter	Description
trigname	Trigger name

The `DROP TRIGGER` statement drops (deletes) an existing trigger.

Who Can Drop a Trigger?

DML triggers can be dropped by:

- Administrators
- The owner of the table (or view)
- Users with the `ALTER ANY TABLE` or — for a view — `ALTER ANY VIEW` privilege

Database and DDL triggers can be dropped by:

- Administrators
- Users with the `ALTER DATABASE` privilege

Example of `DROP TRIGGER`

Deleting the `set_cust_no` *trigger*

```
DROP TRIGGER set_cust_no;
```

See also

`CREATE TRIGGER`, `RECREATE TRIGGER`

5.7.5. `RECREATE TRIGGER`

Used for

Creating a new trigger or recreating an existing trigger

Available in

DSQL

Syntax

```
RECREATE TRIGGER trigname
  { <relation_trigger_legacy>
  | <relation_trigger_sql2003>
  | <database_trigger>
  | <ddl_trigger> }
  {<psql_trigger> | <external-module-body>}

!! See syntax of CREATE TRIGGER for further rules !!
```

The `RECREATE TRIGGER` statement creates a new trigger if no trigger with the specified name exists; otherwise the `RECREATE TRIGGER` statement tries to drop the existing trigger and create a new one. The operation will fail on `COMMIT` if the trigger is in use.

Be aware that dependency errors are not detected until the `COMMIT` phase of this operation.

Example of RECREATE TRIGGER

Creating or recreating the set_cust_no trigger.

```
RECREATE TRIGGER set_cust_no
ACTIVE BEFORE INSERT ON customer POSITION 0
AS
BEGIN
  IF (NEW.cust_no IS NULL) THEN
    NEW.cust_no = GEN_ID(cust_no_gen, 1);
END
```

See also

CREATE TRIGGER, DROP TRIGGER, CREATE OR ALTER TRIGGER

5.8. PROCEDURE

A stored procedure is a software module that can be called from a client, another procedure, function, executable block or trigger. Stored procedures, stored functions, executable blocks and triggers are written in procedural SQL (PSQL). Most SQL statements are available in PSQL as well, sometimes with some limitations or extensions, notable limitations are DDL and transaction control statements.

Stored procedures can have many input and output parameters.

5.8.1. CREATE PROCEDURE

Used for

Creating a new stored procedure

Available in

DSQL, ESQL

Syntax

```
CREATE PROCEDURE procname [ ( [ <in_params> ] ) ]
  [RETURNS (<out_params>)]
  {<psql_procedure> | <external-module-body>}

<in_params> ::= <inparam> [, <inparam> ...]

<inparam> ::= <param_decl> [{= | DEFAULT} <value>]

<out_params> ::= <outparam> [, <outparam> ...]

<outparam> ::= <param_decl>

<value> ::= {<literal> | NULL | <context_var>}
```

```
<param_decl> ::= paramname <domain_or_non_array_type> [NOT NULL]
  [COLLATE collation]

<type> ::=
    <datatype>
  | [TYPE OF] domain
  | TYPE OF COLUMN rel.col

<domain_or_non_array_type> ::=
  !! See Scalar Data Types Syntax !!

<psql_procedure> ::=
  [SQL SECURITY {INVOKER | DEFINER}]
  <psql-module-body>

<psql-module-body> ::=
  !! See Syntax of Module Body !!

<external-module-body> ::=
  !! See Syntax of Module Body !!
```

Table 49. CREATE PROCEDURE Statement Parameters

Parameter	Description
procname	Stored procedure name. The maximum length is 63 characters. Must be unique among all table, view and procedure names in the database
inparam	Input parameter description
outparam	Output parameter description
literal	A literal value that is assignment-compatible with the data type of the parameter
context_var	Any context variable whose type is compatible with the data type of the parameter
paramname	The name of an input or output parameter of the procedure. The maximum length is 63 characters. The name of the parameter must be unique among input and output parameters of the procedure and its local variables
collation	Collation sequence

The CREATE PROCEDURE statement creates a new stored procedure. The name of the procedure must be unique among the names of all stored procedures, tables and views in the database.

CREATE PROCEDURE is a *compound statement*, consisting of a header and a body. The header specifies the name of the procedure and declares input parameters and the output parameters, if any, that are to be returned by the procedure.

The procedure body consists of declarations for any local variables and named cursors that will be used by the procedure, followed by one or more statements, or blocks of statements, all enclosed in

an outer block that begins with the keyword `BEGIN` and ends with the keyword `END`. Declarations and embedded statements are terminated with semi-colons (‘;’).

Statement Terminators

Some SQL statement editors — specifically the *isql* utility that comes with Firebird and possibly some third-party editors — employ an internal convention that requires all statements to be terminated with a semi-colon. This creates a conflict with PSQL syntax when coding in these environments. If you are unacquainted with this problem and its solution, please study the details in the PSQL chapter in the section entitled Switching the Terminator in *isql*.

Parameters

Each parameter has a data type. The `NOT NULL` constraint can also be specified for any parameter, to prevent `NULL` being passed or assigned to it.

A collation sequence can be specified for string-type parameters, using the `COLLATE` clause.

Input Parameters

Input parameters are presented as a parenthesized list following the name of the function. They are passed by value into the procedure, so any changes inside the procedure has no effect on the parameters in the caller. Input parameters may have default values. Parameters with default values specified must be added at the end of the list of parameters.

Output Parameters

The optional `RETURNS` clause is for specifying a parenthesised list of output parameters for the stored procedure.

SQL Security

The `SQL SECURITY` clause specifies the security context for executing other routines or inserting into other tables. When SQL Security is not specified, the default value of the database is applied at runtime.

The `SQL SECURITY` clause can only be specified for PSQL procedures, and is not valid for procedures defined in a package.

See also *SQL Security* in chapter *Security*.

Variable, Cursor and Subroutine Declarations

The optional declarations section, located at the start of the body of the procedure definition, defines variables (including cursors) and subroutines local to the procedure. Local variable declarations follow the same rules as parameters regarding specification of the data type. See details in the PSQL chapter for `DECLARE VARIABLE`, `DECLARE CURSOR`, `DECLARE FUNCTION`, and `DECLARE PROCEDURE`.

External UDR Procedures

A stored procedure can also be located in an external module. In this case, instead of a procedure

body, the CREATE PROCEDURE specifies the location of the procedure in the external module using the EXTERNAL clause. The optional NAME clause specifies the name of the external module, the name of the procedure inside the module, and — optionally — user-defined information. The required ENGINE clause specifies the name of the UDR engine that handles communication between Firebird and the external module. The optional AS clause accepts a string literal "body", which can be used by the engine or module for various purposes.

Who Can Create a Procedure

The CREATE PROCEDURE statement can be executed by:

- Administrators
- Users with the CREATE PROCEDURE privilege

The user executing the CREATE PROCEDURE statement becomes the owner of the table.

Examples

1. Creating a stored procedure that inserts a record into the BREED table and returns the code of the inserted record:

```
CREATE PROCEDURE ADD_BREED (
  NAME D_BREEDNAME, /* Domain attributes are inherited */
  NAME_EN TYPE OF D_BREEDNAME, /* Only the domain type is inherited */
  SHORTNAME TYPE OF COLUMN BREED.SHORTNAME,
    /* The table column type is inherited */
  REMARK VARCHAR(120) CHARACTER SET WIN1251 COLLATE PXW_CYRL,
  CODE_ANIMAL INT NOT NULL DEFAULT 1
)
RETURNS (
  CODE_BREED INT
)
AS
BEGIN
  INSERT INTO BREED (
    CODE_ANIMAL, NAME, NAME_EN, SHORTNAME, REMARK)
  VALUES (
    :CODE_ANIMAL, :NAME, :NAME_EN, :SHORTNAME, :REMARK)
  RETURNING CODE_BREED INTO CODE_BREED;
END
```

2. Creating a selectable stored procedure that generates data for mailing labels (from employee.fdb):

```
CREATE PROCEDURE mail_label (cust_no INTEGER)
RETURNS (line1 CHAR(40), line2 CHAR(40), line3 CHAR(40),
         line4 CHAR(40), line5 CHAR(40), line6 CHAR(40))
AS
  DECLARE VARIABLE customer VARCHAR(25);
```

```
  DECLARE VARIABLE first_name VARCHAR(15);
  DECLARE VARIABLE last_name VARCHAR(20);
  DECLARE VARIABLE addr1 VARCHAR(30);
  DECLARE VARIABLE addr2 VARCHAR(30);
  DECLARE VARIABLE city VARCHAR(25);
  DECLARE VARIABLE state VARCHAR(15);
  DECLARE VARIABLE country VARCHAR(15);
  DECLARE VARIABLE postcode VARCHAR(12);
  DECLARE VARIABLE cnt INTEGER;
BEGIN
  line1 = '';
  line2 = '';
  line3 = '';
  line4 = '';
  line5 = '';
  line6 = '';

  SELECT customer, contact_first, contact_last, address_line1,
    address_line2, city, state_province, country, postal_code
  FROM CUSTOMER
  WHERE cust_no = :cust_no
  INTO :customer, :first_name, :last_name, :addr1, :addr2,
    :city, :state, :country, :postcode;

  IF (customer IS NOT NULL) THEN
    line1 = customer;
  IF (first_name IS NOT NULL) THEN
    line2 = first_name || ' ' || last_name;
  ELSE
    line2 = last_name;
  IF (addr1 IS NOT NULL) THEN
    line3 = addr1;
  IF (addr2 IS NOT NULL) THEN
    line4 = addr2;

  IF (country = 'USA') THEN
  BEGIN
    IF (city IS NOT NULL) THEN
      line5 = city || ', ' || state || '  ' || postcode;
    ELSE
      line5 = state || '  ' || postcode;
  END
  ELSE
  BEGIN
    IF (city IS NOT NULL) THEN
      line5 = city || ', ' || state;
    ELSE
      line5 = state;
    line6 = country || '    ' || postcode;
  END
```

```
  SUSPEND; -- the statement that sends an output row to the buffer
           -- and makes the procedure "selectable"
END
```

3. With DEFINER set for procedure p, user US needs only the EXECUTE privilege on p. If it were set for INVOKER, either the user or the procedure would also need the INSERT privilege on table t.

```
set term ^;
create procedure p (i integer) SQL SECURITY DEFINER
as
begin
  insert into t values (:i);
end^
set term ;^

grant execute on procedure p to user us;
commit;

connect 'localhost:/tmp/17.fdb' user us password 'pas';
execute procedure p(1);
```

See also

CREATE OR ALTER PROCEDURE, ALTER PROCEDURE, RECREATE PROCEDURE, DROP PROCEDURE

5.8.2. ALTER PROCEDURE

Used for

Modifying an existing stored procedure

Available in

DSQL, ESQL

Syntax

```
ALTER PROCEDURE procname [ ( [ <in_params> ] ) ]
  [RETURNS (<out_params>)]
  {<psql_procedure> | <external-module-body>}

!! See syntax of CREATE PROCEDURE for further rules !!
```

The ALTER PROCEDURE statement allows the following changes to a stored procedure definition:

- the set and characteristics of input and output parameters
- local variables
- code in the body of the stored procedure

After ALTER PROCEDURE executes, existing privileges remain intact and dependencies are not affected.

Altering a procedure without specifying the SQL SECURITY clause will remove the SQL Security property if currently set for this procedure. This means the behaviour will revert to the database default.

Take care about changing the number and type of input and output parameters in stored procedures. Existing application code and procedures and triggers that call it could become invalid because the new description of the parameters is incompatible with the old calling format. For information on how to troubleshoot such a situation, see the article The RDB$VALID_BLR Field in the Appendix.

Who Can Alter a Procedure

The ALTER PROCEDURE statement can be executed by:

- Administrators
- The owner of the stored procedure
- Users with the ALTER ANY PROCEDURE privilege

ALTER PROCEDURE Example

Altering the GET_EMP_PROJ *stored procedure.*

```
ALTER PROCEDURE GET_EMP_PROJ (
  EMP_NO SMALLINT)
RETURNS (
  PROJ_ID VARCHAR(20))
AS
BEGIN
  FOR SELECT
      PROJ_ID
    FROM
      EMPLOYEE_PROJECT
    WHERE
      EMP_NO = :emp_no
    INTO :proj_id
  DO
    SUSPEND;
END
```

See also

CREATE PROCEDURE, CREATE OR ALTER PROCEDURE, RECREATE PROCEDURE, DROP PROCEDURE

5.8.3. CREATE OR ALTER PROCEDURE

Used for

Creating a new stored procedure or altering an existing one

Available in

DSQL

Syntax

```
CREATE OR ALTER PROCEDURE procname [ ( [ <in_params> ] ) ]
  [RETURNS (<out_params>)]
  {<psql_procedure> | <external-module-body>}

!! See syntax of CREATE PROCEDURE for further rules !!
```

The `CREATE OR ALTER PROCEDURE` statement creates a new stored procedure or alters an existing one. If the stored procedure does not exist, it will be created by invoking a `CREATE PROCEDURE` statement transparently. If the procedure already exists, it will be altered and compiled without affecting its existing privileges and dependencies.

`CREATE OR ALTER PROCEDURE` Example

Creating or altering the `GET_EMP_PROJ` *procedure.*

```
CREATE OR ALTER PROCEDURE GET_EMP_PROJ (
    EMP_NO SMALLINT)
RETURNS (
    PROJ_ID VARCHAR(20))
AS
BEGIN
  FOR SELECT
      PROJ_ID
    FROM
      EMPLOYEE_PROJECT
    WHERE
      EMP_NO = :emp_no
    INTO :proj_id
  DO
    SUSPEND;
END
```

See also

`CREATE PROCEDURE`, `ALTER PROCEDURE`, `RECREATE PROCEDURE`

5.8.4. DROP PROCEDURE

Used for

Deleting a stored procedure

Available in

DSQL, ESQL

Syntax

```
DROP PROCEDURE procname
```

Table 50. DROP PROCEDURE Statement Parameter

Parameter	Description
procname	Name of an existing stored procedure

The DROP PROCEDURE statement deletes an existing stored procedure. If the stored procedure has any dependencies, the attempt to delete it will fail and the appropriate error will be raised.

Who Can Drop a Procedure

The ALTER PROCEDURE statement can be executed by:

- Administrators
- The owner of the stored procedure
- Users with the DROP ANY PROCEDURE privilege

DROP PROCEDURE Example

Deleting the GET_EMP_PROJ stored procedure.

```
DROP PROCEDURE GET_EMP_PROJ;
```

See also

CREATE PROCEDURE, RECREATE PROCEDURE

5.8.5. RECREATE PROCEDURE

Used for

Creating a new stored procedure or recreating an existing one

Available in

DSQL

Syntax

```
RECREATE PROCEDURE procname [ ( [ <in_params> ] ) ]
  [RETURNS (<out_params>)]
  {<psql_procedure> | <external-module-body>}

!! See syntax of CREATE PROCEDURE for further rules !!
```

The RECREATE PROCEDURE statement creates a new stored procedure or recreates an existing one. If there is a procedure with this name already, the engine will try to delete it and create a new one.

Recreating an existing procedure will fail at the COMMIT request if the procedure has dependencies.

Be aware that dependency errors are not detected until the COMMIT phase of this operation.

After a procedure is successfully recreated, privileges to execute the stored procedure, and the privileges of the stored procedure itself are dropped.

RECREATE PROCEDURE Example

Creating the new GET_EMP_PROJ *stored procedure or recreating the existing* GET_EMP_PROJ *stored procedure.*

```
RECREATE PROCEDURE GET_EMP_PROJ (
  EMP_NO SMALLINT)
RETURNS (
  PROJ_ID VARCHAR(20))
AS
BEGIN
  FOR SELECT
      PROJ_ID
    FROM
      EMPLOYEE_PROJECT
    WHERE
      EMP_NO = :emp_no
    INTO :proj_id
  DO
    SUSPEND;
END
```

See also

CREATE PROCEDURE, DROP PROCEDURE, CREATE OR ALTER PROCEDURE

5.9. FUNCTION

A stored function is a user-defined function stored in the metadata of a database, and running on the server. Stored functions can be called by stored procedures, stored functions (including the function itself), triggers and client programs. When a stored function calls itself, such a stored function is called a recursive function.

Unlike stored procedures, stored functions always return a single scalar value. To return a value from a stored functions, use the RETURN statement, which immediately ends the function.

See also

EXTERNAL FUNCTION

5.9.1. CREATE FUNCTION

Used for

Creating a new stored function

Available in

DSQL

Syntax

```
CREATE FUNCTION funcname [ ( [ <in_params> ] ) ]
  RETURNS <domain_or_non_array_type> [COLLATE collation]
  [DETERMINISTIC]
  {<psql_function> | <external-module-body>}

<in_params> ::= <inparam> [, <inparam> ... ]

<inparam> ::= <param-decl> [ { = | DEFAULT } <value> ]

<value> ::= { <literal> | NULL | <context-var> }

<param-decl> ::= paramname <domain_or_non_array_type> [NOT NULL]
  [COLLATE collation]

<domain_or_non_array_type> ::=
  !! See Scalar Data Types Syntax !!

<psql_function> ::=
  [SQL SECURITY {INVOKER | DEFINER}]
  <psql-module-body>

<psql-module-body> ::=
  !! See Syntax of Module Body !!

<external-module-body> ::=
  !! See Syntax of Module Body !!
```

Table 51. `CREATE FUNCTION` *Statement Parameters*

Parameter	Description
funcname	Stored function name. The maximum length is 63 characters. Must be unique among all function names in the database.
inparam	Input parameter description
collation	Collation sequence
literal	A literal value that is assignment-compatible with the data type of the parameter
context-var	Any context variable whose type is compatible with the data type of the parameter
paramname	The name of an input parameter of the function. The maximum length is 63 characters. The name of the parameter must be unique among input parameters of the function and its local variables.

The CREATE FUNCTION statement creates a new stored function. The stored function name must be unique among the names of all stored and external (legacy) functions, excluding sub-functions or functions in packages. For sub-functions or functions in packages, the name must be unique within its module (package, stored procedure, stored function, trigger).

It is advisable to not reuse function names between global stored functions and stored functions in packages, although this is legal. At the moment, it is not possible to call a function or procedure from the global namespace from inside a package, if that package defines a function or procedure with the same name. In that situation, the function or procedure of the package will be called.

CREATE FUNCTION is a compound statement with a header and a body. The header defines the name of the stored function, and declares input parameters and return type.

The function body consists of optional declarations of local variables, named cursors, and subroutines (sub-functions and sub-procedures), and one or more statements or statement blocks, enclosed in an outer block that starts with the keyword BEGIN and ends with the keyword END. Declarations and statements inside the function body must be terminated with a semicolon (';').

Statement Terminators

Some SQL statement editors — specifically the *isql* utility that comes with Firebird and possibly some third-party editors — employ an internal convention that requires all statements to be terminated with a semi-colon. This creates a conflict with PSQL syntax when coding in these environments. If you are unacquainted with this problem and its solution, please study the details in the PSQL chapter in the section entitled Switching the Terminator in *isql*.

Parameters

Each parameter has a data type.

A collation sequence can be specified for string-type parameters, using the COLLATE clause.

Input Parameters

Input parameters are presented as a parenthesized list following the name of the function. They are passed by value into the function, so any changes inside the function has no effect on the parameters in the caller. The NOT NULL constraint can also be specified for any input parameter, to prevent NULL being passed or assigned to it. Input parameters may have default values. Parameters with default values specified must be added at the end of the list of parameters.

Output Parameter

The RETURNS clause specifies the return type of the stored function. If a function returns a string value, then it is possible to specify the collation using the COLLATE clause. As a return type, you can specify a data type, a domain name, the type of a domain (using TYPE OF), or the type of a column of a table or view (using TYPE OF COLUMN).

Deterministic functions

The optional DETERMINISTIC clause indicates that the function is deterministic. Deterministic

functions always return the same result for the same set of inputs. Non-deterministic functions can return different results for each invocation, even for the same set of inputs. If a function is specified as deterministic, then such a function might not be called again if it has already been called once with the given set of inputs, and instead takes the result from a metadata cache.

Current versions of Firebird do not actually cache results of deterministic functions.

Specifying the `DETERMINISTIC` clause is actually something like a “promise” that the function will return the same thing for equal inputs. At the moment, a deterministic function is considered an invariant, and works like other invariants. That is, they are computed and cached at the current execution level of a given statement.

This is easily demonstrated with an example:

```
CREATE FUNCTION FN_T
RETURNS DOUBLE PRECISION DETERMINISTIC
AS
BEGIN
  RETURN rand();
END;

-- the function will be evaluated twice and will return 2 different
values
SELECT fn_t() FROM rdb$database
UNION ALL
SELECT fn_t() FROM rdb$database;

-- the function will be evaluated once and will return 2 identical
values
WITH t (n) AS (
  SELECT 1 FROM rdb$database
  UNION ALL
  SELECT 2 FROM rdb$database
)
SELECT n, fn_t() FROM t;
```

SQL Security

The `SQL SECURITY` clause specifies the security context for executing other routines or inserting into other tables. When SQL Security is not specified, the default value of the database is applied at runtime.

The `SQL SECURITY` clause can only be specified for PSQL functions, and is not valid for functions defined in a package.

See also *SQL Security* in chapter *Security*.

Variable, Cursor and Subroutine Declarations

The optional declarations section, located at the start of the body of the function definition, defines variables (including cursors) and subroutines local to the function. Local variable declarations follow the same rules as parameters regarding specification of the data type. See details in the PSQL chapter for `DECLARE VARIABLE`, `DECLARE CURSOR`, `DECLARE FUNCTION`, and `DECLARE PROCEDURE`.

Function Body

The header section is followed by the function body, consisting of one or more PSQL statements enclosed between the outer keywords `BEGIN` and `END`. Multiple `BEGIN ⋯ END` blocks of terminated statements may be embedded inside the procedure body.

External UDR Functions

A stored function can also be located in an external module. In this case, instead of a function body, the `CREATE FUNCTION` specifies the location of the function in the external module using the `EXTERNAL` clause. The optional `NAME` clause specifies the name of the external module, the name of the function inside the module, and — optionally — user-defined information. The required `ENGINE` clause specifies the name of the UDR engine that handles communication between Firebird and the external module. The optional `AS` clause accepts a string literal "body", which can be used by the engine or module for various purposes.

External UDR (User Defined Routine) functions created using `CREATE FUNCTION ⋯ EXTERNAL ⋯` should not be confused with legacy UDFs (User Defined Functions) declared using `DECLARE EXTERNAL FUNCTION`.

UDFs are deprecated, and a legacy from previous Firebird functions. Their capabilities are significantly inferior to the capabilities to the new type of external UDR functions.

Who Can Create a Function

The `CREATE FUNCTION` statement can be executed by:

- Administrators
- Users with the `CREATE FUNCTION` privilege

The user who created the stored function becomes its owner.

`CREATE FUNCTION` Examples

1. Creating a stored function

```
CREATE FUNCTION ADD_INT (A INT, B INT DEFAULT 0)
RETURNS INT
AS
BEGIN
  RETURN A + B;
```

```
END
```

Calling in a select:

```
SELECT ADD_INT(2, 3) AS R FROM RDB$DATABASE
```

Call inside PSQL code, the second optional parameter is not specified:

```
MY_VAR = ADD_INT(A);
```

2. Creating a deterministic stored function

```
CREATE FUNCTION FN_E()
RETURNS DOUBLE PRECISION DETERMINISTIC
AS
BEGIN
  RETURN EXP(1);
END
```

3. Creating a stored function with table column type parameters

   Returns the name of a type by field name and value

```
CREATE FUNCTION GET_MNEMONIC (
  AFIELD_NAME TYPE OF COLUMN RDB$TYPES.RDB$FIELD_NAME,
  ATYPE TYPE OF COLUMN RDB$TYPES.RDB$TYPE)
RETURNS TYPE OF COLUMN RDB$TYPES.RDB$TYPE_NAME
AS
BEGIN
  RETURN (SELECT RDB$TYPE_NAME
          FROM RDB$TYPES
          WHERE RDB$FIELD_NAME = :AFIELD_NAME
          AND RDB$TYPE = :ATYPE);
END
```

4. Creating an external stored function

   Create a function located in an external module (UDR). Function implementation is located in the external module `udrcpp_example`. The name of the function inside the module is `wait_event`.

```
CREATE FUNCTION wait_event (
  event_name varchar (31) CHARACTER SET ascii
) RETURNS INTEGER
EXTERNAL NAME 'udrcpp_example!Wait_event'
```

```
ENGINE udr
```

5. Creating a stored function containing a sub-function

   Creating a function to convert a number to hexadecimal format.

```
CREATE FUNCTION INT_TO_HEX (
  ANumber BIGINT ,
  AByte_Per_Number SMALLINT = 8)
RETURNS CHAR (66)
AS
DECLARE VARIABLE xMod SMALLINT ;
DECLARE VARIABLE xResult VARCHAR (64);
DECLARE FUNCTION TO_HEX (ANum SMALLINT ) RETURNS CHAR
  AS
  BEGIN
    RETURN CASE ANum
      WHEN 0 THEN '0'
      WHEN 1 THEN '1'
      WHEN 2 THEN '2'
      WHEN 3 THEN '3'
      WHEN 4 THEN '4'
      WHEN 5 THEN '5'
      WHEN 6 THEN '6'
      WHEN 7 THEN '7'
      WHEN 8 THEN '8'
      WHEN 9 THEN '9'
      WHEN 10 THEN 'A'
      WHEN 11 THEN 'B'
      WHEN 12 THEN 'C'
      WHEN 13 THEN 'D'
      WHEN 14 THEN 'E'
      WHEN 15 THEN 'F'
      ELSE NULL
    END;
  END
BEGIN
  xMod = MOD (ANumber, 16);
  ANumber = ANumber / 16;
  xResult = TO_HEX (xMod);
  WHILE (ANUMBER> 0) DO
  BEGIN
    xMod = MOD (ANumber, 16);
    ANumber = ANumber / 16;
    xResult = TO_HEX (xMod) || xResult;
  END
  RETURN '0x' || LPAD (xResult, AByte_Per_Number * 2, '0' );
END
```

6. With DEFINER set for function f, user US needs only the EXECUTE privilege on f. If it were set for INVOKER, the user would also need the INSERT privilege on table t.

```
set term ^;
create function f (i integer) returns int SQL SECURITY DEFINER
as
begin
  insert into t values (:i);
  return i + 1;
end^
set term ;^
grant execute on function f to user us;

commit;

connect 'localhost:/tmp/59.fdb' user us password 'pas';
select f(3) from rdb$database;
```

See also

CREATE OR ALTER FUNCTION, ALTER FUNCTION, RECREATE FUNCTION, DROP FUNCTION, DECLARE EXTERNAL FUNCTION

5.9.2. ALTER FUNCTION

Used for

Modifying an existing stored function

Available in

DSQL

Syntax

```
ALTER FUNCTION funcname
  [ ( [ <in_params> ] ) ]
  RETURNS <domain_or_non_array_type> [COLLATE collation]
  [DETERMINISTIC]
  {<psql_function> | <external-module-body>}

!! See syntax of CREATE FUNCTION for further rules !!
```

The ALTER FUNCTION statement allows the following changes to a stored function definition:

- the set and characteristics of input and output type
- local variables, named cursors, and subroutines
- code in the body of the stored procedure

For external functions (UDR), you can change the entry point and engine name. For legacy external functions declared using DECLARE EXTERNAL FUNCTION — also known as UDFs — it is not possible to

convert to PSQL and vice versa.

After ALTER FUNCTION executes, existing privileges remain intact and dependencies are not affected.

Altering a function without specifying the SQL SECURITY clause will remove the SQL Security property if currently set for this function. This means the behaviour will revert to the database default.

Take care about changing the number and type of input parameters and the output type of a stored function. Existing application code and procedures, functions and triggers that call it could become invalid because the new description of the parameters is incompatible with the old calling format. For information on how to troubleshoot such a situation, see the article The RDB$VALID_BLR Field in the Appendix.

Who Can Alter a Function

The ALTER FUNCTION statement can be executed by:

- Administrators
- Owner of the stored function
- Users with the ALTER ANY FUNCTION privilege

Examples of ALTER FUNCTION

Altering a stored function

```
ALTER FUNCTION ADD_INT(A INT, B INT, C INT)
RETURNS INT
AS
BEGIN
  RETURN A + B + C;
END
```

See also

CREATE FUNCTION, CREATE OR ALTER FUNCTION, RECREATE FUNCTION, DROP FUNCTION

5.9.3. CREATE OR ALTER FUNCTION

Used for

Creating a new or modifying an existing stored function

Available in

DSQL

Syntax

```
CREATE OR ALTER FUNCTION funcname
```

```
  [ ( [ <in_params> ] ) ]
  RETURNS <domain_or_non_array_type> [COLLATE collation]
  [DETERMINISTIC]
  {<psql_function> | <external-module-body>}

!! See syntax of CREATE FUNCTION for further rules !!
```

The CREATE OR ALTER FUNCTION statement creates a new stored function or alters an existing one. If the stored function does not exist, it will be created by invoking a CREATE FUNCTION statement transparently. If the function already exists, it will be altered and compiled (through ALTER FUNCTION) without affecting its existing privileges and dependencies.

Examples of CREATE OR ALTER FUNCTION

Create a new or alter an existing stored function

```
CREATE OR ALTER FUNCTION ADD_INT(A INT, B INT DEFAULT 0)
RETURNS INT
AS
BEGIN
  RETURN A + B;
END
```

See also

CREATE FUNCTION, ALTER FUNCTION, DROP FUNCTION

5.9.4. DROP FUNCTION

Used for

Dropping a stored function

Available in

DSQL

Syntax

```
DROP FUNCTION funcname
```

Table 52. DROP FUNCTION Statement Parameters

Parameter	Description
funcname	Stored function name. The maximum length is 63 characters. Must be unique among all function names in the database.

The DROP FUNCTION statement deletes an existing stored function. If the stored function has any dependencies, the attempt to delete it will fail, and the appropriate error will be raised.

Who Can Drop a Function

The DROP FUNCTION statement can be executed by:

- Administrators
- Owner of the stored function
- Users with the DROP ANY FUNCTION privilege

Examples of DROP FUNCTION

```
DROP FUNCTION ADD_INT;
```

See also

CREATE FUNCTION, CREATE OR ALTER FUNCTION, RECREATE FUNCTION

5.9.5. RECREATE FUNCTION

Used for

Creating a new stored function or recreating an existing one

Available in

DSQL

Syntax

```
RECREATE FUNCTION funcname
  [ ( [ <in_params> ] ) ]
  RETURNS <domain_or_non_array_type> [COLLATE collation]
  [DETERMINISTIC]
  {<psql_function> | <external-module-body>}

!! See syntax of CREATE FUNCTION for further rules !!
```

The RECREATE FUNCTION statement creates a new stored function or recreates an existing one. If there is a function with this name already, the engine will try to drop it and then create a new one. Recreating an existing function will fail at COMMIT if the function has dependencies.

Be aware that dependency errors are not detected until the COMMIT phase of this operation.

After a procedure is successfully recreated, existing privileges to execute the stored function and the privileges of the stored function itself are dropped.

Examples of RECREATE FUNCTION

Creating or recreating a stored function

```
RECREATE FUNCTION ADD_INT(A INT, B INT DEFAULT 0)
RETURNS INT
AS
BEGIN
  RETURN A + B;
EN
```

See also

`CREATE FUNCTION`, `DROP FUNCTION`

5.10. EXTERNAL FUNCTION

External functions (UDFs) have been aggressively deprecated in Firebird 4.0:

- The default setting for the configuration parameter `UdfAccess` is `None`. In order to run UDFs at all will now require an explicit configuration of `Restrict path-list`
- The UDF libraries (`ib_udf`, `fbudf`) are no longer distributed in the installation kits
- Most of the functions in the libraries previously distributed in the shared (dynamic) libraries `ib_udf` and `fbudf` had already been replaced with built-in functional analogs. A few remaining UDFs have been replaced with either analog routines in a new library of UDRs named `udf_compat` or converted to stored functions.

  Refer to *Deprecation of External Functions (UDFs)* in the *Compatibility* chapter of the Firebird 4.0 Release notes for details and instructions about upgrading to use the safe functions.

- Replacement of UDFs with UDRs or stored functions is strongly recommended

External functions, also known as “User-Defined Functions” (UDFs) are programs written in an external programming language and stored in dynamically loaded libraries. Once declared in a database, they become available in dynamic and procedural statements as though they were implemented in the SQL language.

External functions extend the possibilities for processing data with SQL considerably. To make a function available to a database, it is declared using the statement `DECLARE EXTERNAL FUNCTION`.

The library containing a function is loaded when any function included in it is called.

External functions declared as `DECLARE EXTERNAL FUNCTION` are a legacy from previous versions of Firebird. Their capabilities are inferior to the capabilities of the new type of external functions, UDR (User-Defined Routine). Such functions are declared as `CREATE FUNCTION ⋯ EXTERNAL ⋯`. See `CREATE FUNCTION` for details.

External functions may be contained in more than one library — or “module”, as it is referred to in the syntax.

UDFs are fundamentally insecure. We recommend avoiding their use whenever possible, and disabling UDFs in your database configuration (`UdfAccess = None` in `firebird.conf`; this is the default since Firebird 4). If you do need to call native code from your database, use a UDR external engine instead.

See also

`FUNCTION`

5.10.1. DECLARE EXTERNAL FUNCTION

Used for

Declaring a user-defined function (UDF) to the database

Available in

DSQL, ESQL

Syntax

```
DECLARE EXTERNAL FUNCTION funcname
  [{ <arg_desc_list> | ( <arg_desc_list> ) }]
  RETURNS { <return_value> | ( <return_value> ) }
  ENTRY_POINT 'entry_point' MODULE_NAME 'library_name'

<arg_desc_list> ::=
  <arg_type_decl> [, <arg_type_decl> ...]

<arg_type_decl> ::=
  <udf_data_type> [BY {DESCRIPTOR | SCALAR_ARRAY} | NULL]

<udf_data_type> ::=
    <scalar_datatype>
  | BLOB
  | CSTRING(length) [ CHARACTER SET charset ]

<scalar_datatype> ::=
  !! See Scalar Data Types Syntax !!

<return_value> ::=
  { <udf_data_type> | PARAMETER param_num }
  [{ BY VALUE | BY DESCRIPTOR [FREE_IT] | FREE_IT }]
```

Table 53. `DECLARE EXTERNAL FUNCTION` Statement Parameters

Parameter	Description
funcname	Function name in the database. The maximum length is 63 characters. It should be unique among all internal and external function names in the database and need not be the same name as the name exported from the UDF library via `ENTRY_POINT`.
entry_point	The exported name of the function
library_name	The name of the module (`MODULE_NAME`) from which the function is exported. This will be the name of the file, without the ".dll" or ".so" file extension.
length	The maximum length of a null-terminated string, specified in bytes
charset	Character set of the CSTRING
param_num	The number of the input parameter, numbered from 1 in the list of input parameters in the declaration, describing the data type that will be returned by the function

The `DECLARE EXTERNAL FUNCTION` statement makes a user-defined function available in the database. UDF declarations must be made in *each database* that is going to use them. There is no need to declare UDFs that will never be used.

The name of the external function must be unique among all function names. It may be different from the exported name of the function, as specified in the `ENTRY_POINT` argument.

`DECLARE EXTERNAL FUNCTION` Input Parameters

The input parameters of the function follow the name of the function and are separated with commas. Each parameter has an SQL data type specified for it. Arrays cannot be used as function parameters. In addition to the SQL types, the `CSTRING` type is available for specifying a null-terminated string with a maximum length of `LENGTH` bytes. There are several mechanisms for passing a parameter from the Firebird engine to an external function, each of these mechanisms will be discussed below.

By default, input parameters are passed *by reference*. There is no separate clause to explicitly indicate that parameters are passed by reference.

When passing a `NULL` value by reference, it is converted to the equivalent of zero, for example, a number '`0`' or an empty string ("`''`"). If the keyword `NULL` is specified after a parameter, then with passing a `NULL` values, the null pointer will be passed to the external function.

Declaring a function with the `NULL` keyword does not guarantee that the function will correctly handle a `NULL` input parameter. Any function must be written or rewritten to correctly handle `NULL` values. Always use the function declaration as provided by its developer.

If `BY DESCRIPTOR` is specified, then the input parameter is passed by descriptor. In this case, the UDF parameter will receive a pointer to an internal structure known as a descriptor. The descriptor contains information about the data type, sub-type, precision, character set and collation, scale, a

pointer to the data itself and some flags, including the NULL indicator. This declaration only works if the external function is written using a handle.

When passing a function parameter by descriptor, the passed value is not cast to the declared data type.

The BY SCALAR_ARRAY clause is used when passing arrays as input parameters. Unlike other types, you cannot return an array from a UDF.

Clauses and Keywords

RETURNS clause

(Required) specifies the output parameter returned by the function. A function is scalar, it returns one value (output parameter). The output parameter can be of any SQL type (except an array or an array element) or a null-terminated string (CSTRING). The output parameter can be passed by reference (the default), by descriptor or by value. If the BY DESCRIPTOR clause is specified, the output parameter is passed by descriptor. If the BY VALUE clause is specified, the output parameter is passed by value.

PARAMETER keyword

specifies that the function returns the value from the parameter under number *param_num*. It is necessary if you need to return a value of data type BLOB.

FREE_IT keyword

means that the memory allocated for storing the return value will be freed after the function is executed. It is used only if the memory was allocated dynamically in the UDF. In such a UDF, the memory must be allocated with the help of the ib_util_malloc function from the ib_util module, a requirement for compatibility with the functions used in Firebird code and in the code of the shipped UDF modules, for allocating and freeing memory.

ENTRY_POINT clause

specifies the name of the entry point (the name of the imported function), as exported from the module.

MODULE_NAME clause

defines the name of the module where the exported function is located. The link to the module should not be the full path and extension of the file, if that can be avoided. If the module is located in the default location (in the ../UDF subdirectory of the Firebird server root) or in a location explicitly configured in firebird.conf, it makes it easier to move the database between different platforms. The UDFAccess parameter in the firebird.conf file allows access restrictions to external functions modules to be configured.

Any user connected to the database can declare an external function (UDF).

Who Can Create an External Function

The DECLARE EXTERNAL FUNCTION statement can be executed by:

- Administrators

- Users with the `CREATE FUNCTION` privilege

The user who created the function becomes its owner.

Examples using `DECLARE EXTERNAL FUNCTION`

1. Declaring the `addDay` external function located in the `fbudf` module. The input and output parameters are passed by reference.

```
DECLARE EXTERNAL FUNCTION addDay
  TIMESTAMP, INT
  RETURNS TIMESTAMP
  ENTRY_POINT 'addDay' MODULE_NAME 'fbudf';
```

2. Declaring the `invl` external function located in the `fbudf` module. The input and output parameters are passed by descriptor.

```
DECLARE EXTERNAL FUNCTION invl
  INT BY DESCRIPTOR, INT BY DESCRIPTOR
  RETURNS INT BY DESCRIPTOR
  ENTRY_POINT 'idNvl' MODULE_NAME 'fbudf';
```

3. Declaring the `isLeapYear` external function located in the `fbudf` module. The input parameter is passed by reference, while the output parameter is passed by value.

```
DECLARE EXTERNAL FUNCTION isLeapYear
  TIMESTAMP
  RETURNS INT BY VALUE
  ENTRY_POINT 'isLeapYear' MODULE_NAME 'fbudf';
```

4. Declaring the `i64Truncate` external function located in the `fbudf` module. The input and output parameters are passed by descriptor. The second parameter of the function is used as the return value.

```
DECLARE EXTERNAL FUNCTION i64Truncate
  NUMERIC(18) BY DESCRIPTOR, NUMERIC(18) BY DESCRIPTOR
  RETURNS PARAMETER 2
  ENTRY_POINT 'fbtruncate' MODULE_NAME 'fbudf';
```

See also

`ALTER EXTERNAL FUNCTION`, `DROP EXTERNAL FUNCTION`, `CREATE FUNCTION`

5.10.2. `ALTER EXTERNAL FUNCTION`

Used for

Changing the entry point and/or the module name for a user-defined function (UDF)

Available in

DSQL

Syntax

```
ALTER EXTERNAL FUNCTION funcname
  [ENTRY_POINT 'new_entry_point']
  [MODULE_NAME 'new_library_name']
```

Table 54. `ALTER EXTERNAL FUNCTION` Statement Parameters

Parameter	Description
funcname	Function name in the database
new_entry_point	The new exported name of the function
new_library_name	The new name of the module (`MODULE_NAME` from which the function is exported). This will be the name of the file, without the ".dll" or ".so" file extension.

The `ALTER EXTERNAL FUNCTION` statement changes the entry point and/or the module name for a user-defined function (UDF). Existing dependencies remain intact after the statement containing the change(s) is executed.

The `ENTRY_POINT` clause

is for specifying the new entry point (the name of the function as exported from the module).

The `MODULE_NAME` clause

is for specifying the new name of the module where the exported function is located.

Any user connected to the database can change the entry point and the module name.

Who Can Alter an External Function

The `ALTER EXTERNAL FUNCTION` statement can be executed by:

- Administrators
- Owner of the external function
- Users with the `ALTER ANY FUNCTION` privilege

Examples using `ALTER EXTERNAL FUNCTION`

Changing the entry point for an external function

```
ALTER EXTERNAL FUNCTION invl ENTRY_POINT 'intNvl';
```

Changing the module name for an external function

```
ALTER EXTERNAL FUNCTION invl MODULE_NAME 'fbudf2';
```

See also

`DECLARE EXTERNAL FUNCTION`, `DROP EXTERNAL FUNCTION`

5.10.3. DROP EXTERNAL FUNCTION

Used for

Removing a user-defined function (UDF) from a database

Available in

DSQL, ESQL

Syntax

```
DROP EXTERNAL FUNCTION funcname
```

Table 55. `DROP EXTERNAL FUNCTION` Statement Parameter

Parameter	Description
funcname	Function name in the database

The `DROP EXTERNAL FUNCTION` statement deletes the declaration of a user-defined function from the database. If there are any dependencies on the external function, the statement will fail and the appropriate error will be raised.

Any user connected to the database can delete the declaration of an internal function.

Who Can Drop an External Function

The `DROP EXTERNAL FUNCTION` statement can be executed by:

- Administrators
- Owner of the external function
- Users with the `DROP ANY FUNCTION` privilege

Example using `DROP EXTERNAL FUNCTION`

Deleting the declaration of the `addDay` function.

```
DROP EXTERNAL FUNCTION addDay;
```

See also

`DECLARE EXTERNAL FUNCTION`

5.11. PACKAGE

A package is a group of procedures and functions managed as one entity.

5.11.1. CREATE PACKAGE

Used for

Declaring the package header

Available in

DSQL

Syntax

```
CREATE PACKAGE package_name
[SQL SECURITY {INVOKER | DEFINER}]
AS
BEGIN
  [ <package_item> ... ]
END

<package_item> ::=
    <function_decl>;
  | <procedure_decl>;

<function_decl> ::=
  FUNCTION funcname [ ( [ <in_params> ] ) ]
  RETURNS <domain_or_non_array_type> [COLLATE collation]
  [DETERMINISTIC]

<procedure_decl> ::=
  PROCEDURE procname [ ( [ <in_params> ] ) ]
  [RETURNS (<out_params>)]

<in_params> ::= <inparam> [, <inparam> ... ]

<inparam> ::= <param_decl> [ { = | DEFAULT } <value> ]

<out_params> ::= <outparam> [, <outparam> ...]

<outparam> ::= <param_decl>

<value> ::= { literal | NULL | context_var }

<param-decl> ::= paramname <domain_or_non_array_type> [NOT NULL]
  [COLLATE collation]

<domain_or_non_array_type> ::=
  !! See Scalar Data Types Syntax !!
```

Table 56. `CREATE PACKAGE` *Statement Parameters*

Parameter	Description
package_name	Package name. The maximum length is 63 characters. The package name must be unique among all package names.
function_decl	Function declaration
procedure_decl	Procedure declaration
func_name	Function name. The maximum length is 63 characters. The function name must be unique within the package.
proc_name	Procedure name. The maximum length is 63 characters. The function name must be unique within the package.
collation	Collation sequence
inparam	Input parameter declaration
outparam	Output parameter declaration
literal	A literal value that is assignment-compatible with the data type of the parameter
context_var	Any context variable that is assignment-compatible with the data type of the parameter
paramname	The name of an input parameter of a procedure or function, or an output parameter of a procedure. The maximum length is 63 characters. The name of the parameter must be unique among input and output parameters of the procedure or function.

The `CREATE PACKAGE` statement creates a new package header. Routines (procedures and functions) declared in the package header are available outside the package using the full identifier (*package_name.proc_name* or *package_name.func_name*). Routines defined only in the package body — but not in the package header — are not visible outside the package.

Package procedure and function names may shadow global routines

If a package header or package body declares a procedure or function with the same name as a stored procedure or function in the global namespace, it is not possible to call that global procedure or function from the package body. In this case, the procedure or function of the package will always be called.

For this reason, it is recommended that the names of stored procedures and functions in packages do not overlap with names of stored procedures and functions in the global namespace.

Statement Terminators

Some SQL statement editors — specifically the *isql* utility that comes with Firebird and possibly some third-party editors — employ an internal convention that requires all statements to be terminated with a semicolon. This creates a conflict with PSQL syntax when coding in these environments. If you are unacquainted with this problem and its solution, please study the details

in the PSQL chapter in the section entitled Switching the Terminator in *isql*.

SQL Security

The `SQL SECURITY` clause specifies the security context for executing other routines or inserting into other tables from functions or procedures defined in this package. When SQL Security is not specified, the default value of the database is applied at runtime.

The `SQL SECURITY` clause can only be specified for the package, not for individual procedures and functions of the package.

See also *SQL Security* in chapter *Security*.

Procedure and Function Parameters

For details on stored procedure parameters, see Parameters in `CREATE PROCEDURE`.

For details on function parameters, see Parameters in `CREATE FUNCTION`.

Who Can Create a Package

The `CREATE PACKAGE` statement can be executed by:

- Administrators
- Users with the `CREATE PACKAGE` privilege

The user who created the package header becomes its owner.

Examples of `CREATE PACKAGE`

1. Create a package header

```
CREATE PACKAGE APP_VAR
AS
BEGIN
  FUNCTION GET_DATEBEGIN() RETURNS DATE DETERMINISTIC;
  FUNCTION GET_DATEEND() RETURNS DATE DETERMINISTIC;
  PROCEDURE SET_DATERANGE(ADATEBEGIN DATE,
      ADATEEND DATE DEFAULT CURRENT_DATE);
END
```

1. With `DEFINER` set for package `pk`, user `US` needs only the `EXECUTE` privilege on `pk`. If it were set for `INVOKER`, either the user or the package would also need the `INSERT` privilege on table `t`.

```
create table t (i integer);
set term ^;
create package pk SQL SECURITY DEFINER
as
begin
```

```
    function f(i integer) returns int;
end^

create package body pk
as
begin
    function f(i integer) returns int
    as
    begin
      insert into t values (:i);
      return i + 1;
    end
end^
set term ;^
grant execute on package pk to user us;

commit;

connect 'localhost:/tmp/69.fdb' user us password 'pas';
select pk.f(3) from rdb$database;
```

See also

CREATE PACKAGE BODY, RECREATE PACKAGE BODY, ALTER PACKAGE, DROP PACKAGE, RECREATE PACKAGE

5.11.2. ALTER PACKAGE

Used for

Altering the package header

Available in

DSQL

Syntax

```
ALTER PACKAGE package_name
[SQL SECURITY {INVOKER | DEFINER}]
AS
BEGIN
  [ <package_item> ... ]
END

!! See syntax of CREATE PACKAGE for further rules!!
```

The ALTER PACKAGE statement modifies the package header. It can be used to change the number and definition of procedures and functions, including their input and output parameters. However, the source and compiled form of the package body is retained, though the body might be incompatible after the change to the package header. The validity of a package body for the defined header is stored in the column RDB$PACKAGES.RDB$VALID_BODY_FLAG.

Altering a package without specifying the SQL SECURITY clause will remove the SQL Security property if currently set for this package. This means the behaviour will revert to the database default.

Who Can Alter a Package

The ALTER PACKAGE statement can be executed by:

- Administrators
- The owner of the package
- Users with the ALTER ANY PACKAGE privilege

Examples of ALTER PACKAGE

Modifying a package header

```
ALTER PACKAGE APP_VAR
AS
BEGIN
  FUNCTION GET_DATEBEGIN() RETURNS DATE DETERMINISTIC;
  FUNCTION GET_DATEEND() RETURNS DATE DETERMINISTIC;
  PROCEDURE SET_DATERANGE(ADATEBEGIN DATE,
      ADATEEND DATE DEFAULT CURRENT_DATE);
END
```

See also

CREATE PACKAGE, DROP PACKAGE, RECREATE PACKAGE BODY

5.11.3. CREATE OR ALTER PACKAGE

Used for

Creating a new or altering an existing package header

Available in

DSQL

Syntax

```
CREATE OR ALTER PACKAGE package_name
[SQL SECURITY {INVOKER | DEFINER}]
AS
BEGIN
  [ <package_item> ... ]
END

!! See syntax of CREATE PACKAGE for further rules!!
```

The CREATE OR ALTER PACKAGE statement creates a new package or modifies an existing package

header. If the package header does not exist, it will be created using CREATE PACKAGE. If it already exists, then it will be modified using ALTER PACKAGE while retaining existing privileges and dependencies.

Examples of CREATE OR ALTER PACKAGE

Creating a new or modifying an existing package header

```
CREATE OR ALTER PACKAGE APP_VAR
AS
BEGIN
  FUNCTION GET_DATEBEGIN() RETURNS DATE DETERMINISTIC;
  FUNCTION GET_DATEEND() RETURNS DATE DETERMINISTIC;
  PROCEDURE SET_DATERANGE(ADATEBEGIN DATE,
      ADATEEND DATE DEFAULT CURRENT_DATE);
END
```

See also

CREATE PACKAGE, ALTER PACKAGE, RECREATE PACKAGE, RECREATE PACKAGE BODY

5.11.4. DROP PACKAGE

Used for

Dropping a package header

Available in

DSQL

Syntax

```
DROP PACKAGE package_name
```

Table 57. DROP PACKAGE Statement Parameters

Parameter	Description
package_name	Package name

The DROP PACKAGE statement deletes an existing package header. If a package body exists, it will be dropped together with the package header. If there are still dependencies on the package, an error will be raised.

Who Can Drop a Package

The DROP PACKAGE statement can be executed by:

- Administrators
- The owner of the package
- Users with the DROP ANY PACKAGE privilege

Examples of DROP PACKAGE

Dropping a package header

```
DROP PACKAGE APP_VAR
```

See also

CREATE PACKAGE, DROP PACKAGE BODY

5.11.5. RECREATE PACKAGE

Used for

Creating a new or recreating an existing package header

Available in

DSQL

Syntax

```
RECREATE PACKAGE package_name
[SQL SECURITY {INVOKER | DEFINER}]
AS
BEGIN
  [ <package_item> ... ]
END

!! See syntax of CREATE PACKAGE for further rules!!
```

The RECREATE PACKAGE statement creates a new package or recreates an existing package header. If a package header with the same name already exists, then this statement will first drop it and then create a new package header. It is not possible to recreate the package header if there are still dependencies on the existing package, or if the body of the package exists. Existing privileges of the package itself are not preserved, nor are privileges to execute the procedures or functions of the package.

Examples of RECREATE PACKAGE

Creating a new or recreating an existing package header

```
RECREATE PACKAGE APP_VAR
AS
BEGIN
  FUNCTION GET_DATEBEGIN() RETURNS DATE DETERMINISTIC;
  FUNCTION GET_DATEEND() RETURNS DATE DETERMINISTIC;
  PROCEDURE SET_DATERANGE(ADATEBEGIN DATE,
      ADATEEND DATE DEFAULT CURRENT_DATE);
END
```

See also

CREATE PACKAGE, DROP PACKAGE, CREATE PACKAGE BODY, RECREATE PACKAGE BODY

5.12. PACKAGE BODY

5.12.1. CREATE PACKAGE BODY

Used for

Creating the package body

Available in

DSQL

Syntax

```
CREATE PACKAGE BODY name
AS
BEGIN
  [ <package_item> ... ]
  [ <package_body_item> ... ]
END

<package_item> ::=
  !! See CREATE PACKAGE syntax !!

<package_body_item> ::=
  <function_impl> |
  <procedure_impl>

<function_impl> ::=
  FUNCTION funcname [ ( [ <in_params> ] ) ]
  RETURNS <domain_or_non_array_type> [COLLATE collation]
  [DETERMINISTIC]
  <module-body>

<procedure_impl> ::=
  PROCEDURE procname [ ( [ <in_params> ] ) ]
  [RETURNS (<out_params>)]
  <module-body>

<module-body> ::=
  !! See Syntax of Module Body !!

<in_params> ::=
  !! See CREATE PACKAGE syntax !!
  !! See also Rules below !!

<out_params> ::=
  !! See CREATE PACKAGE syntax !!
```

```
<domain_or_non_array_type> ::=
  !! See Scalar Data Types Syntax !!
```

Table 58. CREATE PACKAGE BODY Statement Parameters

Parameter	Description
package_name	Package name. The maximum length is 63 characters. The package name must be unique among all package names.
function_impl	Function implementation. Essentially a CREATE FUNCTION statement without CREATE.
procedure_impl	Procedure implementation Essentially a CREATE PROCEDURE statement without CREATE.
func_name	Function name. The maximum length is 63 characters. The function name must be unique within the package.
collation	Collation sequence
proc_name	Procedure name. The maximum length is 63 characters. The function name must be unique within the package.

The CREATE PACKAGE BODY statement creates a new package body. The package body can only be created after the package header has been created. If there is no package header with name *package_name*, an appropriate error will be raised.

All procedures and functions declared in the package header must be implemented in the package body. Additional procedures and functions may be defined and implemented in the package body only. Procedure and functions defined in the package body, but not defined in the package header are not visible outside the package body.

The names of procedures and functions defined in the package body must be unique among the names of procedures and functions defined in the package header and implemented in the package body.

Package procedure and function names may shadow global routines

If a package header or package body declares a procedure or function with the same name as a stored procedure or function in the global namespace, it is not possible to call that global procedure or function from the package body. In this case, the procedure or function of the package will always be called.

For this reason, it is recommended that the names of stored procedures and functions in packages do not overlap with names of stored procedures and functions in the global namespace.

Rules

- In the package body, all procedures and functions must be implemented with the same signature as declared in the header and at the beginning of the package body
- The default values for procedure or function parameters cannot be overridden (as specified in

the package header or in <*package_item*>). This means default values can only be defined in <*package_body_item*> for procedures or functions that have not been defined in the package header or earlier in the package body.

UDF declarations (`DECLARE EXTERNAL FUNCTION`) is not supported for packages. Use UDR instead.

Who Can Create a Package Body

The `CREATE PACKAGE BODY` statement can be executed by:

- Administrators
- The owner of the package
- Users with the `ALTER ANY PACKAGE` privilege

Examples of `CREATE PACKAGE BODY`

Creating the package body

```
CREATE PACKAGE BODY APP_VAR
AS
BEGIN
  -- Returns the start date of the period
  FUNCTION GET_DATEBEGIN() RETURNS DATE DETERMINISTIC
  AS
  BEGIN
    RETURN RDB$GET_CONTEXT('USER_SESSION', 'DATEBEGIN');
  END
  -- Returns the end date of the period
  FUNCTION GET_DATEEND() RETURNS DATE DETERMINISTIC
  AS
  BEGIN
    RETURN RDB$GET_CONTEXT('USER_SESSION', 'DATEEND');
  END
  -- Sets the date range of the working period
  PROCEDURE SET_DATERANGE(ADATEBEGIN DATE, ADATEEND DATE)
  AS
  BEGIN
    RDB$SET_CONTEXT('USER_SESSION', 'DATEBEGIN', ADATEBEGIN);
    RDB$SET_CONTEXT('USER_SESSION', 'DATEEND', ADATEEND);
  END
END
```

See also

`DROP PACKAGE BODY`, `RECREATE PACKAGE BODY`, `CREATE PACKAGE`

5.12.2. DROP PACKAGE BODY

Used for

Dropping a package body

Available in

DSQL

Syntax

```
DROP PACKAGE package_name
```

Table 59. DROP PACKAGE BODY Statement Parameters

Parameter	Description
package_name	Package name

The DROP PACKAGE BODY statement deletes the package body.

Who Can Drop a Package Body

The DROP PACKAGE BODY statement can be executed by:

- Administrators
- The owner of the package
- Users with the ALTER ANY PACKAGE privilege

Examples of DROP PACKAGE BODY

Dropping the package body

```
DROP PACKAGE BODY APP_VAR;
```

See also

CREATE PACKAGE BODY, RECREATE PACKAGE BODY, DROP PACKAGE

5.12.3. RECREATE PACKAGE BODY

Used for

Creating a new or recreating an existing package body

Available in

DSQL

Syntax

```
RECREATE PACKAGE BODY name
AS
```

```
BEGIN
  [ <package_item> ... ]
  [ <package_body_item> ... ]
END

!! See syntax of CREATE PACKAGE BODY for further rules !!
```

The RECREATE PACKAGE BODY statement creates a new or recreates an existing package body. If a package body with the same name already exists, the statement will try to drop it and then create a new package body. After recreating the package body, privileges of the package and its routines are preserved.

See CREATE PACKAGE BODY for more details.

Examples of RECREATE PACKAGE BODY

Recreating the package body

```
RECREATE PACKAGE BODY APP_VAR
AS
BEGIN
  -- Returns the start date of the period
  FUNCTION GET_DATEBEGIN() RETURNS DATE DETERMINISTIC
  AS
  BEGIN
    RETURN RDB$GET_CONTEXT('USER_SESSION', 'DATEBEGIN');
  END
  -- Returns the end date of the period
  FUNCTION GET_DATEEND() RETURNS DATE DETERMINISTIC
  AS
  BEGIN
    RETURN RDB$GET_CONTEXT('USER_SESSION', 'DATEEND');
  END
  -- Sets the date range of the working period
  PROCEDURE SET_DATERANGE(ADATEBEGIN DATE, ADATEEND DATE)
  AS
  BEGIN
    RDB$SET_CONTEXT('USER_SESSION', 'DATEBEGIN', ADATEBEGIN);
    RDB$SET_CONTEXT('USER_SESSION', 'DATEEND', ADATEEND);
  END
END
```

See also

CREATE PACKAGE BODY, DROP PACKAGE BODY, RECREATE PACKAGE BODY, ALTER PACKAGE

5.13. FILTER

A BLOB FILTER is a database object that is a special type of external function, with the sole purpose of taking a BLOB object in one format and converting it to a BLOB object in another format. The

formats of the BLOB objects are specified with user-defined BLOB subtypes.

External functions for converting BLOB types are stored in dynamic libraries and loaded when necessary.

For more details on BLOB subtypes, see Binary Data Types.

5.13.1. DECLARE FILTER

Used for

Declaring a BLOB filter to the database

Available in

DSQL, ESQL

Syntax

```
DECLARE FILTER filtername
  INPUT_TYPE <sub_type> OUTPUT_TYPE <sub_type>
  ENTRY_POINT 'function_name' MODULE_NAME 'library_name'

<sub_type> ::= number | <mnemonic>

<mnemonic> ::=
    BINARY | TEXT | BLR | ACL | RANGES
  | SUMMARY | FORMAT | TRANSACTION_DESCRIPTION
  | EXTERNAL_FILE_DESCRIPTION | user_defined
```

Table 60. DECLARE FILTER Statement Parameters

Parameter	Description
filtername	Filter name in the database. The maximum length is 63 characters. It need not be the same name as the name exported from the filter library via ENTRY_POINT.
sub_type	BLOB subtype
number	BLOB subtype number (must be negative)
mnemonic	BLOB subtype mnemonic name
function_name	The exported name (entry point) of the function
library_name	The name of the module where the filter is located
user_defined	User-defined BLOB subtype mnemonic name

The DECLARE FILTER statement makes a BLOB filter available to the database. The name of the BLOB filter must be unique among the names of BLOB filters.

Specifying the Subtypes

The subtypes can be specified as the subtype number or as the subtype mnemonic name. Custom

subtypes must be represented by negative numbers (from -1 to -32,768). An attempt to declare more than one BLOB filter with the same combination of the input and output types will fail with an error.

INPUT_TYPE
: clause defining the BLOB subtype of the object to be converted

OUTPUT_TYPE
: clause defining the BLOB subtype of the object to be created.

Mnemonic names can be defined for custom BLOB subtypes and inserted manually into the system table RDB$TYPES system table:

```
INSERT INTO RDB$TYPES (RDB$FIELD_NAME, RDB$TYPE, RDB$TYPE_NAME)
VALUES ('RDB$FIELD_SUB_TYPE', -33, 'MIDI');
```

After the transaction is committed, the mnemonic names can be used in declarations when you create new filters.

The value of the column RDB$FIELD_NAME must always be 'RDB$FIELD_SUB_TYPE'. If a mnemonic names was defined in upper case, they can be used case-insensitively and without quotation marks when a filter is declared, following the rules for other object names.

Warning

In general, the system tables are not writable by users. However, inserting custom types into RDB$TYPES is still possible if the user is and administrator, or has the system privilege CREATE_USER_TYPES.

Parameters

ENTRY_POINT
: clause defining the name of the entry point (the name of the imported function) in the module.

MODULE_NAME
: The clause defining the name of the module where the exported function is located. By default, modules must be located in the UDF folder of the root directory on the server. The UDFAccess parameter in firebird.conf allows editing of access restrictions to filter libraries.

Any user connected to the database can declare a BLOB filter.

Who Can Create a BLOB Filter?

The DECLARE FILTER statement can be executed by:

- Administrators
- Users with the CREATE FILTER privilege

The user executing the DECLARE FILTER statement becomes the owner of the filter.

Examples of DECLARE FILTER

1. Creating a BLOB filter using subtype numbers.

```
DECLARE FILTER DESC_FILTER
  INPUT_TYPE 1
  OUTPUT_TYPE -4
  ENTRY_POINT 'desc_filter'
  MODULE_NAME 'FILTERLIB';
```

2. Creating a BLOB filter using subtype mnemonic names.

```
DECLARE FILTER FUNNEL
  INPUT_TYPE blr OUTPUT_TYPE text
  ENTRY_POINT 'blr2asc' MODULE_NAME 'myfilterlib';
```

See also

DROP FILTER

5.13.2. DROP FILTER

Used for

Removing a BLOB filter declaration from the database

Available in

DSQL, ESQL

Syntax

```
DROP FILTER filtername
```

Table 61. DROP FILTER Statement Parameter

Parameter	Description
filtername	Filter name in the database

The DROP FILTER statement removes the declaration of a BLOB filter from the database. Removing a BLOB filter from a database makes it unavailable for use from that database. The dynamic library where the conversion function is located remains intact and the removal from one database does not affect other databases in which the same BLOB filter is still declared.

Who Can Drop a BLOB Filter?

The DROP FILTER statement can be executed by:

- Administrators
- The owner of the filter

- Users with the DROP ANY FILTER privilege

DROP FILTER Example

Dropping a BLOB *filter.*

```
DROP FILTER DESC_FILTER;
```

See also

DECLARE FILTER

5.14. SEQUENCE (GENERATOR)

A sequence — or generator — is a database object used to get unique number values to fill a series. "Sequence" is the SQL-compliant term for the same thing which — in Firebird — has traditionally been known as "generator". Firebird has syntax for both terms.

Sequences are stored as 64-bit integers, regardless of the SQL dialect of the database.

If a client is connected using Dialect 1, the server handles sequence values as 32-bit integers. Passing a sequence value to a 32-bit field or variable will not cause errors as long as the current value of the sequence does not exceed the limits of a 32-bit number. However, as soon as the sequence value exceeds this limit, a database in Dialect 3 will produce an error. A database in Dialect 1 will truncate (overflow) the value, which could compromise the uniqueness of the series.

This section describes how to create, alter, set and drop sequences.

5.14.1. CREATE SEQUENCE

Used for

Creating a new SEQUENCE (GENERATOR)

Available in

DSQL, ESQL

Syntax

```
CREATE {SEQUENCE | GENERATOR} seq_name
  [START WITH start_value]
  [INCREMENT [BY] increment]
```

Table 62. CREATE SEQUENCE *Statement Parameters*

Parameter	Description
seq_name	Sequence name. The maximum length is 63 characters

Parameter	Description
start_value	First value produced by `NEXT VALUE FOR seq_name`. A 64-bit integer from -2^{63} to $2^{63}-1$. Default is 1.
increment	Increment of the sequence when using `NEXT VALUE FOR seq_name`; cannot be `0`. Default is 1.

When a sequence is created, its current value is set so that the next value produced by `NEXT VALUE FOR seq_name` is equal to *start_value*. In other words, the current value of the sequence is set to (`start_value - increment`).

The optional `INCREMENT [BY]` clause allows you to specify a non-zero increment for the `NEXT VALUE FOR seq_name` expression.

The `GEN_ID(seq_name, step)` function can be called instead, to "step" the sequence by a different increment. The increment specified through `INCREMENT [BY]` is not used by `GEN_ID`. Using both `NEXT VALUE FOR` and `GEN_ID`, especially when the sequence has an increment other than 1, may result in values you did not expect. For example, if you execute `CREATE SEQUENCE x START WITH 10 INCREMENT BY 10`, and then use `GEN_ID(x, 1)`, the value returned is 1, and if you then call `NEXT VALUE FOR x`, you get 11.

Non-standard behaviour for negative increments

The SQL standard specifies that sequences with a negative increment should start at the maximum value of the sequence (2^{63} - 1) and count down. Firebird does not do that, and instead starts at 1 unless you specify a `START WITH` value.

This may change in a future Firebird version.

The statements `CREATE SEQUENCE` and `CREATE GENERATOR` are synonymous — both create a new sequence. Either can be used, but `CREATE SEQUENCE` is recommended as that is the syntax defined in the SQL standard.

Who Can Create a Sequence?

The `CREATE SEQUENCE` (`CREATE GENERATOR`) statement can be executed by:

- Administrators
- Users with the `CREATE SEQUENCE` (`CREATE GENERATOR`) privilege

The user executing `CREATE SEQUENCE` (`CREATE GENERATOR`) becomes its owner.

Examples of `CREATE SEQUENCE`

1. Creating the `EMP_NO_GEN` sequence using `CREATE SEQUENCE`.

```
CREATE SEQUENCE EMP_NO_GEN;
```

2. Creating the `EMP_NO_GEN` sequence using `CREATE GENERATOR`.

```
CREATE GENERATOR EMP_NO_GEN;
```

3. Creating the EMP_NO_GEN sequence with an initial value of 5 and an increment of 1.

```
CREATE SEQUENCE EMP_NO_GEN START WITH 5;
```

4. Creating the EMP_NO_GEN sequence with an initial value of 1 and an increment of 10.

```
CREATE SEQUENCE EMP_NO_GEN INCREMENT BY 10;
```

5. Creating the EMP_NO_GEN sequence with an initial value of 5 and an increment of 10.

```
CREATE SEQUENCE EMP_NO_GEN START WITH 5 INCREMENT BY 10;
```

See also

ALTER SEQUENCE, CREATE OR ALTER SEQUENCE, DROP SEQUENCE, RECREATE SEQUENCE, SET GENERATOR, NEXT VALUE FOR, GEN_ID() function

5.14.2. ALTER SEQUENCE

Used for

Setting the next value of a sequence or changing its increment

Available in

DSQL

Syntax

```
ALTER {SEQUENCE | GENERATOR} seq_name
  [RESTART [WITH start_value]]
  [INCREMENT [BY] increment]
```

Table 63. ALTER SEQUENCE *Statement Parameters*

Parameter	Description
seq_name	Sequence name
start_value	Next value produced by NEXT VALUE FOR seq_name. A 64-bit integer from -2^{63} to $2^{63}-1$. Default is the start value in the metadata.
increment	Increment of the sequence (when using NEXT VALUE FOR seq_name); cannot be 0.

The ALTER SEQUENCE statement sets the next value of the sequence, and/or changes the increment of the sequence.

The RESTART WITH start_value clause sets the current value of the sequence so that the next value obtained from NEXT VALUE FOR seq_name is equal to *start_value*. To achieve this, the current value of the sequence is set to (start_value - increment) with *increment* either as specified in the statement, or from the metadata of the sequence. The RESTART clause without WITH start_value behaves as if WITH start_value is specified with the start value from the metadata of the sequence.

Contrary to Firebird 3.0, since Firebird 4.0 RESTART WITH start_value only restarts the sequence with the specified value, and does not store *start_value* as the new start value of the sequence. A subsequent ALTER SEQUENCE RESTART will use the start value specified when the sequence was created, and not the *start_value* of this statement. This behaviour is specified in the SQL standard.

It is currently not possible to change the start value stored in the metadata.

Incorrect use of ALTER SEQUENCE — changing the current value of the sequence or generator — is likely to break the logical integrity of data, or result in primary key or unique constraint violations.

INCREMENT [BY] allows you to change the sequence increment for the NEXT VALUE FOR expression.

Changing the increment value takes effect for all queries that run after the transaction commits. Procedures that are called for the first time after changing the commit, will use the new value if they use NEXT VALUE FOR. Procedures that were already cached in the metadata cache will continue to use the old increment. You may need to close all connections to the database for the metadata cache to clear, and the new increment to be used. Procedures using NEXT VALUE FOR do not need to be recompiled to see the new increment. Procedures using GEN_ID(gen, expression) are not affected when the increment is changed.

Who Can Alter a Sequence?

The ALTER SEQUENCE (ALTER GENERATOR) statement can be executed by:

- Administrators
- The owner of the sequence
- Users with the ALTER ANY SEQUENCE (ALTER ANY GENERATOR) privilege

Examples of ALTER SEQUENCE

1. Setting the value of the EMP_NO_GEN sequence so the next value is 145.

```
ALTER SEQUENCE EMP_NO_GEN RESTART WITH 145;
```

2. Resetting the sequence EMP_NO_GEN to the start value stored in the metadata

```
ALTER SEQUENCE EMP_NO_GEN RESTART;
```

3. Changing the increment of sequence EMP_NO_GEN to 10

```
ALTER SEQUENCE EMP_NO_GEN INCREMENT BY 10;
```

See also

SET GENERATOR, CREATE SEQUENCE, CREATE OR ALTER SEQUENCE, DROP SEQUENCE, RECREATE SEQUENCE, NEXT VALUE FOR, GEN_ID() function

5.14.3. CREATE OR ALTER SEQUENCE

Used for

Creating a new or modifying an existing sequence

Available in

DSQL, ESQL

Syntax

```
CREATE OR ALTER {SEQUENCE | GENERATOR} seq_name
  {RESTART | START WITH start_value}
  [INCREMENT [BY] increment]
```

Table 64. CREATE OR ALTER SEQUENCE Statement Parameters

Parameter	Description
seq_name	Sequence name. The maximum length is 63 characters
start_value	First or next value produced by NEXT VALUE FOR seq_name. A 64-bit integer from -2^{63} to $2^{63}-1$. Default is 1.
increment	Increment of the sequence when using NEXT VALUE FOR seq_name; cannot be 0. Default is 1.

If the sequence does not exist, it will be created as documented under CREATE SEQUENCE. An existing sequence will be changed:

- If RESTART is specified, the sequence is restarted with the start value stored in the metadata
- If the START WITH clause is specified, the sequence is restarted with *start_value*, but the *start_value* is not stored. In other words, it behaves as RESTART WITH in ALTER SEQUENCE.
- If the INCREMENT [BY] clause is specified, *increment* is stored as the increment in the metadata, and used for subsequent calls to NEXT VALUE FOR

Example of CREATE OR ALTER SEQUENCE

Create a new or modify an existing sequence EMP_NO_GEN

```
CREATE OR ALTER SEQUENCE EMP_NO_GEN
  START WITH 10
```

```
  INCREMENT BY 1
```

See also

`CREATE SEQUENCE`, `ALTER SEQUENCE`, `DROP SEQUENCE`, `RECREATE SEQUENCE`, `SET GENERATOR`, `NEXT VALUE FOR`, `GEN_ID() function`

5.14.4. DROP SEQUENCE

Used for

Dropping (deleting) a `SEQUENCE` (`GENERATOR`)

Available in

DSQL, ESQL

Syntax

```
DROP {SEQUENCE | GENERATOR} seq_name
```

Table 65. `DROP SEQUENCE` Statement Parameter

Parameter	Description
seq_name	Sequence name. The maximum length is 63 characters

The statements `DROP SEQUENCE` and `DROP GENERATOR` are equivalent: both drop (delete) an existing sequence. Either is valid but `DROP SEQUENCE`, being defined in the SQL standard, is recommended.

The statements will fail if the sequence has dependencies.

Who Can Drop a Sequence?

The `DROP SEQUENCE` (`DROP GENERATOR`) statement can be executed by:

- Administrators
- The owner of the sequence
- Users with the `DROP ANY SEQUENCE` (`DROP ANY GENERATOR`) privilege

Example of `DROP SEQUENCE`

Dropping the `EMP_NO_GEN` series:

```
DROP SEQUENCE EMP_NO_GEN;
```

See also

`CREATE SEQUENCE`, `CREATE OR ALTER SEQUENCE`, `RECREATE SEQUENCE`

5.14.5. RECREATE SEQUENCE

Used for

Creating or recreating a sequence

Available in

DSQL, ESQL

Syntax

```
RECREATE {SEQUENCE | GENERATOR} seq_name
  [START WITH start_value]
  [INCREMENT [BY] increment]
```

Table 66. RECREATE SEQUENCE Statement Parameters

Parameter	Description
seq_name	Sequence name. The maximum length is 63 characters
start_value	First value produced by `NEXT VALUE FOR seq_name`. A 64-bit integer from -2^{63} to $2^{63}-1$. Default is 1.
increment	Increment of the sequence (when using `NEXT VALUE FOR seq_name`); cannot be `0`. Default is 1.

See `CREATE SEQUENCE` for the full syntax of `CREATE SEQUENCE` and descriptions of defining a sequences and its options.

`RECREATE SEQUENCE` creates or recreates a sequence. If a sequence with this name already exists, the `RECREATE SEQUENCE` statement will try to drop it and create a new one. Existing dependencies will prevent the statement from executing.

Example of RECREATE SEQUENCE

Recreating sequence `EMP_NO_GEN`

```
RECREATE SEQUENCE EMP_NO_GEN
  START WITH 10
  INCREMENT BY 2;
```

See also

`CREATE SEQUENCE`, `ALTER SEQUENCE`, `CREATE OR ALTER SEQUENCE`, `DROP SEQUENCE`, `SET GENERATOR`, `NEXT VALUE FOR`, `GEN_ID() function`

5.14.6. SET GENERATOR

Used for

Setting the current value of a sequence or generator to a specified value

Available in

DSQL, ESQL

Syntax

```
SET GENERATOR seq_name TO new_val
```

Table 67. SET GENERATOR Statement Parameters

Parameter	Description
seq_name	Sequence name
new_val	New sequence value. A 64-bit integer from -2^{63} to $2^{63}-1$.

The SET GENERATOR statement sets the current value of a sequence or generator to the specified value.

Although SET GENERATOR is considered outdated, it is retained for backward compatibility. Use of the standards-compliant ALTER SEQUENCE is recommended.

Who Can Use a SET GENERATOR?

The SET GENERATOR statement can be executed by:

- Administrators
- The owner of the sequence
- Users with the ALTER ANY SEQUENCE (ALTER ANY GENERATOR) privilege

Example of SET GENERATOR

Setting the value of the EMP_NO_GEN sequence to 145:

```
SET GENERATOR EMP_NO_GEN TO 145;
```

Similar effects can be achieved with ALTER SEQUENCE:

```
ALTER SEQUENCE EMP_NO_GEN
  RESTART WITH 145 + increment;
```

Here, the value of *increment* is the current increment of the sequence. We need add it as ALTER SEQUENCE calculates the current value to set based on the next value it should produce.

See also

ALTER SEQUENCE, CREATE SEQUENCE, CREATE OR ALTER SEQUENCE, DROP SEQUENCE, NEXT VALUE FOR, GEN_ID() function

5.15. EXCEPTION

This section describes how to create, modify and delete *custom exceptions* for use in error handlers in PSQL modules.

5.15.1. CREATE EXCEPTION

Used for

Creating a new exception for use in PSQL modules

Available in

DSQL, ESQL

Syntax

```
CREATE EXCEPTION exception_name '<message>'

<message> ::= <message-part> [<message-part> ...]

<message-part> ::=
    <text>
  | @<slot>

<slot> ::= one of 1..9
```

Table 68. CREATE EXCEPTION Statement Parameters

Parameter	Description
exception_name	Exception name. The maximum length is 63 characters
message	Default error message. The maximum length is 1,021 characters
text	Text of any character
slot	Slot number of a parameter. Numbering starts at 1. Maximum slot number is 9.

The statement CREATE EXCEPTION creates a new exception for use in PSQL modules. If an exception with the same name exists, the statement will fail with an appropriate error message.

The exception name is a standard identifier. In a Dialect 3 database, it can be enclosed in double quotes to make it case-sensitive and, if required, to use characters that are not valid in regular identifiers. See Identifiers for more information.

The default message is stored in character set NONE, i.e. in characters of any single-byte character set. The text can be overridden in the PSQL code when the exception is thrown.

The error message may contain “parameter slots” that can be filled when raising the exception.

If the *message* contains a parameter slot number that is greater than 9, the second and subsequent digits will be treated as literal text. For example @10 will be

interpreted as slot 1 followed by a literal '0'.

Custom exceptions are stored in the system table RDB$EXCEPTIONS.

Who Can Create an Exception

The CREATE EXCEPTION statement can be executed by:

- Administrators
- Users with the CREATE EXCEPTION privilege

The user executing the CREATE EXCEPTION statement becomes the owner of the exception.

CREATE EXCEPTION Examples

Creating an exception named E_LARGE_VALUE

```
CREATE EXCEPTION E_LARGE_VALUE
  'The value is out of range';
```

Creating a parameterized exception E_INVALID_VALUE

```
CREATE EXCEPTION E_INVALID_VALUE
  'Invalid value @1 for field @2';
```

Tips

Grouping CREATE EXCEPTION statements together in system update scripts will simplify working with them and documenting them. A system of prefixes for naming and categorising groups of exceptions is recommended.

See also

ALTER EXCEPTION, CREATE OR ALTER EXCEPTION, DROP EXCEPTION, RECREATE EXCEPTION

5.15.2. ALTER EXCEPTION

Used for

Modifying the message returned from a custom exception

Available in

DSQL, ESQL

Syntax

```
ALTER EXCEPTION exception_name '<message>'

!! See syntax of CREATE EXCEPTION for further rules !!
```

The statement ALTER EXCEPTION can be used at any time, to modify the default text of the message.

Who Can Alter an Exception

The ALTER EXCEPTION statement can be executed by:

- Administrators
- The owner of the exception
- Users with the ALTER ANY EXCEPTION privilege

ALTER EXCEPTION Examples

Changing the default message for the exception E_LARGE_VALUE

```
ALTER EXCEPTION E_LARGE_VALUE
  'The value exceeds the prescribed limit of 32,765 bytes';
```

See also

CREATE EXCEPTION, CREATE OR ALTER EXCEPTION, DROP EXCEPTION, RECREATE EXCEPTION

5.15.3. CREATE OR ALTER EXCEPTION

Used for

Modifying the message returned from a custom exception, if the exception exists; otherwise, creating a new exception

Available in

DSQL

Syntax

```
CREATE OR ALTER EXCEPTION exception_name '<message>'

!! See syntax of CREATE EXCEPTION for further rules !!
```

The statement CREATE OR ALTER EXCEPTION is used to create the specified exception if it does not exist, or to modify the text of the error message returned from it if it exists already. If an existing exception is altered by this statement, any existing dependencies will remain intact.

CREATE OR ALTER EXCEPTION Example

Changing the message for the exception E_LARGE_VALUE

```
CREATE OR ALTER EXCEPTION E_LARGE_VALUE
  'The value is higher than the permitted range 0 to 32,765';
```

See also

CREATE EXCEPTION, ALTER EXCEPTION, RECREATE EXCEPTION

5.15.4. DROP EXCEPTION

Used for

Deleting a custom exception

Available in

DSQL, ESQL

Syntax

```
DROP EXCEPTION exception_name
```

Table 69. DROP EXCEPTION Statement Parameter

Parameter	Description
exception_name	Exception name

The statement DROP EXCEPTION is used to delete an exception. Any dependencies on the exception will cause the statement to fail, and the exception will not be deleted.

Who Can Drop an Exception

The DROP EXCEPTION statement can be executed by:

- Administrators
- The owner of the exception
- Users with the DROP ANY EXCEPTION privilege

DROP EXCEPTION Examples

Dropping exception E_LARGE_VALUE

```
DROP EXCEPTION E_LARGE_VALUE;
```

See also

CREATE EXCEPTION, RECREATE EXCEPTION

5.15.5. RECREATE EXCEPTION

Used for

Creating a new custom exception or recreating an existing one

Available in

DSQL

Syntax

```
RECREATE EXCEPTION exception_name '<message>'

!! See syntax of CREATE EXCEPTION for further rules !!
```

The statement `RECREATE EXCEPTION` creates a new exception for use in PSQL modules. If an exception with the same name exists already, the `RECREATE EXCEPTION` statement will try to drop it and create a new one. If there are any dependencies on the existing exception, the attempted deletion fails and `RECREATE EXCEPTION` is not executed.

`RECREATE EXCEPTION` Example

Recreating the `E_LARGE_VALUE` *exception*

```
RECREATE EXCEPTION E_LARGE_VALUE
  'The value exceeds its limit';
```

See also

`CREATE EXCEPTION`, `DROP EXCEPTION`, `CREATE OR ALTER EXCEPTION`

5.16. COLLATION

In SQL, text strings are sortable objects. This means that they obey ordering rules, such as alphabetical order. Comparison operations can be applied to such text strings (for example, “less than” or “greater than”), where the comparison must apply a certain sort order or collation. For example, the expression “`'a' < 'b'`” means that ‘`'a'`’ precedes ‘`'b'`’ in the collation. The expression “`'c' > 'b'`” means that ‘`'c'`’ follows ‘`'b'`’ in the collation. Text strings of more than one character are sorted using sequential character comparisons: first the first characters of the two strings are compared, then the second characters, and so on, until a difference is found between the two strings. This difference defines the sort order.

A `COLLATION` is the schema object that defines a collation (or sort order).

5.16.1. CREATE COLLATION

Used for

Creating a new collation for a supported character set available to the database

Available in

DSQL

Syntax

```
CREATE COLLATION collname
    FOR charset
    [FROM {basecoll | EXTERNAL ('extname')}]
    [NO PAD | PAD SPACE]
```

```
    [CASE [IN]SENSITIVE]
    [ACCENT [IN]SENSITIVE]
    ['<specific-attributes>']

<specific-attributes> ::= <attribute> [; <attribute> ...]

<attribute> ::= attrname=attrvalue
```

Table 70. `CREATE COLLATION` *Statement Parameters*

Parameter	Description
collname	The name to use for the new collation. The maximum length is 63 characters
charset	A character set present in the database
basecoll	A collation already present in the database
extname	The collation name used in the `.conf` file

The `CREATE COLLATION` statement does not "create" anything, its purpose is to make a collation known to a database. The collation must already be present on the system, typically in a library file, and must be properly registered in a `.conf` file in the `intl` subdirectory of the Firebird installation.

The collation may alternatively be based on one that is already present in the database.

How the Engine Detects the Collation

The optional `FROM` clause specifies the base collation that is used to derive a new collation. This collation must already be present in the database. If the keyword `EXTERNAL` is specified, then Firebird will scan the `.conf` files in `$fbroot/intl/`, where *extname* must exactly match the name in the configuration file (case-sensitive).

If no `FROM` clause is present, Firebird will scan the `.conf` file(s) in the `intl` subdirectory for a collation with the collation name specified in `CREATE COLLATION`. In other words, omitting the `FROM basecoll` clause is equivalent to specifying `FROM EXTERNAL ('collname')`.

The — single-quoted — *extname* is case-sensitive and must correspond exactly with the collation name in the `.conf` file. The *collname*, *charset* and *basecoll* parameters are case-insensitive unless enclosed in double-quotes.

When creating a collation, you can specify whether trailing spaces are included in the comparison. If the `NO PAD` clause is specified, trailing spaces are taken into account in the comparison. If the `PAD SPACE` clause is specified, trailing spaces are ignored in the comparison.

The optional `CASE` clause allows you to specify whether the comparison is case-sensitive or case-insensitive.

The optional `ACCENT` clause allows you to specify whether the comparison is accent-sensitive or accent-insensitive (e.g. if ‘`'e'`’ and ‘`'é'`’ are considered equal or unequal).

Specific Attributes

The `CREATE COLLATION` statement can also include specific attributes to configure the collation. The available specific attributes are listed in the table below. Not all specific attributes apply to every collation. If the attribute is not applicable to the collation, but is specified when creating it, it will not cause an error.

Specific attribute names are case-sensitive.

In the table, “1 bpc” indicates that an attribute is valid for collations of character sets using 1 byte per character (so-called narrow character sets), and “UNI” for “Unicode collations”.

Table 71. Specific Collation Attributes

Atrribute	Values	Valid for	Comment
`DISABLE-COMPRESSIONS`	`0`, 1	1 bpc, UNI (4.0.1+)	Disables compressions (a.k.a. contractions). Compressions cause certain character sequences to be sorted as atomic units, e.g. Spanish c+h as a single character ch
`DISABLE-EXPANSIONS`	`0`, 1	1 bpc	Disables expansions. Expansions cause certain characters (e.g. ligatures or umlauted vowels) to be treated as character sequences and sorted accordingly
`ICU-VERSION`	default or M.m	UNI	Specifies the ICU library version to use. Valid values are the ones defined in the applicable `<intl_module>` element in `intl/fbintl.conf`. Format: either the string literal “default” or a major+minor version number like “3.0” (both unquoted).
`LOCALE`	xx_YY	UNI	Specifies the collation locale. Requires complete version of ICU libraries. Format: a locale string like “du_NL” (unquoted) Since Firebird 4.0.1 this option also supports ICU locale keywords and attributes.
`MULTI-LEVEL`	`0`, 1	1 bpc	Uses more than one ordering level
`NUMERIC-SORT`	`0`, 1	UNI	Treats contiguous groups of decimal digits in the string as atomic units and sorts them numerically. (This is also known as natural sorting)

Atrribute	Values	Valid for	Comment
SPECIALS-FIRST	0, 1	1 bpc	Orders special characters (spaces, symbols etc.) before alphanumeric characters

If you want to add a new character set with its default collation into your database, declare and run the stored procedure `sp_register_character_set(name, max_bytes_per_character)`, found in `misc/intl.sql` under the Firebird installation directory.

In order for this to work, the character set must be present on the system and registered in a `.conf` file in the `intl` subdirectory.

Who Can Create a Collation

The `CREATE COLLATION` statement can be executed by:

- Administrators
- Users with the `CREATE COLLATION` privilege

The user executing the `CREATE COLLATION` statement becomes the owner of the collation.

Examples using CREATE COLLATION

1. Creating a collation using the name found in the `fbintl.conf` file (case-sensitive)

```
CREATE COLLATION ISO8859_1_UNICODE FOR ISO8859_1;
```

2. Creating a collation using a special (user-defined) name (the “external” name must completely match the name in the `fbintl.conf` file)

```
CREATE COLLATION LAT_UNI
  FOR ISO8859_1
  FROM EXTERNAL ('ISO8859_1_UNICODE');
```

3. Creating a case-insensitive collation based on one already existing in the database

```
CREATE COLLATION ES_ES_NOPAD_CI
  FOR ISO8859_1
  FROM ES_ES
  NO PAD
  CASE INSENSITIVE;
```

4. Creating a case-insensitive collation based on one already existing in the database with specific attributes

```
CREATE COLLATION ES_ES_CI_COMPR
  FOR ISO8859_1
  FROM ES_ES
  CASE INSENSITIVE
  'DISABLE-COMPRESSIONS=0';
```

5. Creating a case-insensitive collation by the value of numbers (the so-called natural collation)

```
CREATE COLLATION nums_coll FOR UTF8
  FROM UNICODE
  CASE INSENSITIVE 'NUMERIC-SORT=1';

CREATE DOMAIN dm_nums AS varchar(20)
  CHARACTER SET UTF8 COLLATE nums_coll; -- original (manufacturer) numbers

CREATE TABLE wares(id int primary key, articul dm_nums ...);
```

See also

`DROP COLLATION`

5.16.2. DROP COLLATION

Used for

Removing a collation from the database

Available in

DSQL

Syntax

```
DROP COLLATION collname
```

Table 72. `DROP COLLATION` Statement Parameters

Parameter	Description
collname	The name of the collation

The `DROP COLLATION` statement removes the specified collation from the database, if it exists. An error will be raised if the specified collation is not present.

If you want to remove an entire character set with all its collations from the database, declare and execute the stored procedure `sp_unregister_character_set(name)` from the `misc/intl.sql` subdirectory of the Firebird installation.

Who Can Drop a Collation

The `Drop COLLATION` statement can be executed by:

- Administrators
- The owner of the collation
- Users with the `DROP ANY COLLATION` privilege

Example using `DROP COLLATION`

Deleting the `ES_ES_NOPAD_CI` *collation.*

```
DROP COLLATION ES_ES_NOPAD_CI;
```

See also
`CREATE COLLATION`

5.17. CHARACTER SET

5.17.1. ALTER CHARACTER SET

Used for

Setting the default collation for a character set

Available in

DSQL

Syntax

```
ALTER CHARACTER SET charset
  SET DEFAULT COLLATION collation
```

Table 73. `ALTER CHARACTER SET` *Statement Parameters*

Parameter	Description
charset	Character set identifier
collation	The name of the collation

The `ALTER CHARACTER SET` statement changes the default collation for the specified character set. It will affect the future usage of the character set, except for cases where the `COLLATE` clause is explicitly overridden. In that case, the collation sequence of existing domains, columns and PSQL variables will remain intact after the change to the default collation of the underlying character set.

If you change the default collation for the database character set (the one defined when the database was created), it will change the default collation for the database.

> If you change the default collation for the character set that was specified during the connection, string constants will be interpreted according to the new collation value, except in those cases where the character set and/or the collation have been overridden.

Who Can Alter a Character Set

The `ALTER CHARACTER SET` statement can be executed by:

- Administrators
- Users with the `ALTER ANY CHARACTER SET` privilege

`ALTER CHARACTER SET` Example

Setting the default `UNICODE_CI_AI` *collation for the* `UTF8` *encoding*

```
ALTER CHARACTER SET UTF8
  SET DEFAULT COLLATION UNICODE_CI_AI;
```

5.18. Comments

Database objects and a database itself may be annotated with comments. It is a convenient mechanism for documenting the development and maintenance of a database. Comments created with `COMMENT ON` will survive a *gbak* backup and restore.

5.18.1. `COMMENT ON`

Used for

Documenting metadata

Available in

DSQL

Syntax

```
COMMENT ON <object> IS {'sometext' | NULL}

<object> ::=
    {DATABASE | SCHEMA}
  | <basic-type> objectname
  | USER username [USING PLUGIN pluginname]
  | COLUMN relationname.fieldname
  | [{PROCEDURE | FUNCTION}] PARAMETER
      [packagename.]routinename.paramname
  | {PROCEDURE | [EXTERNAL] FUNCTION}
      [package_name.]routinename

<basic-type> ::=
```

```
    CHARACTER SET | COLLATION | DOMAIN
  | EXCEPTION     | FILTER    | GENERATOR
  | INDEX         | PACKAGE   | ROLE
  | SEQUENCE      | TABLE     | TRIGGER
  | VIEW
```

Table 74. COMMENT ON Statement Parameters

Parameter	Description
sometext	Comment text
basic-type	Metadata object type
objectname	Metadata object name
username	Username
pluginname	User manager plugin name
relationname	Name of table or view
fieldname	Name of the column
package_name	Name of the package
routinename	Name of stored procedure or function
paramname	Name of a stored procedure or function parameter

The COMMENT ON statement adds comments for database objects (metadata). Comments are saved to the RDB$DESCRIPTION column of the corresponding system tables. Client applications can view comments from these fields.

1. If you add an empty comment (“''”), it will be saved as NULL in the database.
2. By default, the COMMENT ON USER statement will create comments on users managed by the default user manager (the first plugin listed in the UserManager config option). The USING PLUGIN can be used to comment on a user managed by a different user manager.
3. Comments on users are not stored for the Legacy_UserManager.
4. Comments on users are stored in the security database.
5. SCHEMA is currently a synonym for DATABASE; this may change in a future version, so we recommend to always use DATABASE

Comments on users are visible to that user through the SEC$USERS virtual table.

Who Can Add a Comment

The COMMENT ON statement can be executed by:

- Administrators
- The owner of the object that is commented on

- Users with the `ALTER ANY object_type` privilege, where *object_type* is the type of object commented on (e.g. `PROCEDURE`)

Examples using `COMMENT ON`

1. Adding a comment for the current database

```
COMMENT ON DATABASE IS 'It is a test (''my.fdb'') database';
```

2. Adding a comment for the `METALS` table

```
COMMENT ON TABLE METALS IS 'Metal directory';
```

3. Adding a comment for the `ISALLOY` field in the `METALS` table

```
COMMENT ON COLUMN METALS.ISALLOY IS '0 = fine metal, 1 = alloy';
```

4. Adding a comment for a parameter

```
COMMENT ON PARAMETER ADD_EMP_PROJ.EMP_NO IS 'Employee ID';
```

5. Adding a comment for a package, its procedures and functions, and their parameters

```
COMMENT ON PACKAGE APP_VAR IS 'Application Variables';

COMMENT ON FUNCTION APP_VAR.GET_DATEBEGIN
IS 'Returns the start date of the period';

COMMENT ON PROCEDURE APP_VAR.SET_DATERANGE
IS 'Set date range';

COMMENT ON
PROCEDURE PARAMETER APP_VAR.SET_DATERANGE.ADATEBEGIN
IS 'Start Date';
```

Chapter 6. Data Manipulation (DML) Statements

DML — data manipulation language — is the subset of SQL that is used by applications and procedural modules to extract and change data. Extraction, for the purpose of reading data, both raw and manipulated, is achieved with the `SELECT` statement. `INSERT` is for adding new data and `DELETE` is for erasing data that are no longer required. `UPDATE`, `MERGE` and `UPDATE OR INSERT` all modify data in various ways.

6.1. SELECT

Used for

Retrieving data

Available in

DSQL, ESQL, PSQL

Global syntax

```
[WITH [RECURSIVE] <cte> [, <cte> ...]]
SELECT
  [FIRST m] [SKIP n]
  [{DISTINCT | ALL}] <columns>
FROM
  <source> [[AS] alias]
  [<joins>]
[WHERE <condition>]
[GROUP BY <grouping-list>
[HAVING <aggregate-condition>]]
[WINDOW <window_definition> [, <window_definition> ...]
[PLAN <plan-expr>]
[UNION [{DISTINCT | ALL}] <other-select>]
[ORDER BY <ordering-list>]
[{ ROWS <m> [TO <n>]
 | [OFFSET n {ROW | ROWS}]
   [FETCH {FIRST | NEXT} [m] {ROW | ROWS} ONLY]
}]
[FOR UPDATE [OF <columns>]]
[WITH LOCK]
[INTO <variables>]

<variables> ::= [:]varname [, [:]varname ...]
```

The `SELECT` statement retrieves data from the database and hands them to the application or the enclosing SQL statement. Data are returned in zero or more *rows*, each containing one or more *columns* or *fields*. The total of rows returned is the *result set* of the statement.

The only mandatory parts of the SELECT statement are:

- The SELECT keyword, followed by a columns list. This part specifies *what* you want to retrieve.
- The FROM keyword, followed by a selectable object. This tells the engine *where* you want to get it *from*.

In its most basic form, SELECT retrieves a number of columns from a single table or view, like this:

```
select id, name, address
  from contacts
```

Or, to retrieve all the columns:

```
select * from sales
```

In practice, a SELECT statement is usually executed with a WHERE clause, which limits the rows returned. The result set may be sorted by an ORDER BY clause, and FIRST ⋯ SKIP, OFFSET ⋯ FETCH or ROWS may further limit the number of returned rows, and can - for example - be used for pagination.

The column list may contain all kinds of expressions instead of just column names, and the source need not be a table or view: it may also be a derived table, a common table expression (CTE) or a selectable stored procedure (SP). Multiple sources may be combined in a JOIN, and multiple result sets may be combined in a UNION.

The following sections discuss the available SELECT subclauses and their usage in detail.

6.1.1. FIRST, SKIP

Used for

Retrieving a slice of rows from an ordered set

Available in

DSQL, PSQL

Syntax

```
SELECT
  [FIRST <m>] [SKIP <n>]
  FROM ...
  ...

<m>, <n>  ::=
    <integer-literal>
  | <query-parameter>
  | (<integer-expression>)
```

Table 75. Arguments for the FIRST *and* SKIP *Clauses*

Argument	Description
integer-literal	Integer literal
query-parameter	Query parameter place-holder. ? in DSQL and `:paramname` in PSQL
integer-expression	Expression returning an integer value

`FIRST` and `SKIP` are non-standard syntax

`FIRST` and `SKIP` are Firebird-specific clauses. Use the SQL-standard `OFFSET, FETCH` syntax wherever possible.

`FIRST` limits the output of a query to the first *m* rows. `SKIP` will suppress the given *n* rows before starting to return output.

`FIRST` and `SKIP` are both optional. When used together as in "`FIRST m SKIP n`", the *n* topmost rows of the output set are discarded, and the first *m* rows of the rest of the set are returned.

Characteristics of `FIRST` and `SKIP`

- Any argument to `FIRST` and `SKIP` that is not an integer literal or an SQL parameter must be enclosed in parentheses. This implies that a subquery expression must be enclosed in *two* pairs of parentheses.
- `SKIP 0` is allowed but totally pointless.
- `FIRST 0` is also allowed and returns an empty set.
- Negative `SKIP` and/or `FIRST` values result in an error.
- If a `SKIP` lands past the end of the dataset, an empty set is returned.
- If the number of rows in the dataset (or the remainder left after a `SKIP`) is less than the value of the *m* argument supplied for `FIRST`, that smaller number of rows is returned. These are valid results, not error conditions.

Examples of FIRST/SKIP

1. The following query will return the first 10 names from the `People` table:

```
select first 10 id, name from People
  order by name asc
```

2. The following query will return everything *but* the first 10 names:

```
select skip 10 id, name from People
  order by name asc
```

3. And this one returns the last 10 rows. Notice the double parentheses:

```
select skip ((select count(*) - 10 from People))
```

```
    id, name from People
    order by name asc
```

4. This query returns rows 81 to 100 of the People table:

```
select first 20 skip 80 id, name from People
  order by name asc
```

See also

OFFSET, FETCH, ROWS

6.1.2. The SELECT Columns List

The columns list contains one or more comma-separated value expressions. Each expression provides a value for one output column. Alternatively, * (“select star” or “select all”) can be used to stand for all the columns in a relation (i.e. a table, view or selectable stored procedure).

Syntax

```
SELECT
  [...]
  [{DISTINCT | ALL}] <select_list>
  [...]
  FROM ...

<select_list> ::= * | <output_column> [, <output_column> ...]

<output_column> ::=
    <qualifier>.*
  | <value_expression> [COLLATE collation] [[AS] alias]

<value_expression> ::=
    [<qualifier>.]col_name
  | [<qualifier>.]selectable_SP_outparm
  | <literal>
  | <context-variable>
  | <function-call>
  | <single-value-subselect>
  | <CASE-construct>
  | any other expression returning a single
    value of a Firebird data type or NULL

<qualifier> ::= a relation name or alias

<function-call> ::=
    <normal_function>
  | <aggregate_function>
  | <window_function>
```

```
<normal_function> ::=
  !! See Built-in Scalar Functions !!

<aggregate_function> ::=
  !! See Aggregate Functions !!

<window_function> ::=
  !! See Window Functions !!
```

Table 76. Arguments for the `SELECT` *Columns List*

Argument	Description
qualifier	Name of relation (view, stored procedure, derived table); or an alias for it
collation	Only for character-type columns: a collation name that exists and is valid for the character set of the data
alias	Column or field alias
col_name	Name of a table or view column
selectable_SP_outparm	Declared name of an output parameter of a selectable stored procedure
literal	A literal
context-variable	Context variable
function-call	Scalar, aggregate, or window function expression
single-value-subselect	A subquery returning one scalar value (singleton)
CASE-construct	CASE construct setting conditions for a return value

It is always valid to qualify a column name (or "*") with the name or alias of the table, view or selectable SP to which it belongs, followed by a dot ('.'). For example, `relationname.columnname`, `relationname.*`, `alias.columnname`, `alias.*`. Qualifying is *required* if the column name occurs in more than one relation taking part in a join. Qualifying "*" is always mandatory if it is not the only item in the column list.

Aliases hide the original relation name: once a table, view or procedure has been aliased, only the alias can be used as its qualifier throughout the query. The relation name itself becomes unavailable.

The column list may optionally be preceded by one of the keywords `DISTINCT` or `ALL`:

- `DISTINCT` filters out any duplicate rows. That is, if two or more rows have the same values in every corresponding column, only one of them is included in the result set
- `ALL` is the default: it returns all of the rows, including duplicates. `ALL` is rarely used; it is supported for compliance with the SQL standard.

A `COLLATE` clause will not change the appearance of the column as such. However, if the specified collation changes the case or accent sensitivity of the column, it may influence:

- The ordering, if an `ORDER BY` clause is also present and it involves that column

- Grouping, if the column is part of a `GROUP BY` clause
- The rows retrieved (and hence the total number of rows in the result set), if `DISTINCT` is used

Examples of `SELECT` queries with different types of column lists

A simple `SELECT` using only column names:

```
select cust_id, cust_name, phone
  from customers
  where city = 'London'
```

A query featuring a concatenation expression and a function call in the columns list:

```
select 'Mr./Mrs. ' || lastname, street, zip, upper(city)
  from contacts
  where date_last_purchase(id) = current_date
```

A query with two subselects:

```
select p.fullname,
  (select name from classes c where c.id = p.class) as class,
  (select name from mentors m where m.id = p.mentor) as mentor
from pupils p
```

The following query accomplishes the same as the previous one using joins instead of subselects:

```
select p.fullname,
  c.name as class,
  m.name as mentor
  join classes c on c.id = p.class
from pupils p
  join mentors m on m.id = p.mentor
```

This query uses a `CASE` construct to determine the correct title, e.g. when sending mail to a person:

```
select case upper(sex)
    when 'F' then 'Mrs.'
    when 'M' then 'Mr.'
    else ''
  end as title,
  lastname,
  address
from employees
```

Query using a window function. Ranks employees by salary.

```
SELECT
  id,
  salary,
  name ,
  DENSE_RANK() OVER (ORDER BY salary) AS EMP_RANK
FROM employees
ORDER BY salary;
```

Querying a selectable stored procedure:

```
select * from interesting_transactions(2010, 3, 'S')
  order by amount
```

Selecting from columns of a derived table. A derived table is a parenthesized `SELECT` statement whose result set is used in an enclosing query as if it were a regular table or view. The derived table is shown in bold here:

```
select fieldcount,
  count(relation) as num_tables
from (select r.rdb$relation_name as relation,
        count(*) as fieldcount
      from rdb$relations r
        join rdb$relation_fields rf
          on rf.rdb$relation_name = r.rdb$relation_name
      group by relation)
group by fieldcount
```

Asking the time through a context variable (`CURRENT_TIME`):

```
select current_time from rdb$database
```

For those not familiar with `RDB$DATABASE`: this is a system table that is present in all Firebird databases and is guaranteed to contain exactly one row. Although it wasn't created for this purpose, it has become standard practice among Firebird programmers to select from this table if you want to select "from nothing", i.e. if you need data that are not bound to a table or view, but can be derived from the expressions in the output columns alone. Another example is:

```
select power(12, 2) as twelve_squared, power(12, 3) as twelve_cubed
  from rdb$database
```

Finally, an example where you select some meaningful information from `RDB$DATABASE` itself:

```
select rdb$character_set_name from rdb$database
```

As you may have guessed, this will give you the default character set of the database.

See also

Functions, Aggregate Functions, Window Functions, Context Variables, CASE, Subqueries

6.1.3. The FROM clause

The FROM clause specifies the source(s) from which the data are to be retrieved. In its simplest form, this is just a single table or view. However, the source can also be a selectable stored procedure, a derived table, or a common table expression. Multiple sources can be combined using various types of joins.

This section focuses on single-source selects. Joins are discussed in a following section.

Syntax

```
SELECT
  ...
  FROM <source>
  [<joins>]
  [...]

<source> ::=
    table [[AS] alias]
  | selectable-stored-procedure [(<args>)] [[AS] alias]
  | <derived-table>
  | LATERAL <derived-table>

<derived-table> ::=
  (<select-statement>) [[AS] alias] [(<column-aliases>)]

<column-aliases> ::= column-alias [, column-alias ...]
```

Table 77. Arguments for the FROM Clause

Argument	Description
table	Name of a table, view or CTE
selectable-stored-procedure	Name of a selectable stored procedure
args	Selectable stored procedure arguments
derived-table	Derived table query expression
select-statement	Any SELECT statement
column-aliases	Alias for a column in a relation, CTE or derived table
alias	The alias of a data source (table, view, procedure, CTE, derived table)

Selecting `FROM` a table or view

When selecting from a single table or view, the `FROM` clause requires nothing more than the name. An alias may be useful or even necessary if there are subqueries that refer to the main select statement (as they often do — subqueries like this are called *correlated subqueries*).

Examples

```
select id, name, sex, age from actors
where state = 'Ohio'
```

```
select * from birds
where type = 'flightless'
order by family, genus, species
```

```
select firstname,
  middlename,
  lastname,
  date_of_birth,
  (select name from schools s where p.school = s.id) schoolname
from pupils p
where year_started = '2012'
order by schoolname, date_of_birth
```

Never mix column names with column aliases!

If you specify an alias for a table or a view, you must always use this alias in place of the table name whenever you query the columns of the relation (and wherever else you make a reference to columns, such as `ORDER BY`, `GROUP BY` and `WHERE` clauses).

Correct use:

```
SELECT PEARS
FROM FRUIT;

SELECT FRUIT.PEARS
FROM FRUIT;

SELECT PEARS
FROM FRUIT F;

SELECT F.PEARS
FROM FRUIT F;
```

Incorrect use:

```
SELECT FRUIT.PEARS
FROM FRUIT F;
```

Selecting FROM a stored procedure

A *selectable stored procedure* is a procedure that:

- contains at least one output parameter, and
- utilizes the SUSPEND keyword so the caller can fetch the output rows one by one, just as when selecting from a table or view.

The output parameters of a selectable stored procedure correspond to the columns of a regular table.

Selecting from a stored procedure without input parameters is just like selecting from a table or view:

```
select * from suspicious_transactions
  where assignee = 'John'
```

Any required input parameters must be specified after the procedure name, enclosed in parentheses:

```
select name, az, alt from visible_stars('Brugge', current_date, '22:30')
  where alt >= 20
  order by az, alt
```

Values for optional parameters (that is, parameters for which default values have been defined) may be omitted or provided. However, if you provide them only partly, the parameters you omit must all be at the tail end.

Supposing that the procedure visible_stars from the previous example has two optional parameters: min_magn (numeric(3,1)) and spectral_class (varchar(12)), the following queries are all valid:

```
select name, az, alt
from visible_stars('Brugge', current_date, '22:30');

select name, az, alt
from visible_stars('Brugge', current_date, '22:30', 4.0);

select name, az, alt
from visible_stars('Brugge', current_date, '22:30', 4.0, 'G');
```

But this one isn't, because there's a "hole" in the parameter list:

```
select name, az, alt
from visible_stars('Brugge', current_date, '22:30', 'G');
```

An alias for a selectable stored procedure is specified *after* the parameter list:

```
select
  number,
  (select name from contestants c where c.number = gw.number)
from get_winners('#34517', 'AMS') gw
```

If you refer to an output parameter (“column”) by qualifying it with the full procedure name, the procedure alias should be omitted:

```
select
  number,
  (select name from contestants c where c.number = get_winners.number)
from get_winners('#34517', 'AMS')
```

See also

Stored Procedures, `CREATE PROCEDURE`

Selecting `FROM` a derived table

A derived table is a valid `SELECT` statement enclosed in parentheses, optionally followed by a table alias and/or column aliases. The result set of the statement acts as a virtual table which the enclosing statement can query.

Syntax

```
(<select-query>)
  [[AS] derived-table-alias]
  [(<derived-column-aliases>)]

<derived-column-aliases> := column-alias [, column-alias ...]
```

The set returned data set by this “`SELECT FROM (SELECT FROM..)`” style of statement is a virtual table that can be queried within the enclosing statement, as if it were a regular table or view.

`LATERAL` Derived Tables

The keyword `LATERAL` marks a table as a lateral derived table. Lateral derived tables can reference tables (including derived tables) that occur earlier in the `FROM` clause. See Joins with `LATERAL` Derived Tables for more information.

Example using a derived table

The derived table in the query below returns the list of table names in the database, and the number of columns in each table. A “drill-down” query on the derived table returns the counts of fields and the counts of tables having each field count:

```
SELECT
  FIELDCOUNT,
  COUNT(RELATION) AS NUM_TABLES
FROM (SELECT
        R.RDB$RELATION_NAME RELATION,
        COUNT(*) AS FIELDCOUNT
      FROM RDB$RELATIONS R
        JOIN RDB$RELATION_FIELDS RF
        ON RF.RDB$RELATION_NAME = R.RDB$RELATION_NAME
        GROUP BY RELATION)
GROUP BY FIELDCOUNT
```

A trivial example demonstrating how the alias of a derived table and the list of column aliases (both optional) can be used:

```
SELECT
  DBINFO.DESCR, DBINFO.DEF_CHARSET
FROM (SELECT *
      FROM RDB$DATABASE) DBINFO
        (DESCR, REL_ID, SEC_CLASS, DEF_CHARSET)
```

More about Derived Tables

Derived tables can

- be nested
- be unions, and can be used in unions
- contain aggregate functions, subqueries and joins
- be used in aggregate functions, subqueries and joins
- be calls to selectable stored procedures or queries to them
- have `WHERE`, `ORDER BY` and `GROUP BY` clauses, `FIRST`/`SKIP` or `ROWS` directives, et al.

Furthermore,

- Each column in a derived table must have a name. If it does not have a name, such as when it is a constant or a run-time expression, it should be given an alias, either in the regular way or by including it in the list of column aliases in the derived table’s specification.
  - *The list of column aliases is optional but, if it exists, it must contain an alias for every column in the derived table*

- The optimizer can process derived tables very effectively. However, if a derived table is included in an inner join and contains a subquery, the optimizer will be unable to use any join order.

A more useful example

Suppose we have a table `COEFFS` which contains the coefficients of a number of quadratic equations we have to solve. It has been defined like this:

```
create table coeffs (
  a double precision not null,
  b double precision not null,
  c double precision not null,
  constraint chk_a_not_zero check (a <> 0)
)
```

Depending on the values of `a`, `b` and `c`, each equation may have zero, one or two solutions. It is possible to find these solutions with a single-level query on table `COEFFS`, but the code will look rather messy and several values (like the discriminant) will have to be calculated multiple times per row. A derived table can help keep things clean here:

```
select
  iif (D >= 0, (-b - sqrt(D)) / denom, null) sol_1,
  iif (D >  0, (-b + sqrt(D)) / denom, null) sol_2
  from
    (select b, b*b - 4*a*c, 2*a from coeffs) (b, D, denom)
```

If we want to show the coefficients next to the solutions (which may not be a bad idea), we can alter the query like this:

```
select
  a, b, c,
  iif (D >= 0, (-b - sqrt(D)) / denom, null) sol_1,
  iif (D >  0, (-b + sqrt(D)) / denom, null) sol_2
  from
    (select a, b, c, b*b - 4*a*c as D, 2*a as denom
     from coeffs)
```

Notice that whereas the first query used a column aliases list for the derived table, the second adds aliases internally where needed. Both methods work, as long as every column is guaranteed to have a name.

All columns in the derived table will be evaluated as many times as they are specified in the main query. This is important, as it can lead to unexpected results when using non-deterministic functions. The following shows an example of this.

```
SELECT
  UUID_TO_CHAR(X) AS C1,
  UUID_TO_CHAR(X) AS C2,
  UUID_TO_CHAR(X) AS C3
FROM (SELECT GEN_UUID() AS X
      FROM RDB$DATABASE) T;
```

The result if this query produces three different values:

```
C1  80AAECED-65CD-4C2F-90AB-5D548C3C7279
C2  C1214CD3-423C-406D-B5BD-95BF432ED3E3
C3  EB176C10-F754-4689-8B84-64B666381154
```

To ensure a single result of the `GEN_UUID` function, you can use the following method:

```
SELECT
  UUID_TO_CHAR(X) AS C1,
  UUID_TO_CHAR(X) AS C2,
  UUID_TO_CHAR(X) AS C3
FROM (SELECT GEN_UUID() AS X
      FROM RDB$DATABASE
      UNION ALL
      SELECT NULL FROM RDB$DATABASE WHERE 1 = 0) T;
```

This query produces a single result for all three columns:

```
C1  80AAECED-65CD-4C2F-90AB-5D548C3C7279
C2  80AAECED-65CD-4C2F-90AB-5D548C3C7279
C3  80AAECED-65CD-4C2F-90AB-5D548C3C7279
```

An alternative solution is to wrap the `GEN_UUID` query in a subquery:

```
SELECT
  UUID_TO_CHAR(X) AS C1,
  UUID_TO_CHAR(X) AS C2,
  UUID_TO_CHAR(X) AS C3
FROM (SELECT
        (SELECT GEN_UUID() FROM RDB$DATABASE) AS X
      FROM RDB$DATABASE) T;
```

This is an artifact of the current implementation. This behaviour may change in a future Firebird version.

Selecting FROM a Common Table Expression (CTE)

A common table expression — or *CTE* — is a more complex variant of the derived table, but it is also more powerful. A preamble, starting with the keyword WITH, defines one or more named *CTE*'s, each with an optional column aliases list. The main query, which follows the preamble, can then access these *CTE*'s as if they were regular tables or views. The *CTE*'s go out of scope once the main query has run to completion.

For a full discussion of *CTE*'s, please refer to the section Common Table Expressions ("WITH ⋯ AS ⋯ SELECT").

The following is a rewrite of our derived table example as a *CTE*:

```
with vars (b, D, denom) as (
  select b, b*b - 4*a*c, 2*a from coeffs
)
select
  iif (D >= 0, (-b - sqrt(D)) / denom, null) sol_1,
  iif (D >  0, (-b + sqrt(D)) / denom, null) sol_2
from vars
```

Except for the fact that the calculations that have to be made first are now at the beginning, this isn't a great improvement over the derived table version. However, we can now also eliminate the double calculation of sqrt(D) for every row:

```
with vars (b, D, denom) as (
  select b, b*b - 4*a*c, 2*a from coeffs
),
vars2 (b, D, denom, sqrtD) as (
  select b, D, denom, iif (D >= 0, sqrt(D), null) from vars
)
select
  iif (D >= 0, (-b - sqrtD) / denom, null) sol_1,
  iif (D >  0, (-b + sqrtD) / denom, null) sol_2
from vars2
```

The code is a little more complicated now, but it might execute more efficiently (depending on what takes more time: executing the SQRT function or passing the values of b, D and denom through an extra *CTE*). Incidentally, we could have done the same with derived tables, but that would involve nesting.

All columns in the CTE will be evaluated as many times as they are specified in the main query. This is important, as it can lead to unexpected results when using non-deterministic functions. The following shows an example of this.

```
WITH T (X) AS (
  SELECT GEN_UUID()
  FROM RDB$DATABASE)
```

```
SELECT
  UUID_TO_CHAR(X) as c1,
  UUID_TO_CHAR(X) as c2,
  UUID_TO_CHAR(X) as c3
FROM T
```

The result if this query produces three different values:

```
C1  80AAECED-65CD-4C2F-90AB-5D548C3C7279
C2  C1214CD3-423C-406D-B5BD-95BF432ED3E3
C3  EB176C10-F754-4689-8B84-64B666381154
```

To ensure a single result of the `GEN_UUID` function, you can use the following method:

```
WITH T (X) AS (
  SELECT GEN_UUID()
  FROM RDB$DATABASE
  UNION ALL
  SELECT NULL FROM RDB$DATABASE WHERE 1 = 0)
SELECT
  UUID_TO_CHAR(X) as c1,
  UUID_TO_CHAR(X) as c2,
  UUID_TO_CHAR(X) as c3
FROM T;
```

This query produces a single result for all three columns:

```
C1  80AAECED-65CD-4C2F-90AB-5D548C3C7279
C2  80AAECED-65CD-4C2F-90AB-5D548C3C7279
C3  80AAECED-65CD-4C2F-90AB-5D548C3C7279
```

An alternative solution is to wrap the `GEN_UUID` query in a subquery:

```
WITH T (X) AS (
  SELECT (SELECT GEN_UUID() FROM RDB$DATABASE)
  FROM RDB$DATABASE)
SELECT
  UUID_TO_CHAR(X) as c1,
  UUID_TO_CHAR(X) as c2,
  UUID_TO_CHAR(X) as c3
FROM T;
```

This is an artifact of the current implementation. This behaviour may change in a future Firebird version.

See also

Common Table Expressions (“`WITH ⋯ AS ⋯ SELECT`”).

6.1.4. Joins

Joins combine data from two sources into a single set. This is done on a row-by-row basis and usually involves checking a *join condition* in order to determine which rows should be merged and appear in the resulting dataset. There are several types (`INNER`, `OUTER`) and classes (qualified, natural, etc.) of joins, each with its own syntax and rules.

Since joins can be chained, the datasets involved in a join may themselves be joined sets.

Syntax

```
SELECT
   ...
   FROM <source>
   [<joins>]
   [...]

<source> ::=
    table [[AS] alias]
  | selectable-stored-procedure [(<args>)] [[AS] alias]
  | <derived-table>
  | LATERAL <derived-table>

<joins> ::= <join> [<join> ...]

<join> ::=
    [<join-type>] JOIN <source> <join-condition>
  | NATURAL [<join-type>] JOIN <source>
  | {CROSS JOIN | ,} <source>

<join-type> ::= INNER | {LEFT | RIGHT | FULL} [OUTER]

<join-condition> ::= ON <condition> | USING (<column-list>)
```

Table 78. Arguments for `JOIN` Clauses

Argument	Description
table	Name of a table, view or CTE
selectable-stored-procedure	Name of a selectable stored procedure
args	Selectable stored procedure input parameter(s)
derived-table	Derived table query expression
alias	An alias for a data source (table, view, procedure, CTE, derived table)
condition	Join condition (criterion)

Argument	Description
column-list	The list of columns used for an equi-join

Inner vs. Outer Joins

A join always combines data rows from two sets (usually referred to as the left set and the right set). By default, only rows that meet the join condition (i.e. that match at least one row in the other set when the join condition is applied) make it into the result set. This default type of join is called an *inner join*. Suppose we have the following two tables:

Table A

ID	S
87	Just some text
235	Silence

Table B

CODE	X
-23	56.7735
87	416.0

If we join these tables like this:

```
select *
  from A
  join B on A.id = B.code;
```

then the result set will be:

ID	S	CODE	X
87	Just some text	87	416.0

The first row of `A` has been joined with the second row of `B` because together they met the condition "`A.id = B.code`". The other rows from the source tables have no match in the opposite set and are therefore not included in the join. Remember, this is an `INNER` join. We can make that fact explicit by writing:

```
select *
  from A
  inner join B on A.id = B.code;
```

However, since `INNER` is the default, it is usually ommitted.

It is perfectly possible that a row in the left set matches several rows from the right set or vice versa. In that case, all those combinations are included, and we can get results like:

ID	S	CODE	X
87	Just some text	87	416.0
87	Just some text	87	-1.0
-23	Don't know	-23	56.7735
-23	Still don't know	-23	56.7735
-23	I give up	-23	56.7735

Sometimes we want (or need) *all* the rows of one or both of the sources to appear in the joined set, regardless of whether they match a record in the other source. This is where outer joins come in. A `LEFT` outer join includes all the records from the left set, but only matching records from the right set. In a `RIGHT` outer join it's the other way around. `FULL` outer joins include all the records from both sets. In all outer joins, the "holes" (the places where an included source record doesn't have a match in the other set) are filled up with `NULL`s.

In order to make an outer join, you must specify `LEFT`, `RIGHT` or `FULL`, optionally followed by the keyword `OUTER`.

Below are the results of the various outer joins when applied to our original tables `A` and `B`:

```
select *
  from A
  left [outer] join B on A.id = B.code;
```

ID	S	CODE	X
87	Just some text	87	416.0
235	Silence	*<null>*	*<null>*

```
select *
  from A
  right [outer] join B on A.id = B.code
```

ID	S	CODE	X
<null>	*<null>*	-23	56.7735
87	Just some text	87	416.0

```
select *
  from A
  full [outer] join B on A.id = B.code
```

ID	S	CODE	X
<null>	*<null>*	-23	56.7735

ID	S	CODE	X
87	Just some text	87	416.0
235	Silence	*<null>*	*<null>*

Qualified joins

Qualified joins specify conditions for the combining of rows. This happens either explicitly in an `ON` clause or implicitly in a `USING` clause.

Syntax

```
<qualified-join> ::= [<join-type>] JOIN <source> <join-condition>

<join-type> ::= INNER | {LEFT | RIGHT | FULL} [OUTER]

<join-condition> ::= ON <condition> | USING (<column-list>)
```

Explicit-condition joins

Most qualified joins have an `ON` clause, with an explicit condition that can be any valid Boolean expression, but usually involves some comparison between the two sources involved.

Quite often, the condition is an equality test (or a number of `AND`ed equality tests) using the "=" operator. Joins like these are called *equi-joins*. (The examples in the section on inner and outer joins were al equi-joins.)

Examples of joins with an explicit condition:

```
/* Select all Detroit customers who made a purchase
   in 2013, along with the purchase details: */
select * from customers c
  join sales s on s.cust_id = c.id
  where c.city = 'Detroit' and s.year = 2013;
```

```
/* Same as above, but include non-buying customers: */
select * from customers c
  left join sales s on s.cust_id = c.id
  where c.city = 'Detroit' and s.year = 2013;
```

```
/* For each man, select the women who are taller than he.
   Men for whom no such woman exists are not included. */
select m.fullname as man, f.fullname as woman
  from males m
  join females f on f.height > m.height;
```

```
/* Select all pupils with their class and mentor.
   Pupils without a mentor are also included.
   Pupils without a class are not included. */
select p.firstname, p.middlename, p.lastname,
       c.name, m.name
  from pupils p
  join classes c on c.id = p.class
  left join mentors m on m.id = p.mentor;
```

Named columns joins

Equi-joins often compare columns that have the same name in both tables. If this is the case, we can also use the second type of qualified join: the *named columns join*.

Named columns joins are not supported in Dialect 1 databases.

Named columns joins have a `USING` clause which states just the column names. So instead of this:

```
select * from flotsam f
  join jetsam j
  on f.sea = j.sea
  and f.ship = j.ship;
```

we can also write:

```
select * from flotsam
  join jetsam using (sea, ship)
```

which is considerably shorter. The result set is a little different though — at least when using "`SELECT *`":

- The explicit-condition join — with the `ON` clause — will contain each of the columns `SEA` and `SHIP` twice: once from table `FLOTSAM`, and once from table `JETSAM`. Obviously, they will have the same values.
- The named columns join — with the `USING` clause — will contain these columns only once.

If you want all the columns in the result set of the named columns join, set up your query like this:

```
select f.*, j.*
  from flotsam f
  join jetsam j using (sea, ship);
```

This will give you the exact same result set as the explicit-condition join.

For an `OUTER` named columns join, there's an additional twist when using "`SELECT *`" or an

unqualified column name from the USING list:

If a row from one source set doesn't have a match in the other but must still be included because of the LEFT, RIGHT or FULL directive, the merged column in the joined set gets the non-NULL value. That is fair enough, but now you can't tell whether this value came from the left set, the right set, or both. This can be especially deceiving when the value came from the right hand set, because "*" always shows combined columns in the left hand part — even in the case of a RIGHT join.

Whether this is a problem or not depends on the situation. If it is, use the "a.*, b.*" approach shown above, with a and b the names or aliases of the two sources. Or better yet, avoid "*" altogether in your serious queries and qualify all column names in joined sets. This has the additional benefit that it forces you to think about which data you want to retrieve and where from.

It is your responsibility to make sure the column names in the USING list are of compatible types between the two sources. If the types are compatible but not equal, the engine converts them to the type with the broadest range of values before comparing the values. This will also be the data type of the merged column that shows up in the result set if "SELECT *" or the unqualified column name is used. Qualified columns on the other hand will always retain their original data type.

If, when joining by named columns, you are using a join column in the WHERE clause, always use the qualified column name, otherwise an index on this column will not be used.

```
SELECT 1 FROM t1 a JOIN t2 b USING (x) WHERE x = 0;

-- PLAN JOIN (A NATURAL , B INDEX (RDB$2))
```

However:

```
SELECT 1 FROM t1 a JOIN t2 b USING (x) WHERE a.x = 0;
-- PLAN JOIN (A INDEX (RDB$1), B INDEX (RDB$2))

SELECT 1 FROM t1 a JOIN t2 b USING (x) WHERE b.x = 0;
-- PLAN JOIN (A INDEX (RDB$1), B INDEX (RDB$2))
```

The fact is, the unspecified column in this case is implicitly replaced by `COALESCE(a.x, b.x). This clever trick is used to disambiguate column names, but it also interferes with the use of the index.

Natural joins

Taking the idea of the named columns join a step further, a *natural join* performs an automatic equi-join on all the columns that have the same name in the left and right table. The data types of these columns must be compatible.

Natural joins are not supported in Dialect 1 databases.

Syntax

```
<natural-join> ::= NATURAL [<join-type>] JOIN <source>

<join-type> ::= INNER | {LEFT | RIGHT | FULL} [OUTER]
```

Given these two tables:

```
create table TA (
  a bigint,
  s varchar(12),
  ins_date date
);
```

```
create table TB (
  a bigint,
  descr varchar(12),
  x float,
  ins_date date
);
```

A natural join on `TA` and `TB` would involve the columns `a` and `ins_date`, and the following two statements would have the same effect:

```
select * from TA
  natural join TB;
```

```
select * from TA
  join TB using (a, ins_date);
```

Like all joins, natural joins are inner joins by default, but you can turn them into outer joins by specifying `LEFT`, `RIGHT` or `FULL` before the `JOIN` keyword.

If there are no columns with the same name in the two source relations, a `CROSS JOIN` is performed. We'll get to this type of join in a minute.

Cross joins

A cross join produces the full set product of the two data sources. This means that it successfully matches every row in the left source to every row in the right source.

Syntax

```
<cross-join> ::= {CROSS JOIN | ,} <source>
```

Use of the comma syntax is discouraged, and we recommend using the explicit join syntax.

Cross-joining two sets is equivalent to joining them on a tautology (a condition that is always true). The following two statements have the same effect:

```
select * from TA
  cross join TB;
```

```
select * from TA
  join TB on 1 = 1;
```

Cross joins are inner joins, because they only include matching records – it just so happens that *every* record matches! An outer cross join, if it existed, wouldn't add anything to the result, because what outer joins add are non-matching records, and these don't exist in cross joins.

Cross joins are seldom useful, except if you want to list all the possible combinations of two or more variables. Suppose you are selling a product that comes in different sizes, different colors and different materials. If these variables are each listed in a table of their own, this query would return all the combinations:

```
select m.name, s.size, c.name
  from materials m
  cross join sizes s
  cross join colors c;
```

Implicit Joins

In the SQL:89 standard, the tables involved in a join were specified as a comma-delimited list in the `FROM` clause (in other words, a cross join). The join conditions were then specified in the `WHERE` clause among other search terms. This type of join is called an implicit join.

An example of an implicit join:

```
/*
 * A sample of all Detroit customers who
 * made a purchase.
 */
SELECT *
FROM customers c, sales s
WHERE s.cust_id = c.id AND c.city = 'Detroit'
```

Mixing Explicit and Implicit Joins

Mixing explicit and implicit joins is not recommend, but is allowed. However, some types of mixing are not supported by Firebird.

For example, the following query will raise the error “Column does not belong to referenced table”

```
SELECT *
FROM TA, TB
JOIN TC ON TA.COL1 = TC.COL1
WHERE TA.COL2 = TB.COL2
```

That is because the explicit join cannot see the TA table. However, the next query will complete without error, since the restriction is not violated.

```
SELECT *
FROM TA, TB
JOIN TC ON TB.COL1 = TC.COL1
WHERE TA.COL2 = TB.COL2
```

A Note on Equality

This note about equality and inequality operators applies everywhere in Firebird’s SQL language, not just in JOIN conditions.

The “=” operator, which is explicitly used in many conditional joins and implicitly in named column joins and natural joins, only matches values to values. According to the SQL standard, NULL is not a value and hence two NULLs are neither equal nor unequal to one another. If you need NULLs to match each other in a join, use the IS NOT DISTINCT FROM operator. This operator returns true if the operands have the same value *or* if they are both NULL.

```
select *
  from A join B
  on A.id is not distinct from B.code;
```

Likewise, in the — extremely rare — cases where you want to join on *in*equality, use IS DISTINCT FROM, not “<>”, if you want NULL to be considered different from any value and two NULLs considered equal:

```
select *
  from A join B
  on A.id is distinct from B.code;
```

Ambiguous field names in joins

Firebird rejects unqualified field names in a query if these field names exist in more than one dataset involved in a join. This is even true for inner equi-joins where the field name figures in the ON clause like this:

```
select a, b, c
  from TA
  join TB on TA.a = TB.a;
```

There is one exception to this rule: with named columns joins and natural joins, the unqualified field name of a column taking part in the matching process may be used legally and refers to the merged column of the same name. For named columns joins, these are the columns listed in the `USING` clause. For natural joins, they are the columns that have the same name in both relations. But please notice again that, especially in outer joins, plain `colname` isn't always the same as `left.colname` or `right.colname`. Types may differ, and one of the qualified columns may be `NULL` while the other isn't. In that case, the value in the merged, unqualified column may mask the fact that one of the source values is absent.

Joins with `LATERAL` Derived Tables

A derived table defined with the `LATERAL` keyword is called a lateral derived table. If a derived table is defined as lateral, then it is allowed to refer to other tables in the same `FROM` clause, but only those declared before it in the `FROM` clause.

Lateral Derived Table Examples

```
/* select customers with their last order date and number */
select c.name, ox.order_date as last_order, ox.number
from customer c
  left join LATERAL (
    select first 1 o.order_date, o.number
    from orders o
    where o.id_customer = c.id
    order by o.ORDER_DATE desc
  ) as ox on true
--
select dt.population, dt.city_name, c.country_name
from (select distinct country_name from cities) AS c
  cross join LATERAL (
    select first 1 city_name, population
    from cities
    where cities.country_name = c.country_name
    order by population desc
  ) AS dt;
--
select salespeople.name,
       max_sale.amount,
       customer_of_max_sale.customer_name
from salespeople,
  LATERAL ( select max(amount) as amount
            from all_sales
            where all_sales.salesperson_id = salespeople.id
  ) as max_sale,
  LATERAL ( select customer_name
```

```
            from all_sales
            where all_sales.salesperson_id = salespeople.id
            and all_sales.amount = max_sale.amount
  ) as customer_of_max_sale;
```

6.1.5. The WHERE clause

The WHERE clause serves to limit the rows returned to the ones that the caller is interested in. The condition following the keyword WHERE can be as simple as a check like "AMOUNT = 3" or it can be a multilayered, convoluted expression containing subselects, predicates, function calls, mathematical and logical operators, context variables and more.

The condition in the WHERE clause is often called the *search condition*, the *search expression* or simply the *search*.

In DSQL and ESQL, the search expression may contain parameters. This is useful if a query has to be repeated a number of times with different input values. In the SQL string as it is passed to the server, question marks are used as placeholders for the parameters. They are called *positional parameters* because they can only be told apart by their position in the string. Connectivity libraries often support *named parameters* of the form :id, :amount, :a etc. These are more user-friendly; the library takes care of translating the named parameters to positional parameters before passing the statement to the server.

The search condition may also contain local (PSQL) or host (ESQL) variable names, preceded by a colon.

Syntax

```
SELECT ...
  FROM ...
  [...]
  WHERE <search-condition>
  [...]
```

Table 79. Argument of WHERE

Parameter	Description
search-condition	A Boolean expression returning TRUE, FALSE or possibly UNKNOWN (NULL)

Only those rows for which the search condition evaluates to TRUE are included in the result set. Be careful with possible NULL outcomes: if you negate a NULL expression with NOT, the result will still be NULL and the row will not pass. This is demonstrated in one of the examples below.

Examples

```
select genus, species from mammals
  where family = 'Felidae'
```

```
  order by genus;
```

```
select * from persons
  where birthyear in (1880, 1881)
     or birthyear between 1891 and 1898;
```

```
select name, street, borough, phone
  from schools s
  where exists (select * from pupils p where p.school = s.id)
  order by borough, street;
```

```
select * from employees
  where salary >= 10000 and position <> 'Manager';
```

```
select name from wrestlers
  where region = 'Europe'
    and weight > all (select weight from shot_putters
                      where region = 'Africa');
```

```
select id, name from players
  where team_id = (select id from teams where name = 'Buffaloes');
```

```
select sum (population) from towns
  where name like '%dam'
  and province containing 'land';
```

```
select password from usertable
  where username = current_user;
```

The following example shows what can happen if the search condition evaluates to `NULL`.

Suppose you have a table listing some children's names and the number of marbles they possess. At a certain moment, the table contains these data:

CHILD	MARBLES
Anita	23
Bob E.	12
Chris	*<null>*
Deirdre	1

CHILD	MARBLES
Eve	17
Fritz	0
Gerry	21
Hadassah	<*null*>
Isaac	6

First, please notice the difference between `NULL` and 0: Fritz is *known* to have no marbles at all, Chris's and Hadassah's marble counts are unknown.

Now, if you issue this SQL statement:

```
select list(child) from marbletable where marbles > 10;
```

you will get the names Anita, Bob E., Eve and Gerry. These children all have more than 10 marbles.

If you negate the expression:

```
select list(child) from marbletable where not marbles > 10
```

it's the turn of Deirdre, Fritz and Isaac to fill the list. Chris and Hadassah are not included, because they aren't *known* to have ten marbles or less. Should you change that last query to:

```
select list(child) from marbletable where marbles <= 10;
```

the result will still be the same, because the expression `NULL <= 10` yields `UNKNOWN`. This is not the same as `TRUE`, so Chris and Hadassah are not listed. If you want them listed with the "poor" children, change the query to:

```
select list(child) from marbletable
where marbles <= 10 or marbles is null;
```

Now the search condition becomes true for Chris and Hadassah, because "`marbles is null`" obviously returns `TRUE` in their case. In fact, the search condition cannot be `NULL` for anybody now.

Lastly, two examples of `SELECT` queries with parameters in the search. It depends on the application how you should define query parameters and even if it is possible at all. Notice that queries like these cannot be executed immediately: they have to be *prepared* first. Once a parameterized query has been prepared, the user (or calling code) can supply values for the parameters and have it executed many times, entering new values before every call. How the values are entered and the execution started is up to the application. In a GUI environment, the user typically types the parameter values in one or more text boxes and then clicks an "Execute", "Run" or "Refresh" button.

```
select name, address, phone frome stores
  where city = ? and class = ?;
```

```
select * from pants
  where model = :model and size = :size and color = :col;
```

The last query cannot be passed directly to the engine; the application must convert it to the other format first, mapping named parameters to positional parameters.

6.1.6. The `GROUP BY` clause

`GROUP BY` merges output rows that have the same combination of values in its item list into a single row. Aggregate functions in the select list are applied to each group individually instead of to the dataset as a whole.

If the select list only contains aggregate columns or, more generally, columns whose values don't depend on individual rows in the underlying set, `GROUP BY` is optional. When omitted, the final result set of will consist of a single row (provided that at least one aggregated column is present).

If the select list contains both aggregate columns and columns whose values may vary per row, the `GROUP BY` clause becomes mandatory.

Syntax

```
SELECT ... FROM ...
  GROUP BY <grouping-item> [, <grouping-item> ...]
  [HAVING <grouped-row-condition>]
  ...

<grouping-item> ::=
    <non-aggr-select-item>
  | <non-aggr-expression>

<non-aggr-select-item> ::=
    column-copy
  | column-alias
  | column-position
```

Table 80. Arguments for the `GROUP BY` Clause

Argument	Description
non-aggr-expression	Any non-aggregating expression that is not included in the `SELECT` list, i.e. unselected columns from the source set or expressions that do not depend on the data in the set at all
column-copy	A literal copy, from the `SELECT` list, of an expression that contains no aggregate function

Argument	Description
column-alias	The alias, from the SELECT list, of an expression (column) that contains no aggregate function
column-position	The position number, in the SELECT list, of an expression (column) that contains no aggregate function

A general rule of thumb is that every non-aggregate item in the SELECT list must also be in the GROUP BY list. You can do this in three ways:

1. By copying the item verbatim from the select list, e.g. "`class`" or "`'D:' || upper(doccode)`".
2. By specifying the column alias, if it exists.
3. By specifying the column position as an integer *literal* between 1 and the number of columns. Integer values resulting from expressions or parameter substitutions are simply invariables and will be used as such in the grouping. They will have no effect though, as their value is the same for each row.

If you group by a column position, the expression at that position is copied internally from the select list. If it concerns a subquery, that subquery will be executed again in the grouping phase. That is to say, grouping by the column position, rather than duplicating the subquery expression in the grouping clause, saves keystrokes and bytes, but it is not a way of saving processing cycles!

In addition to the required items, the grouping list may also contain:

- Columns from the source table that are not in the select list, or non-aggregate expressions based on such columns. Adding such columns may further subdivide the groups. However, since these columns are not in the select list, you can't tell which aggregated row corresponds to which value in the column. So, in general, if you are interested in this information, you also include the column or expression in the select list — which brings you back to the rule: "every non-aggregate column in the select list must also be in the grouping list".
- Expressions that aren't dependent on the data in the underlying set, e.g. constants, context variables, single-value non-correlated subselects etc. This is only mentioned for completeness, as adding such items is utterly pointless: they don't affect the grouping at all. "Harmless but useless" items like these may also figure in the select list without being copied to the grouping list.

Examples

When the select list contains only aggregate columns, GROUP BY is not mandatory:

```
select count(*), avg(age) from students
  where sex = 'M';
```

This will return a single row listing the number of male students and their average age. Adding expressions that don't depend on values in individual rows of table STUDENTS doesn't change that:

```
select count(*), avg(age), current_date from students
  where sex = 'M';
```

The row will now have an extra column showing the current date, but other than that, nothing fundamental has changed. A `GROUP BY` clause is still not required.

However, in both the above examples it is *allowed*. This is perfectly valid:

```
select count(*), avg(age) from students
  where sex = 'M'
  group by class;
```

This will return a row for each class that has boys in it, listing the number of boys and their average age in that particular class. (If you also leave the `current_date` field in, this value will be repeated on every row, which is not very exciting.)

The above query has a major drawback though: it gives you information about the different classes, but it doesn't tell you which row applies to which class. In order to get that extra bit of information, the non-aggregate column `CLASS` must be added to the select list:

```
select class, count(*), avg(age) from students
  where sex = 'M'
  group by class;
```

Now we have a useful query. Notice that the addition of column `CLASS` also makes the `GROUP BY` clause mandatory. We can't drop that clause anymore, unless we also remove `CLASS` from the column list.

The output of our last query may look something like this:

CLASS	COUNT	AVG
2A	12	13.5
2B	9	13.9
3A	11	14.6
3B	12	14.4
…	…	…

The headings "COUNT" and "AVG" are not very informative. In a simple case like this, you might get away with that, but in general you should give aggregate columns a meaningful name by aliasing them:

```
select class,
       count(*) as num_boys,
       avg(age) as boys_avg_age
```

```
  from students
  where sex = 'M'
  group by class;
```

As you may recall from the formal syntax of the columns list, the `AS` keyword is optional.

Adding more non-aggregate (or rather: row-dependent) columns requires adding them to the `GROUP BY` clause too. For instance, you might want to see the above information for girls as well; and you may also want to differentiate between boarding and day students:

```
select class,
       sex,
       boarding_type,
       count(*) as number,
       avg(age) as avg_age
  from students
  group by class, sex, boarding_type;
```

This may give you the following result:

CLASS	SEX	BOARDING_TYPE	NUMBER	AVG_AGE
2A	F	BOARDING	9	13.3
2A	F	DAY	6	13.5
2A	M	BOARDING	7	13.6
2A	M	DAY	5	13.4
2B	F	BOARDING	11	13.7
2B	F	DAY	5	13.7
2B	M	BOARDING	6	13.8
…	…	…	…	…

Each row in the result set corresponds to one particular combination of the columns `CLASS`, `SEX` and `BOARDING_TYPE`. The aggregate results — number and average age — are given for each of these rather specific groups individually. In a query like this, you don't see a total for boys as a whole, or day students as a whole. That's the tradeoff: the more non-aggregate columns you add, the more you can pinpoint very specific groups, but the more you also lose sight of the general picture. Of course, you can still obtain the "coarser" aggregates through separate queries.

HAVING

Just as a `WHERE` clause limits the rows in a dataset to those that meet the search condition, so the `HAVING` sub-clause imposes restrictions on the aggregated rows in a grouped set. `HAVING` is optional, and can only be used in conjunction with `GROUP BY`.

The condition(s) in the `HAVING` clause can refer to:

- Any aggregated column in the select list. This is the most widely used case.
- Any aggregated expression that is not in the select list, but allowed in the context of the query. This is sometimes useful too.
- Any column in the `GROUP BY` list. While legal, it is more efficient to filter on these non-aggregated data at an earlier stage: in the `WHERE` clause.
- Any expression whose value doesn't depend on the contents of the dataset (like a constant or a context variable). This is valid but utterly pointless, because it will either suppress the entire set or leave it untouched, based on conditions that have nothing to do with the set itself.

A `HAVING` clause can *not* contain:

- Non-aggregated column expressions that are not in the `GROUP BY` list.
- Column positions. An integer in the `HAVING` clause is just an integer.
- Column aliases — not even if they appear in the `GROUP BY` clause!

Examples

Building on our earlier examples, this could be used to skip small groups of students:

```
select class,
       count(*) as num_boys,
       avg(age) as boys_avg_age
  from students
  where sex = 'M'
  group by class
  having count(*) >= 5;
```

To select only groups that have a minimum age spread:

```
select class,
       count(*) as num_boys,
       avg(age) as boys_avg_age
  from students
  where sex = 'M'
  group by class
  having max(age) - min(age) > 1.2;
```

Notice that if you're really interested in this information, you'd normally include `min(age)` and `max(age)` — or the expression "`max(age) - min(age)`" — in the select list as well!

To include only 3rd classes:

```
select class,
       count(*) as num_boys,
       avg(age) as boys_avg_age
  from students
```

```
  where sex = 'M'
  group by class
  having class starting with '3';
```

Better would be to move this condition to the `WHERE` clause:

```
select class,
       count(*) as num_boys,
       avg(age) as boys_avg_age
  from students
  where sex = 'M' and class starting with '3'
  group by class;
```

6.1.7. The `WINDOW` Clause

The `WINDOW` clause defines one or more named Windows that can be referenced by window functions in the current query specification.

Syntax

```
<query_spec> ::=
  SELECT
    [<limit_clause>]
    [<distinct_clause>]
    <select_list>
    <from_clause>
    [<where_clause>]
    [<group_clause>]
    [<having_clause>]
    [<named_windows_clause>]
    [<plan_clause>]

<named_windows_clause> ::=
  WINDOW <window_definition> [, <window_definition> ...]

<window definition> ::=
  new_window_name AS <window_specification>

<window_specification> ::=
  !! See Window (Analytical) Functions !!
```

In a query with multiple `SELECT` and `WINDOW` clauses (for example, with subqueries), the scope of the `new_window_name_ is confined to its query context. That means a window name from an inner context cannot be used in an outer context, nor vice versa. However, the same window name can be used independently in different contexts, though to avoid confusion it might be better to avoid this.

For more information, see Window (Analytical) Functions.

Example Using Named Windows

```
select
  id,
  department,
  salary,
  count(*) over w1,
  first_value(salary) over w2,
  last_value(salary) over w2
from employee
window w1 as (partition by department),
       w2 as (w1 order by salary)
order by department, salary;
```

6.1.8. The PLAN Clause

The PLAN clause enables the user to submit a data retrieval plan, thus overriding the plan that the optimizer would have generated automatically.

Syntax

```
PLAN <plan-expr>

<plan-expr> ::=
    (<plan-item> [, <plan-item> ...])
  | <sorted-item>
  | <joined-item>
  | <merged-item>
  | <hash-item>

<sorted-item> ::= SORT (<plan-item>)

<joined-item> ::=
  JOIN (<plan-item>, <plan-item> [, <plan-item> ...])

<merged-item> ::=
  [SORT] MERGE (<sorted-item>, <sorted-item> [, <sorted-item> ...])

<hash-item> ::=
  HASH (<plan-item>, <plan-item> [, <plan-item> ...])

<plan-item> ::= <basic-item> | <plan-expr>

<basic-item> ::=
  <relation> { NATURAL
             | INDEX (<indexlist>)
             | ORDER index [INDEX (<indexlist>)] }

<relation> ::= table | view [table]
```

```
<indexlist> ::= index [, index ...]
```

Table 81. Arguments for the `PLAN` *Clause*

Argument	Description
table	Table name or its alias
view	View name
index	Index name

Every time a user submits a query to the Firebird engine, the optimizer computes a data retrieval strategy. Most Firebird clients can make this retrieval plan visible to the user. In Firebird's own `isql` utility, this is done with the command `SET PLAN ON`. If you are studying query plans rather than running queries, `SET PLANONLY ON` will show the plan without executing the query. Use `SET PLANONLY OFF` to execute the query and show the plan.

A more detailed plan can be obtained when you enable an advanced plan. In *isql* this can be done with `SET EXPLAIN ON`. The advanced plan displayes more detailed information about the access methods used by the optimizer, however it cannot be included in the `PLAN` clause of a statement. The description of the advanced plan is beyond the scope of this Language Reference.

In most situations, you can trust that Firebird will select the optimal query plan for you. However, if you have complicated queries that seem to be underperforming, it may very well be worth your while to examine the plan and see if you can improve on it.

Simple plans

The simplest plans consist of just a relation name followed by a retrieval method. For example, for an unsorted single-table select without a `WHERE` clause:

```
select * from students
  plan (students natural);
```

Advanced plan:

```
Select Expression
  -> Table "STUDENTS" Full Scan
```

If there's a `WHERE` or a `HAVING` clause, you can specify the index to be used for finding matches:

```
select * from students
  where class = '3C'
  plan (students index (ix_stud_class));
```

Advanced plan:

```
Select Expression
  -> Filter
    -> Table "STUDENTS" Access By ID
      -> Bitmap
        -> Index "IX_STUD_CLASS" Range Scan (full match)
```

The `INDEX` directive is also used for join conditions (to be discussed a little later). It can contain a list of indexes, separated by commas.

`ORDER` specifies the index for sorting the set if an `ORDER BY` or `GROUP BY` clause is present:

```
select * from students
  plan (students order pk_students)
  order by id;
```

Advanced plan:

```
Select Expression
  -> Table "STUDENTS" Access By ID
    -> Index "PK_STUDENTS" Full Scan
```

`ORDER` and `INDEX` can be combined:

```
select * from students
  where class >= '3'
  plan (students order pk_students index (ix_stud_class))
  order by id;
```

Advanced plan:

```
Select Expression
  -> Filter
    -> Table "STUDENTS" Access By ID
      -> Index "PK_STUDENTS" Full Scan
        -> Bitmap
          -> Index "IX_STUD_CLASS" Range Scan (lower bound: 1/1)
```

It is perfectly OK if `ORDER` and `INDEX` specify the same index:

```
select * from students
  where class >= '3'
  plan (students order ix_stud_class index (ix_stud_class))
  order by class;
```

Advanced plan:

```
Select Expression
  -> Filter
    -> Table "STUDENTS" Access By ID
      -> Index "IX_STUD_CLASS" Range Scan (lower bound: 1/1)
        -> Bitmap
          -> Index "IX_STUD_CLASS" Range Scan (lower bound: 1/1)
```

For sorting sets when there's no usable index available (or if you want to suppress its use), leave out `ORDER` and prepend the plan expression with `SORT`:

```
select * from students
  plan sort (students natural)
  order by name;
```

Advanced plan:

```
Select Expression
  -> Sort (record length: 128, key length: 56)
    -> Table "STUDENTS" Full Scan
```

Or when an index is used for the search:

```
select * from students
  where class >= '3'
  plan sort (students index (ix_stud_class))
  order by name;
```

Advanced plan:

```
elect Expression
  -> Sort (record length: 136, key length: 56)
    -> Filter
      -> Table "STUDENTS" Access By ID
        -> Bitmap
          -> Index "IX_STUD_CLASS" Range Scan (lower bound: 1/1)
```

Notice that `SORT`, unlike `ORDER`, is outside the parentheses. This reflects the fact that the data rows are retrieved unordered and sorted afterwards by the engine.

When selecting from a view, specify the view and the table involved. For instance, if you have a view `FRESHMEN` that selects just the first-year students:

```
select * from freshmen
  plan (freshmen students natural);
```

Advanced plan:

```
Select Expression
  -> Table "STUDENTS" as "FRESHMEN" Full Scan
```

Or, for instance:

```
select * from freshmen
  where id > 10
  plan sort (freshmen students index (pk_students))
  order by name desc;
```

Advanced plan:

```
Select Expression
  -> Sort (record length: 144, key length: 24)
    -> Filter
      -> Table "STUDENTS" as "FRESHMEN" Access By ID
        -> Bitmap
          -> Index "PK_STUDENTS" Range Scan (lower bound: 1/1)
```

If a table or view has been aliased, it is the alias, not the original name, that must be used in the `PLAN` clause.

Composite plans

When a join is made, you can specify the index which is to be used for matching. You must also use the `JOIN` directive on the two streams in the plan:

```
select s.id, s.name, s.class, c.mentor
  from students s
  join classes c on c.name = s.class
  plan join (s natural, c index (pk_classes));
```

Advanced plan:

```
Select Expression
  -> Nested Loop Join (inner)
    -> Table "STUDENTS" as "S" Full Scan
    -> Filter
      -> Table "CLASSES" as "C" Access By ID
```

```
        -> Bitmap
          -> Index "PK_CLASSES" Unique Scan
```

The same join, sorted on an indexed column:

```
select s.id, s.name, s.class, c.mentor
  from students s
  join classes c on c.name = s.class
  plan join (s order pk_students, c index (pk_classes))
  order by s.id;
```

Advanced plan:

```
Select Expression
  -> Nested Loop Join (inner)
    -> Table "STUDENTS" as "S" Access By ID
      -> Index "PK_STUDENTS" Full Scan
    -> Filter
      -> Table "CLASSES" as "C" Access By ID
        -> Bitmap
          -> Index "PK_CLASSES" Unique Scan
```

And on a non-indexed column:

```
select s.id, s.name, s.class, c.mentor
  from students s
  join classes c on c.name = s.class
  plan sort (join (s natural, c index (pk_classes)))
  order by s.name;
```

Advanced plan:

```
Select Expression
  -> Sort (record length: 152, key length: 12)
    -> Nested Loop Join (inner)
      -> Table "STUDENTS" as "S" Full Scan
      -> Filter
        -> Table "CLASSES" as "C" Access By ID
          -> Bitmap
            -> Index "PK_CLASSES" Unique Scan
```

With a search condition added:

```
select s.id, s.name, s.class, c.mentor
  from students s
```

```
  join classes c on c.name = s.class
  where s.class <= '2'
  plan sort (join (s index (fk_student_class), c index (pk_classes)))
  order by s.name;
```

Advanced plan:

```
Select Expression
  -> Sort (record length: 152, key length: 12)
    -> Nested Loop Join (inner)
      -> Filter
        -> Table "STUDENTS" as "S" Access By ID
          -> Bitmap
            -> Index "FK_STUDENT_CLASS" Range Scan (lower bound: 1/1)
      -> Filter
        -> Table "CLASSES" as "C" Access By ID
          -> Bitmap
            -> Index "PK_CLASSES" Unique Scan
```

As a left outer join:

```
select s.id, s.name, s.class, c.mentor
  from classes c
  left join students s on c.name = s.class
  where s.class <= '2'
  plan sort (join (c natural, s index (fk_student_class)))
  order by s.name;
```

Advanced plan:

```
Select Expression
  -> Sort (record length: 192, key length: 56)
    -> Filter
      -> Nested Loop Join (outer)
        -> Table "CLASSES" as "C" Full Scan
        -> Filter
          -> Table "STUDENTS" as "S" Access By ID
            -> Bitmap
              -> Index "FK_STUDENT_CLASS" Range Scan (full match)
```

If there are no indices available to match the join condition (or if you don't want to use it), then it is possible connect the streams using `HASH` or `MERGE` method.

To connect using the `HASH` method in the plan, the `HASH` directive is used instead of the `JOIN` directive. In this case, the smaller (secondary) stream is materialized completely into an internal buffer. While reading this secondary stream, a hash function is applied and a pair *{hash, pointer to buffer}* is written to a hash table. Then the primary stream is read and its hash key is tested against the

hash table.

```
select *
  from students s
  join classes c on c.cookie = s.cookie
  plan hash (c natural, s natural)
```

Advanced plan:

```
Select Expression
  -> Filter
    -> Hash Join (inner)
      -> Table "STUDENTS" as "S" Full Scan
      -> Record Buffer (record length: 145)
        -> Table "CLASSES" as "C" Full Scan
```

For a `MERGE` join, the plan must first sort both streams on their join column(s) and then merge. This is achieved with the `SORT` directive (which we've already seen) and `MERGE` instead of `JOIN`:

```
select * from students s
  join classes c on c.cookie = s.cookie
  plan merge (sort (c natural), sort (s natural));
```

Adding an `ORDER BY` clause means the result of the merge must also be sorted:

```
select * from students s
  join classes c on c.cookie = s.cookie
  plan sort (merge (sort (c natural), sort (s natural)))
  order by c.name, s.id;
```

Finally, we add a search condition on two indexable colums of table `STUDENTS`:

```
select * from students s
  join classes c on c.cookie = s.cookie
  where s.id < 10 and s.class <= '2'
  plan sort (merge (sort (c natural),
                    sort (s index (pk_students, fk_student_class))))
  order by c.name, s.id;
```

As follows from the formal syntax definition, `JOIN`s and `MERGE`s in the plan may combine more than two streams. Also, every plan expression may be used as a plan item in an encompassing plan. This means that plans of certain complicated queries may have various nesting levels.

Finally, instead of `MERGE` you may also write `SORT MERGE`. As this makes absolutely no difference and may create confusion with "real" `SORT` directives (the ones that *do* make a difference), it's probably

best to stick to plain MERGE.

In addition to the plan for the main query, you can specify a plan for each subquery. For example, the following query with multiple plans will work:

```
select *
from color
where exists (
  select *
  from hors
  where horse.code_color = color.code_color
  plan (horse index (fk_horse_color)))
plan (color natural)
```

Occasionally, the optimizer will accept a plan and then not follow it, even though it does not reject it as invalid. One such example was

```
MERGE (unsorted stream, unsorted stream)
```

It is advisable to treat such as plan as “deprecated”.

6.1.9. UNION

The UNION clause concatenates two or more datasets, thus increasing the number of rows but not the number of columns. Datasets taking part in a UNION must have the same number of columns, and columns at corresponding positions must be of the same type. Other than that, they may be totally unrelated.

By default, a union suppresses duplicate rows. UNION ALL shows all rows, including any duplicates. The optional DISTINCT keyword makes the default behaviour explicit.

Syntax

```
<union> ::=
  <individual-select>
  UNION [{DISTINCT | ALL}]
  <individual-select>
  [
    [UNION [{DISTINCT | ALL}]
    <individual-select>
    ...
  ]
  [<union-wide-clauses>]

<individual-select> ::=
  SELECT
  [TRANSACTION name]
  [FIRST m] [SKIP n]
```

```
  [{DISTINCT | ALL}] <columns>
  [INTO <host-varlist>]
  FROM <source> [[AS] alias]
  [<joins>]
  [WHERE <condition>]
  [GROUP BY <grouping-list>
  [HAVING <aggregate-condition>]]
  [PLAN <plan-expr>]

<union-wide-clauses> ::=
  [ORDER BY <ordering-list>]
  [{ ROWS <m> [TO <n>]
   | [OFFSET n {ROW | ROWS}]
     [FETCH {FIRST | NEXT} [m] {ROW | ROWS} ONLY]
  }]
  [FOR UPDATE [OF <columns>]]
  [WITH LOCK]
  [INTO <PSQL-varlist>]
```

Unions take their column names from the *first* select query. If you want to alias union columns, do so in the column list of the topmost `SELECT`. Aliases in other participating selects are allowed and may even be useful, but will not propagate to the union level.

If a union has an `ORDER BY` clause, the only allowed sort items are integer literals indicating 1-based column positions, optionally followed by an `ASC`/`DESC` and/or a `NULLS {FIRST | LAST}` directive. This also implies that you cannot order a union by anything that isn't a column in the union. (You can, however, wrap it in a derived table, which gives you back all the usual sort options.)

Unions are allowed in subqueries of any kind and can themselves contain subqueries. They can also contain joins, and can take part in a join when wrapped in a derived table.

Examples

This query presents information from different music collections in one dataset using unions:

```
select id, title, artist, length, 'CD' as medium
  from cds
union
select id, title, artist, length, 'LP'
  from records
union
select id, title, artist, length, 'MC'
  from cassettes
order by 3, 2  -- artist, title;
```

If `id`, `title`, `artist` and `length` are the only fields in the tables involved, the query can also be written as:

```
select c.*, 'CD' as medium
```

```
  from cds c
union
select r.*, 'LP'
  from records r
union
select c.*, 'MC'
  from cassettes c
order by 3, 2  -- artist, title;
```

Qualifying the “stars” is necessary here because they are not the only item in the column list. Notice how the “c” aliases in the first and third select do not conflict with each other: their scopes are not union-wide but apply only to their respective select queries.

The next query retrieves names and phone numbers from translators and proofreaders. Translators who also work as proofreaders will show up only once in the result set, provided their phone number is the same in both tables. The same result can be obtained without `DISTINCT`. With `ALL`, these people would appear twice.

```
select name, phone from translators
  union distinct
select name, telephone from proofreaders;
```

A `UNION` within a subquery:

```
select name, phone, hourly_rate from clowns
where hourly_rate < all
  (select hourly_rate from jugglers
     union
   select hourly_rate from acrobats)
order by hourly_rate;
```

6.1.10. ORDER BY

When a `SELECT` statement is executed, the result set is not sorted in any way. It often happens that rows appear to be sorted chronologically, simply because they are returned in the same order they were added to the table by `INSERT` statements. This is not something you should rely on: the order may change depending on the plan or updates to rows, etc. To specify an explicit sorting order for the set specification, an `ORDER BY` clause is used.

Syntax

```
SELECT ... FROM ...
...
ORDER BY <ordering-item> [, <ordering-item> ⋯]

<ordering-item> ::=
  {col-name | col-alias | col-position | <expression>}
```

```
[COLLATE collation-name]
[ASC[ENDING] | DESC[ENDING]]
[NULLS {FIRST|LAST}]
```

Table 82. Arguments for the `ORDER BY` *Clause*

Argument	Description
col-name	Full column name
col-alias	Column alias
col-position	Column position in the `SELECT` list
expression	Any expression
collation-name	Collation name (sorting order for string types)

The `ORDER BY` consists of a comma-separated list of the columns on which the result data set should be sorted. The sort order can be specified by the name of the column — but only if the column was not previously aliased in the `SELECT` columns list. The alias must be used if it was used in the select list. The ordinal position number of the column in the `SELECT` column list, the alias given to the column in the `SELECT` list with the help of the `AS` keyword, or the number of the column in the `SELECT` list can be used without restriction.

The three forms of expressing the columns for the sort order can be mixed in the same `ORDER BY` clause. For instance, one column in the list can be specified by its name and another column can be specified by its number.

If you sort by column position or alias, then the expression corresponding to this position (alias) will be copied from the `SELECT` list. This also applies to subqueries, thus, the subquery will be executed at least twice.

If you use the column position to specify the sort order for a query of the `SELECT *` style, the server expands the asterisk to the full column list in order to determine the columns for the sort. It is, however, considered “sloppy practice” to design ordered sets this way.

Sorting Direction

The keyword `ASCENDING` — usually abbreviated to `ASC` — specifies a sort direction from lowest to highest. `ASCENDING` is the default sort direction.

The keyword `DESCENDING` — usually abbreviated to `DESC` — specifies a sort direction from highest to lowest.

Specifying ascending order for one column and descending order for another is allowed.

Collation Order

The keyword `COLLATE` specifies the collation order for a string column if you need a collation that is different from the normal one for this column. The normal collation order will be either the default

one for the database character set, or the one set explicitly in the column's definition.

NULLs Position

The keyword `NULLS` defines where NULL in the associated column will fall in the sort order: `NULLS FIRST` places the rows with the `NULL` column *above* rows ordered by that column's value; `NULLS LAST` places those rows *after* the ordered rows.

`NULLS FIRST` is the default.

Ordering `UNION`-ed Sets

The discrete queries contributing to a `UNION` cannot take an `ORDER BY` clause. The only option is to order the entire output, using one `ORDER BY` clause at the end of the overall query.

The simplest — and, in some cases, the only — method for specifying the sort order is by the ordinal column position. However, it is also valid to use the column names or aliases, from the first contributing query *only*.

The `ASC`/`DESC` and/or `NULLS` directives are available for this global set.

If discrete ordering within the contributing set is required, use of derived tables or common table expressions for those sets may be a solution.

Examples of `ORDER BY`

Sorting the result set in ascending order, ordering by the `RDB$CHARACTER_SET_ID` and `RDB$COLLATION_ID` columns of the `RDB$COLLATIONS` table:

```
SELECT
  RDB$CHARACTER_SET_ID AS CHARSET_ID,
  RDB$COLLATION_ID AS COLL_ID,
  RDB$COLLATION_NAME AS NAME
FROM RDB$COLLATIONS
ORDER BY RDB$CHARACTER_SET_ID, RDB$COLLATION_ID;
```

The same, but sorting by the column aliases:

```
SELECT
  RDB$CHARACTER_SET_ID AS CHARSET_ID,
  RDB$COLLATION_ID AS COLL_ID,
  RDB$COLLATION_NAME AS NAME
FROM RDB$COLLATIONS
ORDER BY CHARSET_ID, COLL_ID;
```

Sorting the output data by the column position numbers:

```
SELECT
```

```
  RDB$CHARACTER_SET_ID AS CHARSET_ID,
  RDB$COLLATION_ID AS COLL_ID,
  RDB$COLLATION_NAME AS NAME
FROM RDB$COLLATIONS
ORDER BY 1, 2;
```

Sorting a `SELECT *` query by position numbers — possible, but *nasty* and not recommended:

```
SELECT *
FROM RDB$COLLATIONS
ORDER BY 3, 2;
```

Sorting by the second column in the `BOOKS` table, or — if `BOOKS` has only one column — the `FILMS.DIRECTOR` column:

```
SELECT
    BOOKS.*,
    FILMS.DIRECTOR
FROM BOOKS, FILMS
ORDER BY 2;
```

Sorting in descending order by the values of column `PROCESS_TIME`, with `NULL`s placed at the beginning of the set:

```
SELECT *
FROM MSG
ORDER BY PROCESS_TIME DESC NULLS FIRST;
```

Sorting the set obtained by a `UNION` of two queries. Results are sorted in descending order for the values in the second column, with `NULL`s at the end of the set; and in ascending order for the values of the first column with `NULL`s at the beginning.

```
SELECT
  DOC_NUMBER, DOC_DATE
FROM PAYORDER
UNION ALL
SELECT
  DOC_NUMBER, DOC_DATE
FROM BUDGORDER
ORDER BY 2 DESC NULLS LAST, 1 ASC NULLS FIRST;
```

6.1.11. ROWS

Used for

Retrieving a slice of rows from an ordered set

Available in

DSQL, PSQL

Syntax

```
SELECT <columns> FROM ...
  [WHERE ...]
  [ORDER BY ...]
  ROWS m [TO n]
```

Table 83. Arguments for the `ROWS` *Clause*

Argument	Description
m, n	Any integer expressions

`ROWS` is non-standard syntax

`ROWS` is a Firebird-specific clause. Use the SQL-standard `OFFSET, FETCH` syntax wherever possible.

Limits the amount of rows returned by the `SELECT` statement to a specified number or range.

The `ROWS` clause also does the same job as the `FIRST` and `SKIP` clauses, but neither are SQL-compliant. Unlike `FIRST` and `SKIP`, and `OFFSET` and `FETCH`, the `ROWS` and `TO` clauses accept any type of integer expression as their arguments, without parentheses. Of course, parentheses may still be needed for nested evaluations inside the expression, and a subquery must always be enclosed in parentheses.

- Numbering of rows in the intermediate set — the overall set cached on disk before the "slice" is extracted — starts at 1.
- `OFFSET/FETCH`, `FIRST/SKIP`, and `ROWS` can all be used without the `ORDER BY` clause, although it rarely makes sense to do so — except perhaps when you want to take a quick look at the table data and don't care that rows will be in a non-deterministic order. For this purpose, a query like "`SELECT * FROM TABLE1 ROWS 20`" would return the first 20 rows instead of a whole table that might be rather big.

Calling `ROWS m` retrieves the first *m* records from the set specified.

Characteristics of using `ROWS m` without a `TO` clause:

- If *m* is greater than the total number of records in the intermediate data set, the entire set is returned
- If *m* = 0, an empty set is returned
- If *m* < 0, the `SELECT` statement call fails with an error

Calling `ROWS m TO n` retrieves the rows from the set, starting at row *m* and ending after row *n* — the set is inclusive.

Characteristics of using `ROWS m` with a `TO` clause:

- If *m* is greater than the total number of rows in the intermediate set and *n* >= *m*, an empty set is returned
- If *m* is not greater than *n* and *n* is greater than the total number of rows in the intermediate set, the result set will be limited to rows starting from *m*, up to the end of the set
- If *m* < 1 and *n* < 1, the `SELECT` statement call fails with an error
- If *n* = *m* - 1, an empty set is returned
- If *n* < *m* - 1, the `SELECT` statement call fails with an error

Using a `TO` clause without a `ROWS` clause:

While `ROWS` replaces the `FIRST` and `SKIP` syntax, there is one situation where the `ROWS` syntax does not provide the same behaviour: specifying `SKIP n` on its own returns the entire intermediate set, without the first *n* rows. The `ROWS ⋯ TO` syntax needs a little help to achieve this.

With the `ROWS` syntax, you need a `ROWS` clause *in association with* the `TO` clause and deliberately make the second (*n*) argument greater than the size of the intermediate data set. This is achieved by creating an expression for *n* that uses a subquery to retrieve the count of rows in the intermediate set and adds 1 to it.

Replacing of `FIRST/SKIP` and `OFFSET/FETCH`

The `ROWS` clause can be used instead of the SQL-standard `OFFSET/FETCH` or non-standard `FIRST/SKIP` clauses, except the case where only `OFFSET` or `SKIP` is used, that is when the whole result set is returned except for skipping the specified number of rows from the beginning.

In order to implement this behaviour using `ROWS`, you must specify the `TO` clause with a value larger than the size of the returned result set.

Mixing `ROWS` and `FIRST/SKIP` or `OFFSET/FETCH`

`ROWS` syntax cannot be mixed with `FIRST/SKIP` or `OFFSET/FETCH` in the same `SELECT` expression. Using the different syntaxes in different subqueries in the same statement is allowed.

`ROWS` Syntax in `UNION` Queries

When `ROWS` is used in a `UNION` query, the `ROWS` directive is applied to the unioned set and must be placed after the last `SELECT` statement.

If a need arises to limit the subsets returned by one or more `SELECT` statements inside `UNION`, there are a couple of options:

1. Use `FIRST/SKIP` syntax in these `SELECT` statements — bearing in mind that an ordering clause (`ORDER BY`) cannot be applied locally to the discrete queries, but only to the combined output.
2. Convert the queries to derived tables with their own `ROWS` clauses.

Examples of ROWS

The following examples rewrite the examples used in the section about FIRST and SKIP, earlier in this chapter.

Retrieve the first ten names from the output of a sorted query on the PEOPLE table:

```
SELECT id, name
FROM People
ORDER BY name ASC
ROWS 1 TO 10;
```

or its equivalent

```
SELECT id, name
FROM People
ORDER BY name ASC
ROWS 10;
```

Return all records from the PEOPLE table except for the first 10 names:

```
SELECT id, name
FROM People
ORDER BY name ASC
ROWS 11 TO (SELECT COUNT(*) FROM People);
```

And this query will return the last 10 records (pay attention to the parentheses):

```
SELECT id, name
FROM People
ORDER BY name ASC
ROWS (SELECT COUNT(*) - 9 FROM People)
TO (SELECT COUNT(*) FROM People);
```

This one will return rows 81-100 from the PEOPLE table:

```
SELECT id, name
FROM People
ORDER BY name ASC
ROWS 81 TO 100;
```

ROWS can also be used with the UPDATE and DELETE statements.

See also

FIRST, SKIP, OFFSET, FETCH

6.1.12. OFFSET, FETCH

Used for

Retrieving a slice of rows from an ordered set

Available in

DSQL, PSQL

Syntax

```
SELECT <columns> FROM ...
  [WHERE ...]
  [ORDER BY ...]
  [OFFSET <m> {ROW | ROWS}]
  [FETCH {FIRST | NEXT} [ <n> ] { ROW | ROWS } ONLY]

<m>, <n>  ::=
    <integer-literal>
  | <query-parameter>
```

Table 84. Arguments for the OFFSET and FETCH Clause

Argument	Description
integer-literal	Integer literal
query-parameter	Query parameter place-holder. ? in DSQL and :paramname in PSQL

The OFFSET and FETCH clauses are an SQL:2008 compliant equivalent for FIRST/SKIP, and an alternative for ROWS. The OFFSET clause specifies the number of rows to skip. The FETCH clause specifies the number of rows to fetch.

When <*n*> is left out of the FETCH clause (eg FETCH FIRST ROW ONLY), one row will be fetched.

The choice between ROW or ROWS, or FIRST or NEXT in the clauses is just for aesthetic purposes (eg making the query more readable or grammatically correct). Technically there is no difference between OFFSET 10 ROW or OFFSET 10 ROWS, or FETCH NEXT 10 ROWS ONLY or FETCH FIRST 10 ROWS ONLY.

As with SKIP and FIRST, OFFSET and FETCH clauses can be applied independently, in both top-level and nested query expressions.

1. Firebird doesn't support the percentage FETCH defined in the SQL standard.
2. Firebird doesn't support the FETCH … WITH TIES defined in the SQL standard.
3. The FIRST/SKIP and ROWS clause are non-standard alternatives.
4. The OFFSET and/or FETCH clauses cannot be combined with ROWS or FIRST/SKIP on the same query expression.
5. Expressions, column references, etc are not allowed within either clause.
6. Contrary to the ROWS clause, OFFSET and FETCH are only available on SELECT statements.

Examples of OFFSET and FETCH

Return all rows except the first 10, ordered by column COL1

```
SELECT *
FROM T1
ORDER BY COL1
OFFSET 10 ROWS
```

Return the first 10 rows, ordered by column COL1

```
SELECT *
FROM T1
ORDER BY COL1
FETCH FIRST 10 ROWS ONLY
```

Using OFFSET *and* FETCH *clauses in a derived table and in the outer query*

```
SELECT *
FROM (
  SELECT *
  FROM T1
  ORDER BY COL1 DESC
  OFFSET 1 ROW
  FETCH NEXT 10 ROWS ONLY
) a
ORDER BY a.COL1
FETCH FIRST ROW ONLY
```

The following examples rewrite the FIRST/SKIP examples and ROWS examples earlier in this chapter.

Retrieve the first ten names from the output of a sorted query on the PEOPLE table:

```
SELECT id, name
FROM People
ORDER BY name ASC
FETCH NEXT 10 ROWS ONLY;
```

Return all records from the PEOPLE table except for the first 10 names:

```
SELECT id, name
FROM People
ORDER BY name ASC
OFFSET 10 ROWS;
```

And this query will return the last 10 records. Contrary to FIRST/SKIP and ROWS we cannot use expressions (including sub-queries). To retrieve the last 10 rows, reverse the sort to the first (last)

10 rows, and then sort in the right order.

```
SELECT id, name
FROM (
  SELECT id, name
  FROM People
  ORDER BY name DESC
  FETCH FIRST 10 ROWS ONLY
) a
ORDER BY name ASC;
```

This one will return rows 81-100 from the PEOPLE table:

```
SELECT id, name
FROM People
ORDER BY name ASC
OFFSET 80 ROWS
FETCH NEXT 20 ROWS;
```

See also

FIRST, SKIP, ROWS

6.1.13. FOR UPDATE [OF]

Syntax

```
SELECT ... FROM single_table
  [WHERE ...]
  [FOR UPDATE [OF <column_list>]]
```

FOR UPDATE does not do what its name suggests. It's only effect currently is to disable the pre-fetch buffer.

It is likely to change in future: the plan is to validate cursors marked with FOR UPDATE if they are truly updateable and reject positioned updates and deletes for cursors evaluated as non-updateable.

The OF sub-clause does not do anything at all.

6.1.14. WITH LOCK

Used for

Limited pessimistic locking

Available in

DSQL, PSQL

Syntax

```
SELECT ... FROM single_table
  [WHERE ...]
  [FOR UPDATE [OF <column_list>]]
  WITH LOCK
```

`WITH LOCK` provides a limited explicit pessimistic locking capability for cautious use in conditions where the affected row set is:

a. extremely small (ideally singleton), *and*

b. precisely controlled by the application code.

This is for experts only!

The need for a pessimistic lock in Firebird is very rare indeed and should be well understood before use of this extension is considered.

It is essential to understand the effects of transaction isolation and other transaction attributes before attempting to implement explicit locking in your application.

If the `WITH LOCK` clause succeeds, it will secure a lock on the selected rows and prevent any other transaction from obtaining write access to any of those rows, or their dependants, until your transaction ends.

`WITH LOCK` can only be used with a top-level, single-table `SELECT` statement. It is *not* available:

- in a subquery specification
- for joined sets
- with the `DISTINCT` operator, a `GROUP BY` clause or any other aggregating operation
- with a view
- with the output of a selectable stored procedure
- with an external table
- with a `UNION` query

As the engine considers, in turn, each record falling under an explicit lock statement, it returns either the record version that is the most currently committed, regardless of database state when the statement was submitted, or an exception.

Wait behaviour and conflict reporting depend on the transaction parameters specified in the TPB block:

Table 85. How TPB settings affect explicit locking

TPB mode	Behaviour
isc_tpb_consistency	Explicit locks are overridden by implicit or explicit table-level locks and are ignored.
isc_tpb_concurrency + isc_tpb_nowait	If a record is modified by any transaction that was committed since the transaction attempting to get explicit lock started, or an active transaction has performed a modification of this record, an update conflict exception is raised immediately.
isc_tpb_concurrency + isc_tpb_wait	If the record is modified by any transaction that has committed since the transaction attempting to get explicit lock started, an update conflict exception is raised immediately. If an active transaction is holding ownership on this record (via explicit locking or by a normal optimistic write-lock) the transaction attempting the explicit lock waits for the outcome of the blocking transaction and, when it finishes, attempts to get the lock on the record again. This means that, if the blocking transaction committed a modified version of this record, an update conflict exception will be raised.
isc_tpb_read_committed + isc_tpb_nowait	If there is an active transaction holding ownership on this record (via explicit locking or normal update), an update conflict exception is raised immediately.
isc_tpb_read_committed + isc_tpb_wait	If there is an active transaction holding ownership on this record (via explicit locking or by a normal optimistic write-lock), the transaction attempting the explicit lock waits for the outcome of blocking transaction and when it finishes, attempts to get the lock on the record again. Update conflict exceptions can never be raised by an explicit lock statement in this TPB mode.

Usage with a `FOR UPDATE` Clause

If the `FOR UPDATE` sub-clause precedes the `WITH LOCK` sub-clause, buffered fetches are suppressed. Thus, the lock will be applied to each row, one by one, at the moment it is fetched. It becomes possible, then, that a lock which appeared to succeed when requested will nevertheless *fail subsequently*, when an attempt is made to fetch a row which has become locked by another transaction in the meantime.

As an alternative, it may be possible in your access components to set the size of the fetch buffer to 1. This would enable you to process the currently-locked row before the next is fetched and locked, or to handle errors without rolling back your transaction.

`OF <column_list>`

This optional sub-clause does nothing at all.

See also

`FOR UPDATE [OF]`

How the engine deals with `WITH LOCK`

When an `UPDATE` statement tries to access a record that is locked by another transaction, it either raises an update conflict exception or waits for the locking transaction to finish, depending on TPB mode. Engine behaviour here is the same as if this record had already been modified by the locking transaction.

No special gdscodes are returned from conflicts involving pessimistic locks.

The engine guarantees that all records returned by an explicit lock statement are actually locked and *do* meet the search conditions specified in `WHERE` clause, as long as the search conditions do not depend on any other tables, via joins, subqueries, etc. It also guarantees that rows not meeting the search conditions will not be locked by the statement. It can *not* guarantee that there are no rows which, though meeting the search conditions, are not locked.

This situation can arise if other, parallel transactions commit their changes during the course of the locking statement's execution.

The engine locks rows at fetch time. This has important consequences if you lock several rows at once. Many access methods for Firebird databases default to fetching output in packets of a few hundred rows ("buffered fetches"). Most data access components cannot bring you the rows contained in the last-fetched packet, when an error occurred.

Caveats using `WITH LOCK`

- Rolling back of an implicit or explicit savepoint releases record locks that were taken under that savepoint, but it doesn't notify waiting transactions. Applications should not depend on this behaviour as it may get changed in the future.
- While explicit locks can be used to prevent and/or handle unusual update conflict errors, the volume of deadlock errors will grow unless you design your locking strategy carefully and control it rigorously.
- Most applications do not need explicit locks at all. The main purposes of explicit locks are:

  1. to prevent expensive handling of update conflict errors in heavily loaded applications, and
  2. to maintain integrity of objects mapped to a relational database in a clustered environment.

  If your use of explicit locking doesn't fall in one of these two categories, then it's the wrong way to do the task in Firebird.

- Explicit locking is an advanced feature; do not misuse it! While solutions for these kinds of problems may be very important for web sites handling thousands of concurrent writers, or for ERP/CRM systems operating in large corporations, most application programs do not need to work in such conditions.

Examples using explicit locking

i. Simple:

```
SELECT * FROM DOCUMENT WHERE ID=? WITH LOCK;
```

ii. Multiple rows, one-by-one processing with DSQL cursor:

```
SELECT * FROM DOCUMENT WHERE PARENT_ID=?
  FOR UPDATE WITH LOCK;
```

6.1.15. INTO

Used for

Passing SELECT output into variables

Available in

PSQL

Syntax

In PSQL the INTO clause is placed at the very end of the SELECT statement.

```
SELECT [...] <column-list>
FROM ...
[...]
[INTO <variable-list>]

<variable-list> ::= [:]psqlvar [, [:]psqlvar ...]
```

The colon prefix before local variable names in PSQL is optional in the INTO clause.

In PSQL code (triggers, stored procedures and executable blocks), the results of a SELECT statement can be loaded row-by-row into local variables. It is often the only way to do anything with the returned values at all, unless an explicit or implicit cursor name is specified. The number, order and types of the variables must match the columns in the output row.

A "plain" SELECT statement can only be used in PSQL if it returns at most one row, i.e., if it is a *singleton* select. For multi-row selects, PSQL provides the FOR SELECT loop construct, discussed later in the PSQL chapter. PSQL also supports the DECLARE CURSOR statement, which binds a named cursor to a SELECT statement. The cursor can then be used to walk the result set.

Examples

1. Selecting some aggregated values and passing them into previously declared variables min_amt, avg_amt and max_amt:

```
select min(amount), avg(cast(amount as float)), max(amount)
  from orders
  where artno = 372218
```

```
  into min_amt, avg_amt, max_amt;
```

The CAST serves to make the average a real number; otherwise, since amount is presumably an integer field, SQL rules would truncate it to the nearest lower integer.

2. A PSQL trigger that retrieves two values as a BLOB field (using the LIST() function) and assigns it INTO a third field:

```
select list(name, ', ')
  from persons p
  where p.id in (new.father, new.mother)
  into new.parentnames;
```

6.1.16. Common Table Expressions ("WITH ⋯ AS ⋯ SELECT")

Available in

DSQL, PSQL

Syntax

```
<cte-construct> ::=
  <cte-defs>
  <main-query>

<cte-defs> ::= WITH [RECURSIVE] <cte> [, <cte> ...]

<cte> ::= name [(<column-list>)] AS (<cte-stmt>)

<column-list> ::= column-alias [, column-alias ...]
```

Table 86. Arguments for Common Table Expressions

Argument	Description
cte-stmt	Any SELECT statement, including UNION
main-query	The main SELECT statement, which can refer to the CTEs defined in the preamble
name	Alias for a table expression
column-alias	Alias for a column in a table expression

A common table expression or *CTE* can be described as a virtual table or view, defined in a preamble to a main query, and going out of scope after the main query's execution. The main query can reference any *CTE*s defined in the preamble as if they were regular tables or views. *CTE*s can be recursive, i.e. self-referencing, but they cannot be nested.

CTE Notes

- A *CTE* definition can contain any legal `SELECT` statement, as long as it doesn't have a "`WITH`⋯" preamble of its own (no nesting).
- *CTE*s defined for the same main query can reference each other, but care should be taken to avoid loops.
- *CTE*s can be referenced from anywhere in the main query.
- Each *CTE* can be referenced multiple times in the main query, using different aliases if necessary.
- When enclosed in parentheses, *CTE* constructs can be used as subqueries in `SELECT` statements, but also in `UPDATE`s, `MERGE`s etc.
- In PSQL, *CTE*s are also supported in `FOR` loop headers:

```
for
  with my_rivers as (select * from rivers where owner = 'me')
    select name, length from my_rivers into :rname, :rlen
do
begin
  ..
end
```

Example

```
with dept_year_budget as (
  select fiscal_year,
         dept_no,
         sum(projected_budget) as budget
  from proj_dept_budget
  group by fiscal_year, dept_no
)
select d.dept_no,
       d.department,
       dyb_2008.budget as budget_08,
       dyb_2009.budget as budget_09
from department d
     left join dept_year_budget dyb_2008
       on d.dept_no = dyb_2008.dept_no
       and dyb_2008.fiscal_year = 2008
     left join dept_year_budget dyb_2009
       on d.dept_no = dyb_2009.dept_no
       and dyb_2009.fiscal_year = 2009
where exists (
  select * from proj_dept_budget b
  where d.dept_no = b.dept_no
);
```

Recursive CTEs

A recursive (self-referencing) *CTE* is a `UNION` which must have at least one non-recursive member, called the *anchor*. The non-recursive member(s) must be placed before the recursive member(s). Recursive members are linked to each other and to their non-recursive neighbour by `UNION ALL` operators. The unions between non-recursive members may be of any type.

Recursive *CTE*s require the `RECURSIVE` keyword to be present right after `WITH`. Each recursive union member may reference itself only once, and it must do so in a `FROM` clause.

A great benefit of recursive *CTE*s is that they use far less memory and CPU cycles than an equivalent recursive stored procedure.

Execution Pattern

The execution pattern of a recursive *CTE* is as follows:

- The engine begins execution from a non-recursive member.
- For each row evaluated, it starts executing each recursive member one by one, using the current values from the outer row as parameters.
- If the currently executing instance of a recursive member produces no rows, execution loops back one level and gets the next row from the outer result set.

Example of recursive *CTE*s

```
WITH RECURSIVE DEPT_YEAR_BUDGET AS (
  SELECT
      FISCAL_YEAR,
      DEPT_NO,
      SUM(PROJECTED_BUDGET) BUDGET
  FROM PROJ_DEPT_BUDGET
  GROUP BY FISCAL_YEAR, DEPT_NO
),
DEPT_TREE AS (
  SELECT
      DEPT_NO,
      HEAD_DEPT,
      DEPARTMENT,
      CAST('' AS VARCHAR(255)) AS INDENT
  FROM DEPARTMENT
  WHERE HEAD_DEPT IS NULL
  UNION ALL
  SELECT
      D.DEPT_NO,
      D.HEAD_DEPT,
      D.DEPARTMENT,
      H.INDENT || ' '
  FROM DEPARTMENT D
    JOIN DEPT_TREE H ON H.HEAD_DEPT = D.DEPT_NO
)
```

```
SELECT
    D.DEPT_NO,
    D.INDENT || D.DEPARTMENT DEPARTMENT,
    DYB_2008.BUDGET AS BUDGET_08,
    DYB_2009.BUDGET AS BUDGET_09
FROM DEPT_TREE D
    LEFT JOIN DEPT_YEAR_BUDGET DYB_2008 ON
      (D.DEPT_NO = DYB_2008.DEPT_NO) AND
      (DYB_2008.FISCAL_YEAR = 2008)
    LEFT JOIN DEPT_YEAR_BUDGET DYB_2009 ON
      (D.DEPT_NO = DYB_2009.DEPT_NO) AND
      (DYB_2009.FISCAL_YEAR = 2009);
```

The next example returns the pedigree of a horse. The main difference is that recursion occurs simultaneously in two branches of the pedigree.

```
WITH RECURSIVE PEDIGREE (
  CODE_HORSE,
  CODE_FATHER,
  CODE_MOTHER,
  NAME,
  MARK,
  DEPTH)
AS (SELECT
      HORSE.CODE_HORSE,
      HORSE.CODE_FATHER,
      HORSE.CODE_MOTHER,
      HORSE.NAME,
      CAST('' AS VARCHAR(80)),
      0
    FROM
      HORSE
    WHERE
      HORSE.CODE_HORSE = :CODE_HORSE
    UNION ALL
    SELECT
      HORSE.CODE_HORSE,
      HORSE.CODE_FATHER,
      HORSE.CODE_MOTHER,
      HORSE.NAME,
      'F' || PEDIGREE.MARK,
      PEDIGREE.DEPTH + 1
    FROM
      HORSE
      JOIN PEDIGREE
        ON HORSE.CODE_HORSE = PEDIGREE.CODE_FATHER
    WHERE
      PEDIGREE.DEPTH < :MAX_DEPTH
    UNION ALL
    SELECT
```

```
      HORSE.CODE_HORSE,
      HORSE.CODE_FATHER,
      HORSE.CODE_MOTHER,
      HORSE.NAME,
      'M' || PEDIGREE.MARK,
      PEDIGREE.DEPTH + 1
    FROM
      HORSE
      JOIN PEDIGREE
        ON HORSE.CODE_HORSE = PEDIGREE.CODE_MOTHER
    WHERE
      PEDIGREE.DEPTH < :MAX_DEPTH
)
SELECT
  CODE_HORSE,
  NAME,
  MARK,
  DEPTH
FROM
  PEDIGREE
```

Notes on recursive CTEs

- Aggregates (`DISTINCT`, `GROUP BY`, `HAVING`) and aggregate functions (`SUM`, `COUNT`, `MAX` etc) are not allowed in recursive union members.
- A recursive reference cannot participate in an outer join.
- The maximum recursion depth is 1024.

6.2. INSERT

Used for

Inserting rows of data into a table

Available in

DSQL, ESQL, PSQL

Syntax

```
INSERT INTO target
  { DEFAULT VALUES
  | [(<column_list>)] [<override_opt>] <value_source> }
  [RETURNING <returning_list> [INTO <variables>]]

<column_list> ::= col_name [, col_name ...]

<override_opt> ::=
  OVERRIDING {USER | SYSTEM} VALUE

<value_source> ::= VALUES (<value_list>) | <select_stmt>
```

```
<value_list> ::= <ins_value> [, <ins_value> ...]

<ins_value> :: = <value_expression> | DEFAULT

<returning_list> ::= * | <output_column> [, <output_column]

<output_column> ::=
    target.*
  | <return_expression> [COLLATE collation] [[AS] alias]

<return_expression> ::=
    <value_expression>
  | [target.]col_name

<value_expression> ::=
    <literal>
  | <context-variable>
  | any other expression returning a single
    value of a Firebird data type or NULL

<variables> ::= [:]varname [, [:]varname ...]
```

Table 87. Arguments for the `INSERT` *Statement Parameters*

Argument	Description
target	The name of the table or view to which a new row, or batch of rows, should be added
col_name	Name of a table or view column
value_expression	An expression whose value is used for inserting into the table or for returning
return_expression	The expression to be returned in the `RETURNING` clause
literal	A literal
context-variable	Context variable
varname	Name of a PSQL local variable

The `INSERT` statement is used to add rows to a table or to one or more tables underlying a view:

- If the column values are supplied in a `VALUES` clause, exactly one row is inserted
- The values may be provided instead by a `SELECT` expression, in which case zero to many rows may be inserted
- With the `DEFAULT VALUES` clause, no values are provided at all and exactly one row is inserted.

Restrictions

- Columns returned to the `NEW.column_name` context variables in triggers should not have a colon (":") prefixed to their names

- No column may appear more than once in the column list.

ALERT : `BEFORE INSERT` Triggers

Regardless of the method used for inserting rows, be mindful of any columns in the target table or view that are populated by `BEFORE INSERT` triggers, such as primary keys and case-insensitive search columns. Those columns should be excluded from both the *column_list* and the `VALUES` list if, as they should, the triggers test the `NEW.column_name` for `NULL`.

6.2.1. INSERT ⋯ VALUES

The `VALUES` list must provide a value for every column in the column list, in the same order and of the correct type. The column list need not specify every column in the target but, if the column list is absent, the engine requires a value for every column in the table or view (computed columns excluded).

The value `DEFAULT` allows a column to be specified in the column list, but instructs Firebird to use the default value (either `NULL` or the value specified in the `DEFAULT` clause of the column definition). For identity columns, specifying `DEFAULT` will generate the identity value. It is possible to include calculated columns in the column list and specifying `DEFAULT` as the column value.

Introducer syntax provides a way to identify the character set of a value that is a string constant (literal). Introducer syntax works only with literal strings: it cannot be applied to string variables, parameters, column references or values that are expressions.

Examples

```
INSERT INTO cars (make, model, year)
VALUES ('Ford', 'T', 1908);

INSERT INTO cars
VALUES ('Ford', 'T', 1908, 'USA', 850);

-- notice the '_' prefix (introducer syntax)
INSERT INTO People
VALUES (_ISO8859_1 'Hans-Jörg Schäfer');
```

6.2.2. INSERT ⋯ SELECT

For this method of inserting, the output columns of the `SELECT` statement must provide a value for every target column in the column list, in the same order and of the correct type.

Literal values, context variables or expressions of compatible type can be substituted for any column in the source row. In this case, a source column list and a corresponding `VALUES` list are required.

If the column list is absent — as it is when `SELECT *` is used for the source expression — the

column_list must contain the names of every column in the target table or view (computed columns excluded).

Examples

```
INSERT INTO cars (make, model, year)
  SELECT make, model, year
  FROM new_cars;

INSERT INTO cars
  SELECT * FROM new_cars;

INSERT INTO Members (number, name)
  SELECT number, name FROM NewMembers
    WHERE Accepted = 1
UNION ALL
  SELECT number, name FROM SuspendedMembers
    WHERE Vindicated = 1

INSERT INTO numbers(num)
  WITH RECURSIVE r(n) as (
    SELECT 1 FROM rdb$database
    UNION ALL
    SELECT n+1 FROM r WHERE n < 100
  )
SELECT n FROM r
```

Of course, the column names in the source table need not be the same as those in the target table. Any type of SELECT statement is permitted, as long as its output columns exactly match the insert columns in number, order and type. Types need not be exactly the same, but they must be assignment-compatible.

When using and INSERT ⋯ SELECT with a RETURNING clause, the SELECT has to produce at most one row, as RETURNING currently only works for statements affecting at most one row.

This behaviour may change in future Firebird versions.

6.2.3. INSERT ⋯ DEFAULT VALUES

The DEFAULT VALUES clause allows insertion of a record without providing any values at all, either directly or from a SELECT statement. This is only possible if every NOT NULL or CHECKed column in the table either has a valid default declared or gets such a value from a BEFORE INSERT trigger. Furthermore, triggers providing required field values must not depend on the presence of input values.

Specifying DEFAULT VALUES is equivalent to specifying a values list with value DEFAULT for all columns.

Example

```
INSERT INTO journal
  DEFAULT VALUES
RETURNING entry_id;
```

6.2.4. OVERRIDING

The OVERRIDING clause controls the behaviour of an identity column for this statement only.

OVERRIDING SYSTEM VALUE

The user-provided value for the identity column is used, and no value is generated using the identity. In other words, for this insert, the identity will behave as if it is GENERATED BY DEFAULT. This option can only be specified for tables with a GENERATED ALWAYS identity column.

This can be useful when merging or importing data from another source. After such an insert, it may be necessary to change the next value of the identity sequence using ALTER TABLE to prevent subsequent inserts from generating colliding identity values.

OVERRIDING USER VALUE

The user-provided value for the identity column is ignored, and the column value is generated using the identity. In other words, for this insert, the identity will behave as if it is GENERATED ALWAYS, while allowing the identity column in the column-list. This option can be specified for tables with a GENERATED BY DEFAULT and — since Firebird 4.0.3 — GENERATED ALWAYS identity column.

It is usually simpler to leave out the identity column to achieve the same effect.

Examples of OVERRIDING

```
-- for GENERATED ALWAYS AS IDENTITY
-- value 11 is used anyway
insert into objects_always (id, name)
  OVERRIDING SYSTEM VALUE values (11, 'Laptop');

-- for both BY DEFAULT and - 4.0.3 or higher - ALWAYS
-- value 12 is not used
insert into objects_default (id, name)
  OVERRIDING USER VALUE values (12, 'Laptop');
```

6.2.5. The RETURNING Clause

An INSERT statement adding *at most one row* may optionally include a RETURNING clause in order to return values from the inserted row. The clause, if present, need not contain all of the insert columns and may also contain other columns or expressions. The returned values reflect any changes that may have been made in BEFORE INSERT triggers.

The user executing the statement needs to have SELECT privileges on the columns specified in the

RETURNING clause.

The syntax of the *returning_list* is similar to the column list of a SELECT clause. It is possible to reference all columns using * or table_name.*.

The optional INTO sub-clause is only valid in PSQL.

Multiple INSERTs

In DSQL, a statement with RETURNING always returns only one row. If the RETURNING clause is specified and more than one row is inserted by the INSERT statement, the statement fails and an error message is returned. This behaviour may change in future Firebird versions.

Examples

```
INSERT INTO Scholars (firstname, lastname, address,
  phone, email)
VALUES ('Henry', 'Higgins', '27A Wimpole Street',
  '3231212', NULL)
RETURNING lastname, fullname, id;

INSERT INTO Scholars (firstname, lastname, address,
  phone, email)
VALUES (
  'Henry', 'Higgins', '27A Wimpole Street',
  '3231212', NULL)
RETURNING *;

INSERT INTO Dumbbells (firstname, lastname, iq)
  SELECT fname, lname, iq
FROM Friends
  ORDER BY iq ROWS 1
  RETURNING id, firstname, iq
INTO :id, :fname, :iq;
```

- RETURNING is supported for VALUES and DEFAULT VALUES inserts, and singleton SELECT inserts.
- In DSQL, a statement with a RETURNING clause *always* returns exactly one row. If no record was actually inserted, the fields in this row are all NULL. This behaviour may change in a later version of Firebird. In PSQL, if no row was inserted, nothing is returned, and the target variables keep their existing values.

6.2.6. Inserting into BLOB columns

Inserting into BLOB columns is only possible under the following circumstances:

1. The client application has made special provisions for such inserts, using the Firebird API. In

this case, the *modus operandi* is application-specific and outside the scope of this manual.

2. The value inserted is a string literal of no more than 65,533 bytes (64KB - 3).

A limit, in characters, is calculated at run-time for strings that are in multi-byte character sets, to avoid overrunning the bytes limit. For example, for a UTF8 string (max. 4 bytes/character), the run-time limit is likely to be about (floor(65533/4)) = 16383 characters.

3. You are using the "`INSERT ⋯ SELECT`" form and one or more columns in the result set are `BLOB`s.

6.3. UPDATE

Used for

Modifying rows in tables and views

Available in

DSQL, ESQL, PSQL

Syntax

```
UPDATE target [[AS] alias]
  SET col_name = <upd_value> [, col_name = <upd_value> ...]
  [WHERE {<search-conditions> | CURRENT OF cursorname}]
  [PLAN <plan_items>]
  [ORDER BY <sort_items>]
  [ROWS m [TO n]]
  [RETURNING <returning_list> [INTO <variables>]]

<upd_value> ::= <value_expression> | DEFAULT

<returning_list> ::= * | <output_column> [, <output_column]

<output_column> ::=
    target.* | NEW.* | OLD.*
  | <return_expression> [COLLATE collation] [[AS] alias]

<return_expression> ::=
    <value_expression>
  | [target.]col_name
  | NEW.col_name
  | OLD.col_name

<value_expression> ::=
    <literal>
  | <context-variable>
  | any other expression returning a single
    value of a Firebird data type or NULL
```

```
<variables> ::= [:]varname [, [:]varname ...]
```

Table 88. Arguments for the UPDATE Statement Parameters

Argument	Description
target	The name of the table or view where the records are updated
alias	Alias for the table or view
col_name	Name or alias of a column in the table or view
value_expression	Expression for the new value for a column that is to be updated in the table or view by the statement, or a value to be returned
search-conditions	A search condition limiting the set of the rows to be updated
cursorname	The name of the cursor through which the row(s) to be updated are positioned
plan_items	Clauses in the query plan
sort_items	Columns listed in an `ORDER BY` clause
m, n	Integer expressions for limiting the number of rows to be updated
return_expression	A value to be returned in the `RETURNING` clause
literal	A literal
context-variable	Context variable
varname	Name of a PSQL local variable

The `UPDATE` statement changes values in a table or in one or more of the tables that underlie a view. The columns affected are specified in the `SET` clause. The rows affected may be limited by the `WHERE` and `ROWS` clauses. If neither `WHERE` nor `ROWS` is present, all the records in the table will be updated.

6.3.1. Using an alias

If you assign an alias to a table or a view, the alias *must* be used when specifying columns and also in any column references included in other clauses.

Example

Correct usage:

```
update Fruit set soort = 'pisang' where ...

update Fruit set Fruit.soort = 'pisang' where ...

update Fruit F set soort = 'pisang' where ...

update Fruit F set F.soort = 'pisang' where ...
```

Not possible:

```
update Fruit F set Fruit.soort = 'pisang' where ...
```

6.3.2. The SET Clause

In the SET clause, the assignment phrases, containing the columns with the values to be set, are separated by commas. In an assignment phrase, column names are on the left and the values or expressions containing the assignment values are on the right. A column may be included only once in the SET clause.

A column name can be used in expressions on the right. The old value of the column will always be used in these right-side values, even if the column was already assigned a new value earlier in the SET clause.

Using the value DEFAULT will set the column to its default value (either NULL or the value specified on the DEFAULT clause of the column definition). For an identity column, specifying DEFAULT will generate a new identity value. It is possible to "update" calculated columns in the SET clause if and only if the assigned value is DEFAULT.

It is not possible to assign DEFAULT as a parameter value.

Here is an example

Data in the TSET table:

```
A B
---
1 0
2 0
```

The statement:

```
UPDATE tset SET a = 5, b = a;
```

will change the values to:

```
A B
---
5 1
5 2
```

Notice that the old values (1 and 2) are used to update the b column even after the column was assigned a new value (5).

6.3.3. The WHERE Clause

The WHERE clause sets the conditions that limit the set of records for a *searched update*.

In PSQL, if a named cursor is being used for updating a set, using the WHERE CURRENT OF clause, the action is limited to the row where the cursor is currently positioned. This is a *positioned update*.

To be able to use the WHERE CURRENT OF clause in DSQL, the cursor name needs to be set on the statement handle before executing the statement.

Examples

```
UPDATE People
  SET firstname = 'Boris'
  WHERE lastname = 'Johnson';

UPDATE employee e
  SET salary = salary * 1.05
  WHERE EXISTS(
         SELECT *
           FROM employee_project ep
           WHERE e.emp_no = ep.emp_no);

UPDATE addresses
  SET city = 'Saint Petersburg', citycode = 'PET'
  WHERE city = 'Leningrad'

UPDATE employees
  SET salary = 2.5 * salary
  WHERE title = 'CEO'
```

For string literals with which the parser needs help to interpret the character set of the data, the introducer syntax may be used. The string literal is preceded by the character set name, prefixed with an underscore character:

```
-- notice the '_' prefix

UPDATE People
SET name = _ISO8859_1 'Hans-Jörg Schäfer'
WHERE id = 53662;
```

6.3.4. The ORDER BY and ROWS Clauses

The ORDER BY and ROWS clauses make sense only when used together. However, they can be used separately.

If ROWS has one argument, *m*, the rows to be updated will be limited to the first *m* rows.

Points to note

- If *m* > the number of rows being processed, the entire set of rows is updated
- If *m* = 0, no rows are updated
- If *m* < 0, an error occurs and the update fails

If two arguments are used, *m* and *n*, `ROWS` limits the rows being updated to rows from *m* to *n* inclusively. Both arguments are integers and start from 1.

Points to note

- If *m* > the number of rows being processed, no rows are updated
- If *n* > the number of rows, rows from *m* to the end of the set are updated
- If *m* < 1 or *n* < 1, an error occurs and the update fails
- If *n* = *m* - 1, no rows are updated
- If *n* < *m* -1, an error occurs and the update fails

ROWS Example

```
UPDATE employees
SET salary = salary + 50
ORDER BY salary ASC
ROWS 20;
```

6.3.5. The `RETURNING` Clause

An `UPDATE` statement involving *at most one row* may include `RETURNING` in order to return some values from the row being updated. `RETURNING` may include data from any column of the row, not necessarily the columns that are currently being updated. It can include literals or expressions not associated with columns, if there is a need for that.

The user executing the statement needs to have `SELECT` privileges on the columns specified in the `RETURNING` clause.

When the `RETURNING` set contains data from the current row, the returned values report changes made in the `BEFORE UPDATE` triggers, but not those made in `AFTER UPDATE` triggers.

The context variables `OLD.fieldname` and `NEW.fieldname` can be used as column names. If `OLD.` or `NEW.` is not specified, or if the table name (*target*) is specified instead the column values returned are the `NEW.` ones.

The syntax of the *returning_list* is similar to the column list of a `SELECT` clause. It is possible to reference all columns using *, or `table_name.*`, `NEW.*` and/or `OLD.*`.

In DSQL, a statement with `RETURNING` always returns a single row. Attempts to execute an `UPDATE` ⋯ `RETURNING` ⋯ that affects multiple rows will result in the error “multiple rows in singleton select”. If the statement updates no records, the returned values contain `NULL`. This behaviour may change in future Firebird versions.

The INTO Sub-clause

In PSQL, the INTO clause can be used to pass the returning values to local variables. It is not available in DSQL. If no records are updated, nothing is returned and variables specified in RETURNING will keep their previous values.

RETURNING Example (DSQL)

```
UPDATE Scholars
SET firstname = 'Hugh', lastname = 'Pickering'
WHERE firstname = 'Henry' and lastname = 'Higgins'
RETURNING id, old.lastname, new.lastname;
```

6.3.6. Updating BLOB columns

Updating a BLOB column always replaces the entire contents. Even the BLOB ID, the "handle" that is stored directly in the column, is changed. BLOBs can be updated if:

1. The client application has made special provisions for this operation, using the Firebird API. In this case, the *modus operandi* is application-specific and outside the scope of this manual.
2. The new value is a string literal of no more than 65,533 bytes (64KB - 3).

A limit, in characters, is calculated at run-time for strings that are in multi-byte character sets, to avoid overrunning the bytes limit. For example, for a UTF8 string (max. 4 bytes/character), the run-time limit is likely to be about (floor(65533/4)) = 16383 characters.

3. The source is itself a BLOB column or, more generally, an expression that returns a BLOB.
4. You use the INSERT CURSOR statement (ESQL only).

6.4. UPDATE OR INSERT

Used for

Updating an existing record in a table or, if it does not exist, inserting it

Available in

DSQL, PSQL

Syntax

```
UPDATE OR INSERT INTO
  target [(<column_list>)]
  [<override_opt>]
  VALUES (<value_list>)
  [MATCHING (<column_list>)]
  [RETURNING <returning_list> [INTO <variables>]]
```

```
<column_list> ::= col_name  [, col_name ...]

<override_opt> ::=
  OVERRIDING {USER | SYSTEM} VALUE

<value_list> ::= <ins_value> [, <ins_value> ...]

<ins_value> ::= <value> | DEFAULT

<returning_list> ::= * | <output_column> [, <output_column]

<output_column> ::=
    target.* | NEW.* | OLD.*
  | <return_expression> [COLLATE collation] [[AS] alias]

<return_expression> ::=
    <value_expression>
  | [target.]col_name
  | NEW.col_name
  | OLD.col_name

<value_expression> ::=
    <literal>
  | <context-variable>
  | any other expression returning a single
    value of a Firebird data type or NULL

<variables> ::= [:]varname [, [:]varname ...]
```

Table 89. Arguments for the `UPDATE OR INSERT` *Statement Parameters*

Argument	Description
target	The name of the table or view where the record(s) is to be updated or a new record inserted
col_name	Name of a column in the table or view
value_expression	An expression whose value is to be used for inserting or updating the table, or returning a value
return_expression	An expression returned in the RETURNING clause
varname	Variable name — PSQL only

`UPDATE OR INSERT` inserts a new record or updates one or more existing records. The action taken depends on the values provided for the columns in the `MATCHING` clause (or, if the latter is absent, in the primary key). If there are records found matching those values, they are updated. If not, a new record is inserted. A match only counts if all the values in the `MATCHING` or primary key columns are equal. Matching is done with the `IS NOT DISTINCT` operator, so one `NULL` matches another.

Restrictions

- If the table has no primary key, the MATCHING clause is mandatory.
- In the MATCHING list as well as in the update/insert column list, each column name may occur only once.
- The "INTO <variables>" subclause is only available in PSQL.
- When values are returned into the context variable NEW, this name must not be preceded by a colon (":").

6.4.1. The RETURNING clause

The optional RETURNING clause, if present, need not contain all the columns mentioned in the statement and may also contain other columns or expressions. The returned values reflect any changes that may have been made in BEFORE triggers, but not those in AFTER triggers. OLD.fieldname and NEW.fieldname may both be used in the list of columns to return; for field names not preceded by either of these, the new value is returned.

The user executing the statement needs to have SELECT privileges on the columns specified in the RETURNING clause.

The syntax of the *returning_list* is similar to the column list of a SELECT clause. It is possible to reference all columns using *, or table_name.*, NEW.* and/or OLD.*.

In DSQL, a statement with a RETURNING clause *always* returns exactly one row. If a RETURNING clause is present and more than one matching record is found, an error "multiple rows in singleton select" is raised. This behaviour may change in a later version of Firebird.

The optional INTO sub-clause is only valid in PSQL.

6.4.2. Example of UPDATE OR INSERT

Modifying data in a table, using UPDATE OR INSERT in a PSQL module. The return value is passed to a local variable, whose colon prefix is optional.

```
UPDATE OR INSERT INTO Cows (Name, Number, Location)
  VALUES ('Suzy Creamcheese', 3278823, 'Green Pastures')
  MATCHING (Number)
  RETURNING rec_id into :id;

UPDATE OR INSERT INTO Cows (Name, Number, Location)
  VALUES ('Suzy Creamcheese', 3278823, 'Green Pastures')
  MATCHING (Number)
  RETURNING old.*, new.*;
```

6.5. DELETE

Used for

Deleting rows from a table or view

Available in

DSQL, ESQL, PSQL

Syntax

```
DELETE
  FROM target [[AS] alias]
  [WHERE {<search-conditions> | CURRENT OF cursorname}]
  [PLAN <plan_items>]
  [ORDER BY <sort_items>]
  [ROWS m [TO n]]
  [RETURNING <returning_list> [INTO <variables>]]

<returning_list> ::= * | <output_column> [, <output_column]

<output_column> ::=
    target.*
  | <return_expression> [COLLATE collation] [[AS] alias]

<return_expression> ::=
    <value_expression>
  | [target.]col_name

<value_expression> ::=
    <literal>
  | <context-variable>
  | any other expression returning a single
    value of a Firebird data type or NULL

<variables> ::=
  [:]varname [, [:]varname ...]
```

Table 90. Arguments for the `DELETE` *Statement Parameters*

Argument	Description
target	The name of the table or view from which the records are to be deleted
alias	Alias for the target table or view
search-conditions	Search condition limiting the set of rows being targeted for deletion
cursorname	The name of the cursor in which current record is positioned for deletion
plan_items	Query plan clause
sort_items	`ORDER BY` clause
m, n	Integer expressions for limiting the number of rows being deleted
return_expression	An expression to be returned in the `RETURNING` clause
value_expression	An expression whose value is used for returning
varname	Name of a PSQL variable

DELETE removes rows from a database table or from one or more of the tables that underlie a view. WHERE and ROWS clauses can limit the number of rows deleted. If neither WHERE nor ROWS is present, DELETE removes all the rows in the relation.

6.5.1. Aliases

If an alias is specified for the target table or view, it must be used to qualify all field name references in the DELETE statement.

Examples

Supported usage:

```
delete from Cities where name starting 'Alex';

delete from Cities where Cities.name starting 'Alex';

delete from Cities C where name starting 'Alex';

delete from Cities C where C.name starting 'Alex';
```

Not possible:

```
delete from Cities C where Cities.name starting 'Alex';
```

6.5.2. WHERE

The WHERE clause sets the conditions that limit the set of records for a *searched delete*.

In PSQL, if a named cursor is being used for deleting a set, using the WHERE CURRENT OF clause, the action is limited to the row where the cursor is currently positioned. This is a *positioned delete*.

To be able to use the WHERE CURRENT OF clause in DSQL, the cursor name needs to be set on the statement handle before executing the statement.

Examples

```
DELETE FROM People
  WHERE firstname <> 'Boris' AND lastname <> 'Johnson';

DELETE FROM employee e
  WHERE NOT EXISTS(
    SELECT *
    FROM employee_project ep
     WHERE e.emp_no = ep.emp_no);

DELETE FROM Cities
```

```
  WHERE CURRENT OF Cur_Cities;  -- ESQL and PSQL only
```

6.5.3. PLAN

A PLAN clause allows the user to optimize the operation manually.

Example

```
DELETE FROM Submissions
  WHERE date_entered < '1-Jan-2002'
  PLAN (Submissions INDEX ix_subm_date);
```

6.5.4. ORDER BY and ROWS

The ORDER BY clause orders the set before the actual deletion takes place. It only makes sense in combination with ROWS, but is also valid without it.

The ROWS clause limits the number of rows being deleted. Integer literals or any integer expressions can be used for the arguments *m* and *n*.

If ROWS has one argument, *m*, the rows to be deleted will be limited to the first *m* rows.

Points to note

- If *m* > the number of rows being processed, the entire set of rows is deleted
- If *m* = 0, no rows are deleted
- If *m* < 0, an error occurs and the deletion fails

If two arguments are used, *m* and *n*, ROWS limits the rows being deleted to rows from *m* to *n* inclusively. Both arguments are integers and start from 1.

Points to note

- If *m* > the number of rows being processed, no rows are deleted
- If *m* > 0 and <= the number of rows in the set and *n* is outside these values, rows from *m* to the end of the set are deleted
- If *m* < 1 or *n* < 1, an error occurs and the deletion fails
- If *n* = *m* - 1, no rows are deleted
- If *n* < *m* -1, an error occurs and the deletion fails

Examples

Deleting the oldest purchase:

```
DELETE FROM Purchases
  ORDER BY date ROWS 1;
```

Deleting the highest custno(s):

```
DELETE FROM Sales
  ORDER BY custno DESC ROWS 1 to 10;
```

Deleting all sales, `ORDER BY` clause pointless:

```
DELETE FROM Sales
  ORDER BY custno DESC;
```

Deleting one record starting from the end, i.e. from Z...:

```
DELETE FROM popgroups
  ORDER BY name DESC ROWS 1;
```

Deleting the five oldest groups:

```
DELETE FROM popgroups
  ORDER BY formed ROWS 5;
```

No sorting (`ORDER BY`) is specified so 8 found records, starting from the fifth one, will be deleted:

```
DELETE FROM popgroups
  ROWS 5 TO 12;
```

6.5.5. RETURNING

A `DELETE` statement removing *at most one row* may optionally include a `RETURNING` clause in order to return values from the deleted row. The clause, if present, need not contain all the relation's columns and may also contain other columns or expressions.

The user executing the statement needs to have `SELECT` privileges on the columns specified in the `RETURNING` clause.

The syntax of the *returning_list* is similar to the column list of a `SELECT` clause. It is possible to reference all columns using *, or `table_name`.*.

- In DSQL, a statement with `RETURNING` always returns a singleton, never a multi-row set. If a `RETURNING` clause is present and more than one matching record is found, an error "multiple rows in singleton select" is raised. If no records are deleted, the returned columns contain `NULL`. This behaviour may change in future Firebird versions
- The `INTO` clause is available only in PSQL

- If the row is not deleted, nothing is returned and the target variables keep their values

Examples

```
DELETE FROM Scholars
  WHERE firstname = 'Henry' and lastname = 'Higgins'
  RETURNING lastname, fullname, id;

DELETE FROM Scholars
  WHERE firstname = 'Henry' and lastname = 'Higgins'
  RETURNING *;

DELETE FROM Dumbbells
  ORDER BY iq DESC
  ROWS 1
  RETURNING lastname, iq into :lname, :iq;
```

6.6. MERGE

Used for

Merging data from a source set into a target relation

Available in

DSQL, PSQL

Syntax

```
MERGE INTO target [[AS] target_alias]
  USING <source> [[AS] source_alias]
  ON <join_condition>
  <merge_when> [<merge_when> ...]
  [RETURNING <returning_list> [INTO <variables>]]

<merge_when> ::=
    <merge_when_matched>
  | <merge_when_not_matched>

<merge_when_matched> ::=
  WHEN MATCHED [ AND <condition> ] THEN
  { UPDATE SET <assignment-list>
  | DELETE }

<merge_when_not_matched> ::=
  WHEN NOT MATCHED [ AND <condition> ] THEN
  INSERT [( <column_list> )] [<override_opt>]
  VALUES ( <value_list> )
```

```
<source> ::= tablename | (<select_stmt>)

<assignment_list ::=
  col_name = <m_value> [, <col_name> = <m_value> ...]]

<override_opt> ::=
  OVERRIDING {USER | SYSTEM} VALUE

<column_list> ::= colname [, colname ...]

<value_list> ::= <m_value> [, <m_value> ...]

<m_value> ::= <value_expression> | DEFAULT

<returning_list> ::= * | <output_column> [, <output_column]

<output_column> ::=
    target.* | NEW.* | OLD.*
  | <return_expression> [COLLATE collation] [[AS] alias]

<return_expression> ::=
    <value_expression>
  | [target.]col_name
  | NEW.col_name
  | OLD.col_name

<value_expression> ::=
    <literal>
  | <context-variable>
  | any other expression returning a single
    value of a Firebird data type or NULL

<variables> ::=
  [:]varname [, [:]varname ...]
```

Table 91. Arguments for the `MERGE` *Statement Parameters*

Argument	Description
target	Name of target relation (table or updatable view)
source	Data source. It can be a table, a view, a stored procedure or a derived table
target_alias	Alias for the target relation (table or updatable view)
source_alias	Alias for the source relation or set
join_conditions	The (`ON`) condition(s) for matching the source records with those in the target
condition	Additional test condition in `WHEN MATCHED` or `WHEN NOT MATCHED` clause
tablename	Table or view name

Argument	Description
select_stmt	Select statement of the derived table
col_name	Name of a column in the target relation
value_expression	The value assigned to a column in the target table. This expression may be a literal value, a PSQL variable, a column from the source, or a compatible context variable
return_expression	The expression to be returned in the RETURNING clause Can be a column reference to source or target, or a column reference of the NEW or OLD context of the target, or a value.
ret_alias	Alias for the value expression in the RETURNING clause
varname	Name of a PSQL local variable

The MERGE statement merges records from the source into a target table or updatable view. The source may be a table, view or "anything you can SELECT from" in general. Each source record will be used to update one or more target records, insert a new record in the target table, delete a record from the target table or do nothing.

The action taken depends on the supplied join condition, the WHEN clause(s), and the - optional - condition in the WHEN clause. The join condition and condition in the WHEN will typically contain a comparison of fields in the source and target relations.

Multiple WHEN MATCHED and WHEN NOT MATCHED clauses are allowed. For each row in the source, the WHEN clauses are checked in the order they are specified in the statement. If the condition in the WHEN clause does not evaluate to true, the clause is skipped, and the next clause will be checked. This will be done until the condition for a WHEN clause evaluates to true, or a WHEN clauses without condition matches, or there are no more WHEN clauses. If a matching clause is found, the action associated with the clause is executed. For each row in the source, at most one action is executed. If the WHEN MATCHED clause is present, and several records match a single record in the target table, an error is raised.

At least one WHEN clause must be present.

WHEN NOT MATCHED is evaluated from the source viewpoint, that is, the table or set specified in USING. It has to work this way because if the source record does not match a target record, INSERT is executed. Of course, if there is a target record which does not match a source record, nothing is done.

Currently, the ROW_COUNT variable returns the value 1, even if more than one record is modified or inserted. For details and progress, refer to firebird#4722.

6.6.1. The RETURNING Clause

A MERGE statement that affects at most one row can contain a RETURNING clause to return values added, modified or removed. If a RETURNING clause is present and more than one matching record is found, an error "multiple rows in singleton select" is raised. The RETURNING clause can contain any columns from the target table (or updateable view), as well as other columns (eg from the source)

and expressions.

The user executing the statement needs to have SELECT privileges on the columns specified in the RETURNING clause.

The optional INTO sub-clause is only valid in PSQL.

The restriction that RETURNING can only be used with a statement that affects at most one row might be removed in a future version.

Column names can be qualified by the OLD or NEW prefix to define exactly what value to return: before or after modification. The returned values include the changes made by BEFORE triggers.

The syntax of the *returning_list* is similar to the column list of a SELECT clause. It is possible to reference all columns using *, or table_name.*, NEW.* and/or OLD.*.

For the UPDATE or INSERT action, unqualified column names, or those qualified by the target table name or alias will behave as if qualified by NEW, while for the DELETE action as if qualified by OLD.

The following example modifies the previous example to affect one line, and adds a RETURNING clause to return the old and new quantity of goods, and the difference between those values.

Using MERGE *with a* RETURNING *clause*

```
MERGE INTO PRODUCT_INVENTORY AS TARGET
USING (
  SELECT
    SL.ID_PRODUCT,
    SUM(SL.QUANTITY)
  FROM SALES_ORDER_LINE SL
  JOIN SALES_ORDER S ON S.ID = SL.ID_SALES_ORDER
  WHERE S.BYDATE = CURRENT_DATE
  AND SL.ID_PRODUCT =: ID_PRODUCT
  GROUP BY 1
) AS SRC (ID_PRODUCT, QUANTITY)
ON TARGET.ID_PRODUCT = SRC.ID_PRODUCT
WHEN MATCHED AND TARGET.QUANTITY - SRC.QUANTITY <= 0 THEN
  DELETE
WHEN MATCHED THEN
  UPDATE SET
    TARGET.QUANTITY = TARGET.QUANTITY - SRC.QUANTITY,
    TARGET.BYDATE = CURRENT_DATE
RETURNING OLD.QUANTITY, NEW.QUANTITY, SRC.QUANTITY
INTO : OLD_QUANTITY, :NEW_QUANTITY, :DIFF_QUANTITY
```

6.6.2. Examples of MERGE

1. Update books when present, or add new record if absent

```
MERGE INTO books b
  USING purchases p
  ON p.title = b.title and p.type = 'bk'
  WHEN MATCHED THEN
    UPDATE SET b.desc = b.desc || '; ' || p.desc
  WHEN NOT MATCHED THEN
    INSERT (title, desc, bought) values (p.title, p.desc, p.bought);
```

2. Using a derived table

```
MERGE INTO customers c
  USING (SELECT * from customers_delta WHERE id > 10) cd
  ON (c.id = cd.id)
  WHEN MATCHED THEN
    UPDATE SET name = cd.name
  WHEN NOT MATCHED THEN
    INSERT (id, name) values (cd.id, cd.name);
```

3. Together with a recursive CTE

```
MERGE INTO numbers
  USING (
    WITH RECURSIVE r(n) AS (
      SELECT 1 FROM rdb$database
      UNION ALL
      SELECT n+1 FROM r WHERE n < 200
    )
    SELECT n FROM r
  ) t
  ON numbers.num = t.n
  WHEN NOT MATCHED THEN
    INSERT(num) VALUES(t.n);
```

4. Using `DELETE` clause

```
MERGE INTO SALARY_HISTORY
USING (
  SELECT EMP_NO
  FROM EMPLOYEE
  WHERE DEPT_NO = 120) EMP
ON SALARY_HISTORY.EMP_NO = EMP.EMP_NO
WHEN MATCHED THEN DELETE
```

5. The following example updates the `PRODUCT_INVENTORY` table daily based on orders processed in the `SALES_ORDER_LINE` table. If the stock level of the product would drop to zero or lower, then the row for that product is removed from the `PRODUCT_INVENTORY` table.

```
MERGE INTO PRODUCT_INVENTORY AS TARGET
USING (
  SELECT
    SL.ID_PRODUCT,
    SUM (SL.QUANTITY)
  FROM SALES_ORDER_LINE SL
  JOIN SALES_ORDER S ON S.ID = SL.ID_SALES_ORDER
  WHERE S.BYDATE = CURRENT_DATE
  GROUP BY 1
) AS SRC (ID_PRODUCT, QUANTITY)
ON TARGET.ID_PRODUCT = SRC.ID_PRODUCT
WHEN MATCHED AND TARGET.QUANTITY - SRC.QUANTITY <= 0 THEN
  DELETE
WHEN MATCHED THEN
  UPDATE SET
    TARGET.QUANTITY = TARGET.QUANTITY - SRC.QUANTITY,
    TARGET.BYDATE = CURRENT_DATE
```

See also

`SELECT`, `INSERT`, `UPDATE`, `UPDATE OR INSERT`, `DELETE`

6.7. EXECUTE PROCEDURE

Used for

Executing a stored procedure

Available in

DSQL, ESQL, PSQL

Syntax

```
EXECUTE PROCEDURE procname
   [{ <inparam-list | ( <inparam-list> ) }]
   [RETURNING_VALUES { <outvar-list> | ( <outvar-list ) }]

<inparam-list> ::=
  <inparam> [, <inparam> ...]

<outvar-list> ::=
  <outvar> [, <outvar> ...]

<outvar> ::= [:]varname
```

Table 92. Arguments for the `EXECUTE PROCEDURE` *Statement Parameters*

Argument	Description
procname	Name of the stored procedure

Argument	Description
inparam	An expression evaluating to the declared data type of an input parameter
varname	A PSQL variable to receive the return value

Executes an *executable stored procedure*, taking a list of one or more input parameters, if they are defined for the procedure, and returning a one-row set of output values, if they are defined for the procedure.

6.7.1. "Executable" Stored Procedure

The `EXECUTE PROCEDURE` statement is most commonly used to invoke the style of stored procedure that is written to perform some data-modifying task at the server side — those that do not contain any `SUSPEND` statements in their code. They can be designed to return a result set, consisting of only one row, which is usually passed, via a set of `RETURNING_VALUES()` variables, to another stored procedure that calls it. Client interfaces usually have an API wrapper that can retrieve the output values into a single-row buffer when calling `EXECUTE PROCEDURE` in DSQL.

Invoking the other style of stored procedure — a "selectable" one — is possible with `EXECUTE PROCEDURE`, but it returns only the first row of an output set which is almost surely designed to be multi-row. Selectable stored procedures are designed to be invoked by a `SELECT` statement, producing output that behaves like a virtual table.

- In PSQL and DSQL, input parameters may be any expression that resolves to the expected type.
- Although parentheses are not required after the name of the stored procedure to enclose the input parameters, their use is recommended for the sake of good housekeeping.
- Where output parameters have been defined in a procedure, the `RETURNING_VALUES` clause can be used in PSQL to retrieve them into a list of previously declared variables that conforms in sequence, data type and number with the defined output parameters.
- The list of `RETURNING_VALUES` may be optionally enclosed in parentheses and their use is recommended.
- When DSQL applications call `EXECUTE PROCEDURE` using the Firebird API or some form of wrapper for it, a buffer is prepared to receive the output row and the `RETURNING_VALUES` clause is not used.

6.7.2. Examples of `EXECUTE PROCEDURE`

1. In PSQL, with optional colons and without optional parentheses:

```
EXECUTE PROCEDURE MakeFullName
  :FirstName, :MiddleName, :LastName
  RETURNING_VALUES :FullName;
```

2. In Firebird's command-line utility *isql*, with literal parameters and optional parentheses:

```
EXECUTE PROCEDURE MakeFullName ('J', 'Edgar', 'Hoover');
```

In DSQL (eg in *isql*), RETURNING_VALUES is not used. Any output values are captured by the application and displayed automatically.

3. A PSQL example with expression parameters and optional parentheses:

```
EXECUTE PROCEDURE MakeFullName
  ('Mr./Mrs. ' || FirstName, MiddleName, upper(LastName))
  RETURNING_VALUES (FullName);
```

6.8. EXECUTE BLOCK

Used for

Creating an "anonymous" block of PSQL code in DSQL for immediate execution

Available in

DSQL

Syntax

```
EXECUTE BLOCK [(<inparams>)]
  [RETURNS (<outparams>)]
  <psql-module-body>

<inparams> ::=  <param_decl> = ? [, <inparams> ]

<outparams> ::=  <param_decl> [, <outparams>]

<param_decl> ::=
  paramname <domain_or_non_array_type> [NOT NULL] [COLLATE collation]

<domain_or_non_array_type> ::=
  !! See Scalar Data Types Syntax !!

<psql-module-body> ::=
  !! See Syntax of a Module Body !!
```

Table 93. Arguments for the EXECUTE BLOCK *Statement Parameters*

Argument	Description
param_decl	Name and description of an input or output parameter

Argument	Description
paramname	The name of an input or output parameter of the procedural block, up to 63 characters long. The name must be unique among input and output parameters and local variables in the block
collation	Collation sequence

Executes a block of PSQL code as if it were a stored procedure, optionally with input and output parameters and variable declarations. This allows the user to perform “on-the-fly” PSQL within a DSQL context.

6.8.1. Examples

1. This example injects the numbers 0 through 127 and their corresponding ASCII characters into the table `ASCIITABLE`:

```
EXECUTE BLOCK
AS
declare i INT = 0;
BEGIN
  WHILE (i < 128) DO
  BEGIN
    INSERT INTO AsciiTable VALUES (:i, ascii_char(:i));
    i = i + 1;
  END
END
```

2. The next example calculates the geometric mean of two numbers and returns it to the user:

```
EXECUTE BLOCK (x DOUBLE PRECISION = ?, y DOUBLE PRECISION = ?)
RETURNS (gmean DOUBLE PRECISION)
AS
BEGIN
  gmean = SQRT(x*y);
  SUSPEND;
END
```

   Because this block has input parameters, it has to be prepared first. Then the parameters can be set and the block executed. It depends on the client software how this must be done and even if it is possible at all — see the notes below.

3. Our last example takes two integer values, `smallest` and `largest`. For all the numbers in the range `smallest`...`largest`, the block outputs the number itself, its square, its cube and its fourth power.

```
EXECUTE BLOCK (smallest INT = ?, largest INT = ?)
RETURNS (number INT, square BIGINT, cube BIGINT, fourth BIGINT)
```

```
AS
BEGIN
  number = smallest;
  WHILE (number <= largest) DO
  BEGIN
    square = number * number;
    cube   = number * square;
    fourth = number * cube;
    SUSPEND;
    number = number + 1;
  END
END
```

Again, it depends on the client software if and how you can set the parameter values.

6.8.2. Input and output parameters

Executing a block without input parameters should be possible with every Firebird client that allows the user to enter his or her own DSQL statements. If there are input parameters, things get trickier: these parameters must get their values after the statement is prepared, but before it is executed. This requires special provisions, which not every client application offers. (Firebird's own *isql*, for one, doesn't.)

The server only accepts question marks ("?") as placeholders for the input values, not "`:a`", "`:MyParam`" etc., or literal values. Client software may support the "`:xxx`" form though, and will preprocess it before sending it to the server.

If the block has output parameters, you *must* use `SUSPEND` or nothing will be returned.

Output is always returned in the form of a result set, just as with a `SELECT` statement. You can't use `RETURNING_VALUES` or execute the block `INTO` some variables, even if there is only one result row.

PSQL Links

For more information about writing PSQL, consult Chapter *Procedural SQL (PSQL) Statements*.

6.8.3. Statement Terminators

Some SQL statement editors — specifically the *isql* utility that comes with Firebird and possibly some third-party editors — employ an internal convention that requires all statements to be terminated with a semi-colon. This creates a conflict with PSQL syntax when coding in these environments. If you are unacquainted with this problem and its solution, please study the details in the PSQL chapter in the section entitled Switching the Terminator in *isql*.

Chapter 7. Procedural SQL (PSQL) Statements

Procedural SQL (PSQL) is a procedural extension of SQL. This language subset is used for writing stored procedures, triggers, and PSQL blocks.

PSQL provides all the basic constructs of traditional structured programming languages, and also includes DML statements (`SELECT`, `INSERT`, `UPDATE`, `DELETE`, etc.), with a slight modified syntax in some cases.

7.1. Elements of PSQL

A procedural extension may contain declarations of local variables, routines and cursors, assignments, conditional statements, loops, statements for raising custom exceptions, error handling and sending messages (events) to client applications. Triggers have access to special context variables, two arrays that store, respectively, the `NEW` values for all columns during insert and update activity, and the `OLD` values during update and delete work.

Statements that modify metadata (DDL) are not available in PSQL.

7.1.1. DML Statements with Parameters

If DML statements (`SELECT`, `INSERT`, `UPDATE`, `DELETE`, etc.) in the body of the module (procedure, function, trigger or block) use parameters, only named parameters can be used. If DML statements contain named parameters, then they must be previously declared as local variables using `DECLARE [VARIABLE]` in the declaration section of the module, or as input or output variables in the module header.

When a DML statement with parameters is included in PSQL code, the parameter name must be prefixed by a colon (‘:’) in most situations. The colon is optional in statement syntax that is specific to PSQL, such as assignments and conditionals and the `INTO` clause. The colon prefix on parameters is not required when calling stored procedures from within another PSQL module or in DSQL.

7.1.2. Transactions

Stored procedures and functions (including those defined in packages) are executed in the context of the transaction in which they are called. Triggers are executed as an intrinsic part of the operation of the DML statement: thus, their execution is within the same transaction context as the statement itself. Individual transactions are launched for database event triggers.

Statements that start and end transactions are not available in PSQL, but it is possible to run a statement or a block of statements in an autonomous transaction.

7.1.3. Module Structure

PSQL code modules consist of a header and a body. The DDL statements for defining them are *complex statements*; that is, they consist of a single statement that encloses blocks of multiple statements. These statements begin with a verb (`CREATE`, `ALTER`, `DROP`, `RECREATE`, `CREATE OR ALTER`) and end with the last `END` statement of the body.

The Module Header

The header provides the module name and defines any input and output parameters or — for functions — the return type. Stored procedures and PSQL blocks may have input and output parameters. Functions may have input parameters and must have a scalar return type. Triggers do not have either input or output parameters.

The header of a trigger indicates the database event (insert, update or delete, or a combination) and the phase of operation (`BEFORE` or `AFTER` that event) that will cause it to "fire".

The Module Body

The module body is either a PSQL module body, or an external module body.

Syntax of a Module Body

```
<module-body> ::=
  <psql-module-body> | <external-module-body>

<psql-module-body> ::=
  AS
    [<forward-declarations>]
    [<declarations>]
  BEGIN
    [<PSQL_statements>]
  END

<external-module-body> ::=
  EXTERNAL [NAME <extname>] ENGINE engine
  [AS '<extbody>']

<forward-declarations> ::=
  <forward-declare-item> [<forward-declare-item> ...]

<declarations> ::=
  <declare-item> [<declare-item> ...]

<forward-declare-item> ::=
    <subfunc-forward>
  | <subproc-forward>

<declare-item> ::=
    <declare-var>
  | <declare-cursor>
  | <subfunc-def>
  | <subproc-def>

<extname> ::=
  '<module-name>!<routine-name>[!<misc-info>]'

<declare-var> ::=
```

```
  !! See DECLARE VARIABLE !!

<declare-cursor> ::=
  !! See DECLARE .. CURSOR !!

<subfunc-forward>, <subfunc-def> ::=
  !! See DECLARE FUNCTION !!

<subproc-forward>, <subproc-def> ::=
  !! See DECLARE PROCEDURE !!
```

Table 94. Module Body Parameters

Parameter	Description
declarations	Section for declaring local variables, named cursors, and subroutines
PSQL_statements	Procedural SQL statements. Some PSQL statements may not be valid in all types of PSQL. For example, `RETURN <value>;` is only valid in functions.
subfunc-forward	Sub-function forward declaration
subproc-forward	Sub-procedure forward declaration
declare_var	Local variable declaration
declare_cursor	Named cursor declaration
subfunc-def	Sub-function declaration
subproc-def	Sub-procedure declaration
extname	String identifying the external procedure
engine	String identifying the UDR engine
extbody	External procedure body. A string literal that can be used by UDRs for various purposes.
module-name	The name of the module that contains the procedure
routine-name	The internal name of the procedure inside the external module
misc-info	Optional string that is passed to the procedure in the external module

The PSQL Module Body

The PSQL body starts with an optional section that declares variables and subroutines, followed by a block of statements that run in a logical sequence, like a program. A block of statements — or compound statement — is enclosed by the `BEGIN` and `END` keywords, and is executed as a single unit of code. The main `BEGIN···END` block may contain any number of other `BEGIN···END` blocks, both embedded and sequential. Blocks can be nested to a maximum depth of 512 blocks. All statements except `BEGIN` and `END` are terminated by semicolons (‘;’). No other character is valid for use as a terminator for PSQL statements.

Switching the Terminator in *isql*

Here we digress a little, to explain how to switch the terminator character in the *isql* utility to make it possible to define PSQL modules in that environment without conflicting with *isql* itself, which uses the same character, semicolon (';'), as its own statement terminator.

isql Command `SET TERM`

Used for

Changing the terminator character(s) to avoid conflict with the terminator character in PSQL statements

Available in

ISQL only

Syntax

```
SET TERM new_terminator old_terminator
```

Table 95. `SET TERM` *Parameters*

Argument	Description
new_terminator	New terminator
old_terminator	Old terminator

When you write your triggers and stored procedures in *isql* — either in the interactive interface or in scripts — running a `SET TERM` statement is needed to switch the normal *isql* statement terminator from the semicolon to some other character or short string, to avoid conflict with the non-changeable semicolon terminator in PSQL. The switch to an alternative terminator needs to be done before you begin defining PSQL objects or running your scripts.

The alternative terminator can be any string of characters except for a space, an apostrophe or the current terminator character(s). Any letter character(s) used will be case-sensitive.

Example

Changing the default semicolon to '^' (caret) and using it to submit a stored procedure definition: character as an alternative terminator character:

```
SET TERM ^;

CREATE OR ALTER PROCEDURE SHIP_ORDER (
  PO_NUM CHAR(8))
AS
BEGIN
  /* Stored procedure body */
END^

/* Other stored procedures and triggers */
```

```
SET TERM ;^

/* Other DDL statements */
```

The External Module Body

The external module body specifies the UDR engine used to execute the external module, and optionally specifies the name of the UDR routine to call (<*extname*>) and/or a string (<*extbody*>) with UDR-specific semantics.

Configuration of external modules and UDR engines is not covered further in this Language Reference. Consult the documentation of a specific UDR engine for details.

7.2. Stored Procedures

A stored procedure is executable code stored in the database metadata for execution on the server. A stored procedure can be called by other stored procedures (including itself), functions, triggers and client applications. A procedure that calls itself is known as *recursive*.

7.2.1. Benefits of Stored Procedures

Stored procedures have the following advantages:

Modularity	applications working with the database can use the same stored procedure, thereby reducing the size of the application code and avoiding code duplication.
Simpler Application Support	when a stored procedure is modified, changes appear immediately to all host applications, without the need to recompile them if the parameters were unchanged.
Enhanced Performance	since stored procedures are executed on a server instead of at the client, network traffic is reduced, which improves performance.

7.2.2. Types of Stored Procedures

Firebird supports two types of stored procedures: *executable* and *selectable*.

Executable Procedures

Executable procedures usually modify data in a database. They can receive input parameters and return a single set of output (`RETURNS`) parameters. They are called using the `EXECUTE PROCEDURE` statement. See an example of an executable stored procedure at the end of the `CREATE PROCEDURE` section of Chapter 5.

Selectable Procedures

Selectable stored procedures usually retrieve data from a database, returning an arbitrary number of rows to the caller. The caller receives the output one row at a time from a row buffer that the database engine prepares for it.

Selectable procedures can be useful for obtaining complex sets of data that are often impossible or too difficult or too slow to retrieve using regular DSQL `SELECT` queries. Typically, this style of procedure iterates through a looping process of extracting data, perhaps transforming it before filling the output variables (parameters) with fresh data at each iteration of the loop. A `SUSPEND` statement at the end of the iteration fills the buffer and waits for the caller to fetch the row. Execution of the next iteration of the loop begins when the buffer has been cleared.

Selectable procedures may have input parameters, and the output set is specified by the `RETURNS` clause in the header.

A selectable stored procedure is called with a `SELECT` statement. See an example of a selectable stored procedure at the end of the `CREATE PROCEDURE` section of Chapter 5.

7.2.3. Creating a Stored Procedure

The syntax for creating executable stored procedures and selectable stored procedures is exactly the same. The difference comes in the logic of the program code.

For information about creating stored procedures, see `CREATE PROCEDURE` in Chapter *Data Definition (DDL) Statements*.

7.2.4. Modifying a Stored Procedure

For information about modifying existing stored procedures, see `ALTER PROCEDURE`, `CREATE OR ALTER PROCEDURE`, `RECREATE PROCEDURE`, in Chapter *Data Definition (DDL) Statements*.

7.2.5. Deleting a Stored Procedure

For information about deleting stored procedures, see `DROP PROCEDURE` in Chapter *Data Definition (DDL) Statements*.

7.3. Stored Functions

A stored function is executable code stored in the database metadata for execution on the server. A stored function can be called by other stored functions (including itself), procedures, triggers and client applications. A function that calls itself is known as *recursive*.

Unlike stored procedures, stored functions always return one scalar value. To return a value from a stored function, use the `RETURN` statement, which immediately terminates the function.

7.3.1. Creating a Stored Function

For information about creating stored functions, see `CREATE FUNCTION` in Chapter *Data Definition*

(DDL) Statements.

7.3.2. Modifying a Stored Function

For information about modifying stored functions, see `ALTER FUNCTION`, `CREATE OR ALTER FUNCTION`, `RECREATE FUNCTION`, in Chapter *Data Definition (DDL) Statements*.

7.3.3. Deleting a Stored Function

For information about deleting stored procedures, see `DROP FUNCTION` in Chapter *Data Definition (DDL) Statements*.

7.4. PSQL Blocks

A self-contained, unnamed ("anonymous") block of PSQL code can be executed dynamically in DSQL, using the `EXECUTE BLOCK` syntax. The header of an anonymous PSQL block may optionally contain input and output parameters. The body may contain local variables, cursor declarations and local routines, followed by a block of PSQL statements.

An anonymous PSQL block is not defined and stored as an object, unlike stored procedures and triggers. It executes in run-time and cannot reference itself.

Just like stored procedures, anonymous PSQL blocks can be used to process data and to retrieve data from the database.

Syntax (incomplete)

```
EXECUTE BLOCK
  [(<inparam> = ? [, <inparam> = ? ...])]
  [RETURNS (<outparam> [, <outparam> ...])]
  <psql-module-body>

<psql-module-body> ::=
  !! See Syntax of Module Body !!
```

Table 96. PSQL Block Parameters

Argument	Description
inparam	Input parameter description
outparam	Output parameter description
declarations	A section for declaring local variables and named cursors
PSQL statements	PSQL and DML statements

See also

See `EXECUTE BLOCK` for details.

7.5. Packages

A package is a group of stored procedures and function defined as a single database object.

Firebird packages are made up of two parts: a header (`PACKAGE` keyword) and a body (`PACKAGE BODY` keywords). This separation is very similar to Delphi modules, the header corresponds to the interface part, and the body corresponds to the implementation part.

7.5.1. Benefits of Packages

The notion of "packaging" the code components of a database operation addresses has several advantagrs:

Modularisation

Blocks of interdependent code are grouped into logical modules, as done in other programming languages.

In programming, it is well recognised that grouping code in various ways, in namespaces, units or classes, for example, is a good thing. This is not possible with standard stored procedures and functions in the database. Although they can be grouped in different script files, two problems remain:

a. The grouping is not represented in the database metadata.
b. Scripted routines all participate in a flat namespace and are callable by everyone (we are not referring to security permissions here).

Easier tracking of dependencies

Packages make it easy to track dependencies between a collection of related routines, as well as between this collection and other routines, both packaged and unpackaged.

Whenever a packaged routine determines that it uses a certain database object, a dependency on that object is registered in Firebird's system tables. Thereafter, to drop, or maybe alter that object, you first need to remove what depends on it. Since the dependency on other objects only exists for the package body, and not the package body, this package body can easily be removed, even if some other object depends on this package. When the body is dropped, the header remains, allowing you to recreate its body once the changes related to the removed object are done.

Simplify permission management

As Firebird runs routines with the caller privileges, it is necessary also to grant resource usage to each routine when these resources would not be directly accessible to the caller. Usage of each routine needs to be granted to users and/or roles.

Packaged routines do not have individual privileges. The privileges apply to the package as a whole. Privileges granted to packages are valid for all package body routines, including private ones, but are stored for the package header. An `EXECUTE` privilege on a package granted to a user (or other object), grants that user the privilege to execute all routines defined in the package header.

For example

```
GRANT SELECT ON TABLE secret TO PACKAGE pk_secret;
GRANT EXECUTE ON PACKAGE pk_secret TO ROLE role_secret;
```

Private scopes

Stored procedures and functions can be privates; that is, make them available only for internal usage within the defining package.

All programming languages have the notion of routine scope, which is not possible without some form of grouping. Firebird packages also work like Delphi units in this regard. If a routine is not declared in the package header (interface) and is implemented in the body (implementation), it becomes a private routine. A private routine can only be called from inside its package.

7.5.2. Creating a Package

For information on creating packages, see `CREATE PACKAGE`, `CREATE PACKAGE BODY`

7.5.3. Modifying a Package

For information on modifying existing package header or bodies, see `ALTER PACKAGE`, `CREATE OR ALTER PACKAGE`, `RECREATE PACKAGE`, `RECREATE PACKAGE BODY`

7.5.4. Deleting a Package

For information on deleting a package, see `DROP PACKAGE`, `DROP PACKAGE BODY`

7.6. Triggers

A trigger is another form of executable code that is stored in the metadata of the database for execution by the server. A trigger cannot be called directly. It is called automatically (“fired”) when data-changing events involving one particular table or view occur, or on a specific database event.

A trigger applies to exactly one table or view or database event, and only one *phase* in an event (`BEFORE` or `AFTER` the event). A single DML trigger might be written to fire only when one specific data-changing event occurs (`INSERT`, `UPDATE` or `DELETE`), or it might be written to apply to more than one of those.

A DML trigger is executed in the context of the transaction in which the data-changing DML statement is running. For triggers that respond to database events, the rule is different: for DDL triggers and transaction triggers, the trigger runs in the same transaction that executed the DDL, for other types, a new default transaction is started.

7.6.1. Firing Order (Order of Execution)

More than one trigger can be defined for each phase-event combination. The order in which they are executed (known as “firing order” can be specified explicitly with the optional `POSITION` argument in the trigger definition. You have 32,767 numbers to choose from. Triggers with the

lowest position numbers fire first.

If a POSITION clause is omitted, the position is 0. If multiple triggers have the same position and phase, those triggers will be executed in an undefined order, while respecting the total order by position and phase.

7.6.2. DML Triggers

DML triggers are those that fire when a DML operation changes the state of data: updating rows in tables, inserting new rows or deleting rows. They can be defined for both tables and views.

Trigger Options

Six base options are available for the event-phase combination for tables and views:

Before a new row is inserted	BEFORE INSERT
After a new row is inserted	AFTER INSERT
Before a row is updated	BEFORE UPDATE
After a row is updated	AFTER UPDATE
Before a row is deleted	BEFORE DELETE
After a row is deleted	AFTER DELETE

These base forms are for creating single phase/single-event triggers. Firebird also supports forms for creating triggers for one phase and multiple-events, BEFORE INSERT OR UPDATE OR DELETE, for example, or AFTER UPDATE OR DELETE: the combinations are your choice.

"Multi-phase" triggers, such as BEFORE OR AFTER ⋯, are not possible.

The Boolean context variables INSERTING, UPDATING and DELETING can be used in the body of a trigger to determine the type of event that fired the trigger.

OLD and NEW Context Variables

For DML triggers, the Firebird engine provides access to sets of OLD and NEW context variables. Each is an array of the values of the entire row: one for the values as they are before the data-changing event (the BEFORE phase) and one for the values as they will be after the event (the AFTER phase). They are referenced in statements using the form NEW.column_name and OLD.column_name, respectively. The *column_name* can be any column in the table's definition, not just those that are being updated.

The NEW and OLD variables are subject to some rules:

- In all triggers, the OLD value is read-only
- In BEFORE UPDATE and BEFORE INSERT code, the NEW value is read/write, unless it is a COMPUTED BY column
- In INSERT triggers, references to the OLD variables are invalid and will throw an exception

- In DELETE triggers, references to the NEW variables are invalid and will throw an exception
- In all AFTER trigger code, the NEW variables are read-only

7.6.3. Database Triggers

A trigger associated with a database or transaction event can be defined for the following events:

Connecting to a database	ON CONNECT	Before the trigger is executed, a transaction is automatically started with the default isolation level (snapshot (concurrency), write, wait)
Disconnecting from a database	ON DISCONNECT	Before the trigger is executed, a transaction is automatically started with the default isolation level (snapshot (concurrency), write, wait)
When a transaction is started	ON TRANSACTION START	The trigger is executed in the current transaction context
When a transaction is committed	ON TRANSACTION COMMIT	The trigger is executed in the current transaction context
When a transaction is cancelled	ON TRANSACTION ROLLBACK	The trigger is executed in the current transaction context

7.6.4. DDL Triggers

DDL triggers fire on specified metadata changes events in a specified phase. BEFORE triggers run before changes to system tables. AFTER triggers run after changes in system tables.

DDL triggers are a specific type of database trigger, so most rules for and semantics of database triggers also apply for DDL triggers.

Semantics

1. BEFORE triggers are fired before changes to the system tables. AFTER triggers are fired after system table changes.

Important Rule

The event type [BEFORE | AFTER] of a DDL trigger cannot be changed.

2. When a DDL statement fires a trigger that raises an exception (BEFORE or AFTER, intentionally or unintentionally) the statement will not be committed. That is, exceptions can be used to ensure that a DDL operation will fail if the conditions are not precisely as intended.
3. DDL trigger actions are executed only when *committing* the transaction in which the affected DDL command runs. Never overlook the fact that what is possible to do in an AFTER trigger is exactly what is possible to do after a DDL command without autocommit. You cannot, for example, create a table and then use it in the trigger.
4. With "CREATE OR ALTER" statements, a trigger is fired one time at the CREATE event or the ALTER event, according to the previous existence of the object. With RECREATE statements, a trigger is

fired for the DROP event if the object exists, and for the CREATE event.

5. ALTER and DROP events are generally not fired when the object name does not exist. For the exception, see point 6.
6. The exception to rule 5 is that BEFORE ALTER/DROP USER triggers fire even when the username does not exist. This is because, underneath, these commands perform DML on the security database, and the verification is not done before the command on it is run. This is likely to be different with embedded users, so do not write code that depends on this.
7. If some exception is raised after the DDL command starts its execution and before AFTER triggers are fired, AFTER triggers will not be fired.
8. Packaged procedures and triggers do not fire individual {CREATE | ALTER | DROP} {PROCEDURE | FUNCTION} triggers.

The DDL_TRIGGER Context Namespace

When a DDL trigger is running, the DDL_TRIGGER namespace is available for use with RDB$GET_CONTEXT. This namespace contains information on the currently firing trigger.

See also The DDL_TRIGGER Namespace in RDB$GET_CONTEXT in Chapter *Built-in Scalar Functions*.

7.6.5. Creating Triggers

For information on creating triggers, see CREATE TRIGGER, CREATE OR ALTER TRIGGER, RECREATE TRIGGER in Chapter *Data Definition (DDL) Statements*.

7.6.6. Modifying Triggers

For information on modifying triggers, see ALTER TRIGGER, CREATE OR ALTER TRIGGER, RECREATE TRIGGER in Chapter *Data Definition (DDL) Statements*.

7.6.7. Deleting a Trigger

For information on deleting triggers, see DROP TRIGGER in Chapter *Data Definition (DDL) Statements*.

7.7. Writing the Body Code

This section takes a closer look at the procedural SQL language constructs and statements that are available for coding the body of a stored procedure, trigger or anonymous PSQL block.

Colon Marker (':')

The colon marker prefix (':') is used in PSQL to mark a reference to a variable in a DML statement. The colon marker is not required before variable names in other PSQL code.

Since Firebird 3.0, the colon prefix can also be used for the NEW and OLD contexts, and for cursor variables.

7.7.1. Assignment Statements

Used for

Assigning a value to a variable

Available in

PSQL

Syntax

```
varname = <value_expr>;
```

Table 97. Assignment Statement Parameters

Argument	Description
varname	Name of a parameter or local variable
value_expr	An expression, constant or variable whose value resolves to the same data type as *varname*

PSQL uses the equal symbol ('=') as its assignment operator. The assignment statement assigns an SQL expression value on the right to the variable on the left of the operator. The expression can be any valid SQL expression: it may contain literals, internal variable names, arithmetic, logical and string operations, calls to internal functions, stored functions or external functions (UDFs).

Example using assignment statements

```
CREATE PROCEDURE MYPROC (
  a INTEGER,
  b INTEGER,
  name VARCHAR (30)
)
RETURNS (
  c INTEGER,
  str VARCHAR(100))
AS
BEGIN
  -- assigning a constant
  c = 0;
  str = '';
  SUSPEND;
  -- assigning expression values
  c = a + b;
  str = name || CAST(b AS VARCHAR(10));
  SUSPEND;
  -- assigning expression value
  -- built by a query
  c = (SELECT 1 FROM rdb$database);
  -- assigning a value from a context variable
  str = CURRENT_USER;
```

```
  SUSPEND;
END
```

See also

`DECLARE VARIABLE`

7.7.2. Management Statements in PSQL

Management statement are allowed in PSQL blocks (triggers, procedures, functions and `EXECUTE BLOCK`), which is especially helpful for applications that need some management statements to be executed at the start of a session, specifically in `ON CONNECT` triggers.

The management statements permitted in PSQL are:

- `ALTER SESSION RESET`
- `SET BIND`
- `SET DECFLOAT`
- `SET ROLE`
- `SET SESSION IDLE TIMEOUT`
- `SET STATEMENT TIMEOUT`
- `SET TIME ZONE`
- `SET TRUSTED ROLE`

Example of Management Statements in PSQL

```
create or alter trigger on_connect on connect
as
begin
    set bind of decfloat to double precision;
    set time zone 'America/Sao_Paulo';
end
```

Although useful as a workaround, using `ON CONNECT` triggers to configure bind and time zone is usually not the right approach.

See also

Management Statements

7.7.3. DECLARE VARIABLE

Used for

Declaring a local variable

Available in

PSQL

Syntax

```
DECLARE [VARIABLE] varname
  <domain_or_non_array_type> [NOT NULL] [COLLATE collation]
  [{DEFAULT | = } <initvalue>];

<domain_or_non_array_type> ::=
  !! See Scalar Data Types Syntax !!

<initvalue> ::= <literal> | <context_var>
```

Table 98. DECLARE VARIABLE Statement Parameters

Argument	Description
varname	Name of the local variable
collation	Collation sequence
initvalue	Initial value for this variable
literal	Literal of a type compatible with the type of the local variable
context_var	Any context variable whose type is compatible with the type of the local variable

The statement DECLARE [VARIABLE] is used for declaring a local variable. The keyword VARIABLE can be omitted. One DECLARE [VARIABLE] statement is required for each local variable. Any number of DECLARE [VARIABLE] statements can be included and in any order. The name of a local variable must be unique among the names of local variables and input and output parameters declared for the module.

A special case of DECLARE [VARIABLE] — declaring cursors — is covered separately in DECLARE .. CURSOR

Data Type for Variables

A local variable can be of any SQL type other than an array.

- A domain name can be specified as the type; the variable will inherit all of its attributes.
- If the TYPE OF domain clause is used instead, the variable will inherit only the domain's data type, and, if applicable, its character set and collation attributes. Any default value or constraints such as NOT NULL or CHECK constraints are not inherited.
- If the TYPE OF COLUMN relation.column> option is used to "borrow" from a column in a table or view, the variable will inherit only the column's data type, and, if applicable, its character set and collation attributes. Any other attributes are ignored.

`NOT NULL` Constraint

For local variables, you can specify the `NOT NULL` constraint, disallowing `NULL` values for the variable. If a domain has been specified as the data type and the domain already has the `NOT NULL` constraint, the declaration is unnecessary. For other forms, including use of a domain that is nullable, the `NOT NULL` constraint can be included if needed.

`CHARACTER SET` and `COLLATE` clauses

Unless specified, the character set and collation sequence of a string variable will be the database defaults. A `CHARACTER SET` clause can be included, if required, to handle string data that is going to be in a different character set. A valid collation sequence (`COLLATE` clause) can also be included, with or without the character set clause.

Initializing a Variable

Local variables are `NULL` when execution of the module begins. They can be initialized so that a starting or default value is available when they are first referenced. The `DEFAULT <initvalue>` form can be used, or just the assignment operator, '=': `= <initvalue>`. The value can be any type-compatible literal or context variable, including `NULL`.

Be sure to use this clause for any variables that have a `NOT NULL` constraint and do not otherwise have a default value available.

Examples of various ways to declare local variables

```
CREATE OR ALTER PROCEDURE SOME_PROC
AS
  -- Declaring a variable of the INT type
  DECLARE I INT;
  -- Declaring a variable of the INT type that does not allow NULL
  DECLARE VARIABLE J INT NOT NULL;
  -- Declaring a variable of the INT type with the default value of 0
  DECLARE VARIABLE K INT DEFAULT 0;
  -- Declaring a variable of the INT type with the default value of 1
  DECLARE VARIABLE L INT = 1;
  -- Declaring a variable based on the COUNTRYNAME domain
  DECLARE FARM_COUNTRY COUNTRYNAME;
  -- Declaring a variable of the type equal to the COUNTRYNAME domain
  DECLARE FROM_COUNTRY TYPE OF COUNTRYNAME;
  -- Declaring a variable with the type of the CAPITAL column in the COUNTRY table
  DECLARE CAPITAL TYPE OF COLUMN COUNTRY.CAPITAL;
BEGIN
  /* PSQL statements */
END
```

See also

Data Types and Subtypes, Custom Data Types — Domains, `CREATE DOMAIN`

7.7.4. DECLARE .. CURSOR

Used for

Declaring a named cursor

Available in

PSQL

Syntax

```
DECLARE [VARIABLE] cursor_name
  [[NO] SCROLL] CURSOR
  FOR (<select>);
```

Table 99. DECLARE ⋯ CURSOR Statement Parameters

Argument	Description
cursor_name	Cursor name
select	SELECT statement

The DECLARE ⋯ CURSOR ⋯ FOR statement binds a named cursor to the result set obtained in the SELECT statement specified in the FOR clause. In the body code, the cursor can be opened, used to iterate row-by-row through the result set, and closed. While the cursor is open, the code can perform positioned updates and deletes using the WHERE CURRENT OF in the UPDATE or DELETE statement.

Syntactically, the DECLARE ⋯ CURSOR statement is a special case of DECLARE VARIABLE.

Forward-Only and Scrollable Cursors

The cursor can be forward-only (unidirectional) or scrollable. The optional clause SCROLL makes the cursor scrollable, the NO SCROLL clause, forward-only. By default, cursors are forward-only.

Forward-only cursors can — as the name implies — only move forward in the dataset. Forward-only cursors only support the FETCH [NEXT FROM] statement, other commands raise an error. Scrollable cursors allow you to move not only forward in the dataset, but also back, asl well as *N* positions relative to the current position.

Scrollable cursors are materialized as a temporary dataset, as such, they consume additional memory or disk space, so use them only when you really need them.

Cursor Idiosyncrasies

- The optional FOR UPDATE clause can be included in the SELECT statement, but its absence does not prevent successful execution of a positioned update or delete
- Care should be taken to ensure that the names of declared cursors do not conflict with any names used subsequently in statements for AS CURSOR clauses

- If the cursor is needed only to walk the result set, it is nearly always easier and less error-prone to use a `FOR SELECT` statement with the `AS CURSOR` clause. Declared cursors must be explicitly opened, used to fetch data, and closed. The context variable `ROW_COUNT` has to be checked after each fetch and, if its value is zero, the loop has to be terminated. A `FOR SELECT` statement does this automatically.

  Nevertheless, declared cursors provide a high level of control over sequential events and allow several cursors to be managed in parallel.

- The `SELECT` statement may contain parameters. For instance:

```
SELECT NAME || :SFX FROM NAMES WHERE NUMBER = :NUM
```

  Each parameter has to have been declared beforehand as a PSQL variable, even if they originate as input and output parameters. When the cursor is opened, the parameter is assigned the current value of the variable.

Unstable Variables and Cursors

If the value of the PSQL variable used in the `SELECT` statement of the cursor changes during the execution of the loop, then its new value may — but not always — be used when selecting the next rows. It is better to avoid such situations. If you really need this behaviour, then you should thoroughly test your code and make sure you understand how changes to the variable affect the query results.

Note particularly that the behaviour may depend on the query plan, specifically on the indexes being used. Currently, there are no strict rules for this behaviour, and this may change in future versions of Firebird.

Examples Using Named Cursors

1. Declaring a named cursor in the trigger.

```
CREATE OR ALTER TRIGGER TBU_STOCK
  BEFORE UPDATE ON STOCK
AS
  DECLARE C_COUNTRY CURSOR FOR (
    SELECT
      COUNTRY,
      CAPITAL
    FROM COUNTRY
  );
BEGIN
  /* PSQL statements */
END
```

2. Declaring a scrollable cursor

```
EXECUTE BLOCK
  RETURNS (
    N INT,
    RNAME CHAR(63))
AS
  - Declaring a scrollable cursor
  DECLARE C SCROLL CURSOR FOR (
    SELECT
      ROW_NUMBER() OVER (ORDER BY RDB$RELATION_NAME) AS N,
      RDB$RELATION_NAME
    FROM RDB$RELATIONS
    ORDER BY RDB$RELATION_NAME);
BEGIN
  / * PSQL statements * /
END
```

3. A collection of scripts for creating views with a PSQL block using named cursors.

```
EXECUTE BLOCK
RETURNS (
  SCRIPT BLOB SUB_TYPE TEXT)
AS
  DECLARE VARIABLE FIELDS VARCHAR(8191);
  DECLARE VARIABLE FIELD_NAME TYPE OF RDB$FIELD_NAME;
  DECLARE VARIABLE RELATION RDB$RELATION_NAME;
  DECLARE VARIABLE SOURCE TYPE OF COLUMN RDB$RELATIONS.RDB$VIEW_SOURCE;
  DECLARE VARIABLE CUR_R CURSOR FOR (
    SELECT
      RDB$RELATION_NAME,
      RDB$VIEW_SOURCE
    FROM
      RDB$RELATIONS
    WHERE
      RDB$VIEW_SOURCE IS NOT NULL);
  -- Declaring a named cursor where
  -- a local variable is used
  DECLARE CUR_F CURSOR FOR (
    SELECT
      RDB$FIELD_NAME
    FROM
      RDB$RELATION_FIELDS
    WHERE
      -- It is important that the variable must be declared earlier
      RDB$RELATION_NAME = :RELATION);
BEGIN
  OPEN CUR_R;
  WHILE (1 = 1) DO
  BEGIN
    FETCH CUR_R
```

```
    INTO :RELATION, :SOURCE;
    IF (ROW_COUNT = 0) THEN
      LEAVE;

    FIELDS = NULL;
    -- The CUR_F cursor will use the value
    -- of the RELATION variable initiated above
    OPEN CUR_F;
    WHILE (1 = 1) DO
    BEGIN
      FETCH CUR_F
      INTO :FIELD_NAME;
      IF (ROW_COUNT = 0) THEN
        LEAVE;
      IF (FIELDS IS NULL) THEN
        FIELDS = TRIM(FIELD_NAME);
      ELSE
        FIELDS = FIELDS || ', ' || TRIM(FIELD_NAME);
    END
    CLOSE CUR_F;

    SCRIPT = 'CREATE VIEW ' || RELATION;

    IF (FIELDS IS NOT NULL) THEN
      SCRIPT = SCRIPT || ' (' || FIELDS || ')';

    SCRIPT = SCRIPT || ' AS ' || ASCII_CHAR(13);
    SCRIPT = SCRIPT || SOURCE;

    SUSPEND;
  END
  CLOSE CUR_R;
END
```

See also

OPEN, FETCH, CLOSE

7.7.5. DECLARE FUNCTION

Used for

Declaring a sub-function

Available in

PSQL

Syntax

```
<subfunc-forward> ::= <subfunc-header>;

<subfunc-def> ::= <subfunc-header> <psql-module-body>
```

```
<subfunc-header>  ::=
  DECLARE FUNCTION subfuncname [ ( [ <in_params> ] ) ]
  RETURNS <domain_or_non_array_type> [COLLATE collation]
  [DETERMINISTIC]

<in_params> ::=
  !! See CREATE FUNCTION Syntax !!

<domain_or_non_array_type> ::=
  !! See Scalar Data Types Syntax !!

<psql-module-body> ::=
  !! See Syntax of Module Body !!
```

Table 100. `DECLARE FUNCTION` *Statement Parameters*

Argument	Description
subfuncname	Sub-function name
collation	Collation name

The `DECLARE FUNCTION` statement declares a sub-function. A sub-function is only visible to the PSQL module that defined the sub-function.

Sub-functions have a number of restrictions:

- A sub-function cannot be nested in another subroutine. Subroutines are only supported in top-level PSQL modules (stored procedures, stored functions, triggers and anonymous PSQL blocks). This restriction is not enforced by the syntax, but attempts to create nested sub-functions will raise an error "*feature is not supported*" with detail message "*nested sub function*".
- Currently, the sub-function has no direct access to use variables and cursors from its parent module. However, it can access other routines from its parent modules, including recursive calls to itself. In some cases a forward declaration of the routine may be necessary.

A sub-function can be forward declared to resolve mutual dependencies between subroutine, and must be followed by its actual definition. When a sub-function is forward declared and has parameters with default values, the default values should only be specified in the forward declaration, and should not be repeated in *subfunc_def*.

Declaring a sub-function with the same name as a stored function will hide that stored function from your module. It will not be possible to call that stored function.

Contrary to `DECLARE [VARIABLE]`, a `DECLARE FUNCTION` is not terminated by a semicolon. The `END` of its main `BEGIN ⋯ END` block is considered its terminator.

Examples of Sub-Functions

1. Subfunction within a stored function

```
CREATE OR ALTER FUNCTION FUNC1 (n1 INTEGER, n2 INTEGER)
  RETURNS INTEGER
AS
- Subfunction
  DECLARE FUNCTION SUBFUNC (n1 INTEGER, n2 INTEGER)
    RETURNS INTEGER
  AS
  BEGIN
    RETURN n1 + n2;
  END
BEGIN
  RETURN SUBFUNC (n1, n2);
END
```

2. Recursive function call

```
execute block returns (i integer, o integer)
as
    -- Recursive function without forward declaration.
    declare function fibonacci(n integer) returns integer
    as
    begin
      if (n = 0 or n = 1) then
       return n;
     else
       return fibonacci(n - 1) + fibonacci(n - 2);
    end
begin
  i = 0;

  while (i < 10)
  do
  begin
    o = fibonacci(i);
    suspend;
    i = i + 1;
  end
end
```

See also

DECLARE PROCEDURE, CREATE FUNCTION

7.7.6. DECLARE PROCEDURE

Used for

Declaring a sub-procedure

Available in

PSQL

Syntax

```
<subproc-forward> ::= <subproc-header>;

<subproc-def> ::= <subproc-header> <psql-module-body>

<subproc-header>  ::=
DECLARE subprocname [ ( [ <in_params> ] ) ]
  [RETURNS (<out_params>)]

<in_params> ::=
  !! See CREATE PROCEDURE Syntax !!

<domain_or_non_array_type> ::=
  !! See Scalar Data Types Syntax !!

<psql-module-body> ::=
  !! See Syntax of Module Body !!
```

Table 101. DECLARE PROCEDURE *Statement Parameters*

Argument	Description
subprocname	Sub-procedure name
collation	Collation name

The DECLARE PROCEDURE statement declares a sub-procedure. A sub-procedure is only visible to the PSQL module that defined the sub-procedure.

Sub-procedures have a number of restrictions:

- A sub-procedure cannot be nested in another subroutine. Subroutines are only supported in top-level PSQL modules (stored procedures, stored functions, triggers and anonymous PSQL blocks). This restriction is not enforced by the syntax, but attempts to create nested sub-procedures will raise an error "*feature is not supported*" with detail message "*nested sub procedure*".
- Currently, the sub-procedure has no direct access to use variables and cursors from its parent module. It can access other routines from its parent modules. In some cases a forward declaration may be necessary.

A sub-procedure can be forward declared to resolve mutual dependencies between subroutines, and must be followed by its actual definition. When a sub-procedure is forward declared and has

parameters with default values, the default values should only be specified in the forward declaration, and should not be repeated in *subproc_def*.

Declaring a sub-procedure with the same name as a stored procedure, table or view will hide that stored procedure, table or view from your module. It will not be possible to call that stored procedure, table or view.

Contrary to `DECLARE [VARIABLE]`, a `DECLARE PROCEDURE` is not terminated by a semicolon. The `END` of its main `BEGIN ⋯ END` block is considered its terminator.

Examples of Sub-Procedures

1. Subroutines in `EXECUTE BLOCK`

```
EXECUTE BLOCK
  RETURNS (name VARCHAR(63))
AS
  -- Sub-procedure returning a list of tables
  DECLARE PROCEDURE get_tables
    RETURNS (table_name VARCHAR(63))
  AS
  BEGIN
    FOR SELECT RDB$RELATION_NAME
      FROM RDB$RELATIONS
      WHERE RDB$VIEW_BLR IS NULL
      INTO table_name
    DO SUSPEND;
  END
  -- Sub-procedure returning a list of views
  DECLARE PROCEDURE get_views
    RETURNS (view_name VARCHAR(63))
  AS
  BEGIN
    FOR SELECT RDB$RELATION_NAME
      FROM RDB$RELATIONS
      WHERE RDB$VIEW_BLR IS NOT NULL
      INTO view_name
    DO SUSPEND;
  END
BEGIN
  FOR SELECT table_name
    FROM get_tables
    UNION ALL
    SELECT view_name
    FROM get_views
    INTO name
  DO SUSPEND;
END
```

2. With forward declaration and parameter with default value

```
execute block returns (o integer)
as
    -- Forward declaration of P1.
    declare procedure p1(i integer = 1) returns (o integer);

    -- Forward declaration of P2.
    declare procedure p2(i integer) returns (o integer);

    -- Implementation of P1 should not re-declare parameter default value.
    declare procedure p1(i integer) returns (o integer)
    as
    begin
        execute procedure p2(i) returning_values o;
    end

    declare procedure p2(i integer) returns (o integer)
    as
    begin
        o = i;
    end
begin
    execute procedure p1 returning_values o;
    suspend;
end
```

See also

DECLARE FUNCTION, CREATE PROCEDURE

7.7.7. BEGIN ⋯ END

Used for

Delimiting a block of statements

Available in

PSQL

Syntax

```
<block> ::=
  BEGIN
    [<compound_statement> ...]
    [<when_do> ...]
  END

<compound_statement> ::= {<block> | <statement>}

<when_do> ::=
```

```
!! See WHEN ... DO !!
```

The BEGIN ⋯ END construct is a two-part statement that wraps a block of statements that are executed as one unit of code. Each block starts with the half-statement BEGIN and ends with the other half-statement END. Blocks can be nested a maximum depth of 512 nested blocks. A block can be empty, allowing them to act as stubs, without the need to write dummy statements.

For error handling, you can add one or more WHEN ⋯ DO statements immediately before END. Other statements are not allowed after WHEN ⋯ DO.

The BEGIN ⋯ END itself should not be followed by a statement terminator (semicolon). However, when defining or altering a PSQL module in the *isql* utility, that application requires that the last END statement be followed by its own terminator character, that was previously switched — using SET TERM — to some string other than a semicolon. That terminator is not part of the PSQL syntax.

The final, or outermost, END statement in a trigger terminates the trigger. What the final END statement does in a stored procedure depends on the type of procedure:

- In a selectable procedure, the final END statement returns control to the caller, returning SQLCODE 100, indicating that there are no more rows to retrieve
- In an executable procedure, the final END statement returns control to the caller, along with the current values of any output parameters defined.

BEGIN ⋯ END Examples

A sample procedure from the employee.fdb *database, showing simple usage of* BEGIN⋯END *blocks:*

```
SET TERM ^;
CREATE OR ALTER PROCEDURE DEPT_BUDGET (
  DNO CHAR(3))
RETURNS (
  TOT DECIMAL(12,2))
AS
  DECLARE VARIABLE SUMB DECIMAL(12,2);
  DECLARE VARIABLE RDNO CHAR(3);
  DECLARE VARIABLE CNT  INTEGER;
BEGIN
  TOT = 0;

  SELECT BUDGET
  FROM DEPARTMENT
  WHERE DEPT_NO = :DNO
  INTO :TOT;

  SELECT COUNT(BUDGET)
  FROM DEPARTMENT
  WHERE HEAD_DEPT = :DNO
  INTO :CNT;

  IF (CNT = 0) THEN
```

```
    SUSPEND;

  FOR SELECT DEPT_NO
    FROM DEPARTMENT
    WHERE HEAD_DEPT = :DNO
    INTO :RDNO
  DO
  BEGIN
    EXECUTE PROCEDURE DEPT_BUDGET(:RDNO)
      RETURNING_VALUES :SUMB;
    TOT = TOT + SUMB;
  END

  SUSPEND;
END^
SET TERM ;^
```

See also

EXIT, SET TERM, WHEN ⋯ DO

7.7.8. IF ⋯ THEN ⋯ ELSE

Used for

Conditional branching

Available in

PSQL

Syntax

```
IF (<condition>)
  THEN <compound_statement>
  [ELSE <compound_statement>]
```

Table 102. IF ⋯ THEN ⋯ ELSE *Parameters*

Argument	Description
condition	A logical condition returning TRUE, FALSE or UNKNOWN
compound_statement	A single statement, or two or more statements wrapped in BEGIN ⋯ END

The conditional branch statement IF ⋯ THEN is used to branch the execution process in a PSQL module. The condition is always enclosed in parentheses. If the condition returns the value TRUE, execution branches to the statement or the block of statements after the keyword THEN. If an ELSE is present, and the condition returns FALSE or UNKNOWN, execution branches to the statement or the block of statements after it.

Multi-Branch Decisions

PSQL does not provide more advanced multi-branch jumps, such as `CASE` or `SWITCH`. However, it is possible to chain `IF ⋯ THEN ⋯ ELSE` statements, see the example section below. Alternatively, the `CASE` statement from DSQL is available in PSQL and is able to satisfy at least some use cases in the manner of a switch:

```
CASE <test_expr>
  WHEN <expr> THEN <result>
  [WHEN <expr> THEN <result> ...]
  [ELSE <defaultresult>]
END

CASE
  WHEN <bool_expr> THEN <result>
  [WHEN <bool_expr> THEN <result> ...]
  [ELSE <defaultresult>]
END
```

Example in PSQL

```
...
C = CASE
      WHEN A=2 THEN 1
      WHEN A=1 THEN 3
      ELSE 0
    END;
...
```

`IF` Examples

1. An example using the `IF` statement. Assume that the `FIRST`, `LINE2` and `LAST` variables were declared earlier.

```
...
IF (FIRST IS NOT NULL) THEN
  LINE2 = FIRST || ' ' || LAST;
ELSE
  LINE2 = LAST;
...
```

2. Given `IF ⋯ THEN ⋯ ELSE` is a statement, it is possible to chain them together. Assume that the `INT_VALUE` and `STRING_VALUE` variables were declared earlier.

```
IF (INT_VALUE = 1) THEN
```

```
    STRING_VALUE = 'one';
  ELSE IF (INT_VALUE = 2) THEN
    STRING_VALUE = 'two';
  ELSE IF (INT_VALUE = 3) THEN
    STRING_VALUE = 'three';
  ELSE
    STRING_VALUE = 'too much';
```

This specific example can be replaced with a simple `CASE` or the `DECODE` function.

See also

`WHILE ⋯ DO`, `CASE`

7.7.9. WHILE ⋯ DO

Used for

Looping constructs

Available in

PSQL

Syntax

```
[label:]
WHILE <condition> DO
  <compound_statement>
```

Table 103. `WHILE ⋯ DO` Parameters

Argument	Description
label	Optional label for `LEAVE` and `CONTINUE`. Follows the rules for identifiers.
condition	A logical condition returning TRUE, FALSE or UNKNOWN
compound_statement	A single statement, or two or more statements wrapped in `BEGIN ⋯ END`

A `WHILE` statement implements the looping construct in PSQL. The statement or the block of statements will be executed until the condition returns TRUE. Loops can be nested to any depth.

`WHILE ⋯ DO` Examples

A procedure calculating the sum of numbers from 1 to I shows how the looping construct is used.

```
CREATE PROCEDURE SUM_INT (I INTEGER)
RETURNS (S INTEGER)
AS
BEGIN
  s = 0;
  WHILE (i > 0) DO
  BEGIN
```

```
    s = s + i;
    i = i - 1;
  END
END
```

Executing the procedure in *isql*:

```
EXECUTE PROCEDURE SUM_INT(4);
```

the result is:

```
S
==========
10
```

See also

IF ⋯ THEN ⋯ ELSE, BREAK, LEAVE, CONTINUE, EXIT, FOR SELECT, FOR EXECUTE STATEMENT

7.7.10. BREAK

Used for

Exiting a loop

Available in

PSQL

Syntax

```
[label:]
<loop_stmt>
BEGIN
  ...
  BREAK;
  ...
END

<loop_stmt> ::=
    FOR <select_stmt> INTO <var_list> DO
  | FOR EXECUTE STATEMENT ... INTO <var_list> DO
  | WHILE (<condition>)} DO
```

Table 104. BREAK *Statement Parameters*

Argument	Description
label	Label
select_stmt	SELECT statement

Argument	Description
condition	A logical condition returning TRUE, FALSE or UNKNOWN

The BREAK statement immediately terminates the inner loop of a WHILE or FOR looping statement. Code continues to be executed from the first statement after the terminated loop block.

BREAK is similar to LEAVE, except it doesn't support a label.

See also
LEAVE

7.7.11. LEAVE

Used for

Exiting a loop

Available in

PSQL

Syntax

```
[label:]
<loop_stmt>
BEGIN
  ...
  LEAVE [label];
  ...
END

<loop_stmt> ::=
    FOR <select_stmt> INTO <var_list> DO
  | FOR EXECUTE STATEMENT ... INTO <var_list> DO
  | WHILE (<condition>)} DO
```

Table 105. LEAVE Statement Parameters

Argument	Description
label	Label
select_stmt	SELECT statement
condition	A logical condition returning TRUE, FALSE or UNKNOWN

The LEAVE statement immediately terminates the inner loop of a WHILE or FOR looping statement. Using the optional *label* parameter, LEAVE can also exit an outer loop, that is, the loop labelled with *label*. Code continues to be executed from the first statement after the terminated loop block.

LEAVE Examples

1. Leaving a loop if an error occurs on an insert into the NUMBERS table. The code continues to be

executed from the line `C = 0`.

```
...
WHILE (B < 10) DO
BEGIN
  INSERT INTO NUMBERS(B)
  VALUES (:B);
  B = B + 1;
  WHEN ANY DO
  BEGIN
    EXECUTE PROCEDURE LOG_ERROR (
      CURRENT_TIMESTAMP,
      'ERROR IN B LOOP');
    LEAVE;
  END
END
C = 0;
...
```

2. An example using labels in the `LEAVE` statement. `LEAVE LOOPA` terminates the outer loop and `LEAVE LOOPB` terminates the inner loop. Note that the plain `LEAVE` statement would be enough to terminate the inner loop.

```
...
STMT1 = 'SELECT NAME FROM FARMS';
LOOPA:
FOR EXECUTE STATEMENT :STMT1
INTO :FARM DO
BEGIN
  STMT2 = 'SELECT NAME ' || 'FROM ANIMALS WHERE FARM = ''';
  LOOPB:
  FOR EXECUTE STATEMENT :STMT2 || :FARM || ''''
  INTO :ANIMAL DO
  BEGIN
    IF (ANIMAL = 'FLUFFY') THEN
      LEAVE LOOPB;
    ELSE IF (ANIMAL = FARM) THEN
      LEAVE LOOPA;
    ELSE
      SUSPEND;
  END
END
...
```

See also

`BREAK`, `CONTINUE`, `EXIT`

7.7.12. CONTINUE

Used for

Continuing with the next iteration of a loop

Available in

PSQL

Syntax

```
[label:]
<loop_stmt>
BEGIN
  ...
  CONTINUE [label];
  ...
END

<loop_stmt> ::=
    FOR <select_stmt> INTO <var_list> DO
  | FOR EXECUTE STATEMENT ... INTO <var_list> DO
  | WHILE (<condition>)} DO
```

Table 106. CONTINUE *Statement Parameters*

Argument	Description
label	Label
select_stmt	SELECT statement
condition	A logical condition returning TRUE, FALSE or UNKNOWN

The CONTINUE statement skips the remainder of the current block of a loop and starts the next iteration of the current WHILE or FOR loop. Using the optional *label* parameter, CONTINUE can also start the next iteration of an outer loop, that is, the loop labelled with *label*.

CONTINUE Examples

Using the CONTINUE *statement*

```
FOR SELECT A, D
  FROM ATABLE INTO achar, ddate
DO
BEGIN
  IF (ddate < current_date - 30) THEN
    CONTINUE;
  ELSE
  BEGIN
    /* do stuff */
  END
```

```
END
```

See also

BREAK, LEAVE, EXIT

7.7.13. EXIT

Used for

Terminating module execution

Available in

PSQL

Syntax

```
EXIT;
```

The EXIT statement causes execution of the current PSQL module to jump to the final END statement from any point in the code, thus terminating the program.

Calling EXIT in a function will result in the function returning NULL.

EXIT Examples

Using the EXIT *statement in a selectable procedure*

```
CREATE PROCEDURE GEN_100
  RETURNS (I INTEGER)
AS
BEGIN
  I = 1;
  WHILE (1=1) DO
  BEGIN
    SUSPEND;
    IF (I=100) THEN
      EXIT;
    I = I + 1;
  END
END
```

See also

BREAK, LEAVE, CONTINUE, SUSPEND

7.7.14. SUSPEND

Used for

Passing output to the buffer and suspending execution while waiting for caller to fetch it

Available in

PSQL

Syntax

```
SUSPEND;
```

The SUSPEND statement is used in a selectable stored procedure to pass the values of output parameters to a buffer and suspend execution. Execution remains suspended until the calling application fetches the contents of the buffer. Execution resumes from the statement directly after the SUSPEND statement. In practice, this is likely to be a new iteration of a looping process.

Important Notes

1. The SUSPEND statement can only occur in stored procedures or sub-procedures
2. The presence of the SUSPEND keyword defines a stored procedure as a selectable procedure
3. Applications using interfaces that wrap the API perform the fetches from selectable procedures transparently.
4. If a selectable procedure is executed using EXECUTE PROCEDURE, it behaves as an executable procedure. When a SUSPEND statement is executed in such a stored procedure, it is the same as executing the EXIT statement, resulting in immediate termination of the procedure.
5. SUSPEND"breaks" the atomicity of the block in which it is located. If an error occurs in a selectable procedure, statements executed after the final SUSPEND statement will be rolled back. Statements that executed before the final SUSPEND statement will not be rolled back unless the transaction is rolled back.

SUSPEND Examples

Using the SUSPEND *statement in a selectable procedure*

```
CREATE PROCEDURE GEN_100
  RETURNS (I INTEGER)
AS
BEGIN
  I = 1;
  WHILE (1=1) DO
  BEGIN
    SUSPEND;
    IF (I=100) THEN
      EXIT;
    I = I + 1;
  END
END
```

See also

EXIT

7.7.15. EXECUTE STATEMENT

Used for

Executing dynamically created SQL statements

Available in

PSQL

Syntax

```
<execute_statement> ::= EXECUTE STATEMENT <argument>
  [<option> ...]
  [INTO <variables>];

<argument> ::= <paramless_stmt>
             | (<paramless_stmt>)
             | (<stmt_with_params>) (<param_values>)

<param_values> ::= <named_values> | <positional_values>

<named_values> ::= <named_value> [, <named_value> ...]

<named_value> ::= [EXCESS] paramname := <value_expr>

<positional_values> ::= <value_expr> [, <value_expr> ...]

<option> ::=
    WITH {AUTONOMOUS | COMMON} TRANSACTION
  | WITH CALLER PRIVILEGES
  | AS USER user
  | PASSWORD password
  | ROLE role
  | ON EXTERNAL [DATA SOURCE] <connection_string>

<connection_string> ::=
  !! See <filespec> in the CREATE DATABASE syntax !!

<variables> ::= [:]varname [, [:]varname ...]
```

Table 107. EXECUTE STATEMENT *Statement Parameters*

Argument	Description
paramless_stmt	Literal string or variable containing a non-parameterized SQL query
stmt_with_params	Literal string or variable containing a parameterized SQL query
paramname	SQL query parameter name
value_expr	SQL expression resolving to a value

Argument	Description
user	Username. It can be a string, CURRENT_USER or a string variable
password	Password. It can be a string or a string variable
role	Role. It can be a string, CURRENT_ROLE or a string variable
connection_string	Connection string. It can be a string literal or a string variable
varname	Variable

The statement EXECUTE STATEMENT takes a string parameter and executes it as if it were a DSQL statement. If the statement returns data, it can be passed to local variables by way of an INTO clause.

EXECUTE STATEMENT can only produce a single row of data. Statements producing multiple rows of data must be executed with FOR EXECUTE STATEMENT.

Parameterized Statements

You can use parameters — either named or positional — in the DSQL statement string. Each parameter must be assigned a value.

Special Rules for Parameterized Statements

1. Named and positional parameters cannot be mixed in one query
2. Each parameter must be used in the statement text.

   To relax this rule, named parameters can be prefixed with the keyword EXCESS to indicate that the parameter may be absent from the statement text. This option is useful for dynamically generated statements that conditionally include or exclude certain parameters.

3. If the statement has parameters, they must be enclosed in parentheses when EXECUTE STATEMENT is called, regardless of whether they come directly as strings, as variable names or as expressions
4. Each named parameter must be prefixed by a colon (':') in the statement string itself, but not when the parameter is assigned a value
5. Positional parameters must be assigned their values in the same order as they appear in the query text
6. The assignment operator for parameters is the special operator ":=", similar to the assignment operator in Pascal
7. Each named parameter can be used in the statement more than once, but its value must be assigned only once
8. With positional parameters, the number of assigned values must match the number of parameter placeholders (question marks) in the statement exactly
9. A named parameter in the statement text can only be a regular identifier (it cannot be a quoted identifier)

Examples of `EXECUTE STATEMENT` with parameters

1. With named parameters:

```
...
DECLARE license_num VARCHAR(15);
DECLARE connect_string VARCHAR (100);
DECLARE stmt VARCHAR (100) =
  'SELECT license
   FROM cars
   WHERE driver = :driver AND location = :loc';
BEGIN
  ...
  SELECT connstr
  FROM databases
  WHERE cust_id = :id
  INTO connect_string;
  ...
  FOR
    SELECT id
    FROM drivers
    INTO current_driver
  DO
  BEGIN
    FOR
      SELECT location
      FROM driver_locations
      WHERE driver_id = :current_driver
      INTO current_location
    DO
    BEGIN
      ...
      EXECUTE STATEMENT (stmt)
        (driver := current_driver,
         loc := current_location)
      ON EXTERNAL connect_string
      INTO license_num;
      ...
```

2. The same code with positional parameters:

```
DECLARE license_num VARCHAR (15);
DECLARE connect_string VARCHAR (100);
DECLARE stmt VARCHAR (100) =
  'SELECT license
   FROM cars
   WHERE driver = ? AND location = ?';
BEGIN
  ...
  SELECT connstr
```

```
    FROM databases
    WHERE cust_id = :id
    into connect_string;
    ...
    FOR
      SELECT id
      FROM drivers
      INTO current_driver
    DO
    BEGIN
      FOR
        SELECT location
        FROM driver_locations
        WHERE driver_id = :current_driver
        INTO current_location
      DO
      BEGIN
        ...
        EXECUTE STATEMENT (stmt)
          (current_driver, current_location)
        ON EXTERNAL connect_string
        INTO license_num;
        ...
```

3. Use of `EXCESS` to allow named parameters to be unused (note: this is a `FOR EXECUTE STATEMENT`):

```
CREATE PROCEDURE P_EXCESS (A_ID INT, A_TRAN INT = NULL, A_CONN INT = NULL)
  RETURNS (ID INT, TRAN INT, CONN INT)
AS
DECLARE S VARCHAR(255);
DECLARE W VARCHAR(255) = '';
BEGIN
  S = 'SELECT * FROM TTT WHERE ID = :ID';

  IF (A_TRAN IS NOT NULL)
  THEN W = W || ' AND TRAN = :a';

  IF (A_CONN IS NOT NULL)
  THEN W = W || ' AND CONN = :b';

  IF (W <> '')
  THEN S = S || W;

  -- could raise error if TRAN or CONN is null
  -- FOR EXECUTE STATEMENT (:S) (a := :A_TRAN, b := A_CONN, id := A_ID)

  -- OK in all cases
  FOR EXECUTE STATEMENT (:S) (EXCESS a := :A_TRAN, EXCESS b := A_CONN, id := A_ID)
    INTO :ID, :TRAN, :CONN
      DO SUSPEND;
```

```
END
```

WITH {AUTONOMOUS | COMMON} TRANSACTION

By default, the executed SQL statement runs within the current transaction. Using `WITH AUTONOMOUS TRANSACTION` causes a separate transaction to be started. This separate transaction will be committed when the statement was executed without errors and rolled back otherwise. See `IN AUTONOMOUS TRANSACTION` for more details on autonomous transactions.

The clause `WITH COMMON TRANSACTION` uses the current transaction whenever possible; this is the default behaviour. If the statement must run in a separate connection, an already started transaction within that connection is used, if available. Otherwise, a new transaction is started with the same parameters as the current transaction. Any new transactions started under the "`COMMON`" regime are committed or rolled back with the current transaction.

WITH CALLER PRIVILEGES

By default, the SQL statement is executed with the privileges of the current user. Specifying `WITH CALLER PRIVILEGES` combines the privileges of the calling procedure or trigger with those of the user, just as if the statement were executed directly by the routine. `WITH CALLER PRIVILEGES` has no effect if the `ON EXTERNAL` clause is also present.

ON EXTERNAL [DATA SOURCE]

With `ON EXTERNAL [DATA SOURCE]`, the SQL statement is executed in a separate connection to the same or another database, possibly even on another server. If *connection_string* is NULL or "`''`" (empty string), the entire `ON EXTERNAL [DATA SOURCE]` clause is considered absent, and the statement is executed against the current database.

Connection Pooling

- External connections made by statements `WITH COMMON TRANSACTION` (the default) will remain open until the current transaction ends. They can be reused by subsequent calls to `EXECUTE STATEMENT`, but only if *connection_string* is exactly the same, including case
- External connections made by statements `WITH AUTONOMOUS TRANSACTION` are closed as soon as the statement has been executed
- Statements using `WITH AUTONOMOUS TRANSACTION` can and will re-use connections that were opened earlier by statements `WITH COMMON TRANSACTION`. If this happens, the reused connection will be left open after the statement has been executed. (It must be, because it has at least one active transaction!)

Transaction Pooling

- If `WITH COMMON TRANSACTION` is in effect, transactions will be reused as much as possible. They will be committed or rolled back together with the current transaction
- If `WITH AUTONOMOUS TRANSACTION` is specified, a fresh transaction will always be started for the statement. This transaction will be committed or rolled back immediately after the statement's execution

Exception Handling

When `ON EXTERNAL` is used, the extra connection is always made via a so-called external provider, even if the connection is to the current database. One of the consequences is that exceptions cannot be caught in the usual way. Every exception caused by the statement is wrapped in either an `eds_connection` or an `eds_statement` error. In order to catch them in your PSQL code, you have to use `WHEN GDSCODE eds_connection`, `WHEN GDSCODE eds_statement` or `WHEN ANY`.

Without `ON EXTERNAL`, exceptions are caught in the usual way, even if an extra connection is made to the current database.

Miscellaneous Notes

- The character set used for the external connection is the same as that for the current connection
- Two-phase commits are not supported

`AS USER`, `PASSWORD` and `ROLE`

The optional `AS USER`, `PASSWORD` and `ROLE` clauses allow specification of which user will execute the SQL statement and with which role. The method of user login, and whether a separate connection is opened, depends on the presence and values of the `ON EXTERNAL [DATA SOURCE]`, `AS USER`, `PASSWORD` and `ROLE` clauses:

- If `ON EXTERNAL` is present, a new connection is always opened, and:
  - If at least one of `AS USER`, `PASSWORD` and `ROLE` is present, native authentication is attempted with the given parameter values (locally or remotely, depending on *connection_string*). No defaults are used for missing parameters
  - If all three are absent, and *connection_string* contains no hostname, then the new connection is established on the local server with the same user and role as the current connection. The term 'local' means “on the same machine as the server” here. This is not necessarily the location of the client
  - If all three are absent, and *connection_string* contains a hostname, then trusted authentication is attempted on the remote host (again, 'remote' from the perspective of the server). If this succeeds, the remote operating system will provide the username (usually the operating system account under which the Firebird process runs)
- If `ON EXTERNAL` is absent:
  - If at least one of `AS USER`, `PASSWORD` and `ROLE` is present, a new connection to the current database is opened with the supplied parameter values. No defaults are used for missing parameters
  - If all three are absent, the statement is executed within the current connection

If a parameter value is NULL or “''” (empty string), the entire parameter is considered absent. Additionally, `AS USER` is considered absent if its value is equal to `CURRENT_USER`, and `ROLE` if it is the same as `CURRENT_ROLE`.

Caveats with EXECUTE STATEMENT

1. There is no way to validate the syntax of the enclosed statement
2. There are no dependency checks to discover whether tables or columns have been dropped
3. Even though the performance in loops has been significantly improved in Firebird 2.5, execution is still considerably slower than when the same statements are executed directly
4. Return values are strictly checked for data type in order to avoid unpredictable type-casting exceptions. For example, the string `'1234'` would convert to an integer, 1234, but `'abc'` would give a conversion error

All in all, this feature is meant to be used very cautiously, and you should always take the caveats into account. If you can achieve the same result with PSQL and/or DSQL, it will almost always be preferable.

See also

FOR EXECUTE STATEMENT

7.7.16. FOR SELECT

Used for

Looping row-by-row through a selected result set

Available in

PSQL

Syntax

```
[label:]
FOR <select_stmt> [AS CURSOR cursor_name]
  DO <compound_statement>
```

Table 108. FOR SELECT Statement Parameters

Argument	Description
label	Optional label for LEAVE and CONTINUE. Follows the rules for identifiers.
select_stmt	SELECT statement
cursor_name	Cursor name. It must be unique among cursor names in the PSQL module (stored procedure, stored function, trigger or PSQL block)
compound_statement	A single statement, or a block of statements wrapped in BEGIN…END, that performs all the processing for this FOR loop

The FOR SELECT statement

- retrieves each row sequentially from the result set, and executes the statement or block of statements for each row. In each iteration of the loop, the field values of the current row are copied into pre-declared variables.

Including the AS CURSOR clause enables positioned deletes and updates to be performed — see notes below

- can embed other FOR SELECT statements
- can contain named parameters that must be previously declared in the DECLARE VARIABLE statement or exist as input or output parameters of the procedure
- requires an INTO clause at the end of the SELECT ... FROM ... specification. In each iteration of the loop, the field values of the current row are copied to the list of variables specified in the INTO clause. The loop repeats until all rows are retrieved, after which it terminates
- can be terminated before all rows are retrieved by using a BREAK, LEAVE or EXIT statement

The Undeclared Cursor

The optional AS CURSOR clause surfaces the set in the FOR SELECT structure as an undeclared, named cursor that can be operated on using the WHERE CURRENT OF clause inside the statement or block following the DO command, in order to delete or update the current row before execution moves to the next row. In addition, it is possible to use the cursor name as a record variable (similar to OLD and NEW in triggers), allowing access to the columns of the result set (i.e. *cursor_name.columnname*).

Rules for Cursor Variables

- When accessing a cursor variable in a DML statement, the colon prefix can be added before the cursor name (i.e. `:cursor_name.columnname`) for disambiguation, similar to variables.

  The cursor variable can be referenced without colon prefix, but in that case, depending on the scope of the contexts in the statement, the name may resolve in the statement context instead of to the cursor (e.g. you select from a table with the same name as the cursor).

- Cursor variables are read-only
- In a FOR SELECT statement without an AS CURSOR clause, you must use the INTO clause. If an AS CURSOR clause is specified, the INTO clause is allowed, but optional; you can access the fields through the cursor instead.
- Reading from a cursor variable returns the current field values. This means that an UPDATE statement (with a WHERE CURRENT OF clause) will update not only the table, but also the fields in the cursor variable for subsequent reads. Executing a DELETE statement (with a WHERE CURRENT OF clause) will set all fields in the cursor variable to NULL for subsequent reads

Other points to take into account regarding undeclared cursors:

1. The OPEN, FETCH and CLOSE statements cannot be applied to a cursor surfaced by the AS CURSOR clause
2. The *cursor_name* argument associated with an AS CURSOR clause must not clash with any names created by DECLARE VARIABLE or DECLARE CURSOR statements at the top of the module body, nor with any other cursors surfaced by an AS CURSOR clause
3. The optional FOR UPDATE clause in the SELECT statement is not required for a positioned update

Examples using FOR SELECT

1. A simple loop through query results:

```
CREATE PROCEDURE SHOWNUMS
RETURNS (
  AA INTEGER,
  BB INTEGER,
  SM INTEGER,
  DF INTEGER)
AS
BEGIN
  FOR SELECT DISTINCT A, B
      FROM NUMBERS
    ORDER BY A, B
    INTO AA, BB
  DO
  BEGIN
    SM = AA + BB;
    DF = AA - BB;
    SUSPEND;
  END
END
```

2. Nested FOR SELECT loop:

```
CREATE PROCEDURE RELFIELDS
RETURNS (
  RELATION CHAR(32),
  POS INTEGER,
  FIELD CHAR(32))
AS
BEGIN
  FOR SELECT RDB$RELATION_NAME
      FROM RDB$RELATIONS
      ORDER BY 1
      INTO :RELATION
  DO
  BEGIN
    FOR SELECT
          RDB$FIELD_POSITION + 1,
          RDB$FIELD_NAME
        FROM RDB$RELATION_FIELDS
        WHERE
          RDB$RELATION_NAME = :RELATION
        ORDER BY RDB$FIELD_POSITION
        INTO :POS, :FIELD
    DO
    BEGIN
```

```
      IF (POS = 2) THEN
        RELATION = ' "';

      SUSPEND;
    END
  END
END
```

3. Using the `AS CURSOR` clause to surface a cursor for the positioned delete of a record:

```
CREATE PROCEDURE DELTOWN (
  TOWNTODELETE VARCHAR(24))
RETURNS (
  TOWN VARCHAR(24),
  POP INTEGER)
AS
BEGIN
  FOR SELECT TOWN, POP
      FROM TOWNS
      INTO :TOWN, :POP AS CURSOR TCUR
  DO
  BEGIN
    IF (:TOWN = :TOWNTODELETE) THEN
      -- Positional delete
      DELETE FROM TOWNS
      WHERE CURRENT OF TCUR;
    ELSE
      SUSPEND;
  END
END
```

4. Using an implicitly declared cursor as a cursor variable

```
EXECUTE BLOCK
 RETURNS (o CHAR(63))
AS
BEGIN
  FOR SELECT rdb$relation_name AS name
    FROM rdb$relations AS CURSOR c
  DO
  BEGIN
    o = c.name;
    SUSPEND;
  END
END
```

5. Disambiguating cursor variables within queries

```
EXECUTE BLOCK
  RETURNS (o1 CHAR(63), o2 CHAR(63))
AS
BEGIN
  FOR SELECT rdb$relation_name
    FROM rdb$relations
    WHERE
      rdb$relation_name = 'RDB$RELATIONS' AS CURSOR c
  DO
  BEGIN
    FOR SELECT
        -- with a prefix resolves as a cursor
        :c.rdb$relation_name x1,
        -- no prefix as an alias for the rdb$relations table
        c.rdb$relation_name x2
      FROM rdb$relations c
      WHERE
        rdb$relation_name = 'RDB$DATABASE' AS CURSOR d
    DO
    BEGIN
      o1 = d.x1;
      o2 = d.x2;
      SUSPEND;
    END
  END
END
```

See also

`DECLARE .. CURSOR`, `BREAK`, `LEAVE`, `CONTINUE`, `EXIT`, `SELECT`, `UPDATE`, `DELETE`

7.7.17. FOR EXECUTE STATEMENT

Used for

Executing dynamically created SQL statements that return a row set

Available in

PSQL

Syntax

```
[label:]
FOR <execute_statement> DO <compound_statement>
```

Table 109. `FOR EXECUTE STATEMENT` Statement Parameters

Argument	Description
label	Optional label for `LEAVE` and `CONTINUE`. Follows the rules for identifiers.

Argument	Description
execute_stmt	An `EXECUTE STATEMENT` statement
compound_statement	A single statement, or a block of statements wrapped in `BEGIN`…`END`, that performs all the processing for this `FOR` loop

The statement `FOR EXECUTE STATEMENT` is used, in a manner analogous to `FOR SELECT`, to loop through the result set of a dynamically executed query that returns multiple rows.

`FOR EXECUTE STATEMENT` Examples

Executing a dynamically constructed `SELECT` query that returns a data set

```
CREATE PROCEDURE DynamicSampleThree (
   Q_FIELD_NAME VARCHAR(100),
   Q_TABLE_NAME VARCHAR(100)
) RETURNS(
  LINE VARCHAR(32000)
)
AS
  DECLARE VARIABLE P_ONE_LINE VARCHAR(100);
BEGIN
  LINE = '';
  FOR
    EXECUTE STATEMENT
      'SELECT T1.' || :Q_FIELD_NAME ||
      ' FROM ' || :Q_TABLE_NAME || ' T1 '
    INTO :P_ONE_LINE
  DO
    IF (:P_ONE_LINE IS NOT NULL) THEN
      LINE = :LINE || :P_ONE_LINE || ' ';
  SUSPEND;
END
```

See also

`EXECUTE STATEMENT`, `BREAK`, `LEAVE`, `CONTINUE`

7.7.18. OPEN

Used for

Opening a declared cursor

Available in

PSQL

Syntax

```
OPEN cursor_name;
```

Table 110. OPEN Statement Parameter

Argument	Description
cursor_name	Cursor name. A cursor with this name must be previously declared with a DECLARE CURSOR statement

An OPEN statement opens a previously declared cursor, executes its declared SELECT statement, and makes the first record of the result data set ready to fetch. OPEN can be applied only to cursors previously declared in a DECLARE .. CURSOR statement.

If the SELECT statement of the cursor has parameters, they must be declared as local variables or exist as input or output parameters before the cursor is declared. When the cursor is opened, the parameter is assigned the current value of the variable.

OPEN Examples

1. Using the OPEN statement:

```
SET TERM ^;

CREATE OR ALTER PROCEDURE GET_RELATIONS_NAMES
RETURNS (
  RNAME CHAR(63)
)
AS
  DECLARE C CURSOR FOR (
    SELECT RDB$RELATION_NAME
    FROM RDB$RELATIONS);
BEGIN
  OPEN C;
  WHILE (1 = 1) DO
  BEGIN
    FETCH C INTO :RNAME;
    IF (ROW_COUNT = 0) THEN
      LEAVE;
    SUSPEND;
  END
  CLOSE C;
END^

SET TERM ;^
```

2. A collection of scripts for creating views using a PSQL block with named cursors:

```
EXECUTE BLOCK
RETURNS (
  SCRIPT BLOB SUB_TYPE TEXT)
```

```
AS
  DECLARE VARIABLE FIELDS VARCHAR(8191);
  DECLARE VARIABLE FIELD_NAME TYPE OF RDB$FIELD_NAME;
  DECLARE VARIABLE RELATION RDB$RELATION_NAME;
  DECLARE VARIABLE SOURCE TYPE OF COLUMN RDB$RELATIONS.RDB$VIEW_SOURCE;
  -- named cursor
  DECLARE VARIABLE CUR_R CURSOR FOR (
    SELECT
      RDB$RELATION_NAME,
      RDB$VIEW_SOURCE
    FROM
      RDB$RELATIONS
    WHERE
      RDB$VIEW_SOURCE IS NOT NULL);
  -- named cursor with local variable
  DECLARE CUR_F CURSOR FOR (
    SELECT
      RDB$FIELD_NAME
    FROM
      RDB$RELATION_FIELDS
    WHERE
      -- Important! The variable has to be declared earlier
      RDB$RELATION_NAME = :RELATION);
BEGIN
  OPEN CUR_R;
  WHILE (1 = 1) DO
  BEGIN
    FETCH CUR_R
      INTO :RELATION, :SOURCE;
    IF (ROW_COUNT = 0) THEN
      LEAVE;

    FIELDS = NULL;
    -- The CUR_F cursor will use
    -- variable value of RELATION initialized above
    OPEN CUR_F;
    WHILE (1 = 1) DO
    BEGIN
      FETCH CUR_F
        INTO :FIELD_NAME;
      IF (ROW_COUNT = 0) THEN
        LEAVE;
      IF (FIELDS IS NULL) THEN
        FIELDS = TRIM(FIELD_NAME);
      ELSE
        FIELDS = FIELDS || ', ' || TRIM(FIELD_NAME);
    END
    CLOSE CUR_F;

    SCRIPT = 'CREATE VIEW ' || RELATION;
```

```
    IF (FIELDS IS NOT NULL) THEN
      SCRIPT = SCRIPT || ' (' || FIELDS || ')';

    SCRIPT = SCRIPT || ' AS ' || ASCII_CHAR(13);
    SCRIPT = SCRIPT || SOURCE;

    SUSPEND;
  END
  CLOSE CUR_R;
END
```

See also

DECLARE .. CURSOR, FETCH, CLOSE

7.7.19. FETCH

Used for

Fetching successive records from a data set retrieved by a cursor

Available in

PSQL

Syntax

```
FETCH [<fetch_scroll> FROM] cursor_name
  [INTO [:]varname [, [:]varname ...]];

<fetch_scroll> ::=
    NEXT | PRIOR | FIRST | LAST
  | RELATIVE n
  | ABSOLUTE n
```

Table 111. FETCH *Statement Parameters*

Argument	Description
cursor_name	Cursor name. A cursor with this name must be previously declared with a DECLARE ⋯ CURSOR statement and opened by an OPEN statement.
varname	Variable name
n	Integer expression for the number of rows

The FETCH statement fetches the first and successive rows from the result set of the cursor and assigns the column values to PSQL variables. The FETCH statement can be used only with a cursor declared with the DECLARE .. CURSOR statement.

Using the optional *fetch_scroll* part of the FETCH statement, you can specify in which direction and how many rows to advance the cursor position. The NEXT clause can be used for scrollable and forward-only cursors. Other clauses are only supported for scrollable cursors.

The Scroll Options

`NEXT`

moves the cursor one row forward; this is the default

`PRIOR`

moves the cursor one record back

`FIRST`

moves the cursor to the first record.

`LAST`

moves the cursor to the last record

`RELATIVE n`

moves the cursor *n* rows from the current position; positive numbers move forward, negative numbers move backwards; using zero (`0`) will not move the cursor, and `ROW_COUNT` will be set to zero as no new row was fetched.

`ABSOLUTE n`

moves the cursor to the specified row; *n* is an integer expression, where `1` indicates the first row. For negative values, the absolute position is taken from the end of the result set, so `-1` indicates the last row, `-2` the second to last row, etc. A value of zero (`0`) will position before the first row.

The optional `INTO` clause gets data from the current row of the cursor and loads them into PSQL variables. If fetch moved beyond the bounds of the result set, the variables will be set to `NULL`.

It is also possible to use the cursor name as a variable of a row type (similar to `OLD` and `NEW` in triggers), allowing access to the columns of the result set (i.e. *cursor_name.columnname*).

Rules for Cursor Variables

- When accessing a cursor variable in a DML statement, the colon prefix can be added before the cursor name (i.e. `:cursor_name.columnname`) for disambiguation, similar to variables.

  The cursor variable can be referenced without colon prefix, but in that case, depending on the scope of the contexts in the statement, the name may resolve in the statement context instead of to the cursor (e.g. you select from a table with the same name as the cursor).

- Cursor variables are read-only
- In a `FOR SELECT` statement without an `AS CURSOR` clause, you must use the `INTO` clause. If an `AS CURSOR` clause is specified, the `INTO` clause is allowed, but optional; you can access the fields through the cursor instead.
- Reading from a cursor variable returns the current field values. This means that an `UPDATE` statement (with a `WHERE CURRENT OF` clause) will update not only the table, but also the fields in the cursor variable for subsequent reads. Executing a `DELETE` statement (with a `WHERE CURRENT OF` clause) will set all fields in the cursor variable to `NULL` for subsequent reads
- When the cursor is not positioned on a row — it is positioned before the first row, or after the last row — attempts to read from the cursor variable will result in error *"Cursor **cursor_name***

is not positioned in a valid record"

For checking whether all the rows of the result set have been fetched, the context variable `ROW_COUNT` returns the number of rows fetched by the statement. If a record was fetched, then `ROW_COUNT` is one (`1`), otherwise zero (`0`).

`FETCH` Examples

1. Using the `FETCH` statement:

```
CREATE OR ALTER PROCEDURE GET_RELATIONS_NAMES
  RETURNS (RNAME CHAR(63))
AS
  DECLARE C CURSOR FOR (
    SELECT RDB$RELATION_NAME
    FROM RDB$RELATIONS);
BEGIN
  OPEN C;
  WHILE (1 = 1) DO
  BEGIN
    FETCH C INTO RNAME;
    IF (ROW_COUNT = 0) THEN
      LEAVE;
    SUSPEND;
  END
  CLOSE C;
END
```

2. Using the `FETCH` statement with nested cursors:

```
EXECUTE BLOCK
  RETURNS (SCRIPT BLOB SUB_TYPE TEXT)
AS
  DECLARE VARIABLE FIELDS VARCHAR (8191);
  DECLARE VARIABLE FIELD_NAME TYPE OF RDB$FIELD_NAME;
  DECLARE VARIABLE RELATION RDB$RELATION_NAME;
  DECLARE VARIABLE SRC TYPE OF COLUMN RDB$RELATIONS.RDB$VIEW_SOURCE;
  -- Named cursor declaration
  DECLARE VARIABLE CUR_R CURSOR FOR (
    SELECT
      RDB$RELATION_NAME,
      RDB$VIEW_SOURCE
    FROM RDB$RELATIONS
    WHERE RDB$VIEW_SOURCE IS NOT NULL);
  -- Declaring a named cursor in which
  -- a local variable is used
  DECLARE CUR_F CURSOR FOR (
    SELECT RDB$FIELD_NAME
    FROM RDB$RELATION_FIELDS
```

```
    WHERE
    -- It is important that the variable must be declared earlier
      RDB$RELATION_NAME =: RELATION);
  BEGIN
    OPEN CUR_R;
    WHILE (1 = 1) DO
    BEGIN
      FETCH CUR_R INTO RELATION, SRC;
      IF (ROW_COUNT = 0) THEN
        LEAVE;
      FIELDS = NULL;
      -- Cursor CUR_F will use the value
      -- the RELATION variable initialized above
      OPEN CUR_F;
      WHILE (1 = 1) DO
      BEGIN
        FETCH CUR_F INTO FIELD_NAME;
        IF (ROW_COUNT = 0) THEN
          LEAVE;
        IF (FIELDS IS NULL) THEN
          FIELDS = TRIM (FIELD_NAME);
        ELSE
          FIELDS = FIELDS || ',' || TRIM(FIELD_NAME);
      END
      CLOSE CUR_F;
      SCRIPT = 'CREATE VIEW' || RELATION;
      IF (FIELDS IS NOT NULL) THEN
        SCRIPT = SCRIPT || '(' || FIELDS || ')' ;
      SCRIPT = SCRIPT || 'AS' || ASCII_CHAR (13);
      SCRIPT = SCRIPT || SRC;
      SUSPEND;
    END
    CLOSE CUR_R;
  EN
```

3. An example of using the `FETCH` statement with a scrollable cursor

```
EXECUTE BLOCK
  RETURNS (N INT, RNAME CHAR (63))
AS
  DECLARE C SCROLL CURSOR FOR (
    SELECT
      ROW_NUMBER() OVER (ORDER BY RDB$RELATION_NAME) AS N,
      RDB$RELATION_NAME
    FROM RDB$RELATIONS
    ORDER BY RDB$RELATION_NAME);
BEGIN
  OPEN C;
  -- move to the first record (N = 1)
  FETCH FIRST FROM C;
```

```
  RNAME = C.RDB$RELATION_NAME;
  N = C.N;
  SUSPEND;
  -- move 1 record forward (N = 2)
  FETCH NEXT FROM C;
  RNAME = C.RDB$RELATION_NAME;
  N = C.N;
  SUSPEND;
  -- move to the fifth record (N = 5)
  FETCH ABSOLUTE 5 FROM C;
  RNAME = C.RDB$RELATION_NAME;
  N = C.N;
  SUSPEND;
  -- move 1 record backward (N = 4)
  FETCH PRIOR FROM C;
  RNAME = C.RDB$RELATION_NAME;
  N = C.N;
  SUSPEND;
  -- move 3 records forward (N = 7)
  FETCH RELATIVE 3 FROM C;
  RNAME = C.RDB$RELATION_NAME;
  N = C.N;
  SUSPEND;
  -- move back 5 records (N = 2)
  FETCH RELATIVE -5 FROM C;
  RNAME = C.RDB$RELATION_NAME;
  N = C.N;
  SUSPEND;
  -- move to the first record (N = 1)
  FETCH FIRST FROM C;
  RNAME = C.RDB$RELATION_NAME;
  N = C.N;
  SUSPEND;
  -- move to the last entry
  FETCH LAST FROM C;
  RNAME = C.RDB$RELATION_NAME;
  N = C.N;
  SUSPEND;
  CLOSE C;
END
```

See also

DECLARE .. CURSOR, OPEN, CLOSE

7.7.20. CLOSE

Used for

Closing a declared cursor

Available in

PSQL

Syntax

```
CLOSE cursor_name;
```

Table 112. `CLOSE` *Statement Parameter*

Argument	Description
cursor_name	Cursor name. A cursor with this name must be previously declared with a `DECLARE ⋯ CURSOR` statement and opened by an `OPEN` statement

A `CLOSE` statement closes an open cursor. Any cursors that are still open will be automatically closed after the module code completes execution. Only a cursor that was declared with `DECLARE .. CURSOR` can be closed with a `CLOSE` statement.

`CLOSE` Examples

See `FETCH` Examples

See also

`DECLARE .. CURSOR`, `OPEN`, `FETCH`

7.7.21. `IN AUTONOMOUS TRANSACTION`

Used for

Executing a statement or a block of statements in an autonomous transaction

Available in

PSQL

Syntax

```
IN AUTONOMOUS TRANSACTION DO <compound_statement>
```

Table 113. `IN AUTONOMOUS TRANSACTION` *Statement Parameter*

Argument	Description
compound_statement	A single statement, or a block of statements

The `IN AUTONOMOUS TRANSACTION` statement enables execution of a statement or a block of statements in an autonomous transaction. Code running in an autonomous transaction will be committed right after its successful execution, regardless of the status of its parent transaction. This can be used when certain operations must not be rolled back, even if an error occurs in the parent transaction.

An autonomous transaction has the same isolation level as its parent transaction, except for `READ COMMITTED READ CONSISTENCY`. For `READ COMMITTED READ CONSISTENCY`, a `SNAPSHOT` (a.k.a. "`*concurrency*`") transaction is used with the same snapshot number as the outer execution context — that is, the DSQL statement that directly or indirectly invoked the current PSQL module.

Any exception that is thrown in the block of the autonomous transaction code will result in the autonomous transaction being rolled back and all changes made will be undone. If the code executes successfully, the autonomous transaction will be committed.

`IN AUTONOMOUS TRANSACTION` Examples

Using an autonomous transaction in a trigger for the database `ON CONNECT` event, in order to log all connection attempts, including those that failed:

```
CREATE TRIGGER TR_CONNECT ON CONNECT
AS
BEGIN
  -- Logging all attempts to connect to the database
  IN AUTONOMOUS TRANSACTION DO
    INSERT INTO LOG(MSG)
    VALUES ('USER ' || CURRENT_USER || ' CONNECTS.');
  IF (EXISTS(SELECT *
             FROM BLOCKED_USERS
             WHERE USERNAME = CURRENT_USER)) THEN
  BEGIN
    -- Logging that the attempt to connect
    -- to the database failed and sending
    -- a message about the event
    IN AUTONOMOUS TRANSACTION DO
    BEGIN
      INSERT INTO LOG(MSG)
      VALUES ('USER ' || CURRENT_USER || ' REFUSED.');
      POST_EVENT 'CONNECTION ATTEMPT BY BLOCKED USER!';
    END
    -- now calling an exception
    EXCEPTION EX_BADUSER;
  END
END
```

See also

`Transaction Control`

7.7.22. POST_EVENT

Used for

Notifying listening clients about database events in a module

Available in

PSQL

Syntax

```
POST_EVENT event_name;
```

Table 114. `POST_EVENT` *Statement Parameter*

Argument	Description
event_name	Event name (message) limited to 127 bytes

The `POST_EVENT` statement notifies the event manager about the event, which saves it to an event table. When the transaction is committed, the event manager notifies applications that are signalling their interest in the event.

The event name can be some sort of code, or a short message: the choice is open as it is just a string up to 127 bytes.

The content of the string can be a string literal, a variable or any valid SQL expression that resolves to a string.

`POST_EVENT` Examples

Notifying the listening applications about inserting a record into the `SALES` table:

```
CREATE TRIGGER POST_NEW_ORDER FOR SALES
ACTIVE AFTER INSERT POSITION 0
AS
BEGIN
  POST_EVENT 'new_order';
END
```

7.7.23. `RETURN`

Used for

Return a value from a stored function

Available in

PSQL

Syntax

```
RETURN value;
```

Table 115. `RETURN` *Statement Parameter*

Argument	Description
value	Expression with the value to return; Can be any expression type-compatible with the return type of the function

The `RETURN` statement ends the execution of a function and returns the value of the expression *value*.

`RETURN` can only be used in PSQL functions (stored and local functions).

`RETURN` Examples

See `CREATE FUNCTION` Examples

7.8. Trapping and Handling Errors

Firebird has a useful lexicon of PSQL statements and resources for trapping errors in modules and for handling them. Firebird uses built-in exceptions that are raised for errors occurring when working DML and DDL statements.

In PSQL code, exceptions are handled by means of the `WHEN ... DO` statement. Handling an exception in the code involves either fixing the problem in situ, or stepping past it; either solution allows execution to continue without returning an exception message to the client.

An exception results in execution being terminated in the current block. Instead of passing the execution to the `END` statement, the procedure moves outward through levels of nested blocks, starting from the block where the exception is caught, searching for the code of the handler that "knows" about this exception. It stops searching when it finds the first `WHEN` statement that can handle this exception.

7.8.1. System Exceptions

An exception is a message that is generated when an error occurs.

All exceptions handled by Firebird have predefined numeric values for context variables (symbols) and text messages associated with them. Error messages are output in English by default. Localized Firebird builds are available, where error messages are translated into other languages.

Complete listings of the system exceptions can be found in *Appendix B: Exception Codes and Messages*:

- SQLSTATE Error Codes and Descriptions
- "GDSCODE Error Codes, SQLCODEs and Descriptions"

7.8.2. Custom Exceptions

Custom exceptions can be declared in the database as persistent objects and called in the PSQL code to signal specific errors; for example, to enforce certain business rules. A custom exception consists of an identifier, and a default message of 1021 bytes. For details, see `CREATE EXCEPTION`.

7.8.3. `EXCEPTION`

Used for

Throwing a user-defined exception or re-throwing an exception

Available in

PSQL

Syntax

```
EXCEPTION [
    exception_name
    [ custom_message
    | USING (<value_list>)]
  ]

<value_list> ::= <val> [, <val> ...]
```

Table 116. `EXCEPTION` Statement Parameters

Argument	Description
exception_name	Exception name
custom_message	Alternative message text to be returned to the caller interface when an exception is thrown. Maximum length of the text message is 1,021 bytes
val	Value expression that replaces parameter slots in the exception message text

The `EXCEPTION` statement with *exception_name* throws the user-defined exception with the specified name. An alternative message text of up to 1,021 bytes can optionally override the exception's default message text.

The default exception message can contain slots for parameters that can be filled when throwing an exception. To pass parameter values to an exception, use the `USING` clause. Considering, in left-to-right order, each parameter passed in the exception-raising statement as "the *N*th", with *N* starting at 1:

- If the *N*th parameter is not passed, its slot is not replaced
- If a `NULL` parameter is passed, the slot will be replaced with the string "`*** null ***`"
- If more parameters are passed than are defined in the exception message, the surplus ones are ignored
- The maximum number of parameters is 9
- The maximum message length, including parameter values, is 1053 bytes

The status vector is generated this code combination `isc_except, <exception number>, isc_formatted_exception, <formatted exception message>, <exception parameters>`.

The error code used (`isc_formatted_exception`) was introduced in Firebird 3.0, so the client must be at least version 3.0, or at least use the `firebird.msg` from version 3.0 or higher, in order to translate the status vector to a string.

If the *message* contains a parameter slot number that is greater than 9, the second and subsequent digits will be treated as literal text. For example `@10` will be interpreted as slot 1 followed by a literal '`0`'.

As an example:

```
CREATE EXCEPTION ex1
  'something wrong in @ 1 @ 2 @ 3 @ 4 @ 5 @ 6 @ 7 @ 8 @ 9 @ 10 @ 11';
SET TERM ^;
EXECUTE BLOCK AS
BEGIN
  EXCEPTION ex1 USING ( 'a' , 'b' , 'c' , 'd' , 'e' , 'f' , 'g' , 'h' ,
'i' );
END^
```

This will produce the following output

```
Statement failed, SQLSTATE = HY000
exception 1
-EX1
-something wrong in abcdefghi a0 a1
```

Exceptions can be handled in a `WHEN ⋯ DO` statement. If an exception is not handled in a module, then the effects of the actions executed inside this module are cancelled, and the caller program receives the exception (either the default text, or the custom text).

Within the exception-handling block — and only within it — the caught exception can be re-thrown by executing the `EXCEPTION` statement without parameters. If located outside the block, the re-thrown `EXCEPTION` call has no effect.

Custom exceptions are stored in the system table `RDB$EXCEPTIONS`.

`EXCEPTION` Examples

1. Throwing an exception upon a condition in the `SHIP_ORDER` stored procedure:

```
CREATE OR ALTER PROCEDURE SHIP_ORDER (
  PO_NUM CHAR(8))
AS
  DECLARE VARIABLE ord_stat  CHAR(7);
  DECLARE VARIABLE hold_stat CHAR(1);
  DECLARE VARIABLE cust_no   INTEGER;
  DECLARE VARIABLE any_po    CHAR(8);
BEGIN
  SELECT
    s.order_status,
    c.on_hold,
    c.cust_no
  FROM
    sales s, customer c
  WHERE
```

```
    po_number = :po_num AND
    s.cust_no = c.cust_no
  INTO :ord_stat,
       :hold_stat,
       :cust_no;

  IF (ord_stat = 'shipped') THEN
    EXCEPTION order_already_shipped;
  /* Other statements */
END
```

2. Throwing an exception upon a condition and replacing the original message with an alternative message:

```
CREATE OR ALTER PROCEDURE SHIP_ORDER (
  PO_NUM CHAR(8))
AS
  DECLARE VARIABLE ord_stat  CHAR(7);
  DECLARE VARIABLE hold_stat CHAR(1);
  DECLARE VARIABLE cust_no   INTEGER;
  DECLARE VARIABLE any_po    CHAR(8);
BEGIN
  SELECT
    s.order_status,
    c.on_hold,
    c.cust_no
  FROM
    sales s, customer c
  WHERE
    po_number = :po_num AND
    s.cust_no = c.cust_no
  INTO :ord_stat,
       :hold_stat,
       :cust_no;

  IF (ord_stat = 'shipped') THEN
    EXCEPTION order_already_shipped
      'Order status is "' || ord_stat || '"';
  /* Other statements */
END
```

3. Using a parameterized exception:

```
CREATE EXCEPTION EX_BAD_SP_NAME
  'Name of procedures must start with' '@ 1' ':' '@ 2' '' ;
...
CREATE TRIGGER TRG_SP_CREATE BEFORE CREATE PROCEDURE
AS
  DECLARE SP_NAME VARCHAR(255);
```

```
BEGIN
  SP_NAME = RDB$GET_CONTEXT ('DDL_TRIGGER' , 'OBJECT_NAME');
  IF (SP_NAME NOT STARTING 'SP_') THEN
    EXCEPTION EX_BAD_SP_NAME USING ('SP_', SP_NAME);
END
```

4. Logging an error and re-throwing it in the `WHEN` block:

```
CREATE PROCEDURE ADD_COUNTRY (
  ACountryName COUNTRYNAME,
  ACurrency VARCHAR(10))
AS
BEGIN
  INSERT INTO country (country,
                       currency)
  VALUES (:ACountryName,
          :ACurrency);
  WHEN ANY DO
  BEGIN
    -- write an error in log
    IN AUTONOMOUS TRANSACTION DO
      INSERT INTO ERROR_LOG (PSQL_MODULE,
                             GDS_CODE,
                             SQL_CODE,
                             SQL_STATE)
      VALUES ('ADD_COUNTRY',
              GDSCODE,
              SQLCODE,
              SQLSTATE);
    -- Re-throw exception
    EXCEPTION;
  END
END
```

See also

`CREATE EXCEPTION`, `WHEN ⋯ DO`

7.8.4. WHEN ⋯ DO

Used for

Catching an exception and handling the error

Available in

PSQL

Syntax

```
<block> ::=
```

```
  BEGIN
    [<compound_statement> ...]
    [<when_do> ...]
  END

<compound_statement> ::= {<block> | <statement>}

<<when_do>> ::=
  WHEN {<error> [, <error> ...] | ANY}
  DO <compound_statement>

<error> ::=
  { EXCEPTION exception_name
  | SQLCODE number
  | GDSCODE errcode
  | SQLSTATE sqlstate_code }
```

Table 117. WHEN ⋯ DO Statement Parameters

Argument	Description
exception_name	Exception name
number	SQLCODE error code
errcode	Symbolic GDSCODE error name
sqlstate_code	String literal with the SQLSTATE error code
compound_statement	A single statement, or a block of statements

The WHEN ⋯ DO statement handles Firebird errors and user-defined exceptions. The statement catches all errors and user-defined exceptions listed after the keyword WHEN keyword. If WHEN is followed by the keyword ANY, the statement catches any error or user-defined exception, even if they have already been handled in a WHEN block located higher up.

The WHEN ⋯ DO statements must be located at the end of a block of statements, before the block's END keyword, and after any other statement.

The keyword DO is followed by a statement, or a block of statements inside a BEGIN ⋯ END block, that handles the exception. The SQLCODE, GDSCODE, and SQLSTATE context variables are available in the context of this statement or block. The RDB$ERROR function can be used the obtain the SQLCODE, GDSCODE, SQLSTATE, custom exception name and exception message. The EXCEPTION statement, without parameters, can also be used in this context to re-throw the error or exception.

Targeting GDSCODE

The argument for the WHEN GDSCODE clause is the symbolic name associated with the internally-defined exception, such as grant_obj_notfound for GDS error 335544551.

In statement or block of statements of the DO clause, a GDSCODE context variable, containing the numeric code, becomes available. That numeric code is required if you want to compare a

GDSCODE exception with a targeted error. To compare it with a specific error, you need to use a numeric values, for example 335544551 for grant_obj_notfound.

Similar context variables are available for SQLCODE and SQLSTATE.

The WHEN … DO statement or block is only executed when one of the events targeted by its conditions occurs at run-time. If the WHEN … DO statement is executed, even if it actually does nothing, execution will continue as if no error occurred: the error or user-defined exception neither terminates nor rolls back the operations of the trigger or stored procedure.

However, if the WHEN … DO statement or block does nothing to handle or resolve the error, the DML statement (SELECT, INSERT, UPDATE, DELETE, MERGE) that caused the error will be rolled back and none of the statements below it in the same block of statements are executed.

1. If the error is not caused by one of the DML statements (SELECT, INSERT, UPDATE, DELETE, MERGE), the entire block of statements will be rolled back, not just the one that caused an error. Any operations in the WHEN … DO statement will be rolled back as well. The same limitation applies to the EXECUTE PROCEDURE statement. Read an interesting discussion of the phenomenon in Firebird Tracker ticket firebird#4803.
2. In selectable stored procedures, output rows that were already passed to the client in previous iterations of a FOR SELECT … DO … SUSPEND loop remain available to the client if an exception is thrown subsequently in the process of retrieving rows.

Scope of a WHEN … DO Statement

A WHEN … DO statement catches errors and exceptions in the current block of statements. It also catches similar exceptions in nested blocks, if those exceptions have not been handled in those nested blocks.

All changes made before the statement that caused the error are visible to a WHEN … DO statement. However, if you try to log them in an autonomous transaction, those changes are unavailable, because the transaction where the changes took place is not committed at the point when the autonomous transaction is started. Example 4, below, demonstrates this behaviour.

When handling exceptions, it is sometimes desirable to handle the exception by writing a log message to mark the fault and having execution continue past the faulty record. Logs can be written to regular tables, but there is a problem with that: the log records will “disappear” if an unhandled error causes the module to stop executing, and a rollback is performed. Use of external tables can be useful here, as data written to them is transaction-independent. The linked external file will still be there, regardless of whether the overall process succeeds or not.

Examples using WHEN…DO

1. Replacing the standard error with a custom one:

```
CREATE EXCEPTION COUNTRY_EXIST '';
SET TERM ^;
CREATE PROCEDURE ADD_COUNTRY (
  ACountryName COUNTRYNAME,
  ACurrency VARCHAR(10) )
AS
BEGIN
  INSERT INTO country (country, currency)
    VALUES (:ACountryName, :ACurrency);

  WHEN SQLCODE -803 DO
    EXCEPTION COUNTRY_EXIST 'Country already exists!';
END^
SET TERM ^;
```

2. Logging an error and re-throwing it in the `WHEN` block:

```
CREATE PROCEDURE ADD_COUNTRY (
  ACountryName COUNTRYNAME,
  ACurrency VARCHAR(10) )
AS
BEGIN
  INSERT INTO country (country,
                       currency)
  VALUES (:ACountryName,
          :ACurrency);
  WHEN ANY DO
  BEGIN
    -- write an error in log
    IN AUTONOMOUS TRANSACTION DO
      INSERT INTO ERROR_LOG (PSQL_MODULE,
                             GDS_CODE,
                             SQL_CODE,
                             SQL_STATE,
                             MESSAGE)
      VALUES ('ADD_COUNTRY',
              GDSCODE,
              SQLCODE,
              SQLSTATE,
              RDB$ERROR(MESSAGE));
    -- Re-throw exception
    EXCEPTION;
  END
END
```

3. Handling several errors in one `WHEN` block

```
...
```

```
WHEN GDSCODE GRANT_OBJ_NOTFOUND,
     GDSCODE GRANT_FLD_NOTFOUND,
     GDSCODE GRANT_NOPRIV,
     GDSCODE GRANT_NOPRIV_ON_BASE
DO
BEGIN
  EXECUTE PROCEDURE LOG_GRANT_ERROR(GDSCODE,
    RDB$ERROR(MESSAGE);
  EXIT;
END
...
```

4. Catching errors using the SQLSTATE code

```
EXECUTE BLOCK
AS
  DECLARE VARIABLE I INT;
BEGIN
  BEGIN
    I = 1/0;
    WHEN SQLSTATE '22003' DO
      EXCEPTION E_CUSTOM_EXCEPTION
        'Numeric value out of range.';
    WHEN SQLSTATE '22012' DO
      EXCEPTION E_CUSTOM_EXCEPTION
        'Division by zero.';
    WHEN SQLSTATE '23000' DO
      EXCEPTION E_CUSTOM_EXCEPTION
       'Integrity constraint violation.';
  END
END
```

See also

`EXCEPTION`, `CREATE EXCEPTION`, SQLCODE and GDSCODE Error Codes and Message Texts and SQLSTATE Codes and Message Texts, `GDSCODE`, `SQLCODE`, `SQLSTATE`, `RDB$ERROR()`

Chapter 8. Built-in Scalar Functions

Upgraders: PLEASE READ!

Many functions that were implemented as external functions (UDFs) in earlier versions of Firebird have been progressively re-implemented as internal (built-in) functions. If some external function of the same name as a built-in one is declared in your database, it will remain there and it will override any internal function of the same name.

To make the internal function available, you need either to `DROP` the UDF, or to use `ALTER EXTERNAL FUNCTION` to change the declared name of the UDF.

8.1. Context Functions

8.1.1. RDB$GET_CONTEXT()

Available in

DSQL, PSQL * As a declared UDF it should be available in ESQL

Result type

`VARCHAR(255)`

Syntax

```
RDB$GET_CONTEXT ('<namespace>', <varname>)

<namespace> ::= SYSTEM | USER_SESSION | USER_TRANSACTION | DDL_TRIGGER
<varname>   ::= A case-sensitive quoted string of max. 80 characters
```

Table 118. `RDB$GET_CONTEXT` *Function Parameters*

Parameter	Description
namespace	Namespace
varname	Variable name. Case-sensitive. Maximum length is 80 characters

Retrieves the value of a context variable from one of the namespaces `SYSTEM`, `USER_SESSION` and `USER_TRANSACTION`.

The namespaces

The `USER_SESSION` and `USER_TRANSACTION` namespaces are initially empty. The user can create and set variables in them with `RDB$SET_CONTEXT()` and retrieve them with `RDB$GET_CONTEXT()`. The `SYSTEM` namespace is read-only. The `DDL_TRIGGER` namespace is only valid in DDL triggers, and is read-only. It contains a number of predefined variables, shown below.

Return values and error behaviour

If the polled variable exists in the given namespace, its value will be returned as a string of max.

255 characters. If the namespace doesn't exist or if you try to access a non-existing variable in the `SYSTEM` namespace, an error is raised. If you request a non-existing variable in one of the other namespaces, `NULL` is returned. Both namespace and variable names must be given as single-quoted, case-sensitive, non-`NULL` strings.

The `SYSTEM` Namespace

Context variables in the SYSTEM namespace

`CLIENT_ADDRESS`

For TCP, this is the IP address. For XNET, the local process ID. For all other protocols this variable is `NULL`.

`CLIENT_HOST`

The wire protocol host name of remote client. Value is returned for all supported protocols.

`CLIENT_PID`

Process ID of remote client application.

`CLIENT_PROCESS`

Process name of remote client application.

`CURRENT_ROLE`

Same as global `CURRENT_ROLE` variable.

`CURRENT_USER`

Same as global `CURRENT_USER` variable.

`DB_FILE_ID`

Unique filesystem-level ID of the current database.

`DB_GUID`

GUID of the current database.

`DB_NAME`

Canonical name of current database; either the full path to the database or — if connecting via the path is disallowed — its alias.

`EFFECTIVE_USER`

Effective user at the point `RDB$GET_CONTEXT` is called; indicates privileges of which user is currently used to execute a function, procedure, trigger.

`ENGINE_VERSION`

The Firebird engine (server) version.

`EXT_CONN_POOL_ACTIVE_COUNT`

Count of active connections associated with the external connection pool.

`EXT_CONN_POOL_IDLE_COUNT`

Count of currently inactive connections available in the connection pool.

`EXT_CONN_POOL_LIFETIME`

External connection pool idle connection lifetime, in seconds.

`EXT_CONN_POOL_SIZE`

External connection pool size.

`GLOBAL_CN`

Most current value of global Commit Number counter.

`ISOLATION_LEVEL`

The isolation level of the current transaction: `'READ COMMITTED'`, `'SNAPSHOT'` or `'CONSISTENCY'`.

`LOCK_TIMEOUT`

Lock timeout of the current transaction.

`NETWORK_PROTOCOL`

The protocol used for the connection: `'TCPv4'`, `'TCPv6'`, `'WNET'`, `'XNET'` or `NULL`.

`READ_ONLY`

Returns `'TRUE'` if current transaction is read-only and `'FALSE'` otherwise.

`REPLICA_MODE`

Replica mode of the database: `'READ-ONLY'`, `'READ-WRITE'` and `NULL`.

`REPLICATION_SEQUENCE`

Current replication sequence (number of the latest segment written to the replication journal).

`SESSION_ID`

Same as global `CURRENT_CONNECTION` variable.

`SESSION_IDLE_TIMEOUT`

Connection-level idle timeout, or `0` if no timeout was set. When `0` is reported the database `ConnectionIdleTimeout` from `databases.conf` or `firebird.conf` applies.

`SESSION_TIMEZONE`

Current session time zone.

`SNAPSHOT_NUMBER`

Current snapshot number for the transaction executing this statement. For `SNAPSHOT` and `SNAPSHOT TABLE STABILITY`, this number is stable for the duration of the transaction; for `READ COMMITTED` this number will change (increment) as concurrent transactions are committed.

`STATEMENT_TIMEOUT`

Connection-level statement timeout, or `0` if no timeout was set. When `0` is reported the database `StatementTimeout` from `databases.conf` or `firebird.conf` applies.

`TRANSACTION_ID`

Same as global `CURRENT_TRANSACTION` variable.

`WIRE_COMPRESSED`

Compression status of the current connection. If the connection is compressed, returns `TRUE`; if it is not compressed, returns `FALSE`. Returns `NULL` if the connection is embedded.

`WIRE_CRYPT_PLUGIN`

If connection is encrypted - returns name of current plugin, otherwise `NULL`.

`WIRE_ENCRYPTED`

Encryption status of the current connection. If the connection is encrypted, returns `TRUE`; if it is not encrypted, returns `FALSE`. Returns `NULL` if the connection is embedded.

The `DDL_TRIGGER` Namespace

The `DDL_TRIGGER` namespace is valid only when a DDL trigger is running. Its use is also valid in stored procedures and functions called by DDL triggers.

The `DDL_TRIGGER` context works like a stack. Before a DDL trigger is fired, the values relative to the executed command are pushed onto this stack. After the trigger finishes, the values are popped. So in the case of cascade DDL statements, when a user DDL command fires a DDL trigger and this trigger executes another DDL command with `EXECUTE STATEMENT`, the values of the `DDL_TRIGGER` namespace are the ones relative to the command that fired the last DDL trigger on the call stack.

Context variables in the DDL_TRIGGER namespace

`EVENT_TYPE`

event type (`CREATE`, `ALTER`, `DROP`)

`OBJECT_TYPE`

object type (`TABLE`, `VIEW`, etc)

`DDL_EVENT`

event name (`<ddl event item>`), where `<ddl_event_item>` is `EVENT_TYPE || ' ' || OBJECT_TYPE`

`OBJECT_NAME`

metadata object name

`OLD_OBJECT_NAME`

for tracking the renaming of a domain (see note)

`NEW_OBJECT_NAME`

for tracking the renaming of a domain (see note)

`SQL_TEXT`

sql statement text

`ALTER DOMAIN old-name TO new-name` sets `OLD_OBJECT_NAME` and `NEW_OBJECT_NAME` in

both BEFORE and AFTER triggers. For this command, OBJECT_NAME will have the old object name in BEFORE triggers, and the new object name in AFTER triggers.

Examples

```
select rdb$get_context('SYSTEM', 'DB_NAME') from rdb$database

New.UserAddr = rdb$get_context('SYSTEM', 'CLIENT_ADDRESS');

insert into MyTable (TestField)
  values (rdb$get_context('USER_SESSION', 'MyVar'))
```

See also

RDB$SET_CONTEXT()

8.1.2. RDB$SET_CONTEXT()

Available in

DSQL, PSQL * As a declared UDF it should be available in ESQL

Result type

INTEGER

Syntax

```
RDB$SET_CONTEXT ('<namespace>', <varname>, <value> | NULL)

<namespace> ::= USER_SESSION | USER_TRANSACTION
<varname>   ::= A case-sensitive quoted string of max. 80 characters
<value>     ::= A value of any type, as long as it's castable
                to a VARCHAR(255)
```

Table 119. RDB$SET_CONTEXT *Function Parameters*

Parameter	Description
namespace	Namespace
varname	Variable name. Case-sensitive. Maximum length is 80 characters
value	Data of any type provided it can be cast to VARCHAR(255)

Creates, sets or unsets a variable in one of the user-writable namespaces USER_SESSION and USER_TRANSACTION.

The namespaces

The USER_SESSION and USER_TRANSACTION namespaces are initially empty. The user can create and set variables in them with RDB$SET_CONTEXT() and retrieve them with RDB$GET_CONTEXT(). The USER_SESSION context is bound to the current connection. Variables in USER_TRANSACTION only exist in the transaction in which they have been set. When the transaction ends, the context and all the

variables defined in it are destroyed.

Return values and error behaviour

The function returns 1 when the variable already existed before the call and `0` when it didn't. To remove a variable from a context, set it to `NULL`. If the given namespace doesn't exist, an error is raised. Both namespace and variable names must be entered as single-quoted, case-sensitive, non-`NULL` strings.

- The maximum number of variables in any single context is 1000.
- All `USER_TRANSACTION` variables will survive a `ROLLBACK RETAIN` (see `ROLLBACK` Options) or `ROLLBACK TO SAVEPOINT` unaltered, no matter at which point during the transaction they were set.
- Due to its UDF-like nature, `RDB$SET_CONTEXT` can — in PSQL only — be called like a void function, without assigning the result, as in the second example above. Regular internal functions don't allow this type of use.

Examples

```
select rdb$set_context('USER_SESSION', 'MyVar', 493) from rdb$database

rdb$set_context('USER_SESSION', 'RecordsFound', RecCounter);

select rdb$set_context('USER_TRANSACTION', 'Savepoints', 'Yes')
  from rdb$database
```

See also

`RDB$GET_CONTEXT()`

8.2. Mathematical Functions

8.2.1. ABS()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

Numerical

Syntax

```
ABS (number)
```

Table 120. ABS Function Parameter

Parameter	Description
number	An expression of a numeric type

Returns the absolute value of the argument.

8.2.2. ACOS()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

`DOUBLE PRECISION`

Syntax

```
ACOS (number)
```

Table 121. ACOS Function Parameter

Parameter	Description
number	An expression of a numeric type within the range [-1, 1]

Returns the arc cosine of the argument.

- The result is an angle in the range [0, pi].

See also

COS(), ASIN(), ATAN()

8.2.3. ACOSH()

Available in

DSQL, PSQL

Result type

`DOUBLE PRECISION`

Syntax

```
ACOSH (number)
```

Table 122. ACOSH Function Parameter

Parameter	Description
number	Any non-NULL value in the range [1, INF].

Returns the inverse hyperbolic cosine of the argument.

- The result is in the range [0, INF].

See also

`COSH()`, `ASINH()`, `ATANH()`

8.2.4. ASIN()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

`DOUBLE PRECISION`

Syntax

```
ASIN (number)
```

Table 123. ASIN Function Parameter

Parameter	Description
number	An expression of a numeric type within the range [-1, 1]

Returns the arc sine of the argument.

- The result is an angle in the range [-pi/2, pi/2].

See also

`SIN()`, `ACOS()`, `ATAN()`

8.2.5. ASINH()

Available in

DSQL, PSQL

Result type

`DOUBLE PRECISION`

Syntax

```
ASINH (number)
```

Table 124. ASINH Function Parameter

Parameter	Description
number	Any non-NULL value in the range [-INF, INF].

Returns the inverse hyperbolic sine of the argument.

- The result is in the range [-INF, INF].

See also

SINH(), ACOSH(), ATANH()

8.2.6. ATAN()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

DOUBLE PRECISION

Syntax

```
ATAN (number)
```

Table 125. ATAN Function Parameter

Parameter	Description
number	An expression of a numeric type

The function ATAN returns the arc tangent of the argument. The result is an angle in the range <-pi/2, pi/2>.

See also

ATAN2(), TAN(), ACOS(), ASIN()

8.2.7. ATAN2()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

DOUBLE PRECISION

Syntax

```
ATAN2 (y, x)
```

Table 126. ATAN2 Function Parameters

Parameter	Description
y	An expression of a numeric type
x	An expression of a numeric type

Returns the angle whose sine-to-cosine *ratio* is given by the two arguments, and whose sine and cosine *signs* correspond to the signs of the arguments. This allows results across the entire circle, including the angles -pi/2 and pi/2.

- The result is an angle in the range [-pi, pi].
- If *x* is negative, the result is pi if *y* is 0, and -pi if *y* is -0.
- If both *y* and *x* are 0, the result is meaningless. An error will be raised if both arguments are 0.

- A fully equivalent description of this function is the following: `ATAN2(y, x)` is the angle between the positive X-axis and the line from the origin to the point *(x, y)*. This also makes it obvious that `ATAN2(0, 0)` is undefined.
- If *x* is greater than 0, `ATAN2(y, x)` is the same as `ATAN(y/x)`.
- If both sine and cosine of the angle are already known, `ATAN2(sin, cos)` gives the angle.

8.2.8. ATANH()

Available in

DSQL, PSQL

Result type

`DOUBLE PRECISION`

Syntax

```
ATANH (number)
```

Table 127. ATANH Function Parameter

Parameter	Description
number	Any non-`NULL` value in the range <-1, 1>.

Returns the inverse hyperbolic tangent of the argument.

- The result is a number in the range [-INF, INF].

See also

TANH(), ACOSH(), ASINH()

8.2.9. CEIL(), CEILING()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details (Affects CEILING only)

Result type

BIGINT for exact numeric *number*, or DOUBLE PRECISION for floating point *number*

Syntax

```
CEIL[ING] (number)
```

Table 128. CEIL[ING] Function Parameters

Parameter	Description
number	An expression of a numeric type

Returns the smallest whole number greater than or equal to the argument.

See also

FLOOR(), ROUND(), TRUNC()

8.2.10. COS()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

DOUBLE PRECISION

Syntax

```
COS (angle)
```

Table 129. COS Function Parameter

Parameter	Description
angle	An angle in radians

Returns an angle's cosine. The argument must be given in radians.

- Any non-NULL result is — obviously — in the range [-1, 1].

See also

ACOS(), COT(), SIN(), TAN()

8.2.11. COSH()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

DOUBLE PRECISION

Syntax

```
COSH (number)
```

Table 130. COSH Function Parameter

Parameter	Description
number	A number of a numeric type

Returns the hyperbolic cosine of the argument.

- Any non-NULL result is in the range [1, INF].

See also

ACOSH(), SINH(), TANH()

8.2.12. COT()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

DOUBLE PRECISION

Syntax

```
COT (angle)
```

Table 131. COT Function Parameter

Parameter	Description
angle	An angle in radians

Returns an angle's cotangent. The argument must be given in radians.

See also

`COS()`, `SIN()`, `TAN()`

8.2.13. EXP()

Available in

DSQL, PSQL

Result type

`DOUBLE PRECISION`

Syntax

```
EXP (number)
```

Table 132. `EXP` Function Parameter

Parameter	Description
number	A number of a numeric type

Returns the natural exponential, e^{number}

See also

`LN()`

8.2.14. FLOOR()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

`BIGINT` for exact numeric *number*, or `DOUBLE PRECISION` for floating point *number*

Syntax

```
FLOOR (number)
```

Table 133. `FLOOR` Function Parameter

Parameter	Description
number	An expression of a numeric type

Returns the largest whole number smaller than or equal to the argument.

See also

`CEIL()`, `CEILING()`, `ROUND()`, `TRUNC()`

8.2.15. `LN()`

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

`DOUBLE PRECISION`

Syntax

```
LN (number)
```

Table 134. `LN` Function Parameter

Parameter	Description
number	An expression of a numeric type

Returns the natural logarithm of the argument.

- An error is raised if the argument is negative or 0.

See also

`EXP()`, `LOG()`, `LOG10()`

8.2.16. `LOG()`

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

`DOUBLE PRECISION`

Syntax

```
LOG (x, y)
```

Table 135. LOG Function Parameters

Parameter	Description
x	Base. An expression of a numeric type
y	An expression of a numeric type

Returns the *x*-based logarithm of *y*.

- If either argument is 0 or below, an error is raised. (Before 2.5, this would result in `NaN`, `+/-INF` or 0, depending on the exact values of the arguments.)
- If both arguments are 1, `NaN` is returned.
- If *x* = 1 and *y* < 1, `-INF` is returned.
- If *x* = 1 and *y* > 1, `INF` is returned.

See also

`POWER()`, `LN()`, `LOG10()`

8.2.17. LOG10()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

`DOUBLE PRECISION`

Syntax

```
LOG10 (number)
```

Table 136. LOG10 Function Parameter

Parameter	Description
number	An expression of a numeric type

Returns the 10-based logarithm of the argument.

- An error is raised if the argument is negative or 0. (In versions prior to 2.5, such values would result in `NaN` and `-INF`, respectively.)

See also

POWER(), LN(), LOG()

8.2.18. MOD()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

SMALLINT, INTEGER or BIGINT depending on the type of *a*. If *a* is a floating-point type, the result is a BIGINT.

Syntax

```
MOD (a, b)
```

Table 137. MOD Function Parameters

Parameter	Description
a	An expression of a numeric type
b	An expression of a numeric type

Returns the remainder of an integer division.

- Non-integer arguments are rounded before the division takes place. So, "`mod(7.5, 2.5)`" gives 2 ("`mod(8, 3)`"), not 0.

8.2.19. PI()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

DOUBLE PRECISION

Syntax

```
PI ()
```

Returns an approximation of the value of *pi*.

8.2.20. POWER()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

`DOUBLE PRECISION`

Syntax

```
POWER (x, y)
```

Table 138. POWER Function Parameters

Parameter	Description
x	An expression of a numeric type
y	An expression of a numeric type

Returns *x* to the power of *y* (x^y).

See also

`EXP()`, `LOG()`, `LOG10()`, `SQRT()`

8.2.21. RAND()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

`DOUBLE PRECISION`

Syntax

```
RAND ()
```

Returns a random number between 0 and 1.

8.2.22. ROUND()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

`INTEGER`, (scaled) `BIGINT` or `DOUBLE PRECISION`

Syntax

```
ROUND (number [, scale])
```

Table 139. `ROUND` Function Parameters

Parameter	Description
number	An expression of a numeric type
scale	An integer specifying the number of decimal places toward which rounding is to be performed, e.g.: • 2 for rounding to the nearest multiple of 0.01 • 1 for rounding to the nearest multiple of 0.1 • 0 for rounding to the nearest whole number • -1 for rounding to the nearest multiple of 10 • -2 for rounding to the nearest multiple of 100

Rounds a number to the nearest integer. If the fractional part is exactly `0.5`, rounding is upward for positive numbers and downward for negative numbers. With the optional *scale* argument, the number can be rounded to powers-of-ten multiples (tens, hundreds, tenths, hundredths, etc.) instead of just integers.

If you are used to the behaviour of the external function `ROUND`, please notice that the *internal* function always rounds halves away from zero, i.e. downward for negative numbers.

`ROUND` Examples

If the *scale* argument is present, the result usually has the same scale as the first argument:

```
ROUND(123.654, 1) -- returns 123.700 (not 123.7)
ROUND(8341.7, -3) -- returns 8000.0 (not 8000)
ROUND(45.1212, 0) -- returns 45.0000 (not 45)
```

Otherwise, the result scale is 0:

```
ROUND(45.1212) -- returns 45
```

See also

CEIL(), CEILING(), FLOOR(), TRUNC()

8.2.23. SIGN()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

SMALLINT

Syntax

```
SIGN (number)
```

Table 140. SIGN Function Parameter

Parameter	Description
number	An expression of a numeric type

Returns the sign of the argument: -1, 0 or 1.

8.2.24. SIN()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

DOUBLE PRECISION

Syntax

```
SIN (angle)
```

Table 141. SIN Function Parameter

Parameter	Description
angle	An angle, in radians

Returns an angle's sine. The argument must be given in radians.

- Any non-NULL result is — obviously — in the range [-1, 1].

See also

ASIN(), COS(), COT(), TAN()

8.2.25. SINH()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

DOUBLE PRECISION

Syntax

```
SINH (number)
```

Table 142. SINH Function Parameter

Parameter	Description
number	An expression of a numeric type

Returns the hyperbolic sine of the argument.

See also

ASINH(), COSH(), TANH()

8.2.26. SQRT()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

DOUBLE PRECISION

Syntax

```
SQRT (number)
```

Table 143. SQRT Function Parameter

Parameter	Description
number	An expression of a numeric type

Returns the square root of the argument.

- If *number* is negative, an error is raised.

See also

`POWER()`

8.2.27. TAN()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

`DOUBLE PRECISION`

Syntax

```
TAN (angle)
```

Table 144. TAN Function Parameter

Parameter	Description
angle	An angle, in radians

Returns an angle's tangent. The argument must be given in radians.

See also

`ATAN()`, `ATAN2()`, `COS()`, `COT()`, `SIN()`, `TAN()`

8.2.28. TANH()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

`DOUBLE PRECISION`

Syntax

```
TANH (number)
```

Table 145. TANH Function Parameters

Parameter	Description
number	An expression of a numeric type

Returns the hyperbolic tangent of the argument.

- Due to rounding, any non-NULL result is in the range [-1, 1] (mathematically, it's <-1, 1>).

See also

ATANH(), COSH(), TANH()

8.2.29. TRUNC()

Available in

DSQL, PSQL

Result type

INTEGER, (scaled) BIGINT or DOUBLE PRECISION

Syntax

```
TRUNC (number [, scale])
```

Table 146. TRUNC Function Parameters

Parameter	Description
number	An expression of a numeric type
scale	An integer specifying the number of decimal places toward which truncating is to be performed, e.g.: • 2 for truncating to the nearest multiple of 0.01 • 1 for truncating to the nearest multiple of 0.1 • 0 for truncating to the nearest whole number • -1 for truncating to the nearest multiple of 10 • -2 for truncating to the nearest multiple of 100

Returns the integer part of a number. With the optional *scale* argument, the number can be truncated to powers-of-ten multiples (tens, hundreds, tenths, hundredths, etc.) instead of just integers.

- If the *scale* argument is present, the result usually has the same scale as the first argument, e.g.
  - TRUNC(789.2225, 2) returns 789.2200 (not 789.22)
  - TRUNC(345.4, -2) returns 300.0 (not 300)
  - TRUNC(-163.41, 0) returns -163.00 (not -163)
- Otherwise, the result scale is 0:
  - TRUNC(-163.41) returns -163

If you are used to the behaviour of the external function `TRUNCATE`, please notice that the *internal* function `TRUNC` always truncates toward zero, i.e. upward for negative numbers.

See also

`CEIL()`, `CEILING()`, `FLOOR()`, `ROUND()`

8.3. String and Binary Functions

8.3.1. ASCII_CHAR()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

`CHAR(1) CHARACTER SET NONE`

Syntax

```
ASCII_CHAR (code)
```

Table 147. `ASCII_CHAR` Function Parameter

Parameter	Description
code	An integer within the range from 0 to 255

Returns the ASCII character corresponding to the number passed in the argument.

- If you are used to the behaviour of the `ASCII_CHAR` UDF, which returns an empty string if the argument is 0, please notice that the internal function correctly returns a character with ASCII code 0 here.

8.3.2. ASCII_VAL()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

`SMALLINT`

Syntax

```
ASCII_VAL (ch)
```

Table 148. ASCII_VAL Function Parameter

Parameter	Description
ch	A string of the [VAR]CHAR data type or a text BLOB with the maximum size of 32,767 bytes

Returns the ASCII code of the character passed in.

- If the argument is a string with more than one character, the ASCII code of the first character is returned.
- If the argument is an empty string, 0 is returned.
- If the argument is NULL, NULL is returned.
- If the first character of the argument string is multi-byte, an error is raised. (A bug in Firebird 2.1 - 2.1.3 and 2.5.0 causes an error to be raised if *any* character in the string is multi-byte. This is fixed in versions 2.1.4 and 2.5.1.)

8.3.3. BASE64_DECODE()

Available in

DSQL, PSQL

Result type

VARBINARY or BLOB

Syntax

```
BASE64_DECODE (base64_data)
```

Table 149. BASE64_DECODE Function Parameter

Parameter	Description
base64_data	Base64 encoded data, padded with = to multiples of 4

BASE64_DECODE decodes a string with base64-encoded data, and returns the decoded value as VARBINARY or BLOB as appropriate for the input. If the length of the type of *base64_data* is not a multiple of 4, an error is raised at prepare time. If the length of the value of *base64_data* is not a multiple of 4, an error is raised at execution time.

When the input is not BLOB, the length of the resulting type is calculated as `type_length * 3 / 4`, where *type_length* is the maximum length in characters of the input type.

Example of BASE64_DECODE

```
select cast(base64_decode('VGVzdCBiYXNlNjQ=') as varchar(12))
from rdb$database;

CAST
============
Test base64
```

See also

BASE64_ENCODE(), HEX_DECODE()

8.3.4. BASE64_ENCODE()

Available in

DSQL, PSQL

Result type

VARCHAR CHARACTER SET ASCII or BLOB SUB_TYPE TEXT CHARACTER SET ASCII

Syntax

```
BASE64_ENCODE (binary_data)
```

Table 150. BASE64_ENCODE *Function Parameter*

Parameter	Description
binary_data	Binary data (or otherwise convertible to binary) to encode

BASE64_ENCODE encodes *binary_data* with base64, and returns the encoded value as a VARCHAR CHARACTER SET ASCII or BLOB SUB_TYPE TEXT CHARACTER SET ASCII as appropriate for the input. The returned value is padded with '=' so its length is a multiple of 4.

When the input is not BLOB, the length of the resulting type is calculated as `type_length * 4 / 3` rounded up to a multiple of four, where *type_length* is the maximum length in bytes of the input type. If this length exceeds the maximum length of VARCHAR, the function returns a BLOB.

Example of BASE64_ENCODE

```
select base64_encode('Test base64')
from rdb$database;

BASE64_ENCODE
================
VGVzdCBiYXNlNjQ=
```

See also

BASE64_DECODE(), HEX_ENCODE()

8.3.5. BIT_LENGTH()

Available in

DSQL, PSQL

Result type

INTEGER

Syntax

```
BIT_LENGTH (string)
```

Table 151. BIT_LENGTH Function Parameter

Parameter	Description
string	An expression of a string type

Gives the length in bits of the input string. For multi-byte character sets, this may be less than the number of characters times 8 times the "formal" number of bytes per character as found in RDB$CHARACTER_SETS.

With arguments of type CHAR, this function takes the entire formal string length (i.e. the declared length of a field or variable) into account. If you want to obtain the "logical" bit length, not counting the trailing spaces, right-TRIM the argument before passing it to BIT_LENGTH.

BLOB *support*

Since Firebird 2.1, this function fully supports text BLOBs of any length and character set.

BIT_LENGTH Examples

```
select bit_length('Hello!') from rdb$database
-- returns 48

select bit_length(_iso8859_1 'Grüß di!') from rdb$database
-- returns 64: ü and ß take up one byte each in ISO8859_1

select bit_length
  (cast (_iso8859_1 'Grüß di!' as varchar(24) character set utf8))
from rdb$database
-- returns 80: ü and ß take up two bytes each in UTF8

select bit_length
  (cast (_iso8859_1 'Grüß di!' as char(24) character set utf8))
from rdb$database
-- returns 208: all 24 CHAR positions count, and two of them are 16-bit
```

See also

OCTET_LENGTH(), CHAR_LENGTH(), CHARACTER_LENGTH()

8.3.6. BLOB_APPEND()

Available in

DSQL, PSQL

Added in

4.0.2

Result type

BLOB

Syntax

```
BLOB_APPEND(expr1, expr2 [, exprN ... ])
```

Table 152. BLOB_APPEND Function Parameters

Parameter	Description
expr*N*	An expression of a type convertible to BLOB

The BLOB_APPEND function concatenates blobs without creating intermediate BLOBs, avoiding excessive memory consumption and growth of the database file. The BLOB_APPEND function takes two or more arguments and adds them to a BLOB which remains open for further modification by a subsequent BLOB_APPEND call.

The resulting BLOB is left open for writing instead of being closed when the function returns. In other words, the BLOB can be appended as many times as required. The engine marks the BLOB returned by BLOB_APPEND with an internal flag, BLB_close_on_read, and closes it automatically when needed.

The first argument determines the behaviour of the function:

1. NULL: new, empty BLOB SUB_TYPE TEXT CHARACTER SET NONE is created

   In Firebird 5.0 (and — maybe — Firebird 4.0.3), this will change to use the connection character set instead of NONE.

2. permanent BLOB (from a table) or temporary BLOB which was already closed: new BLOB SUB_TYPE TEXT is created, populated with the content of the original BLOB. If the original BLOB is SUB_TYPE TEXT, its character set is used, otherwise character set OCTETS.

   In Firebird 5.0 (and — maybe — Firebird 4.0.3), this will change to use the subtype of the initial BLOB.

3. temporary unclosed BLOB with the BLB_close_on_read flag (e.g. created by another call to BLOB_APPEND): used as-is, remaining arguments are appended to this BLOB

4. other data types: a new `BLOB SUB_TYPE TEXT` is created, populated with the original argument converted to string. If the original value is a character type, its character set is used (for string literals, the connection character set), otherwise character set `NONE` (will be changed in Firebird 5.0 and — maybe — Firebird 4.0.3 to use the connection character set).

Other arguments can be of any type. The following behavior is defined for them:

1. `NULL`s are ignored (behaves as empty string)
2. `BLOB`s, if necessary, are transliterated to the character set of the first argument and their contents are appended to the result
3. other data types are converted to strings (as usual) and appended to the result

The `BLOB_APPEND` function returns a temporary unclosed `BLOB` with the `BLB_close_on_read` flag. If the first argument is such a temporary unclosed `BLOB` (e.g. created by a previous call to `BLOB_APPEND`), it will be used as-is, otherwise a new `BLOB` is created. Thus, a series of operations like `blob = BLOB_APPEND (blob, ⋯)` will result in the creation of at most one `BLOB` (unless you try to append a `BLOB` to itself). This blob will be automatically closed by the engine when the client reads it, assigns it to a table, or uses it in other expressions that require reading the content.

Important caveats for `BLOB_APPEND`

1. The `NULL` behaviour of `BLOB_APPEND` is different from normal concatenation (using `||`). Occurrence of `NULL` will behave as if an empty string was used. In other words, `NULL` is effectively ignored.

   In normal concatenation, concatenating with `NULL` results in `NULL`.

2. The result is always a `BLOB SUB_TYPE TEXT`.

   This has been identified as a bug, which will be fixed in Firebird 5.0 (and — maybe — Firebird 4.0.3), see issue #7256.

Testing a blob for `NULL` using the `IS [NOT] NULL` operator does not read it and therefore a temporary blob with the `BLB_close_on_read` flag will not be closed after such a test.

Use `LIST` or `BLOB_APPEND` functions to concatenate blobs. This reduces memory consumption and disk I/O, and also prevents database growth due to the creation of many temporary blobs when using the concatenation operator.

`BLOB_APPEND` Examples

```
execute block
returns (b blob sub_type text)
as
begin
  -- creates a new temporary not closed BLOB
  -- and writes the string from the 2nd argument into it
```

```
  b = blob_append(null, 'Hello ');

  -- adds two strings to the temporary BLOB without closing it
  b = blob_append(b, 'World', '!');

  -- comparing a BLOB with a string will close it, because the BLOB needs to be read
  if (b = 'Hello World!') then
  begin
  -- ...
  end

  -- creates a temporary closed BLOB by adding a string to it
  b = b || 'Close';

  suspend;
end
```

See also

Concatenation Operator, `LIST()`

8.3.7. CHAR_LENGTH(), CHARACTER_LENGTH()

Available in

DSQL, PSQL

Result type

`INTEGER`

Syntax

```
  CHAR_LENGTH (string)
| CHARACTER_LENGTH (string)
```

Table 153. `CHAR[ACTER]_LENGTH` Function Parameter

Parameter	Description
string	An expression of a string type

Gives the length in characters of the input string.

- With arguments of type `CHAR`, this function returns the formal string length (i.e. the declared length of a field or variable). If you want to obtain the "logical" length, not counting the trailing spaces, right-`TRIM` the argument before passing it to `CHAR[ACTER]_LENGTH`.
- **`BLOB` support**: Since Firebird 2.1, this function fully supports text `BLOB`s of any length and character set.

CHAR_LENGTH Examples

```
select char_length('Hello!') from rdb$database
-- returns 6

select char_length(_iso8859_1 'Grüß di!') from rdb$database
-- returns 8

select char_length
  (cast (_iso8859_1 'Grüß di!' as varchar(24) character set utf8))
from rdb$database
-- returns 8; the fact that ü and ß take up two bytes each is irrelevant

select char_length
  (cast (_iso8859_1 'Grüß di!' as char(24) character set utf8))
from rdb$database
-- returns 24: all 24 CHAR positions count
```

See also

BIT_LENGTH(), OCTET_LENGTH()

8.3.8. CRYPT_HASH()

Available in

DSQL, PSQL

Result type

VARBINARY

Syntax

```
CRYPT_HASH (value USING <hash>)

<hash> ::= MD5 | SHA1 | SHA256 | SHA512
```

Table 154. CRYPT_HASH Function Parameter

Parameter	Description
value	Expression of value of any type; non-string or non-binary types are converted to string
hash	Cryptographic hash algorithm to apply

CRYPT_HASH returns a cryptographic hash calculated from the input argument using the specified algorithm. If the input argument is not a string or binary type, it is converted to string before hashing.

This function returns a VARBINARY with the length depending on the specified algorithm.

- The MD5 and SHA1 algorithms are not recommended for security purposes due to known attacks to generate hash collisions. These two algorithms are provided for backward-compatibility only.
- When hashing string or binary values, it is important to take into account the effects of trailing blanks (spaces or NULs). The value 'ab' in a CHAR(5) (3 trailing spaces) has a different hash than if it is stored in a VARCHAR(5) (no trailing spaces) or CHAR(6) (4 trailing spaces).

  To avoid this, make sure you always use a variable length data type, or the same fixed length data type, or normalize values before hashing, for example using TRIM(TRAILING FROM value).

Examples of CRYPT_HASH

Hashing x *with the SHA512 algorithm*

```
select crypt_hash(x using sha512) from y;
```

See also

HASH()

8.3.9. HASH()

Available in

DSQL, PSQL

Result type

INTEGER,BIGINT

Syntax

```
HASH (value [USING <hash>])

<hash> ::= CRC32
```

Table 155. HASH *Function Parameter*

Parameter	Description
value	Expression of value of any type; non-string or non-binary types are converted to string
hash	Non-cryptographic hash algorithm to apply

HASH returns a hash value for the input argument. If the input argument is not a string or binary type, it is converted to string before hashing.

The optional USING clause specifies the non-cryptographic hash algorithm to apply. When the USING clause is absent, the legacy PJW algorithm is applied; this is identical to its behaviour in previous

Firebird versions.

This function fully supports text BLOBs of any length and character set.

Supported algorithms

not specified

When no algorithm is specified, Firebird applies the 64-bit variant of the non-cryptographic PJW hash function (also known as ELF64). This is a very fast algorithm for general purposes (hash tables, etc.), but its collision quality is sub-optimal. Other hash functions — specified explicitly in the USING clause, or cryptographic hashes through CRYPT_HASH() — should be used for more reliable hashing.

The HASH function returns BIGINT for this algorithm

CRC32

With CRC32, Firebird applies the CRC32 algorithm using the polynomial 0x04C11DB7.

The HASH function returns INTEGER for this algorithm.

Examples of HASH

1. Hashing x with the CRC32 algorithm

```
select hash(x using crc32) from y;
```

2. Hashing x with the legacy PJW algorithm

```
select hash(x) from y;
```

See also

CRYPT_HASH()

8.3.10. HEX_DECODE()

Available in

DSQL, PSQL

Result type

VARBINARY or BLOB

Syntax

```
HEX_DECODE (hex_data)
```

Table 156. HEX_DECODE Function Parameter

Parameter	Description
hex_data	Hex encoded data

HEX_DECODE decodes a string with hex-encoded data, and returns the decoded value as VARBINARY or BLOB as appropriate for the input. If the length of the type of *hex_data* is not a multiple of 2, an error is raised at prepare time. If the length of the value of *hex_data* is not a multiple of 2, an error is raised at execution time.

When the input is not BLOB, the length of the resulting type is calculated as `type_length / 2`, where *type_length* is the maximum length in characters of the input type.

Example of HEX_DECODE

```
select cast(hex_decode('48657861646563696D616C') as varchar(12))
from rdb$database;

CAST
============
Hexadecimal
```

See also

HEX_ENCODE(), BASE64_DECODE()

8.3.11. HEX_ENCODE()

Available in

DSQL, PSQL

Result type

VARCHAR CHARACTER SET ASCII or BLOB SUB_TYPE TEXT CHARACTER SET ASCII

Syntax

```
HEX_ENCODE (binary_data)
```

Table 157. HEX_ENCODE Function Parameter

Parameter	Description
binary_data	Binary data (or otherwise convertible to binary) to encode

HEX_ENCODE encodes *binary_data* with hex, and returns the encoded value as a VARCHAR CHARACTER SET ASCII or BLOB SUB_TYPE TEXT CHARACTER SET ASCII as appropriate for the input.

When the input is not BLOB, the length of the resulting type is calculated as `type_length * 2`, where *type_length* is the maximum length in bytes of the input type. If this length exceeds the maximum length of VARCHAR, the function returns a BLOB.

Example of HEX_ENCODE

```
select hex_encode('Hexadecimal')
from rdb$database;

HEX_ENCODE
======================
486578616465636963616C
```

See also

HEX_DECODE(), BASE64_ENCODE()

8.3.12. LEFT()

Available in

DSQL, PSQL

Result type

VARCHAR or BLOB

Syntax

```
LEFT (string, length)
```

Table 158. LEFT Function Parameters

Parameter	Description
string	An expression of a string type
length	Integer expression. Defines the number of characters to return

Returns the leftmost part of the argument string. The number of characters is given in the second argument.

- This function fully supports text BLOBs of any length, including those with a multi-byte character set.
- If *string* is a BLOB, the result is a BLOB. Otherwise, the result is a VARCHAR(n) with *n* the length of the input string.
- If the *length* argument exceeds the string length, the input string is returned unchanged.
- If the *length* argument is not a whole number, bankers' rounding (round-to-even) is applied, i.e. 0.5 becomes 0, 1.5 becomes 2, 2.5 becomes 2, 3.5 becomes 4, etc.

See also

RIGHT()

8.3.13. LOWER()

Available in

DSQL, ESQL, PSQL

Possible name conflict

YES → Read details below

Result type

(VAR)CHAR, (VAR)BINARY or BLOB

Syntax

```
LOWER (string)
```

Table 159. LOWER Function ParameterS

Parameter	Description
string	An expression of a string type

Returns the lower-case equivalent of the input string. The exact result depends on the character set. With ASCII or NONE for instance, only ASCII characters are lowercased; with character set OCTETS /(VAR)BINARY, the entire string is returned unchanged. Since Firebird 2.1 this function also fully supports text BLOBs of any length and character set.

Name Clash

Because LOWER is a reserved word, the internal function will take precedence even if the external function by that name has also been declared. To call the (inferior!) external function, use double-quotes and the exact capitalisation, as in "LOWER"(string).

LOWER Examples

```
select Sheriff from Towns
  where lower(Name) = 'cooper''s valley'
```

See also

UPPER()

8.3.14. LPAD()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

VARCHAR or BLOB

Syntax

```
LPAD (str, endlen [, padstr])
```

Table 160. LPAD Function Parameters

Parameter	Description
str	An expression of a string type
endlen	Output string length
padstr	The character or string to be used to pad the source string up to the specified length. Default is space (“' '”)

Left-pads a string with spaces or with a user-supplied string until a given length is reached.

- This function fully supports text BLOBs of any length and character set.
- If *str* is a BLOB, the result is a BLOB. Otherwise, the result is a VARCHAR(endlen).
- If *padstr* is given and equals '' (empty string), no padding takes place.
- If *endlen* is less than the current string length, the string is truncated to *endlen*, even if *padstr* is the empty string.

In Firebird 2.1-2.1.3, all non-BLOB results were of type VARCHAR(32765), which made it advisable to cast them to a more modest size. This is no longer the case.

When used on a BLOB, this function may need to load the entire object into memory. Although it does try to limit memory consumption, this may affect performance if huge BLOBs are involved.

LPAD Examples

```
lpad ('Hello', 12)              -- returns '       Hello'
lpad ('Hello', 12, '-')         -- returns '-------Hello'
lpad ('Hello', 12, '')          -- returns 'Hello'
lpad ('Hello', 12, 'abc')       -- returns 'abcabcaHello'
lpad ('Hello', 12, 'abcdefghij') -- returns 'abcdefgHello'
lpad ('Hello', 2)               -- returns 'He'
lpad ('Hello', 2, '-')          -- returns 'He'
lpad ('Hello', 2, '')           -- returns 'He'
```

See also

RPAD()

8.3.15. OCTET_LENGTH()

Available in

DSQL, PSQL

Result type

INTEGER

Syntax

```
OCTET_LENGTH (string)
```

Table 161. OCTET_LENGTH Function Parameter

Parameter	Description
string	An expression of a string type

Gives the length in bytes (octets) of the input string. For multi-byte character sets, this may be less than the number of characters times the "formal" number of bytes per character as found in RDB$CHARACTER_SETS.

With arguments of type CHAR or BINARY, this function takes the entire formal string length (i.e. the declared length of a field or variable) into account. If you want to obtain the "logical" byte length, not counting the trailing spaces, right-TRIM the argument before passing it to OCTET_LENGTH.

BLOB *support*

Since Firebird 2.1, this function fully supports text BLOBs of any length and character set.

OCTET_LENGTH Examples

```
select octet_length('Hello!') from rdb$database
-- returns 6

select octet_length(_iso8859_1 'Grüß di!') from rdb$database
-- returns 8: ü and ß take up one byte each in ISO8859_1

select octet_length
  (cast (_iso8859_1 'Grüß di!' as varchar(24) character set utf8))
from rdb$database
-- returns 10: ü and ß take up two bytes each in UTF8

select octet_length
  (cast (_iso8859_1 'Grüß di!' as char(24) character set utf8))
from rdb$database
-- returns 26: all 24 CHAR positions count, and two of them are 2-byte
```

See also

BIT_LENGTH(), CHAR_LENGTH(), CHARACTER_LENGTH()

8.3.16. OVERLAY()

Available in

DSQL, PSQL

Result type

VARCHAR or BLOB

Syntax

```
OVERLAY (string PLACING replacement FROM pos [FOR length])
```

Table 162. OVERLAY Function Parameters

Parameter	Description
string	The string into which the replacement takes place
replacement	Replacement string
pos	The position from which replacement takes place (starting position)
length	The number of characters that are to be overwritten

OVERLAY() overwrites part of a string with another string. By default, the number of characters removed from (overwritten in) the host string equals the length of the replacement string. With the optional fourth argument, a different number of characters can be specified for removal.

- This function supports BLOBs of any length.
- If *string* or *replacement* is a BLOB, the result is a BLOB. Otherwise, the result is a VARCHAR(n) with *n* the sum of the lengths of *string* and *replacement*.
- As usual in SQL string functions, *pos* is 1-based.
- If *pos* is beyond the end of *string*, *replacement* is placed directly after *string*.
- If the number of characters from *pos* to the end of *string* is smaller than the length of *replacement* (or than the *length* argument, if present), *string* is truncated at *pos* and *replacement* placed after it.
- The effect of a "FOR 0" clause is that *replacement* is simply inserted into *string*.
- If any argument is NULL, the result is NULL.
- If *pos* or *length* is not a whole number, bankers' rounding (round-to-even) is applied, i.e. 0.5 becomes 0, 1.5 becomes 2, 2.5 becomes 2, 3.5 becomes 4, etc.

When used on a BLOB, this function may need to load the entire object into memory. This may affect performance if huge BLOBs are involved.

OVERLAY Examples

```
overlay ('Goodbye' placing 'Hello' from 2)   -- returns 'GHelloe'
overlay ('Goodbye' placing 'Hello' from 5)   -- returns 'GoodHello'
overlay ('Goodbye' placing 'Hello' from 8)   -- returns 'GoodbyeHello'
overlay ('Goodbye' placing 'Hello' from 20)  -- returns 'GoodbyeHello'

overlay ('Goodbye' placing 'Hello' from 2 for 0) -- r. 'GHellooodbye'
overlay ('Goodbye' placing 'Hello' from 2 for 3) -- r. 'GHellobye'
overlay ('Goodbye' placing 'Hello' from 2 for 6) -- r. 'GHello'
overlay ('Goodbye' placing 'Hello' from 2 for 9) -- r. 'GHello'

overlay ('Goodbye' placing '' from 4)        -- returns 'Goodbye'
overlay ('Goodbye' placing '' from 4 for 3)  -- returns 'Gooe'
overlay ('Goodbye' placing '' from 4 for 20) -- returns 'Goo'

overlay ('' placing 'Hello' from 4)          -- returns 'Hello'
overlay ('' placing 'Hello' from 4 for 0)    -- returns 'Hello'
overlay ('' placing 'Hello' from 4 for 20)   -- returns 'Hello'
```

See also

REPLACE()

8.3.17. POSITION()

Available in

DSQL, PSQL

Result type

INTEGER

Syntax

```
  POSITION (substr IN string)
| POSITION (substr, string [, startpos])
```

Table 163. POSITION Function Parameters

Parameter	Description
substr	The substring whose position is to be searched for
string	The string which is to be searched
startpos	The position in *string* where the search is to start

Returns the (1-based) position of the first occurrence of a substring in a host string. With the optional third argument, the search starts at a given offset, disregarding any matches that may occur earlier in the string. If no match is found, the result is 0.

- The optional third argument is only supported in the second syntax (comma

syntax).

- The empty string is considered a substring of every string. Therefore, if *substr* is `''` (empty string) and *string* is not `NULL`, the result is:
  - 1 if *startpos* is not given;
  - *startpos* if *startpos* lies within *string*;
  - 0 if *startpos* lies beyond the end of *string*.

  Notice: A bug in Firebird 2.1 - 2.1.3 and 2.5.0 causes `POSITION` to *always* return 1 if *substr* is the empty string. This is fixed in 2.1.4 and 2.5.1.
- This function fully supports text `BLOB`s of any size and character set.

When used on a `BLOB`, this function may need to load the entire object into memory. This may affect performance if huge `BLOB`s are involved.

`POSITION` Examples

```
position ('be' in 'To be or not to be')   -- returns 4
position ('be', 'To be or not to be')     -- returns 4
position ('be', 'To be or not to be', 4)  -- returns 4
position ('be', 'To be or not to be', 8)  -- returns 17
position ('be', 'To be or not to be', 18) -- returns 0
position ('be' in 'Alas, poor Yorick!')   -- returns 0
```

See also

`SUBSTRING()`

8.3.18. `REPLACE()`

Available in

DSQL, PSQL

Result type

`VARCHAR` or `BLOB`

Syntax

```
REPLACE (str, find, repl)
```

Table 164. `REPLACE` Function Parameters

Parameter	Description
str	The string in which the replacement is to take place
find	The string to search for

Parameter	Description
repl	The replacement string

Replaces all occurrences of a substring in a string.

- This function fully supports text BLOBs of any length and character set.
- If any argument is a BLOB, the result is a BLOB. Otherwise, the result is a VARCHAR(n) with *n* calculated from the lengths of *str*, *find* and *repl* in such a way that even the maximum possible number of replacements won't overflow the field.
- If *find* is the empty string, *str* is returned unchanged.
- If *repl* is the empty string, all occurrences of *find* are deleted from *str*.
- If any argument is NULL, the result is always NULL, even if nothing would have been replaced.

When used on a BLOB, this function may need to load the entire object into memory. This may affect performance if huge BLOBs are involved.

REPLACE Examples

```
replace ('Billy Wilder',  'il', 'oog') -- returns 'Boogly Woogder'
replace ('Billy Wilder',  'il',    '') -- returns 'Bly Wder'
replace ('Billy Wilder',  null, 'oog') -- returns NULL
replace ('Billy Wilder',  'il',  null) -- returns NULL
replace ('Billy Wilder', 'xyz',  null) -- returns NULL (!)
replace ('Billy Wilder', 'xyz', 'abc') -- returns 'Billy Wilder'
replace ('Billy Wilder',    '', 'abc') -- returns 'Billy Wilder'
```

See also

OVERLAY(), SUBSTRING(), POSITION(), CHAR_LENGTH(), CHARACTER_LENGTH()

8.3.19. REVERSE()

Available in

DSQL, PSQL

Result type

VARCHAR

Syntax

```
REVERSE (string)
```

Table 165. REVERSE Function Parameter

Parameter	Description
string	An expression of a string type

Returns a string backwards.

REVERSE Examples

```
reverse ('spoonful')            -- returns 'lufnoops'
reverse ('Was it a cat I saw?') -- returns '?was I tac a ti saW'
```

This function comes in very handy if you want to group, search or order on string endings, e.g. when dealing with domain names or email addresses:

```
create index ix_people_email on people
  computed by (reverse(email));

select * from people
  where reverse(email) starting with reverse('.br');
```

8.3.20. RIGHT()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

VARCHAR or BLOB

Syntax

```
RIGHT (string, length)
```

Table 166. RIGHT Function Parameters

Parameter	Description
string	An expression of a string type
length	Integer. Defines the number of characters to return

Returns the rightmost part of the argument string. The number of characters is given in the second argument.

- This function supports text BLOBs of any length, but has a bug in versions 2.1 - 2.1.3 and 2.5.0 that makes it fail with text BLOBs larger than 1024 bytes that have a multi-byte character set. This has been fixed in versions 2.1.4 and 2.5.1.
- If *string* is a BLOB, the result is a BLOB. Otherwise, the result is a VARCHAR(n) with *n* the length of the input string.

- If the *length* argument exceeds the string length, the input string is returned unchanged.
- If the *length* argument is not a whole number, bankers' rounding (round-to-even) is applied, i.e. 0.5 becomes 0, 1.5 becomes 2, 2.5 becomes 2, 3.5 becomes 4, etc.

When used on a BLOB, this function may need to load the entire object into memory. This may affect performance if huge BLOBs are involved.

See also

LEFT(), SUBSTRING()

8.3.21. RPAD()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

VARCHAR or BLOB

Syntax

```
RPAD (str, endlen [, padstr])
```

Table 167. RPAD Function Parameters

Parameter	Description
str	An expression of a string type
endlen	Output string length
endlen	The character or string to be used to pad the source string up to the specified length. Default is space (' ')

Right-pads a string with spaces or with a user-supplied string until a given length is reached.

- This function fully supports text BLOBs of any length and character set.
- If *str* is a BLOB, the result is a BLOB. Otherwise, the result is a VARCHAR(endlen).
- If *padstr* is given and equals '' (empty string), no padding takes place.
- If *endlen* is less than the current string length, the string is truncated to *endlen*, even if *padstr* is the empty string.

In Firebird 2.1-2.1.3, all non-BLOB results were of type VARCHAR(32765), which made it advisable to cast them to a more modest size. This is no longer the case.

When used on a BLOB, this function may need to load the entire object into memory.

> Although it does try to limit memory consumption, this may affect performance if huge BLOBs are involved.

RPAD Examples

```
rpad ('Hello', 12)              -- returns 'Hello       '
rpad ('Hello', 12, '-')         -- returns 'Hello-------'
rpad ('Hello', 12, '')          -- returns 'Hello'
rpad ('Hello', 12, 'abc')       -- returns 'Helloabcabca'
rpad ('Hello', 12, 'abcdefghij') -- returns 'Helloabcdefg'
rpad ('Hello', 2)               -- returns 'He'
rpad ('Hello', 2, '-')          -- returns 'He'
rpad ('Hello', 2, '')           -- returns 'He'
```

See also

LPAD()

8.3.22. SUBSTRING()

Available in

DSQL, PSQL

Result types

VARCHAR or BLOB

Syntax

```
SUBSTRING ( <substring-args> )

<substring-args> ::=
    str FROM startpos [FOR length]
  | str SIMILAR <similar-pattern> ESCAPE <escape>

<similar-pattern> ::=
  <similar-pattern-R1>
  <escape> " <similar-pattern-R2> <escape> "
  <similar-pattern-R3>
```

Table 168. SUBSTRING Function Parameters

Parameter	Description
str	An expression of a string type
startpos	Integer expression, the position from which to start retrieving the substring
length	The number of characters to retrieve after the *startpos*
similar-pattern	SQL regular expression pattern to search for the substring

Parameter	Description
escape	Escape character

Returns a string's substring starting at the given position, either to the end of the string or with a given length, or extracts a substring using an SQL regular expression pattern.

If any argument is NULL, the result is also NULL.

When used on a BLOB, this function may need to load the entire object into memory. Although it does try to limit memory consumption, this may affect performance if huge BLOBs are involved.

Positional SUBSTRING

In its simple, positional form (with FROM), this function returns the substring starting at character position *startpos* (the first character being 1). Without the FOR argument, it returns all the remaining characters in the string. With FOR, it returns *length* characters or the remainder of the string, whichever is shorter.

Since Firebird 4.0, *startpos* can be smaller than 1. When *startpos* is smaller than 1, substring behaves as if the string has `1 - startpos` extra positions before the actual first character at position 1. The *length* is considered from this imaginary start of the string, so the resulting string could be shorter than the specified *length*, or even empty.

The function fully supports binary and text BLOBs of any length, and with any character set. If *str* is a BLOB, the result is also a BLOB. For any other argument type, the result is a VARCHAR.

For non-BLOB arguments, the width of the result field is always equal to the length of *str*, regardless of *startpos* and *length*. So, `substring('pinhead' from 4 for 2)` will return a `VARCHAR(7)` containing the string `'he'`.

Example

```
insert into AbbrNames(AbbrName)
  select substring(LongName from 1 for 3) from LongNames;

select substring('abcdef' from 1 for 2) from rdb$database;
-- result: 'ab'

select substring('abcdef' from 2) from rdb$database;
-- result: 'bcdef'

select substring('abcdef' from 0 for 2) from rdb$database;
-- result: 'a'
-- and NOT 'ab', because there is "nothing" at position 0

select substring('abcdef' from -5 for 2) from rdb$database;
-- result: ''
-- length ends before the actual start of the string
```

Regular Expression SUBSTRING

In the regular expression form (with SIMILAR), the SUBSTRING function returns part of the string matching an SQL regular expression pattern. If no match is found, NULL is returned.

The SIMILAR pattern is formed from three SQL regular expression patterns, *R1*, *R2* and *R3*. The entire pattern takes the form of R1 || '<escape>"' || R2 || '<escape>"' || R3, where <*escape*> is the escape character defined in the ESCAPE clause. *R2* is the pattern that matches the substring to extract, and is enclosed between escaped double quotes (<escape>", e.g. "#"" with escape character '#'). *R1* matches the prefix of the string, and *R3* the suffix of the string. Both *R1* and *R3* are optional (they can be empty), but the pattern must match the entire string. In other words, it is not sufficient to specify a pattern that only finds the substring to extract.

The escaped double quotes around *R2* can be compared to defining a single capture group in more common regular expression syntax like PCRE. That is, the full pattern is equivalent to R1(R2)R3, which must match the entire input string, and the capture group is the substring to be returned.

If any one of *R1*, *R2*, or *R3* is not a zero-length string and does not have the format of an SQL regular expression, then an exception is raised.

The full SQL regular expression format is described in Syntax: SQL Regular Expressions

Examples

```
substring('abcabc' similar 'a#"bcab#"c' escape '#')  -- bcab
substring('abcabc' similar 'a#"%#"c' escape '#')     -- bcab
substring('abcabc' similar '_#"%#"_' escape '#')     -- bcab
substring('abcabc' similar '#"(abc)*#"' escape '#')  -- abcabc
substring('abcabc' similar '#"abc#"' escape '#')     -- <null>
```

See also

POSITION(), LEFT(), RIGHT(), CHAR_LENGTH(), CHARACTER_LENGTH(), SIMILAR TO

8.3.23. TRIM()

Available in

DSQL, PSQL

Result type

VARCHAR or BLOB

Syntax

```
TRIM ([<adjust>] str)

<adjust> ::=  {[<where>] [what]} FROM
```

```
<where> ::=  BOTH | LEADING | TRAILING
```

Table 169. TRIM Function Parameters

Parameter	Description
str	An expression of a string type
where	The position the substring is to be removed from — BOTH | LEADING | TRAILING. BOTH is the default
what	The substring that should be removed (multiple times if there are several matches) from the beginning, the end, or both sides of the input string *str*. By default it is space (' ')

Removes leading and/or trailing spaces (or optionally other strings) from the input string. Since Firebird 2.1 this function fully supports text BLOBs of any length and character set.

If *str* is a BLOB, the result is a BLOB. Otherwise, it is a VARCHAR(n) with *n* the formal length of *str*.

When used on a BLOB, this function may need to load the entire object into memory. This may affect performance if huge BLOBs are involved.

TRIM Examples

```
select trim ('  Waste no space   ') from rdb$database
-- returns 'Waste no space'

select trim (leading from '  Waste no space   ') from rdb$database
-- returns 'Waste no space   '

select trim (leading '.' from '  Waste no space   ') from rdb$database
-- returns '  Waste no space   '

select trim (trailing '!' from 'Help!!!!') from rdb$database
-- returns 'Help'

select trim ('la' from 'lalala I love you Ella') from rdb$database
-- returns ' I love you El'

select trim ('la' from 'Lalala I love you Ella') from rdb$database
-- returns 'Lalala I love you El'
```

8.3.24. UPPER()

Available in

DSQL, ESQL, PSQL

Result type

(VAR)CHAR, (VAR)BINARY or BLOB

Syntax

```
UPPER (str)
```

Table 170. UPPER Function Parameter

Parameter	Description
str	An expression of a string type

Returns the upper-case equivalent of the input string. The exact result depends on the character set. With ASCII or NONE for instance, only ASCII characters are uppercased; with character set OCTETS /(VAR)BINARY, the entire string is returned unchanged. Since Firebird 2.1 this function also fully supports text BLOBs of any length and character set.

UPPER Examples

```
select upper(_iso8859_1 'Débâcle')
from rdb$database
-- returns 'DÉBÂCLE' (before Firebird 2.0: 'DéBâCLE')

select upper(_iso8859_1 'Débâcle' collate fr_fr)
from rdb$database
-- returns 'DEBACLE', following French uppercasing rules
```

See also

LOWER()

8.4. Date and Time Functions

8.4.1. CURRENT_DATE

Documented in CURRENT_DATE.

8.4.2. CURRENT_TIME

Documented in CURRENT_TIME.

8.4.3. CURRENT_TIMESTAMP

Documented in CURRENT_TIMESTAMP.

8.4.4. DATEADD()

Available in

DSQL, PSQL

Result type

DATE, TIME or TIMESTAMP

Syntax

```
DATEADD (<args>)

<args> ::=
    <amount> <unit> TO <datetime>
  | <unit>, <amount>, <datetime>

<amount> ::= an integer expression (negative to subtract)
<unit> ::=
    YEAR | MONTH | WEEK | DAY
  | HOUR | MINUTE | SECOND | MILLISECOND
<datetime> ::= a DATE, TIME or TIMESTAMP expression
```

Table 171. DATEADD Function Parameters

Parameter	Description
amount	An integer expression of the SMALLINT, INTEGER or BIGINT type. For unit MILLISECOND, the type is NUMERIC(18, 1). A negative value is subtracted.
unit	Date/time unit
datetime	An expression of the DATE, TIME or TIMESTAMP type

Adds the specified number of years, months, weeks, days, hours, minutes, seconds or milliseconds to a date/time value.

- The result type is determined by the third argument.
- With TIMESTAMP and DATE arguments, all units can be used.
- With TIME arguments, only HOUR, MINUTE, SECOND and MILLISECOND can be used.

Examples of DATEADD

```
dateadd (28 day to current_date)
dateadd (-6 hour to current_time)
dateadd (month, 9, DateOfConception)
dateadd (-38 week to DateOfBirth)
dateadd (minute, 90, cast('now' as time))
dateadd (? year to date '11-Sep-1973')
```

```
select
  cast(dateadd(-1 * extract(millisecond from ts) millisecond to ts) as varchar(30)) as
t,
```

```
  extract(millisecond from ts) as ms
from (
  select timestamp '2014-06-09 13:50:17.4971' as ts
  from rdb$database
) a
```

```
T                       MS
----------------------- ------
2014-06-09 13:50:17.0000  497.1
```

See also

`DATEDIFF()`, Operations Using Date and Time Values

8.4.5. DATEDIFF()

Available in

DSQL, PSQL

Result type

`BIGINT`, or — since Firebird 4.0.1 — `NUMERIC(18,1)` for `MILLISECOND`

Syntax

```
DATEDIFF (<args>)

<args> ::=
    <unit> FROM <moment1> TO <moment2>
  | <unit>, <moment1>, <moment2>

<unit> ::=
    YEAR | MONTH | WEEK | DAY
  | HOUR | MINUTE | SECOND | MILLISECOND
<momentN> ::= a DATE, TIME or TIMESTAMP expression
```

Table 172. `DATEDIFF` *Function Parameters*

Parameter	Description
unit	Date/time unit
moment1	An expression of the `DATE`, `TIME` or `TIMESTAMP` type
moment2	An expression of the `DATE`, `TIME` or `TIMESTAMP` type

Returns the number of years, months, weeks, days, hours, minutes, seconds or milliseconds elapsed between two date/time values. (The `WEEK` unit is new in 2.5.)

- `DATE` and `TIMESTAMP` arguments can be combined. No other mixes are allowed.
- With `TIMESTAMP` and `DATE` arguments, all units can be used. (Prior to Firebird 2.5, units smaller

than DAY were disallowed for DATEs.)

- With TIME arguments, only HOUR, MINUTE, SECOND and MILLISECOND can be used.

Computation

- DATEDIFF doesn't look at any smaller units than the one specified in the first argument. As a result,
  - `datediff (year, date '1-Jan-2009', date '31-Dec-2009')` returns 0, but
  - `datediff (year, date '31-Dec-2009', date '1-Jan-2010')` returns 1
- It does, however, look at all the *bigger* units. So:
  - `datediff (day, date '26-Jun-1908', date '11-Sep-1973')` returns 23818
- A negative result value indicates that *moment2* lies before *moment1*.

DATEDIFF Examples

```
datediff (hour from current_timestamp to timestamp '12-Jun-2059 06:00')
datediff (minute from time '0:00' to current_time)
datediff (month, current_date, date '1-1-1900')
datediff (day from current_date to cast(? as date))
```

See also

DATEADD(), Operations Using Date and Time Values

8.4.6. EXTRACT()

Available in

DSQL, ESQL, PSQL

Result type

SMALLINT or NUMERIC

Syntax

```
EXTRACT (<part> FROM <datetime>)

<part> ::=
    YEAR | MONTH | WEEK
  | DAY | WEEKDAY | YEARDAY
  | HOUR | MINUTE | SECOND | MILLISECOND
  | TIMEZONE_HOUR | TIMEZONE_MINUTE
<datetime> ::= a DATE, TIME or TIMESTAMP expression
```

Table 173. EXTRACT Function Parameters

Parameter	Description
part	Date/time unit

Parameter	Description
datetime	An expression of the DATE, TIME or TIMESTAMP type

Extracts and returns an element from a DATE, TIME or TIMESTAMP expression.

Returned Data Types and Ranges

The returned data types and possible ranges are shown in the table below. If you try to extract a part that isn't present in the date/time argument (e.g. SECOND from a DATE or YEAR from a TIME), an error occurs.

Table 174. Types and ranges of EXTRACT *results*

Part	Type	Range	Comment
YEAR	SMALLINT	1-9999	
MONTH	SMALLINT	1-12	
WEEK	SMALLINT	1-53	
DAY	SMALLINT	1-31	
WEEKDAY	SMALLINT	0-6	0 = Sunday
YEARDAY	SMALLINT	0-365	0 = January 1
HOUR	SMALLINT	0-23	
MINUTE	SMALLINT	0-59	
SECOND	NUMERIC(9,4)	0.0000-59.9999	includes millisecond as fraction
MILLISECOND	NUMERIC(9,1)	0.0-999.9	broken in 2.1, 2.1.1
TIMEZONE_HOUR	SMALLINT	-23 - +23	
TIMEZONE_MINUTE	SMALLINT	-59 - +59	

MILLISECOND

Firebird 2.1 and up support extraction of the millisecond from a TIME or TIMESTAMP. The data type returned is NUMERIC(9,1).

If you extract the millisecond from CURRENT_TIME, be aware that this variable defaults to seconds precision, so the result will always be 0. Extract from CURRENT_TIME(3) or CURRENT_TIMESTAMP to get milliseconds precision.

WEEK

Firebird 2.1 and up support extraction of the ISO-8601 week number from a DATE or TIMESTAMP. ISO-8601 weeks start on a Monday and always have the full seven days. Week 1 is the first week that has a majority (at least 4) of its days in the new year. The first 1-3 days of the year may belong to the last week (52 or 53) of the previous year. Likewise, a year's final 1-3 days may belong to week 1 of the following year.

Be careful when combining WEEK and YEAR results. For instance, 30 December 2008

lies in week 1 of 2009, so `extract(week from date '30 Dec 2008')` returns 1. However, extracting `YEAR` always gives the calendar year, which is 2008. In this case, `WEEK` and `YEAR` are at odds with each other. The same happens when the first days of January belong to the last week of the previous year.

Please also notice that `WEEKDAY` is *not* ISO-8601 compliant: it returns 0 for Sunday, whereas ISO-8601 specifies 7.

See also

Data Types for Dates and Times

8.4.7. FIRST_DAY()

Available in

DSQL, PSQL

Result Type

`DATE`, `TIMESTAMP` (with or without time zone)

Syntax

```
FIRST_DAY(OF <period> FROM date_or_timestamp)

<period> ::= YEAR | MONTH | WEEK
```

Table 175. `FIRST_DAY` Function Parameters

Parameter	Description
date_or_timestamp	Expression of type `DATE`, `TIMESTAMP WITHOUT TIME ZONE` or `TIMESTAMP WITH TIME ZONE`

`FIRST_DAY` returns a date or timestamp (same as the type of *date_or_timestamp*) with the first day of the year, month or week of a given date or timestamp value.

- The first day of the week is considered as Sunday, following the same rules as for `EXTRACT()` with `WEEKDAY`.
- When a timestamp is passed, the return value preserves the time part.

Examples of FIRST_DAY

```
select first_day(of month from current_date) from rdb$database;
select first_day(of year from current_timestamp) from rdb$database;
select first_day(of week from date '2017-11-01') from rdb$database;
```

8.4.8. LAST_DAY()

Available in

DSQL, PSQL

Result Type

DATE, TIMESTAMP (with or without time zone)

Syntax

```
LAST_DAY(OF <period> FROM date_or_timestamp)

<period> ::= YEAR | MONTH | WEEK
```

Table 176. LAST_DAY Function Parameters

Parameter	Description
date_or_timestamp	Expression of type DATE, TIMESTAMP WITHOUT TIME ZONE or TIMESTAMP WITH TIME ZONE

LAST_DAY returns a date or timestamp (same as the type of *date_or_timestamp*) with the last day of the year, month or week of a given date or timestamp value.

- The last day of the week is considered as Saturday, following the same rules as for EXTRACT() with WEEKDAY.
- When a timestamp is passed, the return value preserves the time part.

Examples of LAST_DAY

```
select last_day(of month from current_date) from rdb$database;
select last_day(of year from current_timestamp) from rdb$database;
select last_day(of week from date '2017-11-01') from rdb$database;
```

8.4.9. LOCALTIME

Documented in LOCALTIME.

8.4.10. LOCALTIMESTAMP

Documented in LOCALTIMESTAMP.

8.5. Type Casting Functions

8.5.1. CAST()

Available in

DSQL, ESQL, PSQL

Result type

As specified by *target_type*

Syntax

```
CAST (<expression> AS <target_type>)

<target_type> ::= <domain_or_non_array_type> | <array_datatype>

<domain_or_non_array_type> ::=
  !! See Scalar Data Types Syntax !!

<array_datatype> ::=
  !! See Array Data Types Syntax !!
```

Table 177. CAST Function Parameters

Parameter	Description
expression	SQL expression
sql_datatype	SQL data type

CAST converts an expression to the desired data type or domain. If the conversion is not possible, an error is raised.

Casting BLOBs

Successful casting to and from BLOBs is possible since Firebird 2.1.

"Shorthand" Syntax

Alternative syntax, supported only when casting a string literal to a DATE, TIME or TIMESTAMP:

```
datatype 'date/timestring'
```

This syntax was already available in InterBase, but was never properly documented. In the SQL standard, this feature is called "datetime literals".

Since Firebird 4.0 the use of 'NOW', 'YESTERDAY' and 'TOMORROW' in the shorthand cast is no longer allowed; only literals defining a fixed moment in time are supported.

Allowed Type Conversions

The following table shows the type conversions possible with CAST.

Table 178. Possible Type-castings with CAST

From	To
Numeric types	Numeric types [VAR]CHAR BLOB
[VAR]CHAR BLOB	[VAR]CHAR BLOB Numeric types DATE TIME TIMESTAMP
DATE TIME	[VAR]CHAR BLOB TIMESTAMP
TIMESTAMP	[VAR]CHAR BLOB DATE TIME

Keep in mind that sometimes information is lost, for instance when you cast a TIMESTAMP to a DATE. Also, the fact that types are CAST-compatible is in itself no guarantee that a conversion will succeed. "CAST(123456789 as SMALLINT)" will definitely result in an error, as will "CAST('Judgement Day' as DATE)".

Casting Parameters

Since Firebird 2.0, you can cast statement parameters to a data type:

```
cast (? as integer)
```

This gives you control over the type of the parameter set up by the engine. Please notice that with statement parameters, you always need a full-syntax cast — shorthand casts are not supported.

Casting to a Domain or its Type

Firebird 2.1 and above support casting to a domain or its base type. When casting to a domain, any constraints (NOT NULL and/or CHECK) declared for the domain must be satisfied, or the cast will fail. Please be aware that a CHECK passes if it evaluates to TRUE *or* NULL! So, given the following statements:

```
create domain quint as int check (value >= 5000);
select cast (2000 as quint) from rdb$database;     ①
select cast (8000 as quint) from rdb$database;     ②
select cast (null as quint) from rdb$database;     ③
```

only cast number *1* will result in an error.

When the TYPE OF modifier is used, the expression is cast to the base type of the domain, ignoring any constraints. With domain quint defined as above, the following two casts are equivalent and will both succeed:

```
select cast (2000 as type of quint) from rdb$database;
select cast (2000 as int) from rdb$database;
```

If TYPE OF is used with a (VAR)CHAR type, its character set and collation are retained:

```
create domain iso20 varchar(20) character set iso8859_1;
create domain dunl20 varchar(20) character set iso8859_1 collate du_nl;
create table zinnen (zin varchar(20));
commit;
insert into zinnen values ('Deze');
insert into zinnen values ('Die');
insert into zinnen values ('die');
insert into zinnen values ('deze');

select cast(zin as type of iso20) from zinnen order by 1;
-- returns Deze -> Die -> deze -> die

select cast(zin as type of dunl20) from zinnen order by 1;
-- returns deze -> Deze -> die -> Die
```

If a domain's definition is changed, existing CASTs to that domain or its type may become invalid. If these CASTs occur in PSQL modules, their invalidation may be detected. See the note *The RDB$VALID_BLR field*, in Appendix A.

Casting to a Column's Type

In Firebird 2.5 and above, it is possible to cast expressions to the type of an existing table or view column. Only the type itself is used; in the case of string types, this includes the character set but not the collation. Constraints and default values of the source column are not applied.

```
create table ttt (
  s varchar(40) character set utf8 collate unicode_ci_ai
);
commit;

select cast ('Jag har många vänner' as type of column ttt.s)
from rdb$database;
```

Warnings

If a column's definition is altered, existing CASTs to that column's type may become invalid. If these CASTs occur in PSQL modules, their invalidation may be detected.

> See the note *The RDB$VALID_BLR field*, in Appendix A.

Cast Examples

A full-syntax cast:

```
select cast ('12' || '-June-' || '1959' as date) from rdb$database
```

A shorthand string-to-date cast:

```
update People set AgeCat = 'Old'
  where BirthDate < date '1-Jan-1943'
```

Notice that you can drop even the shorthand cast from the example above, as the engine will understand from the context (comparison to a `DATE` field) how to interpret the string:

```
update People set AgeCat = 'Old'
  where BirthDate < '1-Jan-1943'
```

However, this is not always possible. The cast below cannot be dropped, otherwise the engine would find itself with an integer to be subtracted from a string:

```
select cast('today' as date) - 7 from rdb$database
```

8.6. Bitwise Functions

8.6.1. BIN_AND()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

`SMALLINT`, `INTEGER` or `BIGINT`

> `SMALLINT` result is returned only if all the arguments are explicit `SMALLINT`s or `NUMERIC(n, 0)` with *n* <= 4; otherwise small integers return an `INTEGER` result.

Syntax

```
BIN_AND (number, number [, number ...])
```

Table 179. BIN_AND Function Parameters

Parameter	Description
number	Any integer number (literal, smallint/integer/bigint, numeric/decimal with scale 0)

Returns the result of the bitwise *AND* operation on the argument(s).

See also

BIN_OR(), BIN_XOR()

8.6.2. BIN_NOT()

Available in

DSQL, PSQL

Result type

SMALLINT, INTEGER or BIGINT

SMALLINT result is returned only if all the arguments are explicit SMALLINTs or NUMERIC(n, 0) with *n* <= 4; otherwise small integers return an INTEGER result.

Syntax

```
BIN_NOT (number)
```

Table 180. BIN_NOT Function Parameter

Parameter	Description
number	Any integer number (literal, smallint/integer/bigint, numeric/decimal with scale 0)

Returns the result of the bitwise *NOT* operation on the argument, i.e. *one's complement*.

See also

BIN_OR(), BIN_XOR() and others in this set.

8.6.3. BIN_OR()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

SMALLINT, INTEGER or BIGINT

`SMALLINT` result is returned only if all the arguments are explicit `SMALLINT`s or `NUMERIC(n, 0)` with *n* <= 4; otherwise small integers return an `INTEGER` result.

Syntax

```
BIN_OR (number, number [, number ...])
```

Table 181. `BIN_OR` Function Parameters

Parameter	Description
number	Any integer number (literal, smallint/integer/bigint, numeric/decimal with scale 0)

Returns the result of the bitwise *OR* operation on the argument(s).

See also

`BIN_AND()`, `BIN_XOR()`

8.6.4. BIN_SHL()

Available in

DSQL, PSQL

Result type

`BIGINT`

Syntax

```
BIN_SHL (number, shift)
```

Table 182. `BIN_SHL` Function Parameters

Parameter	Description
number	A number of an integer type
shift	The number of bits the number value is shifted by

Returns the first argument bitwise left-shifted by the second argument, i.e. `a << b` or $a \cdot 2^b$.

See also

`BIN_SHR()`

8.6.5. BIN_SHR()

Available in

DSQL, PSQL

Result type

`BIGINT`

Syntax

```
BIN_SHR (number, shift)
```

Table 183. BIN_SHR Function Parameters

Parameter	Description
number	A number of an integer type
shift	The number of bits the number value is shifted by

Returns the first argument bitwise right-shifted by the second argument, i.e. `a >> b` or $a/2^b$.

- The operation performed is an arithmetic right shift (SAR), meaning that the sign of the first operand is always preserved.

See also

`BIN_SHL()`

8.6.6. BIN_XOR()

Available in

DSQL, PSQL

Possible name conflict

YES → Read details

Result type

`SMALLINT`, `INTEGER` or `BIGINT`

`SMALLINT` result is returned only if all the arguments are explicit `SMALLINT`s or `NUMERIC(n, 0)` with *n* <= 4; otherwise small integers return an `INTEGER` result.

Syntax

```
BIN_XOR (number, number [, number ...])
```

Table 184. BIN_XOR Function Parameters

Parameter	Description
number	Any integer number (literal, smallint/integer/bigint, numeric/decimal with scale 0)

Returns the result of the bitwise *XOR* operation on the argument(s).

See also

`BIN_AND()`, `BIN_OR()`

8.7. UUID Functions

8.7.1. CHAR_TO_UUID()

Available in

DSQL, PSQL

Result type

`BINARY(16)`

Syntax

```
CHAR_TO_UUID (ascii_uuid)
```

Table 185. `CHAR_TO_UUID` Function Parameter

Parameter	Description
ascii_uuid	A 36-character representation of UUID. '-' (hyphen) in positions 9, 14, 19 and 24; valid hexadecimal digits in any other positions, e.g. 'A0bF4E45-3029-2a44-D493-4998c9b439A3'

Converts a human-readable 36-char UUID string to the corresponding 16-byte UUID.

`CHAR_TO_UUID` Examples

```
select char_to_uuid('A0bF4E45-3029-2a44-D493-4998c9b439A3') from rdb$database
-- returns A0BF4E4530292A44D4934998C9B439A3 (16-byte string)

select char_to_uuid('A0bF4E45-3029-2A44-X493-4998c9b439A3') from rdb$database
-- error: -Human readable UUID argument for CHAR_TO_UUID must
--         have hex digit at position 20 instead of "X (ASCII 88)"
```

See also

`UUID_TO_CHAR()`, `GEN_UUID()`

8.7.2. GEN_UUID()

Available in

DSQL, PSQL

Result type

`BINARY(16)`

Syntax

```
GEN_UUID ()
```

Returns a universally unique ID as a 16-byte character string.

GEN_UUID Example

```
select gen_uuid() from rdb$database
-- returns e.g. 017347BFE212B2479C00FA4323B36320 (16-byte string)
```

See also

UUID_TO_CHAR(), CHAR_TO_UUID()

8.7.3. UUID_TO_CHAR()

Available in

DSQL, PSQL

Result type

CHAR(36)

Syntax

```
UUID_TO_CHAR (uuid)
```

Table 186. UUID_TO_CHAR Function Parameters

Parameter	Description
uuid	16-byte UUID

Converts a 16-byte UUID to its 36-character, human-readable ASCII representation.

UUID_TO_CHAR Examples

```
select uuid_to_char(x'876C45F4569B320DBCB4735AC3509E5F') from rdb$database
-- returns '876C45F4-569B-320D-BCB4-735AC3509E5F'

select uuid_to_char(gen_uuid()) from rdb$database
-- returns e.g. '680D946B-45FF-DB4E-B103-BB5711529B86'

select uuid_to_char('Firebird swings!') from rdb$database
-- returns '46697265-6269-7264-2073-77696E677321'
```

See also

CHAR_TO_UUID(), GEN_UUID()

8.8. Functions for Sequences (Generators)

8.8.1. GEN_ID()

Available in

DSQL, ESQL, PSQL

Result type

`BIGINT` — dialect 2 and 3
`INTEGER` — dialect 1

Syntax

```
GEN_ID (generator-name, step)
```

Table 187. `GEN_ID` Function Parameters

Parameter	Description
generator-name	Name of a generator (sequence) that exists. If it has been defined in double quotes with a case-sensitive identifier, it must be used in the same form unless the name is all upper-case.
step	An integer expression

Increments a generator or sequence and returns its new value. If step equals 0, the function will leave the value of the generator unchanged and return its current value.

- From Firebird 2.0 onward, the SQL-compliant `NEXT VALUE FOR` syntax is preferred, except when an increment other than 1 is needed.

If the value of the step parameter is less than zero, it will decrease the value of the generator. Attention! You should be extremely cautious with such manipulations in the database, as they could compromise data integrity.

In dialect 1, the result type is `INTEGER`, in dialect 2 and 3 it is `BIGINT`.

`GEN_ID` Example

```
new.rec_id = gen_id(gen_recnum, 1);
```

See also

`NEXT VALUE FOR`, `CREATE SEQUENCE (GENERATOR)`

8.9. Conditional Functions

8.9.1. COALESCE()

Available in

DSQL, PSQL

Result type

Depends on input

Syntax

```
COALESCE (<exp1>, <exp2> [, <expN> ... ])
```

Table 188. COALESCE Function Parameters

Parameter	Description
exp1, exp2 … expN	A list of expressions of any compatible types

The COALESCE function takes two or more arguments and returns the value of the first non-NULL argument. If all the arguments evaluate to NULL, the result is NULL.

COALESCE Examples

This example picks the Nickname from the Persons table. If it happens to be NULL, it goes on to FirstName. If that too is NULL, "'Mr./Mrs.'" is used. Finally, it adds the family name. All in all, it tries to use the available data to compose a full name that is as informal as possible. Notice that this scheme only works if absent nicknames and first names are really NULL: if one of them is an empty string instead, COALESCE will happily return that to the caller.

```
select
  coalesce (Nickname, FirstName, 'Mr./Mrs.') || ' ' || LastName
    as FullName
from Persons
```

See also

IIF(), NULLIF(), CASE

8.9.2. DECODE()

Available in

DSQL, PSQL

Result type

Depends on input

Syntax

```
DECODE(<testexpr>,
  <expr1>, <result1>
  [<expr2>, <result2> ⋯]
  [, <defaultresult>])
```

The equivalent CASE construct:

```
CASE <testexpr>
  WHEN <expr1> THEN <result1>
  [WHEN <expr2> THEN <result2> ⋯]
  [ELSE <defaultresult>]
END
```

Table 189. DECODE Function Parameters

Parameter	Description
testexpr	An expression of any compatible type that is compared to the expressions expr1, expr2 … exprN
expr1, expr2, … exprN	Expressions of any compatible types, to which the *testexpr* expression is compared
result1, result2, … resultN	Returned values of any type
defaultresult	The expression to be returned if none of the conditions is met

DECODE is a shorthand for the so-called "simple CASE" construct, in which a given expression is compared to a number of other expressions until a match is found. The result is determined by the value listed after the matching expression. If no match is found, the default result is returned, if present. Otherwise, NULL is returned.

Matching is done with the '=' operator, so if *testexpr* is NULL, it won't match any of the *expr*s, not even those that are NULL.

DECODE Examples

```
select name,
  age,
  decode(upper(sex),
         'M', 'Male',
         'F', 'Female',
         'Unknown'),
  religion
from people
```

See also

CASE, Simple CASE

8.9.3. IIF()

Available in

DSQL, PSQL

Result type

Depends on input

Syntax

```
IIF (<condition>, ResultT, ResultF)
```

Table 190. IIF Function Parameters

Parameter	Description
condition	A true|false expression
resultT	The value returned if the condition is true
resultF	The value returned if the condition is false

IIF takes three arguments. If the first evaluates to true, the second argument is returned; otherwise the third is returned.

IIF could be likened to the ternary "?:" operator in C-like languages.

IIF(<Cond>, Result1, Result2) is a shorthand for "CASE WHEN <Cond> THEN Result1 ELSE Result2 END".

IIF Examples

```
select iif( sex = 'M', 'Sir', 'Madam' ) from Customers
```

See also

CASE, DECODE()

8.9.4. MAXVALUE()

Available in

DSQL, PSQL

Result type

Varies according to input — result will be of the same data type as the first expression in the list (*expr1*).

Syntax

```
MAXVALUE (<expr1> [, ... , <exprN> ])
```

Table 191. MAXVALUE Function Parameters

Parameter	Description
expr1 ... exprN	List of expressions of compatible types

Returns the maximum value from a list of numerical, string, or date/time expressions. This function fully supports text BLOBs of any length and character set.

If one or more expressions resolve to NULL, MAXVALUE returns NULL. This behaviour differs from the aggregate function MAX.

MAXVALUE Examples

```
SELECT MAXVALUE(PRICE_1, PRICE_2) AS PRICE
  FROM PRICELIST
```

See also

MINVALUE()

8.9.5. MINVALUE()

Available in

DSQL, PSQL

Result type

Varies according to input — result will be of the same data type as the first expression in the list (*expr1*).

Syntax

```
MINVALUE (<expr1> [, ... , <exprN> ])
```

Table 192. MINVALUE Function Parameters

Parameter	Description
expr1 ... exprN	List of expressions of compatible types

Returns the minimum value from a list of numerical, string, or date/time expressions. This function fully supports text BLOBs of any length and character set.

If one or more expressions resolve to NULL, MINVALUE returns NULL. This behaviour differs from the aggregate function MIN.

MINVALUE Examples

```
SELECT MINVALUE(PRICE_1, PRICE_2) AS PRICE
  FROM PRICELIST
```

See also

MAXVALUE()

8.9.6. NULLIF()

Available in

DSQL, PSQL

Result type

Depends on input

Syntax

```
NULLIF (<exp1>, <exp2>)
```

Table 193. NULLIF Function Parameters

Parameter	Description
exp1	An expression
exp2	Another expression of a data type compatible with *exp1*

NULLIF returns the value of the first argument, unless it is equal to the second. In that case, NULL is returned.

NULLIF Example

```
select avg( nullif(Weight, -1) ) from FatPeople
```

This will return the average weight of the persons listed in FatPeople, excluding those having a weight of -1, since AVG skips NULL data. Presumably, -1 indicates "weight unknown" in this table. A plain AVG(Weight) would include the -1 weights, thus skewing the result.

See also

COALESCE(), DECODE(), IIF(), CASE

8.10. Special Functions for DECFLOAT

8.10.1. COMPARE_DECFLOAT()

Available in

DSQL, PSQL

Result type

SMALLINT

Syntax

```
COMPARE_DECFLOAT (decfloat1, decfloat2)
```

Table 194. `COMPARE_DECFLOAT` *Function Parameters*

Parameter	Description
decfloat*n*	Value or expression of type `DECFLOAT`, or cast-compatible with `DECFLOAT`

`COMPARE_DECFLOAT` compares two `DECFLOAT` values to be equal, different or unordered. The result is a `SMALLINT` value, as follows:

`0` Values are equal

`1` First value is less than second

`2` First value is greater than second

`3` Values are unordered, i.e. one or both is `NaN`/`sNaN`

Unlike the comparison operators ('<', '=', '>', etc.), comparison is exact: `COMPARE_DECFLOAT(2.17, 2.170)` returns `2` not `0`.

See also

`TOTALORDER()`

8.10.2. `NORMALIZE_DECFLOAT()`

Available in

DSQL, PSQL

Result type

`DECFLOAT`

Syntax

```
NORMALIZE_DECFLOAT (decfloat_value)
```

Table 195. `NORMALIZE_DECFLOAT` *Function Parameters*

Parameter	Description
decfloat_value	Value or expression of type `DECFLOAT`, or cast-compatible with `DECFLOAT`

`NORMALIZE_DECFLOAT` takes a single `DECFLOAT` argument and returns it in its simplest form. That means that for any non-zero value, trailing zeroes are removed with appropriate correction of the exponent.

Examples of `NORMALIZE_DECFLOAT`

```
-- will return 12
select normalize_decfloat(12.00)
from rdb$database;

-- will return 1.2E+2
```

```
select normalize_decfloat(120)
from rdb$database;
```

8.10.3. QUANTIZE()

Available in

DSQL, PSQL

Syntax

```
QUANTIZE (decfloat_value, exp_value)
```

Table 196. QUANTIZE Function Parameters

Parameter	Description
decfloat_value	Value or expression to quantize; needs to be of type DECFLOAT, or cast-compatible with DECFLOAT
exp_value	Value or expression to use for its exponent; needs to be of type DECFLOAT, or cast-compatible with DECFLOAT

QUANTIZE returns a DECFLOAT value that is equal in value and sign (except for rounding) to *decfloat_value*, and that has an exponent equal to the exponent of *exp_value*. The type of the return value is DECFLOAT(16) if both arguments are DECFLOAT(16), otherwise the result type is DECFLOAT(34).

The target exponent is the exponent used in the Decimal64 or Decimal128 storage format of DECFLOAT of *exp_value*. This is not necessarily the same as the exponent displayed in tools like *isql*. For example, the value 1.23E+2 is coefficient 123 and exponent 0, while 1.2 is coefficient 12 and exponent -1.

If the exponent of *decfloat_value* is greater than the one of *exp_value*, the coefficient of *decfloat_value* is multiplied by a power of ten, and its exponent decreased, if the exponent is smaller, then its coefficient is rounded using the current decfloat rounding mode, and its exponent is increased.

When it is not possible to achieve the target exponent because the coefficient would exceed the target precision (16 or 34 decimal digits), either a "*Decfloat float invalid operation*" error is raised or NaN is returned (depending on the current decfloat traps configuration).

There are almost no restrictions on the *exp_value*. However, in almost all usages, NaN/sNaN/Infinity will produce an exception (unless allowed by the current decfloat traps configuration), NULL will make the function return NULL, and so on.

Examples of QUANTIZE

```
select v, pic, quantize(v, pic) from examples;

     V    PIC QUANTIZE
```

```
====== ====== ========
  3.16  0.001    3.160
  3.16   0.01     3.16
  3.16    0.1      3.2
  3.16      1        3
  3.16   1E+1     0E+1
  -0.1      1       -0
     0   1E+5     0E+5
   316    0.1    316.0
   316      1      316
   316   1E+1   3.2E+2
   316   1E+2     3E+2
```

8.10.4. TOTALORDER()

Available in

DSQL, PSQL

Result type

SMALLINT

Syntax

```
TOTALORDER (decfloat1, decfloat2)
```

Table 197. TOTALORDER Function Parameters

Parameter	Description
decfloat*n*	Value or expression of type DECFLOAT, or cast-compatible with DECFLOAT

TOTALORDER compares two DECFLOAT values including any special values. The comparison is exact, and returns a SMALLINT, one of:

`-1` First value is less than second

`0` Values are equal

`1` First value is greater than second.

For TOTALORDER comparisons, DECFLOAT values are ordered as follows:

```
-NaN < -sNaN < -INF < -0.1 < -0.10 < -0 < 0 < 0.10 < 0.1 < INF < sNaN < NaN
```

See also

COMPARE_DECFLOAT()

8.11. Cryptographic Functions

8.11.1. DECRYPT()

Available in

DSQL, PSQL

Result type

VARBINARY or BLOB

Syntax

```
DECRYPT ( encrypted_input
  USING <algorithm> [MODE <mode>]
  KEY key
  [IV iv] [<ctr_type>] [CTR_LENGTH ctr_length]
  [COUNTER initial_counter] )

!! See syntax of <<fblangref40-scalarfuncs-encrypt,ENCRYPT>> for further rules !!
```

Table 198. DECRYPT Function Parameters

Parameter	Description
encrypted_input	Encrypted input as a blob or (binary) string
See ENCRYPT Function Parameters for other parameters	

DECRYPT decrypts data using a symmetric cipher.

- Sizes of data strings (like *encrypted_input*, *key* and *iv*) must meet the requirements of the selected algorithm and mode.
- This function returns BLOB SUB_TYPE BINARY when the first argument is a BLOB, and VARBINARY for all other text and binary types.
- When the encrypted data was text, it must be explicitly cast to a string type of appropriate character set.
- The ins and outs of the various algorithms are considered beyond the scope of this language reference. We recommend searching the internet for further details on the algorithms.

DECRYPT Examples

```
select decrypt(x'0154090759DF' using sober128 key 'AbcdAbcdAbcdAbcd' iv '01234567')
  from rdb$database;
select decrypt(secret_field using aes mode ofb key '0123456701234567' iv init_vector)
  from secure_table;
```

See also

`ENCRYPT()`, `RSA_DECRYPT()`

8.11.2. ENCRYPT()

Available in

DSQL, PSQL

Result type

`VARBINARY` or `BLOB`

Syntax

```
ENCRYPT ( input
  USING <algorithm> [MODE <mode>]
  KEY key
  [IV iv] [<ctr_type>] [CTR_LENGTH ctr_length]
  [COUNTER initial_counter] )

<algorithm> ::= <block_cipher> | <stream_cipher>

<block_cipher> ::=
    AES | ANUBIS | BLOWFISH | KHAZAD | RC5
  | RC6 | SAFER+ | TWOFISH | XTEA

<stream_cipher> ::= CHACHA20 | RC4 | SOBER128

<mode> ::= CBC | CFB | CTR | ECB | OFB

<ctr_type> ::= CTR_BIG_ENDIAN | CTR_LITTLE_ENDIAN
```

Table 199. `ENCRYPT` *Function Parameters*

Parameter	Description
input	Input to encrypt as a blob or (binary) string
algorithm	The algorithm to use for decryption
mode	The algorithm mode; only for block ciphers
key	The encryption/decryption key
iv	Initialization vector or nonce; should be specified for block ciphers in all modes except `ECB`, and all stream ciphers except `RC4`
ctr_type	Endianness of the counter; only for `CTR` mode. Default is `CTR_LITTLE_ENDIAN`.
ctr_length	Counter length; only for `CTR` mode. Default is size of *iv*.
initial_counter	Initial counter value; only for `CHACHA20`. Default is `0`.

`ENCRYPT` can encrypt data using a symmetric cipher.

- This function returns `BLOB SUB_TYPE BINARY` when the first argument is a `BLOB`, and `VARBINARY` for all other text and binary types.
- Sizes of data strings (like *key* and *iv*) must meet the requirements of the selected algorithm and mode, see table Encryption Algorithm Requirements.
  - In general, the size of *iv* must match the block size of the algorithm
  - For ECB and CBC mode, *input* must be multiples of the block size, you will need to manually pad with zeroes or spaces as appropriate.
- The ins and outs of the various algorithms and modes are considered beyond the scope of this language reference. We recommend searching the internet for further details on the algorithms.
- Although specified as separate options in this Language Reference, in the actual Firebird 4.0 syntax `CTR_LENGTH` and `COUNTER` are aliases.

Table 200. Encryption Algorithm Requirements

Algorithm	Key size (bytes)	Block size (bytes)	Notes
Block Ciphers			
`AES`	16, 24, 32	16	Key size determines the AES variant: 16 bytes → AES-128 24 bytes → AES-192 32 bytes → AES-256
`ANUBIS`	16 - 40, in steps of 4	16	
`BLOWFISH`	8 - 56	8	
`KHAZAD`	16	8	
`RC5`	8 - 128	8	
`RC6`	8 - 128	16	
`SAFER+`	16, 24, 32	16	
`TWOFISH`	16, 24, 32	16	
`XTEA`	16	8	
Stream Ciphers			
`CHACHA20`	16, 32	1	Nonce size (IV) is 8 or 12 bytes. For nonce size 8, *initial_counter* is a 64-bit integer, for size 12, 32-bit.
`RC4`	5 - 256	1	
`SOBER128`	4*x*	1	Nonce size (IV) is 4*y* bytes, the length is independent of key size.

ENCRYPT Examples

```
select encrypt('897897' using sober128 key 'AbcdAbcdAbcdAbcd' iv '01234567')
  from rdb$database;
```

See also

DECRYPT(), RSA_ENCRYPT()

8.11.3. RSA_DECRYPT()

Available in

DSQL, PSQL

Result type

VARBINARY

Syntax

```
RSA_DECRYPT (encrypted_input KEY private_key
  [LPARAM tag_string] [HASH <hash>] [PKCS_1_5])

<hash> ::= MD5 | SHA1 | SHA256 | SHA512
```

Table 201. RSA_DECRYPT *Function Parameters*

Parameter	Description
encrypted_input	Input data to decrypt
private_key	Private key to apply, PKCS#1 format
tag_string	An additional system-specific tag to identify which system encrypted the message; default is NULL. If the tag does not match what was used during encryption, RSA_DECRYPT will not decrypt the data.
hash	The hash used for OAEP padding; default is SHA256.

RSA_DECRYPT decrypts *encrypted_input* using the RSA private key and then OAEP de-pads the resulting data.

By default, OAEP padding is used. The PKCS_1_5 option will switch to the less secure PKCS 1.5 padding. This option was introduced in Firebird 4.0.1.

The PKCS_1_5 option is only for backward compatibility with systems applying PKCS 1.5 padding. For security reasons, it should **not** be used in new projects.

- This function returns VARBINARY`.
- When the encrypted data was text, it must be explicitly cast to a string type of appropriate character set.

RSA_DECRYPT Examples

Run the examples of the RSA_PRIVATE and RSA_PUBLIC, RSA_ENCRYPT functions first.

```
select cast(rsa_decrypt(rdb$get_context('USER_SESSION', 'msg')
  key rdb$get_context('USER_SESSION', 'private_key')) as varchar(128))
from rdb$database;
```

See also

RSA_ENCRYPT(), RSA_PRIVATE(), DECRYPT()

8.11.4. RSA_ENCRYPT()

Available in

DSQL, PSQL

Result type

VARBINARY

Syntax

```
RSA_ENCRYPT (input KEY public_key
  [LPARAM tag_string] [HASH <hash>] [PKCS_1_5])

<hash> ::= MD5 | SHA1 | SHA256 | SHA512
```

Table 202. RSA_ENCRYPT Function Parameters

Parameter	Description
input	Input data to encrypt
public_key	Public key to apply, PKCS#1 format
tag_string	An additional system-specific tag to identify which system encrypted the message; default is NULL.
hash	The hash used for OAEP padding; default is SHA256.

RSA_ENCRYPT pads *input* using the OAEP padding scheme and then encrypts it using the specified RSA public key. This function is normally used to encrypt short symmetric keys which are then used in block ciphers to encrypt a message.

By default, OAEP padding is used. The PKCS_1_5 option will switch to the less secure PKCS 1.5 padding. This option was introduced in Firebird 4.0.1.

The PKCS_1_5 option is only for backward compatibility with systems applying PKCS 1.5 padding. For security reasons, it should **not** be used in new projects.

RSA_ENCRYPT Examples

Run the examples of the RSA_PRIVATE and RSA_PUBLIC functions first.

```
select rdb$set_context('USER_SESSION', 'msg', rsa_encrypt('Some message'
  key rdb$get_context('USER_SESSION', 'public_key'))) from rdb$database;
```

See also

RSA_DECRYPT(), RSA_PUBLIC(), ENCRYPT()

8.11.5. RSA_PRIVATE()

Available in

DSQL, PSQL

Result type

VARBINARY

Syntax

```
RSA_PRIVATE (key_length)
```

Table 203. RSA_PRIVATE Function Parameters

Parameter	Description
key_length	Key length in bytes; minimum 4, maximum 1024. A size of 256 bytes (2048 bits) or larger is recommended.

RSA_PRIVATE generates an RSA private key of the specified length (in bytes) in PKCS#1 format.

The larger the length specified, the longer it takes for the function to generate a private key.

RSA_PRIVATE Examples

```
select rdb$set_context('USER_SESSION', 'private_key', rsa_private(256))
  from rdb$database;
```

Putting private keys in the context variables is not secure. SYSDBA and users with the role RDB$ADMIN or the system privilege MONITOR_ANY_ATTACHMENT can see all context variables from all attachments.

See also

RSA_PUBLIC(), RSA_DECRYPT()

8.11.6. RSA_PUBLIC()

Available in

DSQL, PSQL

Result type

VARBINARY

Syntax

```
RSA_PUBLIC (private_key)
```

Table 204. RSA_PUBLIC Function Parameters

Parameter	Description
private_key	RSA private key in PKCS#1 format

RSA_PUBLIC returns the RSA public key in PKCS#1 format for the provided RSA private key (also PKCS#1 format).

RSA_PUBLIC Examples

Run the example of the RSA_PRIVATE function first.

```
select rdb$set_context('USER_SESSION', 'public_key',
  rsa_public(rdb$get_context('USER_SESSION', 'private_key'))) from rdb$database;
```

See also

RSA_PRIVATE(), RSA_ENCRYPT()

8.11.7. RSA_SIGN_HASH()

Available in

DSQL, PSQL

Result type

VARBINARY

Syntax

```
RSA_SIGN_HASH (message_digest
  KEY private_key
  [HASH <hash>] [SALT_LENGTH salt_length]
  [PKCS_1_5])

<hash> ::= MD5 | SHA1 | SHA256 | SHA512
```

Table 205. RSA_SIGN_HASH Function Parameters

Parameter	Description
message_digest	Hash of message to sign. The hash algorithm used should match *hash*
private_key	RSA private key in PKCS#1 format
hash	Hash to generate PSS encoding; default is SHA256. This should be the same hash as used to generate *message_digest*.
salt_length	Length of the desired salt in bytes; default is 8; minimum 1, maximum 32. The recommended value is between 8 and 16.

RSA_SIGN_HASH performs PSS encoding of the *message_digest* to be signed, and signs using the RSA private key.

By default, OAEP padding is used. The PKCS_1_5 option will switch to the less secure PKCS 1.5 padding. This option was introduced in Firebird 4.0.1.

The PKCS_1_5 option is only for backward compatibility with systems applying PKCS 1.5 padding. For security reasons, it should **not** be used in new projects.

This function expects the hash of a message (or message digest), not the actual message. The *hash* argument should specify the algorithm that was also used to generate that hash.

A function that accepts the actual message to hash might be introduced in a future version of Firebird.

PSS encoding

Probabilistic Signature Scheme (PSS) is a cryptographic signature scheme specifically developed to allow modern methods of security analysis to prove that its security directly relates to that of the RSA problem. There is no such proof for the traditional PKCS#1 v1.5 scheme.

RSA_SIGN_HASH Examples

Run the example of the RSA_PRIVATE function first.

```
select rdb$set_context('USER_SESSION', 'msg',
  rsa_sign_hash(crypt_hash('Test message' using sha256)
    key rdb$get_context('USER_SESSION', 'private_key'))) from rdb$database;
```

See also

RSA_VERIFY_HASH(), RSA_PRIVATE(), CRYPT_HASH()

8.11.8. RSA_VERIFY_HASH()

Available in

DSQL, PSQL

Result type

BOOLEAN

Syntax

```
RSA_VERIFY_HASH (message_digest
  SIGNATURE signature KEY public_key
  [HASH <hash>] [SALT_LENGTH salt_length]
  [PKCS_1_5])

<hash> ::= MD5 | SHA1 | SHA256 | SHA512
```

Table 206. RSA_VERIFY Function Parameters

Parameter	Description
message_digest	Hash of message to verify. The hash algorithm used should match *hash*
signature	Expected signature of *input* generated by RSA_SIGN_HASH
public_key	RSA public key in PKCS#1 format matching the private key used to sign
hash	Hash to use for the message digest; default is SHA256. This should be the same hash as used to generate *message_digest*, and as used in RSA_SIGN_HASH
salt_length	Length of the salt in bytes; default is 8; minimum 1, maximum 32. Value must match the length used in RSA_SIGN_HASH.

RSA_VERIFY_HASH performs PSS encoding of the *message_digest* to be verified, and verifies the digital signature using the provided RSA public key.

By default, OAEP padding is used. The PKCS_1_5 option will switch to the less secure PKCS 1.5 padding. This option was introduced in Firebird 4.0.1.

The PKCS_1_5 option is only for backward compatibility with systems applying PKCS 1.5 padding. For security reasons, it should **not** be used in new projects.

This function expects the hash of a message (or message digest), not the actual message. The *hash* argument should specify the algorithm that was also used to generate that hash.

A function that accepts the actual message to hash might be introduced in a future version of Firebird.

RSA_VERIFY_HASH Examples

Run the examples of the RSA_PRIVATE, RSA_PUBLIC and RSA_SIGN_HASH functions first.

```
select rsa_verify_hash(
  crypt_hash('Test message' using sha256)
  signature rdb$get_context('USER_SESSION', 'msg')
  key rdb$get_context('USER_SESSION', 'public_key'))
from rdb$database
```

See also

RSA_SIGN_HASH(), RSA_PUBLIC(), CRYPT_HASH()

8.12. Other Functions

Functions that don't really fit in any other category.

8.12.1. MAKE_DBKEY()

Available in

DSQL, PSQL

Result type

BINARY(8)

Syntax

```
MAKE_DBKEY (relation, recnum [, dpnum [, ppnum]])
```

Table 207. MAKE_DBKEY Function Parameters

Parameter	Description
relation	Relation name or relation id
recnum	Record number. Either absolute (if *dpnum* and *ppnum* are absent), or relative (if *dpnum* present)
dpnum	Data page number. Either absolute (if *ppnum* is absent) or relative (if *ppnum* present)
ppnum	Pointer page number.

MAKE_DBKEY creates a DBKEY value using a relation name or ID, record number, and (optionally) logical numbers of data page and pointer page.

1. If *relation* is a string expression or literal, then it is treated as a relation name, and the engine searches for the corresponding relation ID. The search is case-sensitive. In the case of string literal, relation ID is evaluated at query preparation time. In the case of expression, relation ID is evaluated at

execution time. If the relation cannot be found, then error `isc_relnotdef` is raised.

2. If *relation* is a numeric expression or literal, then it is treated as a relation ID and used "as is", without verification against existing relations. If the argument value is negative or greater than the maximum allowed relation ID (65535 currently), then `NULL` is returned.
3. Argument *recnum* represents an absolute record number in the relation (if the next arguments *dpnum* and *ppnum* are missing), or a record number relative to the first record, specified by the next arguments.
4. Argument *dpnum* is a logical number of data page in the relation (if the next argument *ppnum* is missing), or number of data pages relative to the first data page addressed by the given *ppnum*.
5. Argument *ppnum* is a logical number of pointer page in the relation.
6. All numbers are zero-based. Maximum allowed value for *dpnum* and *ppnum* is 2^{32} (4294967296). If *dpnum* is specified, then *recnum* can be negative. If *dpnum* is missing and *recnum* is negative, then `NULL` is returned. If *ppnum* is specified, then *dpnum* can be negative. If *ppnum* is missing and *dpnum* is negative, then `NULL` is returned.
7. If any of specified arguments is `NULL`, the result is also `NULL`.
8. Argument *relation* is described as `INTEGER` during query preparation, but it can be overridden by a client application as `VARCHAR` or `CHAR`. Arguments *recnum*, *dpnum* and *ppnum* are described as `BIGINT`.

Examples of `MAKE_DBKEY`

1. Select record using relation name (note that relation name is uppercase)

```
select *
from rdb$relations
where rdb$db_key = make_dbkey('RDB$RELATIONS', 0)
```

2. Select record using relation ID

```
select *
from rdb$relations
where rdb$db_key = make_dbkey(6, 0)
```

3. Select all records physically residing on the first data page

```
select *
from rdb$relations
where rdb$db_key >= make_dbkey(6, 0, 0)
and rdb$db_key < make_dbkey(6, 0, 1)
```

4. Select all records physically residing on the first data page of 6th pointer page

```
select *
from SOMETABLE
where rdb$db_key >= make_dbkey('SOMETABLE', 0, 0, 5)
and rdb$db_key < make_dbkey('SOMETABLE', 0, 1, 5)
```

8.12.2. RDB$ERROR()

Available in

PSQL

Result type

Varies (see table below)

Syntax

```
RDB$ERROR (<context>)

<context> ::=
  GDSCODE | SQLCODE | SQLSTATE | EXCEPTION | MESSAGE
```

Table 208. Contexts

Context	Result type	Description
GDSCODE	INTEGER	Firebird error code, see also GDSCODE
SQLCODE	INTEGER	(deprecated) SQL code, see also SQLCODE
SQLSTATE	CHAR(5) CHARACTER SET ASCII	SQLstate, see also SQLSTATE
EXCEPTION	VARCHAR(63) CHARACTER SET UTF8	Name of the active user-defined exception or NULL if the active exception is a system exception
MESSAGE	VARCHAR(1024) CHARACTER SET UTF8	Message text of the active exception

RDB$ERROR returns data of the specified context about the active PSQL exception. Its scope is confined to exception-handling blocks in PSQL (WHEN ⋯ DO). Outside the exception handling blocks, RDB$ERROR always returns NULL. This function cannot be called from DSQL.

Example of RDB$ERROR

```
BEGIN
  ...
WHEN ANY DO
  EXECUTE PROCEDURE P_LOG_EXCEPTION(RDB$ERROR(MESSAGE));
END
```

See also

Trapping and Handling Errors, GDSCODE, SQLCODE, SQLSTATE

8.12.3. RDB$GET_TRANSACTION_CN()

Available in

DSQL, PSQL

Result type

BIGINT

Syntax

```
RDB$GET_TRANSACTION_CN (transaction_id)
```

Table 209. RDB$GET_TRANSACTION_CN *Function Parameters*

Parameter	Description
transaction_id	Transaction id

RDB$GET_TRANSACTION_CN returns the commit number ("CN") of the supplied transaction.

If the return value is greater than 1, it is the actual *CN* of the transaction if it was committed after the database was started.

The function can also return one of the following results, indicating the commit status of the transaction:

-2 Transaction is dead (rolled back)

-1 Transaction is in limbo

0 Transaction is still active

1 Transaction committed before the database started or less than the Oldest Interesting Transaction for the database

NULL Transaction number supplied is NULL or greater than Next Transaction for the database

For more information about *CN*, consult the *Firebird 4.0 Release Notes*.

RDB$GET_TRANSACTION_CN Examples

```
select rdb$get_transaction_cn(current_transaction) from rdb$database;
select rdb$get_transaction_cn(123) from rdb$database;
```

8.12.4. RDB$ROLE_IN_USE()

Available in

DSQL, PSQL

Result type

BOOLEAN

Syntax

```
RDB$ROLE_IN_USE (role_name)
```

Table 210. RDB$ROLE_IN_USE Function Parameters

Parameter	Description
role_name	String expression for the role to check. Case-sensitive, must match the role name as stored in RDB$ROLES

RDB$ROLE_IN_USE returns TRUE if the specified role is active for the current connection, and FALSE otherwise. Contrary to CURRENT_ROLE — which only returns the explicitly specified role — this function can be used to check for roles that are active by default, or cumulative roles activated by an explicitly specified role.

RDB$ROLE_IN_USE Examples

List currently active roles

```
select rdb$role_name
from rdb$roles
where rdb$role_in_use(rdb$role_name);
```

See also

CURRENT_ROLE

8.12.5. RDB$SYSTEM_PRIVILEGE()

Available in

DSQL, PSQL

Result type

BOOLEAN

Syntax

```
RDB$SYSTEM_PRIVILEGE (<sys_privilege>)

<sys_privilege> ::=
  !! See CREATE ROLE !!
```

Table 211. `RDB$SYSTEM_PRIVILEGE` *Function Parameters*

Parameter	Description
sys_privilege	System privilege

`RDB$SYSTEM_PRIVILEGE` accepts a system privilege name and returns TRUE if the current attachment has the given system privilege, and FALSE otherwise.

`RDB$SYSTEM_PRIVILEGE` Examples

```
select rdb$system_privilege(user_management) from rdb$database;
```

See also

Fine-grained System Privileges

Chapter 9. Aggregate Functions

Aggregate functions operate on groups of records, rather than on individual records or variables. They are often used in combination with a `GROUP BY` clause.

Syntax

```
<aggregate_function> ::=
    aggragate_function ([<expr> [, <expr> ...]])
      [FILTER (WHERE <condition>)]
```

The aggregate functions can also be used as window functions with the `OVER ()` clause. See Window (Analytical) Functions for more information.

9.1. `FILTER` Clause for Aggregate Functions

The `FILTER` clause extends aggregate functions (`SUM`, `AVG`, `COUNT`, etc.) with an additional `WHERE` clause. This limits the rows processed by the aggregate functions to the rows that satisfy the conditions of both the main `WHERE` clause and those inside the `FILTER` clause.

It can be thought of as a more explicit form of using an aggregate function with a condition (`decode`, `case`, `iif`) to ignore some values that would otherwise be considered by the aggregation.

The clause can be used with any aggregate functions in aggregate or windowed (`OVER`) statements, but not with window-only functions like `DENSE_RANK`.

Example of `FILTER`

Suppose you need a query to count the number of `status = 'A'` and the number of `status = 'E'` as different columns. The old way to do it would be:

```
select count(decode(status, 'A', 1)) status_a,
       count(decode(status, 'E', 1)) status_e
from data;
```

The `FILTER` clause lets you express those conditions more explicitly:

```
select count(*) filter (where status = 'A') status_a,
       count(*) filter (where status = 'E') status_e
from data;
```

You can use more than one `FILTER` modifier in an aggregate query. You could, for example, use 12 filters on totals aggregating sales for a year to produce monthly figures for a pivot set.

9.2. General-purpose Aggregate Functions

9.2.1. AVG()

Available in

DSQL, ESQL, PSQL

Result type

Depends on the input type

Syntax

```
AVG ([ALL | DISTINCT] <expr>)
```

Table 212. AVG Function Parameters

Parameter	Description
expr	Expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF that returns a numeric data type. Aggregate functions are not allowed as expressions

AVG returns the average argument value in the group. NULL is ignored.

- Parameter ALL (the default) applies the aggregate function to all values.
- Parameter DISTINCT directs the AVG function to consider only one instance of each unique value, no matter how many times this value occurs.
- If the set of retrieved records is empty or contains only NULL, the result will be NULL.

The result type of AVG depends on the input type:

FLOAT, DOUBLE PRECISION	DOUBLE PRECISION
SMALLINT, INTEGER, BIGINT	BIGINT
INT128	INT128
DECIMAL/NUMERIC(p, n) with p < 19	DECIMAL/NUMERIC(18, n)
DECIMAL/NUMERIC(p, n) with p >= 19	DECIMAL/NUMERIC(38, n)
DECFLOAT(16)	DECFLOAT(16)
DECFLOAT(34)	DECFLOAT(34)

In Firebird 4.0.0, the result type is determined the same as SUM(). This was fixed in 4.0.1, see firebird#6845.

AVG Examples

```
SELECT
  dept_no,
```

```
  AVG(salary)
FROM employee
GROUP BY dept_no
```

See also

`SELECT`

9.2.2. `COUNT()`

Available in

DSQL, ESQL, PSQL

Result type

`BIGINT`

Syntax

```
COUNT ([ALL | DISTINCT] <expr> | *)
```

Table 213. `COUNT` Function Parameters

Parameter	Description
expr	Expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF that returns a numeric data type. Aggregate functions are not allowed as expressions

`COUNT` returns the number of non-null values in a group.

- `ALL` is the default: it simply counts all values in the set that are not `NULL`.
- If `DISTINCT` is specified, duplicates are excluded from the counted set.
- If `COUNT (*)` is specified instead of the expression *expr*, all rows will be counted. `COUNT (*)` —
  - does not accept parameters
  - cannot be used with the keyword `DISTINCT`
  - does not take an *expr* argument, since its context is column-unspecific by definition
  - counts each row separately and returns the number of rows in the specified table or group without omitting duplicate rows
  - counts rows containing `NULL`
- If the result set is empty or contains only `NULL` in the specified column(s), the returned count is zero.

`COUNT` Examples

```
SELECT
  dept_no,
  COUNT(*) AS cnt,
```

```
  COUNT(DISTINCT name) AS cnt_name
FROM employee
GROUP BY dept_no
```

See also

SELECT.

9.2.3. LIST()

Available in

DSQL, PSQL

Result type

BLOB

Syntax

```
LIST ([ALL | DISTINCT] <expr> [, separator ])
```

Table 214. LIST Function Parameters

Parameter	Description
expr	Expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF that returns the string data type or a BLOB. Fields of numeric and date/time types are converted to strings. Aggregate functions are not allowed as expressions.
separator	Optional alternative separator, a string expression. Comma is the default separator

LIST returns a string consisting of the non-NULL argument values in the group, separated either by a comma or by a user-supplied separator. If there are no non-NULL values (this includes the case where the group is empty), NULL is returned.

- ALL (the default) results in all non-NULL values being listed. With DISTINCT, duplicates are removed, except if *expr* is a BLOB.
- In Firebird 2.5 and up, the optional *separator* argument may be any string expression. This makes it possible to specify e.g. ascii_char(13) as a separator. (This improvement has also been backported to 2.1.4.)
- The *expr* and *separator* arguments support BLOBs of any size and character set.
- Date/time and numeric arguments are implicitly converted to strings before concatenation.
- The result is a text BLOB, except when *expr* is a BLOB of another subtype.
- The ordering of the list values is undefined — the order in which the strings are concatenated is determined by read order from the source set which, in tables, is not generally defined. If ordering is important, the source data can be pre-sorted using a derived table or similar.

This is a trick/workaround, and it depends on implementation details of the optimizer/execution order. This trick doesn't always work, and it is not guaranteed to work across versions.

`LIST` Examples

1. Retrieving the list, order undefined:

```
SELECT LIST (display_name, '; ') FROM GR_WORK;
```

2. Retrieving the list in alphabetical order, using a derived table:

```
SELECT LIST (display_name, '; ')
FROM (SELECT display_name
      FROM GR_WORK
      ORDER BY display_name);
```

See also

`SELECT`

9.2.4. `MAX()`

Available in

DSQL, ESQL, PSQL

Result type

Returns a result of the same data type the input expression.

Syntax

```
MAX ([ALL | DISTINCT] <expr>)
```

Table 215. `MAX` Function Parameters

Parameter	Description
expr	Expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.

`MAX` returns the maximum non-`NULL` element in the result set.

- If the group is empty or contains only `NULL`s, the result is `NULL`.
- If the input argument is a string, the function will return the value that will be sorted last if `COLLATE` is used.
- This function fully supports text `BLOB`s of any size and character set.

The DISTINCT parameter makes no sense if used with MAX() and is implemented only for compliance with the standard.

MAX Examples

```
SELECT
  dept_no,
  MAX(salary)
FROM employee
GROUP BY dept_no
```

See also

MIN(), SELECT

9.2.5. MIN()

Available in

DSQL, ESQL, PSQL

Result type

Returns a result of the same data type the input expression.

Syntax

```
MIN ([ALL | DISTINCT] <expr>)
```

Table 216. MIN Function Parameters

Parameter	Description
expr	Expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.

MIN returns the minimum non-NULL element in the result set.

- If the group is empty or contains only NULLs, the result is NULL.
- If the input argument is a string, the function will return the value that will be sorted first if COLLATE is used.
- This function fully supports text BLOBs of any size and character set.

The DISTINCT parameter makes no sense if used with MIN() and is implemented only for compliance with the standard.

MIN Examples

```
SELECT
```

```
  dept_no,
  MIN(salary)
FROM employee
GROUP BY dept_no
```

See also

MAX(), SELECT

9.2.6. SUM()

Available in

DSQL, ESQL, PSQL

Result type

Depends on the input type

Syntax

```
SUM ([ALL | DISTINCT] <expr>)
```

Table 217. SUM Function Parameters

Parameter	Description
expr	Numeric expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.

SUM calculates and returns the sum of non-null values in the group.

- If the group is empty or contains only NULLs, the result is NULL.
- ALL is the default option — all values in the set that are not NULL are processed. If DISTINCT is specified, duplicates are removed from the set and the SUM evaluation is done afterward.

The result type of SUM depends on the input type:

FLOAT, DOUBLE PRECISION	DOUBLE PRECISION
SMALLINT, INTEGER	BIGINT
BIGINT, INT128	INT128
DECIMAL/NUMERIC(p, n) with p < 10	DECIMAL/NUMERIC(18, n)
DECIMAL/NUMERIC(p, n) with p >= 10	DECIMAL/NUMERIC(38, n)
DECFLOAT(16), DECFLOAT(34)	DECFLOAT(34)

SUM Examples

```
SELECT
  dept_no,
```

```
  SUM (salary),
FROM employee
GROUP BY dept_no
```

See also

SELECT

9.3. Statistical Aggregate Functions

9.3.1. CORR()

Available in

DSQL, PSQL

Result type

DOUBLE PRECISION

Syntax

```
CORR ( <expr1>, <expr2> )
```

Table 218. CORR Function Parameters

Parameter	Description
expr*N*	Numeric expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.

The CORR function return the correlation coefficient for a pair of numerical expressions.

The function CORR(<expr1>, <expr2>) is equivalent to

```
COVAR_POP(<expr1>, <expr2>) / (STDDEV_POP(<expr2>) * STDDEV_POP(<expr1>))
```

This is also known as the Pearson correlation coefficient.

In a statistical sense, correlation is the degree of to which a pair of variables are linearly related. A linear relation between variables means that the value of one variable can to a certain extent predict the value of the other. The correlation coefficient represents the degree of correlation as a number ranging from -1 (high inverse correlation) to 1 (high correlation). A value of 0 corresponds to no correlation.

If the group or window is empty, or contains only NULL values, the result will be NULL.

CORR Examples

```
select
```

```
  corr(alength, aheight) AS c_corr
from measure
```

See also

`COVAR_POP()`, `STDDEV_POP()`

9.3.2. COVAR_POP()

Available in

DSQL, PSQL

Result type

`DOUBLE PRECISION`

Syntax

```
COVAR_POP ( <expr1>, <expr2> )
```

Table 219. `COVAR_POP` Function Parameters

Parameter	Description
expr*N*	Numeric expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.

The function `COVAR_POP` returns the population covariance for a pair of numerical expressions.

The function `COVAR_POP(<expr1>, <expr2>)` is equivalent to

```
(SUM(<expr1> * <expr2>) - SUM(<expr1>) * SUM(<expr2>) / COUNT(*)) / COUNT(*)
```

If the group or window is empty, or contains only `NULL` values, the result will be `NULL`.

`COVAR_POP` Examples

```
select
  covar_pop(alength, aheight) AS c_covar_pop
from measure
```

See also

`COVAR_SAMP()`, `SUM()`, `COUNT()`

9.3.3. COVAR_SAMP()

Available in

DSQL, PSQL

Result type

DOUBLE PRECISION

Syntax

```
COVAR_SAMP ( <expr1>, <expr2> )
```

Table 220. COVAR_SAMP Function Parameters

Parameter	Description
expr*N*	Numeric expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.

The function COVAR_SAMP returns the sample covariance for a pair of numerical expressions.

The function COVAR_SAMP(<expr1>, <expr2>) is equivalent to

```
(SUM(<expr1> * <expr2>) - SUM(<expr1>) * SUM(<expr2>) / COUNT(*)) / (COUNT(*) - 1)
```

If the group or window is empty, contains only 1 row, or contains only NULL values, the result will be NULL.

COVAR_SAMP Examples

```
select
  covar_samp(alength, aheight) AS c_covar_samp
from measure
```

See also

COVAR_POP(), SUM(), COUNT()

9.3.4. STDDEV_POP()

Available in

DSQL, PSQL

Result type

DOUBLE PRECISION or NUMERIC depending on the type of *expr*

Syntax

```
STDDEV_POP ( <expr> )
```

Table 221. STDDEV_POP Function Parameters

Parameter	Description
expr	Numeric expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.

The function STDDEV_POP returns the population standard deviation for a group or window. NULL values are skipped.

The function STDDEV_POP(<expr>) is equivalent to

```
SQRT(VAR_POP(<expr>))
```

If the group or window is empty, or contains only NULL values, the result will be NULL.

STDDEV_POP Examples

```
select
  dept_no
  stddev_pop(salary)
from employee
group by dept_no
```

See also

STDDEV_SAMP(), VAR_POP(), SQRT

9.3.5. STDDEV_SAMP()

Available in

DSQL, PSQL

Result type

DOUBLE PRECISION or NUMERIC depending on the type of *expr*

Syntax

```
STDDEV_POP ( <expr> )
```

Table 222. STDDEV_SAMP *Function Parameters*

Parameter	Description
expr	Numeric expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.

The function STDDEV_SAMP returns the sample standard deviation for a group or window. NULL values are skipped.

The function STDDEV_SAMP(<expr>) is equivalent to

```
SQRT(VAR_SAMP(<expr>))
```

If the group or window is empty, contains only 1 row, or contains only NULL values, the result will be NULL.

STDDEV_SAMP Examples

```
select
  dept_no
  stddev_samp(salary)
from employee
group by dept_no
```

See also

STDDEV_POP(), VAR_SAMP(), SQRT

9.3.6. VAR_POP()

Available in

DSQL, PSQL

Result type

DOUBLE PRECISION or NUMERIC depending on the type of *expr*

Syntax

```
VAR_POP ( <expr> )
```

Table 223. VAR_POP Function Parameters

Parameter	Description
expr	Numeric expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.

The function VAR_POP returns the population variance for a group or window. NULL values are skipped.

The function VAR_POP(<expr>) is equivalent to

```
(SUM(<expr> * <expr>) - SUM (<expr>) * SUM (<expr>) / COUNT(<expr>))
  / COUNT (<expr>)
```

If the group or window is empty, or contains only NULL values, the result will be NULL.

VAR_POP Examples

```
select
  dept_no
  var_pop(salary)
from employee
group by dept_no
```

See also

VAR_SAMP(), SUM(), COUNT()

9.3.7. VAR_SAMP()

Available in

DSQL, PSQL

Result type

DOUBLE PRECISION or NUMERIC depending on the type of *expr*

Syntax

```
VAR_SAMP ( <expr> )
```

Table 224. VAR_SAMP Function Parameters

Parameter	Description
expr	Numeric expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.

The function VAR_POP returns the sample variance for a group or window. NULL values are skipped.

The function VAR_SAMP(<expr>) is equivalent to

```
(SUM(<expr> * <expr>) - SUM(<expr>) * SUM (<expr>) / COUNT (<expr>))
  / (COUNT(<expr>) - 1)
```

If the group or window is empty, contains only 1 row, or contains only NULL values, the result will be NULL.

VAR_SAMP Examples

```
select
  dept_no
  var_samp(salary)
from employee
```

```
group by dept_no
```

See also

`VAR_POP()`, `SUM()`, `COUNT()`

9.4. Linear Regression Aggregate Functions

Linear regression functions are useful for trend line continuation. The trend or regression line is usually a pattern followed by a set of values. Linear regression is useful to predict future values. To continue the regression line, you need to know the slope and the point of intersection with the y-axis. As set of linear functions can be used for calculating these values.

In the function syntax, *y* is interpreted as an *x*-dependent variable.

The linear regression aggregate functions take a pair of arguments, the dependent variable expression (*y*) and the independent variable expression (*x*), which are both numeric value expressions. Any row in which either argument evaluates to `NULL` is removed from the rows that qualify. If there are no rows that qualify, then the result of `REGR_COUNT` is `0` (zero), and the other linear regression aggregate functions result in `NULL`.

9.4.1. REGR_AVGX()

Available in

DSQL, PSQL

Result type

`DOUBLE PRECISION`

Syntax

```
REGR_AVGX ( <y>, <x> )
```

Table 225. `REGR_AVGX` Function Parameters

Parameter	Description
y	Dependent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.
x	Independent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.

The function `REGR_AVGX` calculates the average of the independent variable (*x*) of the regression line.

The function `REGR_AVGX(<y>, <x>)` is equivalent to

```
SUM(<exprX>) / REGR_COUNT(<y>, <x>)
```

```
<exprX> :==
  CASE WHEN <x> IS NOT NULL AND <y> IS NOT NULL THEN <x> END
```

See also

REGR_AVGY(), REGR_COUNT(), SUM()

9.4.2. REGR_AVGY()

Available in

DSQL, PSQL

Result type

DOUBLE PRECISION

Syntax

```
REGR_AVGY ( <y>, <x> )
```

Table 226. REGR_AVGY Function Parameters

Parameter	Description
y	Dependent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.
x	Independent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.

The function REGR_AVGY calculates the average of the dependent variable (*y*) of the regression line.

The function REGR_AVGY(<y>, <x>) is equivalent to

```
SUM(<exprY>) / REGR_COUNT(<y>, <x>)

<exprY> :==
  CASE WHEN <x> IS NOT NULL AND <y> IS NOT NULL THEN <y> END
```

See also

REGR_AVGX(), REGR_COUNT(), SUM()

9.4.3. REGR_COUNT()

Available in

DSQL, PSQL

Result type

DOUBLE PRECISION

Syntax

```
REGR_COUNT ( <y>, <x> )
```

Table 227. REGR_COUNT *Function Parameters*

Parameter	Description
y	Dependent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.
x	Independent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.

The function REGR_COUNT counts the number of non-empty pairs of the regression line.

The function REGR_COUNT(<y>, <x>) is equivalent to

```
COUNT(*) FILTER (WHERE <x> IS NOT NULL AND <y> IS NOT NULL)
```

See also
COUNT()

9.4.4. REGR_INTERCEPT()

Available in

DSQL, PSQL

Result type
DOUBLE PRECISION

Syntax

```
REGR_INTERCEPT ( <y>, <x> )
```

Table 228. REGR_INTERCEPT *Function Parameters*

Parameter	Description
y	Dependent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.
x	Independent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.

The function REGR_INTERCEPT calculates the point of intersection of the regression line with the y-axis.

The function REGR_INTERCEPT(<y>, <x>) is equivalent to

```
REGR_AVGY(<y>, <x>) - REGR_SLOPE(<y>, <x>) * REGR_AVGX(<y>, <x>)
```

REGR_INTERCEPT Examples

Forecasting sales volume

```
with recursive years (byyear) as (
  select 1991
  from rdb$database
  union all
  select byyear + 1
  from years
  where byyear < 2020
),
s as (
  select
    extract(year from order_date) as byyear,
    sum(total_value) as total_value
  from sales
  group by 1
),
regr as (
  select
    regr_intercept(total_value, byyear) as intercept,
    regr_slope(total_value, byyear) as slope
  from s
)
select
  years.byyear as byyear,
  intercept + (slope * years.byyear) as total_value
from years
cross join regr
```

```
BYYEAR TOTAL_VALUE
------ ------------
  1991    118377.35
  1992    414557.62
  1993    710737.89
  1994   1006918.16
  1995   1303098.43
  1996   1599278.69
  1997   1895458.96
  1998   2191639.23
```

```
   1999   2487819.50
   2000   2783999.77
  ...
```

See also

REGR_AVGX(), REGR_AVGY(), REGR_SLOPE()

9.4.5. REGR_R2()

Available in

DSQL, PSQL

Result type

DOUBLE PRECISION

Syntax

```
REGR_R2 ( <y>, <x> )
```

Table 229. REGR_R2 Function Parameters

Parameter	Description
y	Dependent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.
x	Independent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.

The REGR_R2 function calculates the coefficient of determination, or R-squared, of the regression line.

The function REGR_R2(<y>, <x>) is equivalent to

```
POWER(CORR(<y>, <x>), 2)
```

See also

CORR(), POWER

9.4.6. REGR_SLOPE()

Available in

DSQL, PSQL

Result type

DOUBLE PRECISION

Syntax

```
REGR_SLOPE ( <y>, <x> )
```

Table 230. REGR_SLOPE Function Parameters

Parameter	Description
y	Dependent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.
x	Independent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.

The function REGR_SLOPE calculates the slope of the regression line.

The function REGR_SLOPE(<y>, <x>) is equivalent to

```
COVAR_POP(<y>, <x>) / VAR_POP(<exprX>)

<exprX> :==
  CASE WHEN <x> IS NOT NULL AND <y> IS NOT NULL THEN <x> END
```

See also

COVAR_POP(), VAR_POP()

9.4.7. REGR_SXX()

Available in

DSQL, PSQL

Result type

DOUBLE PRECISION

Syntax

```
REGR_SXX ( <y>, <x> )
```

Table 231. REGR_SXX Function Parameters

Parameter	Description
y	Dependent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.

Parameter	Description
x	Independent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.

The function REGR_SXX calculates the sum of squares of the independent expression variable (*x*).

The function REGR_SXX(<y>, <x>) is equivalent to

```
REGR_COUNT(<y>, <x>) * VAR_POP(<exprX>)

<exprX> :==
  CASE WHEN <x> IS NOT NULL AND <y> IS NOT NULL THEN <x> END
```

See also

REGR_COUNT(), VAR_POP()

9.4.8. REGR_SXY()

Available in

DSQL, PSQL

Result type

DOUBLE PRECISION

Syntax

```
REGR_SXY ( <y>, <x> )
```

Table 232. REGR_SXY Function Parameters

Parameter	Description
y	Dependent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.
x	Independent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.

The function REGR_SXY calculates the sum of products of independent variable expression (*x*) times dependent variable expression (*y*).

The function REGR_SXY(<y>, <x>) is equivalent to

```
REGR_COUNT(<y>, <x>) * COVAR_POP(<y>, <x>)
```

See also

COVAR_POP(), REGR_COUNT()

9.4.9. REGR_SYY()

Available in

DSQL, PSQL

Result type

DOUBLE PRECISION

Syntax

```
REGR_SYY ( <y>, <x> )
```

Table 233. REGR_SYY Function Parameters

Parameter	Description
y	Dependent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.
x	Independent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.

The function REGR_SYY calculates the sum of squares of the dependent variable (*y*).

The function REGR_SYY(<y>, <x>) is equivalent to

```
REGR_COUNT(<y>, <x>) * VAR_POP(<exprY>)

<exprY> :==
  CASE WHEN <x> IS NOT NULL AND <y> IS NOT NULL THEN <y> END
```

See also

REGR_COUNT(), VAR_POP()

Chapter 10. Window (Analytical) Functions

According to the SQL specification, window functions (also known as analytical functions) are a kind of aggregation, but one that does not “filter” the result set of a query. The rows of aggregated data are mixed with the query result set.

The window functions are used with the `OVER` clause. They may appear only in the `SELECT` list, or the `ORDER BY` clause of a query.

Firebird window functions may be partitioned and ordered.

Syntax

```
<window_function> ::=
    <aggregate_function> OVER <window_name_or_spec>
  | <window_function_name> ([<expr> [, <expr> ...]])
  OVER <window_name_or_spec>

<aggregate_function> ::=
  !! See Aggregate Functions !!

<window_name_or_spec> ::=
  <window_specification> | existing_window_name

<window_function_name> ::=
    <ranking_function>
  | <navigational_function>

<ranking_function> ::=
    RANK | DENSE_RANK | PERCENT_RANK | ROW_NUMBER
  | CUME_DIST | NTILE

<navigational_function>
  LEAD | LAG | FIRST_VALUE | LAST_VALUE | NTH_VALUE

<window_specification> ::=
  ( [existing_window_name] [<window_partition>]
    [<window_order>] [<window_frame>] )

<window_partition> ::=
  [PARTITION BY <expr> [, <expr> ...]]

<window_order> ::=
  [ORDER BY
    <expr> [<direction>] [<nulls_placement>]
    [, <expr> [<direction>] [<nulls_placement>] ...]

<direction> ::= {ASC | DESC}

<nulls_placement> ::= NULLS {FIRST | LAST}
```

```
<window_frame> ::= {RANGE | ROWS} <window_frame_extent>

<window_frame_extent> ::=
  <window_frame_start> | <window_frame_between>

<window_frame_start> ::=
  UNBOUNDED PRECEDING | <expr> PRECEDING | CURRENT ROW

<window_frame_between> ::=
  BETWEEN <window_frame_bound_1> AND <window_frame_bound_2>

<window_frame_bound_1> ::=
    UNBOUNDED PRECEDING | <expr> PRECEDING | CURRENT ROW
  | <expr> FOLLOWING

<window_frame_bound_2> ::=
    <expr> PRECEDING | CURRENT ROW | <expr> FOLLOWING
  | UNBOUNDED FOLLOWING
```

Table 234. Window Function Arguments

Argument	Description
expr	Expression. May contain a table column, constant, variable, expression, scalar or aggregate function. Window functions are not allowed as an expression.
aggregate_function	An aggregate function used as a window function
existing_window_name	A named window defined using the `WINDOW` clause of the current query specification.

10.1. Aggregate Functions as Window Functions

All aggregate functions — including `FILTER` clause — can be used as window functions, by adding the `OVER` clause.

Imagine a table `EMPLOYEE` with columns `ID`, `NAME` and `SALARY`, and the need to show each employee with their respective salary and the percentage of their salary over the payroll.

A normal query could achieve this, as follows:

```
select
    id,
    department,
    salary,
    salary / (select sum(salary) from employee) portion
  from employee
  order by id;
```

Results

```
id  department  salary  portion
--  ----------  ------  ----------
1   R & D        10.00      0.2040
2   SALES        12.00      0.2448
3   SALES         8.00      0.1632
4   R & D         9.00      0.1836
5   R & D        10.00      0.2040
```

The query is repetitive and lengthy to run, especially if `EMPLOYEE` happens to be a complex view.

The same query could be specified in a much faster and more elegant way using a window function:

```
select
    id,
    department,
    salary,
    salary / sum(salary) OVER () portion
  from employee
  order by id;
```

Here, `sum(salary) over ()` is computed with the sum of all `SALARY` from the query (the `EMPLOYEE` table).

10.2. Partitioning

Like aggregate functions, that may operate alone or in relation to a group, window functions may also operate on a group, which is called a “partition”.

Syntax

```
<window function>(...) OVER (PARTITION BY <expr> [, <expr> ...])
```

Aggregation over a group could produce more than one row, so the result set generated by a partition is joined with the main query using the same expression list as the partition.

Continuing the `EMPLOYEE` example, instead of getting the portion of each employee’s salary over the all-employees total, we would like to get the portion based on just the employees in the same department:

```
select
    id,
    department,
    salary,
    salary / sum(salary) OVER (PARTITION BY department) portion
```

```
  from employee
  order by id;
```

Results

```
id  department  salary  portion
--  ----------  ------  ----------
1   R & D        10.00      0.3448
2   SALES        12.00      0.6000
3   SALES         8.00      0.4000
4   R & D         9.00      0.3103
5   R & D        10.00      0.3448
```

10.3. Ordering

The `ORDER BY` sub-clause can be used with or without partitions. The `ORDER BY` clause within `OVER` specifies the order in which the window function will process rows. This order does not have to be the same as the order rows appear in the output.

There is an important concept associated with window functions: for each row there is a set of rows in its partition called the *window frame*. By default, when specifying `ORDER BY`, the frame consists of all rows from the beginning of the partition to the current row and rows equal to the current `ORDER BY` expression. Without `ORDER BY`, the default frame consists of all rows in the partition.

As a result, for standard aggregate functions, the `ORDER BY` clause produces partial aggregation results as rows are processed.

Example

```
select
    id,
    salary,
    sum(salary) over (order by salary) cumul_salary
  from employee
  order by salary;
```

Results

```
id  salary  cumul_salary
--  ------  ------------
3     8.00          8.00
4     9.00         17.00
1    10.00         37.00
5    10.00         37.00
2    12.00         49.00
```

Then `cumul_salary` returns the partial/accumulated (or running) aggregation (of the `SUM` function). It may appear strange that 37.00 is repeated for the ids 1 and 5, but that is how it should work. The

`ORDER BY` keys are grouped together, and the aggregation is computed once (but summing the two 10.00). To avoid this, you can add the `ID` field to the end of the `ORDER BY` clause.

It's possible to use multiple windows with different orders, and `ORDER BY` parts like `ASC/DESC` and `NULLS FIRST/LAST`.

With a partition, `ORDER BY` works the same way, but at each partition boundary the aggregation is reset.

All aggregation functions can use `ORDER BY`, except for `LIST()`.

10.4. Window Frames

A *window frame* specifies which rows to consider for the current row when evaluating the window function.

The frame comprises three pieces: unit, start bound, and end bound. The unit can be `RANGE` or `ROWS`, which defines how the bounds will work.

The bounds are:

```
<expr> PRECEDING

<expr> FOLLOWING

CURRENT ROW
```

- With `RANGE`, the `ORDER BY` should specify exactly one expression, and that expression should be of a numeric, date, time, or timestamp type. For `<expr> PRECEDING`, *expr* is subtracted from the `ORDER BY` expression, and for `<expr> FOLLOWING`, *expr* is added. For `CURRENT ROW`, the expression is used as-is.

  All rows inside the current partition that are between the bounds are considered part of the resulting window frame.

- With `ROWS`, `ORDER BY` expressions are not limited by number or type. For this unit, `<expr> PRECEDING` and `<expr FOLLOWING` relate to the row position within the current partition, and not the values of the ordering keys.

Both `UNBOUNDED PRECEDING` and `UNBOUNDED FOLLOWING` work identical with `RANGE` and `ROWS`. `UNBOUNDED PRECEDING` start at the first row of the current partition, and `UNBOUNDED FOLLOWING` the last row of the current partition.

The frame syntax with `<window_frame_start> specifies the start-frame, with the end-frame being` `CURRENT ROW`.

Some window functions discard frames:

- `ROW_NUMBER`, `LAG` and `LEAD` always work as `ROWS BETWEEN UNBOUNDED PRECEDING AND CURRENT ROW`
- `DENSE_RANK`, `RANK`, `PERCENT_RANK` and `CUME_DIST` always work as `RANGE BETWEEN UNBOUNDED PRECEDING AND CURRENT ROW`

- `FIRST_VALUE`, `LAST_VALUE` and `NTH_VALUE` respect frames, but the `RANGE` unit behaviour is identical to `ROWS`.

Example Using Frame

When the `ORDER BY` clause is used, but a frame clause is omitted, the default considers the partition up to the current row. When combined with `SUM`, this results in a running total:

```
select
  id,
  salary,
  sum(salary) over (order by salary) sum_salary
from employee
order by salary;
```

Result:

```
| id | salary | sum_salary |
|---:|-------:|-----------:|
|  3 |   8.00 |       8.00 |
|  4 |   9.00 |      17.00 |
|  1 |  10.00 |      37.00 |
|  5 |  10.00 |      37.00 |
|  2 |  12.00 |      49.00 |
```

On the other hand, if we apply a frame for the entire partition, we get the total for the entire partition.

```
select
  id,
  salary,
  sum(salary) over (
    order by salary
    ROWS BETWEEN UNBOUNDED PRECEDING AND UNBOUNDED FOLLOWING
  ) sum_salary
from employee
order by salary;
```

Result:

```
| id | salary | sum_salary |
|---:|-------:|-----------:|
|  3 |   8.00 |      49.00 |
|  4 |   9.00 |      49.00 |
|  1 |  10.00 |      49.00 |
|  5 |  10.00 |      49.00 |
```

```
|  2 |  12.00 |      49.00 |
```

This example is just to demonstrate how this works; the result of this specific example would be simpler to produce with just `sum(salary) over()`.

We can use a range frame to compute the count of employees with salaries between (an employee's salary - 1) and (their salary + 1) with this query:

```
select
  id,
  salary,
  count(*) over (
    order by salary
    RANGE BETWEEN 1 PRECEDING AND 1 FOLLOWING
  ) range_count
from employee
order by salary;
```

Result:

```
| id | salary | range_count |
|---:|-------:|------------:|
|  3 |   8.00 |           2 |
|  4 |   9.00 |           4 |
|  1 |  10.00 |           3 |
|  5 |  10.00 |           3 |
|  2 |  12.00 |           1 |
```

10.5. Named Windows

The `WINDOW` clause can be used to explicitly name a window, for example to avoid repetitive or confusing expression.

A named window can be used

a. in the `OVER` clause to reference a window definition, e.g. `OVER window_name`
b. as a base window of another named or inline (`OVER`) window, if it is not a window with a frame (`ROWS` or `RANGE` clauses)

A window with a base windows cannot have `PARTITION BY`, nor override the ordering (`ORDER BY`) of a base window.

10.6. Ranking Functions

The ranking functions compute the ordinal rank of a row within the window partition.

These functions can be used with or without partitioning and ordering. However, using them without ordering almost never makes sense.

The ranking functions can be used to create different type of incremental counters. Consider `SUM(1) OVER (ORDER BY SALARY)` as an example of what they can do, each of them differently. Following is an example query, also comparing with the `SUM` behavior.

```
select
    id,
    salary,
    dense_rank() over (order by salary),
    rank() over (order by salary),
    row_number() over (order by salary),
    sum(1) over (order by salary)
  from employee
  order by salary;
```

Results

```
id  salary  dense_rank  rank  row_number  sum
--  ------  ----------  ----  ----------  ---
 3    8.00           1     1           1    1
 4    9.00           2     2           2    2
 1   10.00           3     3           3    4
 5   10.00           3     3           4    4
 2   12.00           4     5           5    5
```

The difference between `DENSE_RANK` and `RANK` is that there is a gap related to duplicate rows (relative to the window ordering) only in `RANK`. `DENSE_RANK` continues assigning sequential numbers after the duplicate salary. On the other hand, `ROW_NUMBER` always assigns sequential numbers, even when there are duplicate values.

10.6.1. CUME_DIST()

Available in

DSQL, PSQL

Result type

`DOUBLE PRECISION`

Syntax

```
CUME_DIST () OVER <window_name_or_spec>
```

The distribution function `CUME_DIST` computes the relative rank of a row within a window partition. `CUME_DIST` is calculated as the number of rows preceding or peer of the current row divided by the number of rows in the partition.

In other words, `CUME_DIST() OVER <window_name_or_spec>` is equivalent to `COUNT(*) OVER <window_name_or_spec> / COUNT(*) OVER()`

`CUME_DIST` Examples

```
select
  id,
  salary,
  cume_dist() over (order by salary)
from employee
order by salary;
```

Result

```
id salary cume_dist
-- ------ ---------
 3   8.00       0.2
 4   9.00       0.4
 1  10.00       0.8
 5  10.00       0.8
 2  12.00         1
```

10.6.2. `DENSE_RANK()`

Available in

DSQL, PSQL

Result type

`BIGINT`

Syntax

```
DENSE_RANK () OVER <window_name_or_spec>
```

Returns the rank of rows in a partition of a result set without ranking gaps. Rows with the same *window_order* values get the same rank within the partition *window_partition*, if specified. The dense rank of a row is equal to the number of different rank values in the partition preceding the current row, plus one.

`DENSE_RANK` Examples

```
select
  id,
  salary,
  dense_rank() over (order by salary)
from employee
order by salary;
```

Result

```
id salary dense_rank
-- ------ ----------
 3  8.00           1
 4  9.00           2
 1 10.00           3
 5 10.00           3
 2 12.00           4
```

10.6.3. NTILE()

Available in

DSQL, PSQL

Result type

`BIGINT`

Syntax

```
NTILE ( number_of_tiles ) OVER <window_name_or_spec>
```

Table 235. Arguments of `NTILE`

Argument	Description
number_of_tiles	Number of tiles (groups). Restricted to a positive integer literal, a named parameter (PSQL), or a positional parameter (DSQL).

`NTILE` distributes the rows of the current window partition into the specified number of tiles (groups).

`NTILE` Examples

```
select
  id,
  salary,
  rank() over (order by salary),
  ntile(3) over (order by salary)
from employee
order by salary;
```

Result

```
ID SALARY RANK NTILE
== ====== ==== =====
 3   8.00    1     1
 4   9.00    2     1
 1  10.00    3     2
```

```
  5  10.00    3     2
  2  12.00    5     3
```

10.6.4. PERCENT_RANK()

Available in

DSQL, PSQL

Result type

`DOUBLE PRECISION`

Syntax

```
PERCENT_RANK () OVER <window_name_or_spec>
```

The distribution function `PERCENT_RANK` computes the relative rank of a row within a window partition. `PERCENT_RANK` is calculated as the `RANK()` minus 1 of the current row divided by the number of rows in the partition minus 1.

In other words, `PERCENT_RANK() OVER <window_name_or_spec>` is equivalent to `(RANK() OVER <window_name_or_spec> - 1) / CAST(COUNT(*) OVER() - 1 AS DOUBLE PRECISION)`

`PERCENT_RANK` Examples

```
select
  id,
  salary,
  rank() over (order by salary),
  percent_rank() over (order by salary)
from employee
order by salary;
```

Result

```
id salary rank percent_rank
-- ------ ---- ------------
 3   8.00    1            0
 4   9.00    2         0.25
 1  10.00    3          0.5
 5  10.00    3          0.5
 2  12.00    5            1
```

10.6.5. RANK()

Available in

DSQL, PSQL

Result type

`BIGINT`

Syntax

```
RANK () OVER <window_name_or_spec>
```

Returns the rank of each row in a partition of the result set. Rows with the same values of *window-order* get the same rank with in the partition _window-partition, if specified. The rank of a row is equal to the number of rank values in the partition preceding the current row, plus one.

`RANK` Examples

```
select
  id,
  salary,
  rank() over (order by salary)
from employee
order by salary;
```

Result

```
id salary rank
-- ------ ----
 3  8.00     1
 4  9.00     2
 1 10.00     3
 5 10.00     3
 2 12.00     5
```

See also

`DENSE_RANK()`, `ROW_NUMBER()`

10.6.6. `ROW_NUMBER()`

Available in

DSQL, PSQL

Result type

`BIGINT`

Syntax

```
ROW_NUMBER () OVER <window_name_or_spec>
```

Returns the sequential row number in the partition of the result set, where 1 is the first row in each of the partitions.

ROW_NUMBER Examples

```
select
  id,
  salary,
  row_number() over (order by salary)
from employee
order by salary;
```

Result

```
id salary rank
-- ------ ----
 3  8.00     1
 4  9.00     2
 1 10.00     3
 5 10.00     4
 2 12.00     5
```

See also

DENSE_RANK(), RANK()

10.7. Navigational Functions

The navigational functions get the simple (non-aggregated) value of an expression from another row of the query, within the same partition.

FIRST_VALUE, LAST_VALUE and NTH_VALUE also operate on a window frame. For navigational functions, Firebird applies a default frame from the first to the current row of the partition, not to the last. In other words, it behaves as if the following frame is specified:

```
RANGE BETWEEN UNBOUNDED PRECEDING AND CURRENT ROW
```

This is likely to produce strange or unexpected results for NTH_VALUE and especially LAST_VALUE.

Example of Navigational Functions

```
select
    id,
    salary,
    first_value(salary) over (order by salary),
    last_value(salary) over (order by salary),
    nth_value(salary, 2) over (order by salary),
    lag(salary) over (order by salary),
```

```
    lead(salary) over (order by salary)
  from employee
  order by salary;
```

Results

```
id  salary  first_value  last_value  nth_value     lag    lead
--  ------  -----------  ----------  ---------  ------  ------
3     8.00         8.00        8.00     <null>  <null>    9.00
4     9.00         8.00        9.00       9.00    8.00   10.00
1    10.00         8.00       10.00       9.00    9.00   10.00
5    10.00         8.00       10.00       9.00   10.00   12.00
2    12.00         8.00       12.00       9.00   10.00  <null>
```

10.7.1. FIRST_VALUE()

Available in

DSQL, PSQL

Result type

The same as type as *expr*

Syntax

```
FIRST_VALUE ( <expr> ) OVER <window_name_or_spec>
```

Table 236. Arguments of FIRST_VALUE

Argument	Description
expr	Expression. May contain a table column, constant, variable, expression, scalar function. Aggregate functions are not allowed as an expression.

Returns the first value from the current partition.

See also

LAST_VALUE(), NTH_VALUE()

10.7.2. LAG()

Available in

DSQL, PSQL

Result type

The same as type as *expr*

Syntax

```
LAG ( <expr> [, <offset [, <default>]])
```

```
  OVER <window_name_or_spec>
```

Table 237. Arguments of `LAG`

Argument	Description
expr	Expression. May contain a table column, constant, variable, expression, scalar function. Aggregate functions are not allowed as an expression.
offset	The offset in rows before the current row to get the value identified by *expr*. If *offset* is not specified, the default is 1. *offset* can be a column, subquery or other expression that results in a positive integer value, or another type that can be implicitly converted to `BIGINT`. `offset` cannot be negative (use `LEAD` instead).
default	The default value to return if *offset* points outside the partition. Default is `NULL`.

The `LAG` function provides access to the row in the current partition with a given *offset* before the current row.

If *offset* points outside the current partition, *default* will be returned, or `NULL` if no default was specified.

`LAG` Examples

Suppose you have `RATE` table that stores the exchange rate for each day. To trace the change of the exchange rate over the past five days you can use the following query.

```
select
  bydate,
  cost,
  cost - lag(cost) over (order by bydate) as change,
  100 * (cost - lag(cost) over (order by bydate)) /
    lag(cost) over (order by bydate) as percent_change
from rate
where bydate between dateadd(-4 day to current_date)
and current_date
order by bydate
```

Result

```
bydate     cost   change percent_change
---------- ------ ------ --------------
27.10.2014  31.00 <null>         <null>
28.10.2014  31.53   0.53         1.7096
29.10.2014  31.40  -0.13        -0.4123
30.10.2014  31.67   0.27         0.8598
31.10.2014  32.00   0.33         1.0419
```

See also

`LEAD()`

10.7.3. LAST_VALUE()

Available in

DSQL, PSQL

Result type

The same as type as *expr*

Syntax

```
LAST_VALUE ( <expr> ) OVER <window_name_or_spec>
```

Table 238. Arguments of `LAST_VALUE`

Argument	Description
expr	Expression. May contain a table column, constant, variable, expression, scalar function. Aggregate functions are not allowed as an expression.

Returns the last value from the current partition.

See also note on frame for navigational functions.

See also

`FIRST_VALUE()`, `NTH_VALUE()`

10.7.4. LEAD()

Available in

DSQL, PSQL

Result type

The same as type as *expr*

Syntax

```
LEAD ( <expr> [, <offset [, <default>]])
  OVER <window_name_or_spec>
```

Table 239. Arguments of `LEAD`

Argument	Description
expr	Expression. May contain a table column, constant, variable, expression, scalar function. Aggregate functions are not allowed as an expression.

Argument	Description
offset	The offset in rows after the current row to get the value identified by *expr*. If *offset* is not specified, the default is 1. *offset* can be a column, subquery or other expression that results in a positive integer value, or another type that can be implicitly converted to `BIGINT`. `offset` cannot be negative (use `LAG` instead).
default	The default value to return if *offset* points outside the partition. Default is `NULL`.

The `LEAD` function provides access to the row in the current partition with a given *offset* after the current row.

If *offset* points outside the current partition, *default* will be returned, or `NULL` if no default was specified.

See also

`LAG()`

10.7.5. NTH_VALUE()

Available in

DSQL, PSQL

Result type

The same as type as *expr*

Syntax

```
NTH_VALUE ( <expr>, <offset> )
  [FROM {FIRST | LAST}]
  OVER <window_name_or_spec>
```

Table 240. Arguments of `NTH_VALUE`

Argument	Description
expr	Expression. May contain a table column, constant, variable, expression, scalar function. Aggregate functions are not allowed as an expression.
offset	The offset in rows from the start (`FROM FIRST`), or the last (`FROM LAST`) to get the value identified by *expr*. *offset* can be a column, subquery or other expression that results in a positive integer value, or another type that can be implicitly converted to `BIGINT`. `offset` cannot be zero or negative.

The `NTH_VALUE` function returns the *N*th value starting from the first (`FROM FIRST`) or the last (`FROM LAST`) row of the current frame, see also note on frame for navigational functions. Offset 1 with `FROM FIRST` is equivalent to `FIRST_VALUE`, and offset 1 with `FROM LAST` is equivalent to `LAST_VALUE`.

See also

`FIRST_VALUE()`, `LAST_VALUE()`

10.8. Aggregate Functions Inside Window Specification

It is possible to use aggregate functions (but not window functions) inside the `OVER` clause. In that case, first the aggregate function is applied to determine the windows, and only then the window functions are applied on those windows.

When using aggregate functions inside `OVER`, all columns not used in aggregate functions must be specified in the `GROUP BY` clause of the `SELECT`.

Using an Aggregate Function in a Window Specification

```
select
  code_employee_group,
  avg(salary) as avg_salary,
  rank() over (order by avg(salary)) as salary_rank
from employee
group by code_employee_group
```

Chapter 11. Context Variables

11.1. CURRENT_CONNECTION

Available in

DSQL, PSQL

Type
`BIGINT`

Syntax

```
CURRENT_CONNECTION
```

`CURRENT_CONNECTION` contains the unique identifier of the current connection.

Its value is derived from a counter on the database header page, which is incremented for each new connection. When a database is restored, this counter is reset to zero.

Examples

```
select current_connection from rdb$database

execute procedure P_Login(current_connection)
```

11.2. CURRENT_DATE

Available in

DSQL, PSQL, ESQL

Type
`DATE`

Syntax

```
CURRENT_DATE
```

`CURRENT_DATE` returns the current server date in the session time zone.

Within a PSQL module (procedure, trigger or executable block), the value of `CURRENT_DATE` will remain constant every time it is read. If multiple modules call or trigger each other, the value will remain constant throughout the duration of the outermost module. If you need a progressing value in PSQL (e.g. to measure time intervals), use `'TODAY'`.

Examples

```
select current_date from rdb$database
-- returns e.g. 2011-10-03
```

11.3. CURRENT_ROLE

Available in

DSQL, PSQL

Type

`VARCHAR(63)`

Syntax

```
CURRENT_ROLE
```

`CURRENT_ROLE` is a context variable containing the explicitly specified role of the currently connected user. If there is no explicitly specified role, `CURRENT_ROLE` is `'NONE'`.

`CURRENT_ROLE` always represents a valid role or `'NONE'`. If a user connects with a non-existing role, the engine silently resets it to `'NONE'` without returning an error.

Roles that are active by default and not explicitly specified on connect or using `SET ROLE` are not returned by `CURRENT_ROLE`. Use `RDB$ROLE_IN_USE` to check for all active roles.

Example

```
if (current_role <> 'MANAGER')
  then exception only_managers_may_delete;
else
  delete from Customers where custno = :custno;
```

See also

`RDB$ROLE_IN_USE`

11.4. CURRENT_TIME

Available in

DSQL, PSQL, ESQL

Type

`TIME WITH TIME ZONE`

Data type changed in Firebird 4.0 from `TIME WITHOUT TIME ZONE` to `TIME WITH TIME`

ZONE. Use LOCALTIME to obtain TIME WITHOUT TIME ZONE.

Syntax

```
CURRENT_TIME [ (<precision>) ]

<precision> ::= 0 | 1 | 2 | 3
```

The optional *precision* argument is not supported in ESQL.

Table 241. CURRENT_TIME Parameter

Parameter	Description
precision	Precision. The default value is 0. Not supported in ESQL

CURRENT_TIME returns the current server time in the session time zone. The default is 0 decimals, i.e. seconds precision.

- CURRENT_TIME has a default precision of 0 decimals, where CURRENT_TIMESTAMP has a default precision of 3 decimals. As a result, CURRENT_TIMESTAMP is not the exact sum of CURRENT_DATE and CURRENT_TIME, unless you explicitly specify a precision (i.e. CURRENT_TIME(3) or CURRENT_TIMESTAMP(0)).
- Within a PSQL module (procedure, trigger or executable block), the value of CURRENT_TIME will remain constant every time it is read. If multiple modules call or trigger each other, the value will remain constant throughout the duration of the outermost module. If you need a progressing value in PSQL (e.g. to measure time intervals), use 'NOW'.

CURRENT_TIME and Firebird 4.0 Time Zone Support

Firebird 4.0 added support for time zones. As part of this support, an incompatibility with the CURRENT_TIME expression was introduced compared to previous version.

In Firebird 4.0, CURRENT_TIME returns the TIME WITH TIME ZONE type. In order for your queries to be compatible with database code of Firebird 4.0 and higher, Firebird 3.0.4 and Firebird 2.5.9 introduced the LOCALTIME expression. In Firebird 3.0.4 and Firebird 2.5.9, LOCALTIME is a synonym for CURRENT_TIME.

In Firebird 4.0, LOCALTIME continues to work as it does in Firebird 3.0.4 and higher and Firebird 2.5.9 (returning TIME [WITHOUT TIME ZONE]), while CURRENT_TIME now returns a different data type, TIME WITH TIME ZONE.

Examples

```
select current_time from rdb$database
-- returns e.g. 14:20:19.0000

select current_time(2) from rdb$database
```

```
-- returns e.g. 14:20:23.1200
```

See also

CURRENT_TIMESTAMP, LOCALTIME, LOCALTIMESTAMP

11.5. CURRENT_TIMESTAMP

Available in

DSQL, PSQL, ESQL

Type

TIMESTAMP WITH TIME ZONE

Data type changed in Firebird 4.0 from TIMESTAMP WITHOUT TIME ZONE to TIMESTAMP WITH TIME ZONE. Use LOCALTIMESTAMP to obtain TIMESTAMP WITHOUT TIME ZONE.

Syntax

```
CURRENT_TIMESTAMP [ (<precision>) ]

<precision> ::= 0 | 1 | 2 | 3
```

The optional *precision* argument is not supported in ESQL.

Table 242. CURRENT_TIMESTAMP Parameter

Parameter	Description
precision	Precision. The default value is 3. Not supported in ESQL

CURRENT_TIMESTAMP returns the current server date and time in the session time zone. The default is 3 decimals, i.e. milliseconds precision.

- The default precision of CURRENT_TIME is 0 decimals, so CURRENT_TIMESTAMP is not the exact sum of CURRENT_DATE and CURRENT_TIME, unless you explicitly specify a precision (i.e. CURRENT_TIME(3) or CURRENT_TIMESTAMP(0)).
- Within a PSQL module (procedure, trigger or executable block), the value of CURRENT_TIMESTAMP will remain constant every time it is read. If multiple modules call or trigger each other, the value will remain constant throughout the duration of the outermost module. If you need a progressing value in PSQL (e.g. to measure time intervals), use 'NOW'.

CURRENT_TIMESTAMP and Firebird 4.0 Time Zone Support

Firebird 4.0 added support for time zones. As part of this support, an incompatibility with the CURRENT_TIMESTAMP expression was introduced compared to previous versions.

> In Firebird 4.0, CURRENT_TIMESTAMP returns the TIMESTAMP WITH TIME ZONE type. In order for your queries to be compatible with database code of Firebird 4.0 and higher, Firebird 3.0.4 and Firebird 2.5.9 introduced the LOCALTIMESTAMP expression. In Firebird 3.0.4 and Firebird 2.5.9, LOCALTIMESTAMP is a synonym for CURRENT_TIMESTAMP.
>
> In Firebird 4.0, LOCALTIMESTAMP continues to work as it does in Firebird 3.0.4 and higher and Firebird 2.5.9 (returning TIMESTAMP [WITHOUT TIME ZONE]), while CURRENT_TIMESTAMP now returns a different data type, TIMESTAMP WITH TIME ZONE.

Examples

```
select current_timestamp from rdb$database
-- returns e.g. 2008-08-13 14:20:19.6170

select current_timestamp(2) from rdb$database
-- returns e.g. 2008-08-13 14:20:23.1200
```

See also

CURRENT_TIME, LOCALTIME, LOCALTIMESTAMP

11.6. CURRENT_TRANSACTION

Available in

DSQL, PSQL

Type

BIGINT

Syntax

```
CURRENT_TRANSACTION
```

CURRENT_TRANSACTION contains the unique identifier of the current transaction.

Its value is derived from a counter on the database header page, which is incremented for each new transaction. When a database is restored, this counter is reset to zero.

Examples

```
select current_transaction from rdb$database

New.Txn_ID = current_transaction;
```

11.7. CURRENT_USER

Available in

DSQL, PSQL

Type
VARCHAR(63)

Syntax

```
CURRENT_USER
```

CURRENT_USER is a context variable containing the name of the currently connected user. It is fully equivalent to USER.

Example

```
create trigger bi_customers for customers before insert as
begin
    New.added_by  = CURRENT_USER;
    New.purchases = 0;
end
```

11.8. DELETING

Available in

PSQL

Type
BOOLEAN

Syntax

```
DELETING
```

Available in triggers only, DELETING indicates if the trigger fired for a DELETE operation. Intended for use in multi-action triggers.

Example

```
if (deleting) then
begin
  insert into Removed_Cars (id, make, model, removed)
    values (old.id, old.make, old.model, current_timestamp);
end
```

11.9. GDSCODE

Available in

PSQL

Type

INTEGER

Syntax

```
GDSCODE
```

In a "WHEN … DO" error handling block, the GDSCODE context variable contains the numerical representation of the current Firebird error code. Prior to Firebird 2.0, GDSCODE was only set in WHEN GDSCODE handlers. Now it may also be non-zero in WHEN ANY, WHEN SQLCODE, WHEN SQLSTATE and WHEN EXCEPTION blocks, provided that the condition raising the error corresponds with a Firebird error code. Outside error handlers, GDSCODE is always 0. Outside PSQL, it doesn't exist at all.

After WHEN GDSCODE, you must use symbolic names like grant_obj_notfound etc. But the GDSCODE context variable is an INTEGER. If you want to compare it against a specific error, the numeric value must be used, e.g. 335544551 for grant_obj_notfound.

Example

```
when gdscode grant_obj_notfound, gdscode grant_fld_notfound,
   gdscode grant_nopriv, gdscode grant_nopriv_on_base
do
begin
  execute procedure log_grant_error(gdscode);
  exit;
end
```

11.10. INSERTING

Available in

PSQL

Type

BOOLEAN

Syntax

```
INSERTING
```

Available in triggers only, INSERTING indicates if the trigger fired because of an INSERT operation. Intended for use in multi-action triggers.

Example

```
if (inserting or updating) then
begin
  if (new.serial_num is null) then
```

```
    new.serial_num = gen_id(gen_serials, 1);
end
```

11.11. LOCALTIME

Available in

DSQL, PSQL, ESQL

Type

`TIME WITHOUT TIME ZONE`

Syntax

```
LOCALTIME [ (<precision>) ]

<precision> ::= 0 | 1 | 2 | 3
```

The optional *precision* argument is not supported in ESQL.

Table 243. `LOCALTIME` Parameter

Parameter	Description
precision	Precision. The default value is 0. Not supported in ESQL

`LOCALTIME` returns the current server time in the session time zone. The default is 0 decimals, i.e. seconds precision.

- In Firebird 4.0, `CURRENT_TIME` returns a `TIME WITH TIME ZONE` instead of a `TIME [WITHOUT TIME ZONE]`, while `LOCALTIME` returns `TIME [WITHOUT TIME ZONE]`. It is recommended to use `LOCALTIME` when you do not need time zone information.
- `LOCALTIME` has a default precision of 0 decimals, where `LOCALTIMESTAMP` has a default precision of 3 decimals. As a result, `LOCALTIMESTAMP` is not the exact sum of `CURRENT_DATE` and `LOCALTIME`, unless you explicitly specify a precision (i.e. `LOCALTIME(3)` or `LOCALTIMESTAMP(0)`).
- Within a PSQL module (procedure, trigger or executable block), the value of `LOCALTIME` will remain constant every time it is read. If multiple modules call or trigger each other, the value will remain constant throughout the duration of the outermost module. If you need a progressing value in PSQL (e.g. to measure time intervals), use `'NOW'`.

Examples

```
select localtime from rdb$database
-- returns e.g. 14:20:19.0000

select localtime(2) from rdb$database
```

```
-- returns e.g. 14:20:23.1200
```

See also

CURRENT_TIME, LOCALTIMESTAMP

11.12. LOCALTIMESTAMP

Available in

DSQL, PSQL, ESQL

Type

TIMESTAMP WITHOUT TIME ZONE

Syntax

```
LOCALTIMESTAMP [ (<precision>) ]

<precision> ::= 0 | 1 | 2 | 3
```

The optional *precision* argument is not supported in ESQL.

Table 244. LOCALTIMESTAMP *Parameter*

Parameter	Description
precision	Precision. The default value is 3. Not supported in ESQL

LOCALTIMESTAMP returns the current server date and time in the session time zone. The default is 3 decimals, i.e. milliseconds precision.

- In Firebird 4.0, CURRENT_TIMESTAMP returns a TIMESTAMP WITH TIME ZONE instead of a TIMESTAMP [WITHOUT TIME ZONE], while LOCALTIMESTAMP returns TIMESTAMP [WITHOUT TIME ZONE]. It is recommended to use LOCALTIMESTAMP when you do not need time zone information.
- The default precision of LOCALTIME is 0 decimals, so LOCALTIMESTAMP is not the exact sum of CURRENT_DATE and LOCALTIME, unless you explicitly specify a precision (i.e. LOCATIME(3) or LOCALTIMESTAMP(0)).
- Within a PSQL module (procedure, trigger or executable block), the value of LOCALTIMESTAMP will remain constant every time it is read. If multiple modules call or trigger each other, the value will remain constant throughout the duration of the outermost module. If you need a progressing value in PSQL (e.g. to measure time intervals), use 'NOW'.

Examples

```
select localtimestamp from rdb$database
-- returns e.g. 2008-08-13 14:20:19.6170
```

```
select localtimestamp(2) from rdb$database
-- returns e.g. 2008-08-13 14:20:23.1200
```

See also

`CURRENT_TIMESTAMP`, `LOCALTIME`

11.13. NEW

Available in

PSQL, triggers only

Type

Record type

Syntax

```
NEW.column_name
```

Table 245. `NEW` Parameters

Parameter	Description
column_name	Column name to access

`NEW` contains the new version of a database record that has just been inserted or updated. Starting with Firebird 2.0 it is read-only in `AFTER` triggers.

In multi-action triggers — introduced in Firebird 1.5 — `NEW` is always available. However, if the trigger is fired by a `DELETE`, there will be no new version of the record. In that situation, reading from `NEW` will always return `NULL`; writing to it will cause a runtime exception.

11.14. 'NOW'

Available in

DSQL, PSQL, ESQL

Type

`CHAR(3)`

`'NOW'` is not a variable, but a string literal or datetime mnemonic. It is, however, special in the sense that when you `CAST()` it to a date/time type, you will get the current date and/or time. Since Firebird 2.0 the precision is 3 decimals, i.e. milliseconds. `'NOW'` is case-insensitive, and the engine ignores leading or trailing spaces when casting.

- `'NOW'` always returns the actual date/time, even in PSQL modules, where `CURRENT_DATE`, `CURRENT_TIME` and `CURRENT_TIMESTAMP` return the same value throughout the duration of the outermost routine. This makes `'NOW'` useful for

measuring time intervals in triggers, procedures and executable blocks.

- Except in the situation mentioned above, reading `CURRENT_DATE`, `CURRENT_TIME` and `CURRENT_TIMESTAMP` is generally preferable to casting `'NOW'`. Be aware though that `CURRENT_TIME` defaults to seconds precision; to get milliseconds precision, use `CURRENT_TIME(3)`.
- Firebird 3.0 and earlier allowed the use of `'NOW'` in datetime literals (a.k.a. "`shorthand casts"`), this is no longer allowed in Firebird 4.0.

Examples

```
select 'Now' from rdb$database
-- returns 'Now'

select cast('Now' as date) from rdb$database
-- returns e.g. 2008-08-13

select cast('now' as time) from rdb$database
-- returns e.g. 14:20:19.6170

select cast('NOW' as timestamp) from rdb$database
-- returns e.g. 2008-08-13 14:20:19.6170
```

11.15. OLD

Available in

PSQL, triggers only

Type

Record type

Syntax

```
OLD.column_name
```

Table 246. OLD Parameters

Parameter	Description
column_name	Column name to access

`OLD` contains the existing version of a database record just before a deletion or update. Starting with Firebird 2.0 it is read-only.

In multi-action triggers — introduced in Firebird 1.5 — `OLD` is always available. However, if the trigger is fired by an `INSERT`, there is obviously no pre-existing version of the record. In that situation, reading from `OLD` will always return `NULL`; writing to it will cause a runtime exception.

11.16. RESETTING

Available in

PSQL

Type

BOOLEAN

Syntax

```
RESETTING
```

Available in triggers only, RESETTING indicates if the trigger fired during a session reset. Its value is TRUE if session reset is in progress and FALSE otherwise. Intended for use in ON DISCONNECT and ON CONNECT database triggers to detect an ALTER SESSION RESET.

11.17. ROW_COUNT

Available in

PSQL

Type

INTEGER

Syntax

```
ROW_COUNT
```

The ROW_COUNT context variable contains the number of rows affected by the most recent DML statement (INSERT, UPDATE, DELETE, SELECT or FETCH) in the current trigger, stored procedure or executable block.

Behaviour with SELECT *and* FETCH

- After a singleton SELECT, ROW_COUNT is 1 if a data row was retrieved and 0 otherwise.
- In a FOR SELECT loop, ROW_COUNT is incremented with every iteration (starting at 0 before the first).
- After a FETCH from a cursor, ROW_COUNT is 1 if a data row was retrieved and 0 otherwise. Fetching more records from the same cursor does *not* increment ROW_COUNT beyond 1.
- In Firebird 1.5.x, ROW_COUNT is 0 after any type of SELECT statement.

ROW_COUNT cannot be used to determine the number of rows affected by an EXECUTE STATEMENT or EXECUTE PROCEDURE command.

Example

```
update Figures set Number = 0 where id = :id;
```

```
if (row_count = 0) then
  insert into Figures (id, Number) values (:id, 0);
```

11.18. SQLCODE

Available in

PSQL

Deprecated in

2.5.1

Type

`INTEGER`

Syntax

```
SQLCODE
```

In a "`WHEN ... DO`" error handling block, the `SQLCODE` context variable contains the current SQL error code. Prior to Firebird 2.0, `SQLCODE` was only set in `WHEN SQLCODE` and `WHEN ANY` handlers. Now it may also be non-zero in `WHEN GDSCODE`, `WHEN SQLSTATE` and `WHEN EXCEPTION` blocks, provided that the condition raising the error corresponds with an SQL error code. Outside error handlers, `SQLCODE` is always 0. Outside PSQL, it doesn't exist at all.

`SQLCODE` is now deprecated in favour of the SQL-2003-compliant `SQLSTATE` status code. Support for `SQLCODE` and `WHEN SQLCODE` will be discontinued in some future version of Firebird.

Example

```
when any
do
begin
  if (sqlcode <> 0) then
    Msg = 'An SQL error occurred!';
  else
    Msg = 'Something bad happened!';
  exception ex_custom Msg;
end
```

11.19. SQLSTATE

Available in

PSQL

Type

`CHAR(5)`

Syntax

```
SQLSTATE
```

In a "`WHEN … DO`" error handler, the `SQLSTATE` context variable contains the 5-character, SQL-2003-compliant status code resulting from the statement that raised the error. Outside error handlers, `SQLSTATE` is always `'00000'`. Outside PSQL, it is not available at all.

- `SQLSTATE` is destined to replace `SQLCODE`. The latter is now deprecated in Firebird and will disappear in some future version.
- Firebird does not (yet) support the syntax "`WHEN SQLSTATE … DO`". You have to use `WHEN ANY` and test the `SQLSTATE` variable within the handler.
- Each `SQLSTATE` code is the concatenation of a 2-character class and a 3-character subclass. Classes *00* (successful completion), *01* (warning) and *02* (no data) represent *completion conditions*. Every status code outside these classes is an *exception*. Because classes *00*, *01* and *02* don't raise an error, they won't ever show up in the `SQLSTATE` variable.
- For a complete listing of `SQLSTATE` codes, consult the SQLSTATE Codes and Message Texts section in *Appendix B: Exception Handling, Codes and Messages*.

Example

```
when any
do
begin
  Msg = case sqlstate
          when '22003' then 'Numeric value out of range.'
          when '22012' then 'Division by zero.'
          when '23000' then 'Integrity constraint violation.'
          else 'Something bad happened! SQLSTATE = ' || sqlstate
        end;
  exception ex_custom Msg;
end
```

11.20. 'TODAY'

Available in

DSQL, PSQL, ESQL

Type

`CHAR(5)`

`'TODAY'` is not a variable, but a string literal or date mnemonic. It is, however, special in the sense that when you `CAST()` it to a date/time type, you will get the current date. `'TODAY'` is case-insensitive, and the engine ignores leading or trailing spaces when casting.

- `'TODAY'` always returns the actual date, even in PSQL modules, where `CURRENT_DATE`, `CURRENT_TIME` and `CURRENT_TIMESTAMP` return the same value throughout the duration of the outermost routine. This makes `'TODAY'` useful for measuring time intervals in triggers, procedures and executable blocks (at least if your procedures are running for days).
- Except in the situation mentioned above, reading `CURRENT_DATE`, is generally preferable to casting `'TODAY'`.
- Firebird 3.0 and earlier allowed the use of `'TODAY'` in datetime literals (a.k.a. "`shorthand casts"`), this is no longer allowed in Firebird 4.0.

Examples

```
select 'Today' from rdb$database
-- returns 'Today'

select cast('Today' as date) from rdb$database
-- returns e.g. 2011-10-03

select cast('TODAY' as timestamp) from rdb$database
-- returns e.g. 2011-10-03 00:00:00.0000
```

11.21. 'TOMORROW'

Available in

DSQL, PSQL, ESQL

Type

`CHAR(8)`

`'TOMORROW'` is not a variable, but a string literal. It is, however, special in the sense that when you `CAST()` it to a date/time type, you will get the date of the next day. See also `'TODAY'`.

Examples

```
select 'Tomorrow' from rdb$database
-- returns 'Tomorrow'

select cast('Tomorrow' as date) from rdb$database
-- returns e.g. 2011-10-04

select cast('TOMORROW' as timestamp) from rdb$database
-- returns e.g. 2011-10-04 00:00:00.0000
```

11.22. UPDATING

Available in

PSQL

Type
`BOOLEAN`

Syntax

```
UPDATING
```

Available in triggers only, `UPDATING` indicates if the trigger fired because of an `UPDATE` operation. Intended for use in multi-action triggers.

Example

```
if (inserting or updating) then
begin
  if (new.serial_num is null) then
    new.serial_num = gen_id(gen_serials, 1);
end
```

11.23. 'YESTERDAY'

Available in

DSQL, PSQL, ESQL

Type
`CHAR(9)`

`'YESTERDAY'` is not a variable, but a string literal. It is, however, special in the sense that when you `CAST()` it to a date/time type, you will get the date of the day before. See also `'TODAY'`.

Examples

```
select 'Yesterday' from rdb$database
-- returns 'Yesterday'

select cast('Yesterday as date) from rdb$database
-- returns e.g. 2011-10-02

select cast('YESTERDAY' as timestamp) from rdb$database
-- returns e.g. 2011-10-02 00:00:00.0000
```

11.24. USER

Available in

DSQL, PSQL

Type

`VARCHAR(63)`

Syntax

```
USER
```

`USER` is a context variable containing the name of the currently connected user. It is fully equivalent to `CURRENT_USER`.

Example

```
create trigger bi_customers for customers before insert as
begin
  New.added_by  = USER;
  New.purchases = 0;
end
```

Chapter 12. Transaction Control

Everything in Firebird happens in transactions. Units of work are isolated between a start point and end point. Changes to data remain reversible until the moment the client application instructs the server to commit them.

12.1. Transaction Statements

Firebird has a small lexicon of SQL statements that are used by client applications to start, manage, commit and reverse (roll back) the transactions that form the boundaries of all database tasks:

SET TRANSACTION
: for configuring and starting a transaction

COMMIT
: to signal the end of a unit of work and write changes permanently to the database

ROLLBACK
: to reverse the changes performed in the transaction

SAVEPOINT
: to mark a position in the log of work done, in case a partial rollback is needed

RELEASE SAVEPOINT
: to erase a savepoint

12.1.1. SET TRANSACTION

Used for

Configuring and starting a transaction

Available in

DSQL, ESQL

Syntax

```
SET TRANSACTION
   [NAME tr_name]
   [<tr_option> ...]

<tr_option> ::=
     READ {ONLY | WRITE}
   | [NO] WAIT
   | [ISOLATION LEVEL] <isolation_level>
   | NO AUTO UNDO
   | RESTART REQUESTS
   | AUTO COMMIT
   | IGNORE LIMBO
```

```
    | LOCK TIMEOUT seconds
    | RESERVING <tables>
    | USING <dbhandles>

<isolation_level> ::=
    SNAPSHOT [AT NUMBER snapshot_number]
  | SNAPSHOT TABLE [STABILITY]
  | READ {UNCOMMITED | COMMITTED} [<read-commited-opt>]

<read-commited-opt> ::=
  [NO] RECORD_VERSION | READ CONSISTENCY

<tables> ::= <table_spec> [, <table_spec> ...]

<table_spec> ::= tablename [, tablename ...]
  [FOR [SHARED | PROTECTED] {READ | WRITE}]

<dbhandles> ::= dbhandle [, dbhandle ...]
```

Table 247. SET TRANSACTION Statement Parameters

Parameter	Description
tr_name	Transaction name. Available only in ESQL
tr_option	Optional transaction option. Each option should be specified at most once, some options are mutually exclusive (e.g. READ ONLY vs READ WRITE, WAIT vs NO WAIT)
seconds	The time in seconds for the statement to wait in case a conflict occurs. Has to be greater than or equal to 0.
snapshot_number	Snapshot number to use for this transaction
tables	The list of tables to reserve
dbhandles	The list of databases the database can access. Available only in ESQL
table_spec	Table reservation specification
tablename	The name of the table to reserve
dbhandle	The handle of the database the transaction can access. Available only in ESQL

The SET TRANSACTION statement configures the transaction and starts it. As a rule, only client applications start transactions. Exceptions are when the server starts an autonomous transaction, and transactions for certain background system threads/processes, such as sweeping.

A client application can start any number of concurrently running transactions. A single connection can have multiple concurrent active transactions (though not all drivers or access components support this). A limit does exist, for the total number of running transactions in all client applications working with one particular database from the moment the database was restored from its backup copy or from the moment the database was created originally. The limit is 2^{48} — 281,474,976,710,656 — in Firebird 3.0 and higher, and 2^{31}-1 — or 2,147,483,647 — in earlier

versions.

All clauses in the SET TRANSACTION statement are optional. If the statement starting a transaction has no clauses specified, the transaction will be started with default values for access mode, lock resolution mode and isolation level, which are:

```
SET TRANSACTION
  READ WRITE
  WAIT
  ISOLATION LEVEL SNAPSHOT;
```

Database drivers or access components may use different defaults for transactions started through their API. Check their documentation for details.

The server assigns integer numbers to transactions sequentially. Whenever a client starts any transaction, either explicitly defined or by default, the server sends the transaction ID to the client. This number can be retrieved in SQL using the context variable CURRENT_TRANSACTION.

Some database drivers — or their governing specifications — require that you configure and start transaction through API methods. In that case, using SET TRANSACTION is either not supported, or may result in unspecified behaviour. An example of this is JDBC and the Firebird JDBC driver Jaybird.

Check the documentation of your driver for details.

The NAME and USING clauses are only valid in ESQL.

Transaction Name

The optional NAME attribute defines the name of a transaction. Use of this attribute is available only in Embedded SQL. In ESQL applications, named transactions make it possible to have several transactions active simultaneously in one application. If named transactions are used, a host-language variable with the same name must be declared and initialized for each named transaction. This is a limitation that prevents dynamic specification of transaction names and thus rules out transaction naming in DSQL.

Transaction Parameters

The main parameters of a transaction are:

- data access mode (READ WRITE, READ ONLY)
- lock resolution mode (WAIT, NO WAIT) with an optional LOCK TIMEOUT specification
- isolation level (READ COMMITTED, SNAPSHOT, SNAPSHOT TABLE STABILITY).

The READ UNCOMMITTED isolation level is a synonym for READ COMMITTED, and provided only for syntax compatibility. It provides the exact same semantics as READ COMMITTED, and does not allow you to view uncommitted changes of other

transactions.

- a mechanism for reserving or releasing tables (the RESERVING clause)

Access Mode

The two database access modes for transactions are READ WRITE and READ ONLY.

- If the access mode is READ WRITE, operations in the context of this transaction can be both read operations and data update operations. This is the default mode.
- If the access mode is READ ONLY, only SELECT operations can be executed in the context of this transaction. Any attempt to change data in the context of such a transaction will result in database exceptions. However, this does not apply to global temporary tables (GTT), which are allowed to be changed in READ ONLY transactions, see *Global Temporary Tables (GTT)* in Chapter *Data Definition (DDL) Statements* for details.

Lock Resolution Mode

When several client processes work with the same database, locks may occur when one process makes uncommitted changes in a table row, or deletes a row, and another process tries to update or delete the same row. Such locks are called *update conflicts*.

Locks may occur in other situations when multiple transaction isolation levels are used.

The two lock resolution modes are WAIT and NO WAIT.

WAIT Mode

In the WAIT mode (the default mode), if a conflict occurs between two parallel processes executing concurrent data updates in the same database, a WAIT transaction will wait till the other transaction has finished — by committing (COMMIT) or rolling back (ROLLBACK). The client application with the WAIT transaction will be put on hold until the conflict is resolved.

If a LOCK TIMEOUT is specified for the WAIT transaction, waiting will continue only for the number of seconds specified in this clause. If the lock is unresolved at the end of the specified interval, the error message “Lock time-out on wait transaction” is returned to the client.

Lock resolution behaviour can vary a little, depending on the transaction isolation level.

NO WAIT Mode

In the NO WAIT mode, a transaction will immediately throw a database exception if a conflict occurs.

LOCK TIMEOUT is a separate transaction option, but can only be used for WAIT transactions. Specifying LOCK TIMEOUT with a NO WAIT transaction will raise an error “*invalid parameter in transaction parameter block -Option isc_tpb_lock_timeout is not valid if isc_tpb_nowait was used previously in TPB*”

Isolation Level

Keeping the work of one database task separated from others is what isolation is about. Changes made by one statement become visible to all remaining statements executing within the same transaction, regardless of its isolation level. Changes that are in progress within other transactions remain invisible to the current transaction as long as they remain uncommitted. The isolation level and, sometimes, other attributes, determine how transactions will interact when another transaction wants to commit work.

The `ISOLATION LEVEL` attribute defines the isolation level for the transaction being started. It is the most significant transaction parameter for determining its behavior towards other concurrently running transactions.

The three isolation levels supported in Firebird are:

- `SNAPSHOT`
- `SNAPSHOT TABLE STABILITY`
- `READ COMMITTED` with three specifications (`READ CONSISTENCY`, `NO RECORD_VERSION` and `RECORD_VERSION`)

`SNAPSHOT` Isolation Level

`SNAPSHOT` isolation level — the default level — allows the transaction to see only those changes that were committed before it was started. Any committed changes made by concurrent transactions will not be seen in a `SNAPSHOT` transaction while it is active. The changes will become visible to a new transaction once the current transaction is either committed or rolled back completely, but not if it is just rolled back to a savepoint.

The `SNAPSHOT` isolation level is also known as "*concurrency*".

Autonomous Transactions

Changes made by autonomous transactions are not seen in the context of the `SNAPSHOT` transaction that launched it.

Sharing Snapshot Transactions

Using `SNAPSHOT AT NUMBER snaphot_number`, a `SNAPSHOT` transaction can be started sharing the snapshot of another transaction. With this feature it's possible to create parallel processes (using different attachments) reading consistent data from a database. For example, a backup process may create multiple threads reading data from the database in parallel. Or a web service may dispatch distributed sub-services doing some processing in parallel.

Alternatively, this feature can also be used via the API, using Transaction Parameter Buffer item `isc_tpb_at_snapshot_number`.

The *snapshot_number* from an active transaction can be obtained with `RDB$GET_CONTEXT('SYSTEM', 'SNAPSHOT_NUMBER')` in SQL or using the transaction information API call with `fb_info_tra_snapshot_number` information tag. The *snapshot_number* passed to the new transaction must be a snapshot of a currently active transaction.

To share a stable view between transactions, the other transaction also needs to have isolation level SNAPSHOT. With READ COMMITTED, the snapshot number will move forward

Example

```
SET TRANSACTION SNAPSHOT AT NUMBER 12345;
```

SNAPSHOT TABLE STABILITY Isolation Level

The SNAPSHOT TABLE STABILITY — or SNAPSHOT TABLE — isolation level is the most restrictive. As in SNAPSHOT, a transaction in SNAPSHOT TABLE STABILITY isolation sees only those changes that were committed before the current transaction was started. After a SNAPSHOT TABLE STABILITY is started, no other transactions can make any changes to any table in the database that has changes pending for this transaction. Other transactions are able to read other data, but any attempt at inserting, updating or deleting by a parallel process will cause conflict exceptions.

The RESERVING clause can be used to allow other transactions to change data in some tables.

If any other transaction has an uncommitted change pending in any (non-SHARED) table listed in the RESERVING clause, trying to start a SNAPSHOT TABLE STABILITY transaction will result in an indefinite wait (default or explicit WAIT), or an exception (NO WAIT or after expiration of the LOCK TIMEOUT).

The SNAPSHOT TABLE STABILITY isolation level is also known as "*consistency*".

READ COMMITTED Isolation Level

The READ COMMITTED isolation level allows all data changes that other transactions have committed since it started to be seen immediately by the uncommitted current transaction. Uncommitted changes are not visible to a READ COMMITTED transaction.

To retrieve the updated list of rows in the table you are interested in — "refresh" — the SELECT statement just needs to be requested again, whilst still in the uncommitted READ COMMITTED transaction.

Variants of READ COMMITTED

One of three modifying parameters can be specified for READ COMMITTED transactions, depending on the kind of conflict resolution desired: READ CONSISTENCY, RECORD_VERSION or NO RECORD_VERSION. When the ReadConsistency setting is set to 1 in firebird.conf (the default) or in databases.conf, these variants are effectively ignored and behave as READ CONSISTENCY. Otherwise, these variants are mutually exclusive.

- NO RECORD_VERSION (the default if ReadConsistency = 0) is a kind of two-phase locking mechanism: it will make the transaction unable to write to any row that has an update pending from another transaction.
  - if NO WAIT is the lock resolution strategy specified, it will throw a lock conflict error immediately

    - with `WAIT` specified, it will wait until the other transaction either commits or is rolled back. If the other transaction is rolled back, or if it is committed and its transaction ID is older than the current transaction's ID, then the current transaction's change is allowed. A lock conflict error is returned if the other transaction was committed and its ID was newer than that of the current transaction.

- With `RECORD_VERSION` specified, the transaction reads the latest committed version of the row, regardless of other pending versions of the row. The lock resolution strategy (`WAIT` or `NO WAIT`) does not affect the behavior of the transaction at its start in any way.
- With `READ CONSISTENCY` specified, or for all variants if `ReadConsistency = 1`, the execution of a statement obtains a snapshot of the database to ensure a consistent read at the statement-level of the transactions committed when execution started.

  The other two variants can result in statement-level inconsistent reads as they may read some but not all changes of a concurrent transaction if that transaction commits during statement execution. For example, a `SELECT COUNT(*)` could read some, but not all inserted records of another transaction if the commit of that transaction occurs while the statement is reading records.

  This statement-level snapshot is obtained for the execution of a top-level statement, nested statements (triggers, stored procedures and functions, dynamics statements, etc) use the statement-level snapshot created for the top-level statement.

Obtaining a snapshot for `READ CONSISTENCY` is a very cheap action.

Setting `ReadConsistency` is set to 1 by default in `firebird.conf`.

Handling of Update Conflicts with `READ CONSISTENCY`

When a statement executes in a *READ COMMITTED READ CONSISTENCY* transaction, its database view is retained in a fashion similar to a *SNAPSHOT* transaction. This makes it pointless to wait for the concurrent transaction to commit, in the hope of being able to read the newly-committed record version. So, when a *READ COMMITTED READ CONSISTENCY* transaction reads data, it behaves similarly to *READ COMMITTED RECORD VERSION* transaction: it walks the back versions chain looking for a record version visible to the current snapshot.

When an update conflict occurs, the behaviour of a *READ COMMITTED READ CONSISTENCY* transaction is different to that of one in *READ COMMITTED RECORD VERSION*. The following actions are performed:

1. Transaction isolation mode is temporarily switched to *READ COMMITTED NO RECORD VERSION*.
2. A write-lock is taken for the conflicting record.
3. Remaining records of the current `UPDATE/DELETE` cursor are processed, and they are write-locked too.
4. Once the cursor is fetched, all modifications performed since the top-level statement was

started are undone, already taken write-locks for every updated/deleted/locked record are preserved, all inserted records are removed.

5. Transaction isolation mode is restored to *READ COMMITTED READ CONSISTENCY*, a new statement-level snapshot is created, and the top-level statement is restarted.

This algorithm ensures that already updated records remain locked after restart, they are visible to the new snapshot, and could be updated again with no further conflicts. Also, due to *READ CONSISTENCY* nature, the modified record set remains consistent.

- This restart algorithm is applied to `UPDATE`, `DELETE`, `SELECT WITH LOCK` and `MERGE` statements, with or without the `RETURNING` clause, executed directly by a client application or inside some PSQL object (stored procedure/function, trigger, `EXECUTE BLOCK`, etc).
- If an `UPDATE/DELETE` statement is positioned on some explicit cursor (using the `WHERE CURRENT OF` clause), then the step (3) above is skipped, i.e. remaining cursor records are not fetched and write-locked.
- If the top-level statement is selectable and update conflict happens after one or more records were returned to the client side, then an update conflict error is reported as usual and restart is not initiated.
- Restart does not happen for statements executed inside autonomous blocks (`IN AUTONOMOUS TRANSACTION DO ⋯`).
- After 10 unsuccessful attempts the restart algorithm is aborted, all write locks are released, transaction isolation mode is restored to *READ COMMITTED READ CONSISTENCY*, and an update conflict error is raised.
- Any error not handled at step (3) above aborts the restart algorithm and statement execution continues normally.
- `UPDATE/DELETE` triggers fire multiple times for the same record if the statement execution was restarted and record is updated/deleted again.
- Statement restart is usually fully transparent to client applications and no special actions should be taken by developers to handle it in any way. The only exception is the code with side effects that are outside the transactional control, for example:
  - usage of external tables, sequences or context variables
  - sending e-mails using UDF
  - usage of autonomous transactions or external queries

  and so on. Beware that such code could be executed more than once if update conflict happens.
- There is no way to detect whether a restart happened, but it could be done manually using code with side effects as described above, for example using a context variable.
- Due to historical reasons, error *isc_update_conflict* is reported as the secondary error code, with the primary error code being *isc_deadlock*.

NO AUTO UNDO

The NO AUTO UNDO option affects the handling of record versions (garbage) produced by the transaction in the event of rollback. With NO AUTO UNDO flagged, the ROLLBACK statement just marks the transaction as rolled back without deleting the record versions created in the transaction. They are left to be mopped up later by garbage collection.

NO AUTO UNDO might be useful when a lot of separate statements are executed that change data in conditions where the transaction is likely to be committed successfully most of the time.

The NO AUTO UNDO option is ignored for transactions where no changes are made.

RESTART REQUESTS

According to the Firebird sources, this will

> Restart all requests in the current attachment to utilize the passed transaction.
>
> — src/jrd/tra.cpp

The exact semantics and effects of this clause are not clear, and we recommend you do not use this clause.

AUTO COMMIT

Specifying AUTO COMMIT enables auto-commit mode for the transaction. In auto-commit mode, Firebird will internally execute the equivalent of COMMIT RETAIN after each statement execution.

This is not a generally useful auto-commit mode; the same transaction context is retained until the transaction is ended through a commit or rollback. In other words, when you use SNAPSHOT or SNAPSHOT TABLE STABILITY, this auto-commit will not change record visibility (effects of transactions that were committed after this transaction was started will not be visible).

For READ COMMITTED, the same warnings apply as for commit retaining: prolonged use of a single transaction in auto-commit mode can inhibit garbage collection and degrade performance.

IGNORE LIMBO

This flag is used to signal that records created by limbo transactions are to be ignored. Transactions are left “in limbo” if the second stage of a two-phase commit fails.

Historical Note

IGNORE LIMBO surfaces the TPB parameter isc_tpb_ignore_limbo, available in the API since InterBase times and is mainly used by *gfix*.

RESERVING

The RESERVING clause in the SET TRANSACTION statement reserves tables specified in the table list.

Reserving a table prevents other transactions from making changes in them or even, with the inclusion of certain parameters, from reading data from them while this transaction is running.

A RESERVING clause can also be used to specify a list of tables that can be changed by other transactions, even if the transaction is started with the SNAPSHOT TABLE STABILITY isolation level.

One RESERVING clause is used to specify as many reserved tables as required.

Options for RESERVING Clause

If one of the keywords SHARED or PROTECTED is omitted, SHARED is assumed. If the whole FOR clause is omitted, FOR SHARED READ is assumed. The names and compatibility of the four access options for reserving tables are not obvious.

Table 248. Compatibility of Access Options for RESERVING

	SHARED READ	SHARED WRITE	PROTECTED READ	PROTECTED WRITE
SHARED READ	Yes	Yes	Yes	Yes
SHARED WRITE	Yes	Yes	No	No
PROTECTED READ	Yes	No	Yes	No
PROTECTED WRITE	Yes	No	No	No

The combinations of these RESERVING clause flags for concurrent access depend on the isolation levels of the concurrent transactions:

- SNAPSHOT isolation
  - Concurrent SNAPSHOT transactions with SHARED READ do not affect one other's access
  - A concurrent mix of SNAPSHOT and READ COMMITTED transactions with SHARED WRITE do not affect one another's access, but they block transactions with SNAPSHOT TABLE STABILITY isolation from either reading from or writing to the specified table(s)
  - Concurrent transactions with any isolation level and PROTECTED READ can only read data from the reserved tables. Any attempt to write to them will cause an exception
  - With PROTECTED WRITE, concurrent transactions with SNAPSHOT and READ COMMITTED isolation cannot write to the specified tables. Transactions with SNAPSHOT TABLE STABILITY isolation cannot read from or write to the reserved tables at all.
- SNAPSHOT TABLE STABILITY isolation
  - All concurrent transactions with SHARED READ, regardless of their isolation levels, can read from or write (if in READ WRITE mode) to the reserved tables
  - Concurrent transactions with SNAPSHOT and READ COMMITTED isolation levels and SHARED WRITE can read data from and write (if in READ WRITE mode) to the specified tables but concurrent access to those tables from transactions with SNAPSHOT TABLE STABILITY is blocked completely whilst these transactions are active
  - Concurrent transactions with any isolation level and PROTECTED READ can only read from the

reserved tables

- With PROTECTED WRITE, concurrent SNAPSHOT and READ COMMITTED transactions can read from but not write to the reserved tables. Access by transactions with the SNAPSHOT TABLE STABILITY isolation level is blocked completely.

- READ COMMITTED isolation
  - With SHARED READ, all concurrent transactions with any isolation level can both read from and write (if in READ WRITE mode) to the reserved tables
  - SHARED WRITE allows all transactions in SNAPSHOT and READ COMMITTED isolation to read from and write (if in READ WRITE mode) to the specified tables and blocks access completely from transactions with SNAPSHOT TABLE STABILITY isolation
  - With PROTECTED READ, concurrent transactions with any isolation level can only read from the reserved tables
  - With PROTECTED WRITE, concurrent transactions in SNAPSHOT and READ COMMITTED isolation can read from but not write to the specified tables. Access from transactions in SNAPSHOT TABLE STABILITY isolation is blocked completely.

In Embedded SQL, the USING clause can be used to conserve system resources by limiting the number of databases a transaction can access. USING is mutually exclusive with RESERVING. A USING clause in SET TRANSACTION syntax is not supported in DSQL.

See also

COMMIT, ROLLBACK

12.1.2. COMMIT

Used for

Committing a transaction

Available in

DSQL, ESQL

Syntax

```
COMMIT [TRANSACTION tr_name] [WORK]
  [RETAIN [SNAPSHOT] | RELEASE];
```

Table 249. COMMIT Statement Parameter

Parameter	Description
tr_name	Transaction name. Available only in ESQL

The COMMIT statement commits all work carried out in the context of this transaction (inserts, updates, deletes, selects, execution of procedures). New record versions become available to other transactions and, unless the RETAIN clause is employed, all server resources allocated to its work are

released.

If any conflicts or other errors occur in the database during the process of committing the transaction, the transaction is not committed, and the reasons are passed back to the user application for handling, and the opportunity to attempt another commit or to roll the transaction back.

The `TRANSACTION` and `RELEASE` clauses are only valid in ESQL.

`COMMIT` Options

- The optional `TRANSACTION tr_name` clause, available only in Embedded SQL, specifies the name of the transaction to be committed. With no `TRANSACTION` clause, `COMMIT` is applied to the default transaction.

In ESQL applications, named transactions make it possible to have several transactions active simultaneously in one application. If named transactions are used, a host-language variable with the same name must be declared and initialized for each named transaction. This is a limitation that prevents dynamic specification of transaction names and thus, rules out transaction naming in DSQL.

- The optional keyword `WORK` is supported just for compatibility with other relational database management systems that require it.
- The keyword `RELEASE` is available only in Embedded SQL and enables disconnection from all databases after the transaction is committed. `RELEASE` is retained in Firebird only for compatibility with legacy versions of InterBase. It has been superseded in ESQL by the `DISCONNECT` statement.
- The `RETAIN [SNAPSHOT]` clause is used for the “soft” commit, variously referred to amongst host languages and their practitioners as `COMMIT WITH RETAIN`, “CommitRetaining”, “warm commit”, et al. The transaction is committed, but some server resources are retained and a new transaction is restarted transparently with the same Transaction ID. The state of row caches and cursors is kept as it was before the soft commit.

  For soft-committed transactions whose isolation level is `SNAPSHOT` or `SNAPSHOT TABLE STABILITY`, the view of database state is not updated to reflect changes by other transactions, and the user of the application instance continues to have the same view as when the transaction started originally. Changes made during the life of the retained transaction are visible to that transaction, of course.

Recommendation

Use of the `COMMIT` statement in preference to `ROLLBACK` is recommended for ending transactions that only read data from the database, because `COMMIT` consumes fewer server resources and helps to optimize the performance of subsequent transactions.

See also

SET TRANSACTION, ROLLBACK

12.1.3. ROLLBACK

Used for

Rolling back a transaction

Available in

DSQL, ESQL

Syntax

```
  ROLLBACK [TRANSACTION tr_name] [WORK]
    [RETAIN [SNAPSHOT] | RELEASE]
| ROLLBACK [WORK] TO [SAVEPOINT] sp_name
```

Table 250. ROLLBACK Statement Parameters

Parameter	Description
tr_name	Transaction name. Available only in ESQL
sp_name	Savepoint name. Available only in DSQL

The ROLLBACK statement rolls back all work carried out in the context of this transaction (inserts, updates, deletes, selects, execution of procedures). ROLLBACK never fails and, thus, never causes exceptions. Unless the RETAIN clause is employed, all server resources allocated to the work of the transaction are released.

The TRANSACTION and RELEASE clauses are only valid in ESQL. The ROLLBACK TO SAVEPOINT statement is not available in ESQL.

ROLLBACK Options

- The optional TRANSACTION tr_name clause, available only in Embedded SQL, specifies the name of the transaction to be committed. With no TRANSACTION clause, ROLLBACK is applied to the default transaction.

In ESQL applications, named transactions make it possible to have several transactions active simultaneously in one application. If named transactions are used, a host-language variable with the same name must be declared and initialized for each named transaction. This is a limitation that prevents dynamic specification of transaction names and thus, rules out transaction naming in DSQL.

- The optional keyword WORK is supported just for compatibility with other relational database management systems that require it.
- The keyword RETAIN keyword specifies that, although all work of the transaction is to be rolled back, the transaction context is to be retained. Some server resources are retained, and the transaction is restarted transparently with the same Transaction ID. The state of row caches and

cursors is kept as it was before the “soft” rollback.

For transactions whose isolation level is SNAPSHOT or SNAPSHOT TABLE STABILITY, the view of database state is not updated by the soft rollback to reflect changes by other transactions. The user of the application instance continues to have the same view as when the transaction started originally. Changes that were made and soft-committed during the life of the retained transaction are visible to that transaction, of course.

See also

SET TRANSACTION, COMMIT

ROLLBACK TO SAVEPOINT

The alternative ROLLBACK TO SAVEPOINT statement specifies the name of a savepoint to which changes are to be rolled back. The effect is to roll back all changes made within the transaction, from the specified savepoint forward until the point when ROLLBACK TO SAVEPOINT is requested.

ROLLBACK TO SAVEPOINT performs the following operations:

- Any database mutations performed since the savepoint was created are undone. User variables set with RDB$SET_CONTEXT() remain unchanged.
- Any savepoints that were created after the one named are destroyed. Savepoints earlier than the one named are preserved, along with the named savepoint itself. Repeated rollbacks to the same savepoint are thus allowed.
- All implicit and explicit record locks that were acquired since the savepoint are released. Other transactions that have requested access to rows locked after the savepoint must continue to wait until the transaction is committed or rolled back. Other transactions that have not already requested the rows can request and access the unlocked rows immediately.

See also

SAVEPOINT, RELEASE SAVEPOINT

12.1.4. SAVEPOINT

Used for

Creating a savepoint

Available in

DSQL

Syntax

```
SAVEPOINT sp_name
```

Table 251. SAVEPOINT Statement Parameter

Parameter	Description
sp_name	Savepoint name. Available only in DSQL

The SAVEPOINT statement creates an SQL:99-compliant savepoint that acts as a marker in the “stack” of data activities within a transaction. Subsequently, the tasks performed in the “stack” can be undone back to this savepoint, leaving the earlier work and older savepoints untouched. Savepoint mechanisms are sometimes characterised as “nested transactions”.

If a savepoint already exists with the same name as the name supplied for the new one, the existing savepoint is released, and a new one is created using the supplied name.

To roll changes back to the savepoint, the statement ROLLBACK TO SAVEPOINT is used.

Memory Considerations

The internal mechanism beneath savepoints can consume large amounts of memory, especially if the same rows receive multiple updates in one transaction. When a savepoint is no longer needed, but the transaction still has work to do, a RELEASE SAVEPOINT statement will erase it and thus free the resources.

Sample DSQL session with savepoints

```
CREATE TABLE TEST (ID INTEGER);
COMMIT;
INSERT INTO TEST VALUES (1);
COMMIT;
INSERT INTO TEST VALUES (2);
SAVEPOINT Y;
DELETE FROM TEST;
SELECT * FROM TEST; -- returns no rows
ROLLBACK TO Y;
SELECT * FROM TEST; -- returns two rows
ROLLBACK;
SELECT * FROM TEST; -- returns one row
```

See also

ROLLBACK TO SAVEPOINT, RELEASE SAVEPOINT

12.1.5. RELEASE SAVEPOINT

Used for

Erasing a savepoint

Available in

DSQL

Syntax

```
RELEASE SAVEPOINT sp_name [ONLY]
```

Table 252. RELEASE SAVEPOINT Statement Parameter

Parameter	Description
sp_name	Savepoint name. Available only in DSQL

The statement `RELEASE SAVEPOINT` erases a named savepoint, freeing up all the resources it encompasses. By default, all the savepoints created after the named savepoint are released as well. The qualifier `ONLY` directs the engine to release only the named savepoint.

See also

`SAVEPOINT`

12.1.6. Internal Savepoints

By default, the engine uses an automatic transaction-level system savepoint to perform transaction rollback. When a `ROLLBACK` statement is issued, all changes performed in this transaction are backed out via a transaction-level savepoint, and the transaction is then committed. This logic reduces the amount of garbage collection caused by rolled back transactions.

When the volume of changes performed under a transaction-level savepoint is getting large (~50000 records affected), the engine releases the transaction-level savepoint and uses the Transaction Inventory Page (TIP) as a mechanism to roll back the transaction if needed.

If you expect the volume of changes in your transaction to be large, you can specify the `NO AUTO UNDO` option in your `SET TRANSACTION` statement to block the creation of the transaction-level savepoint. Using the API instead, you would set the TPB flag `isc_tpb_no_auto_undo`.

12.1.7. Savepoints and PSQL

Transaction control statements are not allowed in PSQL, as that would break the atomicity of the statement that calls the procedure. However, Firebird does support the raising and handling of exceptions in PSQL, so that actions performed in stored procedures and triggers can be selectively undone without the entire procedure failing.

Internally, automatic savepoints are used to:

- undo all actions in the `BEGIN···END` block where an exception occurs
- undo all actions performed by the procedure or trigger or, in a selectable procedure, all actions performed since the last `SUSPEND`, when execution terminates prematurely because of an uncaught error or exception

Each PSQL exception handling block is also bounded by automatic system savepoints.

A `BEGIN···END` block does not itself create an automatic savepoint. A savepoint is created only in blocks that contain the WHEN statement for handling exceptions.

Chapter 13. Security

Databases must be secure and so must the data stored in them. Firebird provides three levels of data security: user authentication at the server level, SQL privileges within databases, and — optionally — database encryption. This chapter describes how to manage security at these three levels.

There is also a fourth level of data security: wire protocol encryption, which encrypts data in transit between client and server. Wire protocol encryption is out of scope for this Language Reference.

13.1. User Authentication

The security of the entire database depends on identifying a user and verifying its authority, a procedure known as *authentication*. User authentication can be performed in several ways, depending on the setting of the `AuthServer` parameter in the `firebird.conf` configuration file. This parameter contains the list of authentication plugins that can be used when connecting to the server. If the first plugin fails when authenticating, then the client can proceed with the next plugin, etc. When no plugin could authenticate the user, the user receives an error message.

The information about users authorised to access a specific Firebird server is stored in a special security database named `security4.fdb`. Each record in `security4.fdb` is a user account for one user. For each database, the security database can be overridden in the `databases.conf` file (parameter `SecurityDatabase`). Any database can be a security database, even for that database itself.

A username, with a maximum length of 63 characters, is an identifier, following the normal rules for identifiers (unquoted case-insensitive, double-quoted case-sensitive). For backwards compatibility, some statements (e.g. *isql*s `CONNECT`) accept usernames enclosed in single quotes, which will behave as normal, unquoted identifiers.

The maximum password length depends on the user manager plugin (parameter `UserManager`, in `firebird.conf` or `databases.conf`). Passwords are case-sensitive. The default user manager is the first plugin in the `UserManager` list, but this can be overridden in the SQL user management statements. For the `Srp` plugin, the maximum password length is 255 characters, for an effective length of 20 bytes (see also Why is the effective password length of SRP 20 bytes?). For the `Legacy_UserManager` plugin only the first eight bytes are significant; whilst it is valid to enter a password longer than eight bytes for `Legacy_UserManager`, any subsequent characters are ignored.

Why is the effective password length of SRP 20 bytes?

The SRP plugin does not actually have a 20 byte limit on password length, and longer passwords can be used. Hashes of different passwords longer than 20 bytes are also — usually — different. This effective limit comes from the limited hash length in SHA1 (used inside Firebirds SRP implementation), 20 bytes or 160 bits, and the “pigeonhole principle”. Sooner or later, there will be a shorter (or longer) password that has the same hash (e.g. in a brute force attack). That is why often the effective password length for the

SHA1 algorithm is said to be 20 bytes.

The embedded version of the server does not use authentication. However, the username, and — if necessary — the role, must be specified in the connection parameters, as they control access to database objects.

SYSDBA or the owner of the database get unrestricted access to all objects of the database. Users with the `RDB$ADMIN` role get similar unrestricted access if they specify the role when connecting.

13.1.1. Specially Privileged Users

In Firebird, the SYSDBA account is a “Superuser” that exists beyond any security restrictions. It has complete access to all objects in all regular databases on the server, and full read/write access to the accounts in the security database `security4.fdb`. No user has access to the metadata of the security database.

For `Srp`, the SYSDBA account does not exist by default; it will need to be created using an embedded connection. For `Legacy_Auth`, the default SYSDBA password on Windows and MacOS is “masterkey” — or “masterke”, to be exact, because of the 8-character length limit.

Extremely Important!

The default password “masterkey” is known across the universe. It should be changed as soon as the Firebird server installation is complete.

Other users can acquire elevated privileges in several ways, some of which are dependent on the operating system platform. These are discussed in the sections that follow and are summarised in Administrators and Fine-grained System Privileges.

POSIX Hosts

On POSIX systems, including MacOS, the POSIX username will be used as the Firebird Embedded username if username is not explicitly specified.

The `SYSDBA` User on POSIX

On POSIX hosts, other than MacOSX, the SYSDBA user does not have a default password. If the full installation is done using the standard scripts, a one-off password will be created and stored in a text file in the same directory as `security4.fdb`, commonly `/opt/firebird/`. The name of the password file is `SYSDBA.password`.

In an installation performed by a distribution-specific installer, the location of the security database and the password file may be different from the standard one.

The *root* User

The **root** user can act directly as SYSDBA on Firebird Embedded. Firebird will treat **root** as though it were SYSDBA, and it provides access to all databases on the server.

Windows Hosts

On Windows server-capable operating systems, operating system accounts can be used. Windows authentication (also known as “trusted authentication”) can be enabled by including the `Win_Sspi` plugin in the `AuthServer` list in `firebird.conf`. The plugin must also be present in the `AuthClient` setting at the client-side.

Windows operating system administrators are not automatically granted SYSDBA privileges when connecting to a database. To make that happen, the internally-created role `RDB$ADMIN` must be altered by SYSDBA or the database owner, to enable it. For details, refer to the later section entitled `AUTO ADMIN MAPPING`.

Prior to Firebird 3.0, with trusted authentication enabled, users who passed the default checks were automatically mapped to `CURRENT_USER`. In Firebird 3.0 and later, the mapping must be done explicitly using `CREATE MAPPING`.

The Database Owner

The “owner” of a database is either the user who was `CURRENT_USER` at the time of creation (or restore) of the database or, if the `USER` parameter was supplied in the `CREATE DATABASE` statement, the specified user.

“Owner” is not a username. The user who is the owner of a database has full administrator privileges with respect to that database, including the right to drop it, to restore it from a backup and to enable or disable the `AUTO ADMIN MAPPING` capability.

Prior to Firebird 2.1, the owner had no automatic privileges over any database objects that were created by other users.

Users with the `USER_MANAGEMENT` System Privilege

A user with the `USER_MANAGEMENT` system privilege in the security database can create, alter and drop users. To receive the `USER_MANAGEMENT` privilege, the security database must have a role with that privilege:

```
create role MANAGE_USERS
  set system privileges to USER_MANAGEMENT;
```

There are two options for the user to exercise these privileges:

1. Grant the role as a *default* role. The user will always be able to create, alter or drop users.

   ```
   grant default MANAGE_USERS to user ALEX;
   ```

2. Grant the role as a normal role. The user will only be able to create, alter or drop users when the role is specified explicitly on login or using `SET ROLE`.

```
grant MANAGE_USERS to user ALEX;
```

If the security database is a different database than the user connects to — which is usually the case when using `security4.fdb` — then a role with the same name must also exist and be granted to the user in that database for the user to be able to activate the role. The role in the other database does not need any system privileges or other privileges.

The `USER_MANAGEMENT` system privilege does not allow a user to grant or revoke the admin role. This requires the `RDB$ADMIN` role.

13.1.2. `RDB$ADMIN` Role

The internally-created role `RDB$ADMIN` is present in all databases. Assigning the `RDB$ADMIN` role to a regular user in a database grants that user the privileges of the `SYSDBA`, in that database only.

The elevated privileges take effect when the user is logged in to that regular database under the `RDB$ADMIN` role, and gives full control over all objects in that database.

Being granted the `RDB$ADMIN` role in the security database confers the authority to create, edit and delete user accounts.

In both cases, the user with the elevated privileges can assign `RDB$ADMIN` role to any other user. In other words, specifying `WITH ADMIN OPTION` is unnecessary because it is built into the role.

Granting the `RDB$ADMIN` Role in the Security Database

Since nobody — not even SYSDBA — can connect to the security database remotely, the `GRANT` and `REVOKE` statements are of no use for this task. Instead, the `RDB$ADMIN` role is granted and revoked using the SQL statements for user management:

```
CREATE USER new_user
  PASSWORD 'password'
  GRANT ADMIN ROLE;

ALTER USER existing_user
  GRANT ADMIN ROLE;

ALTER USER existing_user
  REVOKE ADMIN ROLE;
```

`GRANT ADMIN ROLE` and `REVOKE ADMIN ROLE` are not statements in the `GRANT` and `REVOKE` lexicon. They are three-word clauses to the statements `CREATE USER` and `ALTER USER`.

Table 253. Parameters for `RDB$ADMIN` *Role* `GRANT` *and* `REVOKE`

Parameter	Description
new_user	Name for the new user

Parameter	Description
existing_user	Name of an existing user
password	User password

The grantor must be logged in as an administrator.

See also

`CREATE USER`, `ALTER USER`, `GRANT`, `REVOKE`

Doing the Same Task Using *gsec*

With Firebird 3.0, *gsec* was deprecated. It is recommended to use the SQL user management statements instead.

An alternative is to use *gsec* with the `-admin` parameter to store the `RDB$ADMIN` attribute on the user's record:

```
gsec -add new_user -pw password -admin yes
gsec -mo existing_user -admin yes
gsec -mo existing_user -admin no
```

Depending on the administrative status of the current user, more parameters may be needed when invoking *gsec*, e.g. `-user` and `-pass`, or `-trusted`.

Using the `RDB$ADMIN` Role in the Security Database

To manage user accounts through SQL, the user must have the `RDB$ADMIN` role in the security database. No user can connect to the security database remotely, so the solution is that the user connects to a regular database. From there, they can submit any SQL user management command.

Contrary to Firebird 3.0 or earlier, the user does not need to specify the `RDB$ADMIN` role on connect, nor do they need to have the `RDB$ADMIN` role in the database used to connect.

Using *gsec* with `RDB$ADMIN` Rights

To perform user management with *gsec*, the user must provide the extra switch `-role rdb$admin`.

Granting the `RDB$ADMIN` Role in a Regular Database

In a regular database, the `RDB$ADMIN` role is granted and revoked with the usual syntax for granting and revoking roles:

```
GRANT [DEFAULT] RDB$ADMIN TO username

REVOKE [DEFAULT] RDB$ADMIN FROM username
```

Table 254. Parameters for RDB$ADMIN *Role* GRANT *and* REVOKE

Parameter	Description
username	Name of the user

In order to grant and revoke the RDB$ADMIN role, the grantor must be logged in as an administrator.

See also

GRANT, REVOKE

Using the RDB$ADMIN Role in a Regular Database

To exercise their RDB$ADMIN privileges, the grantee has to include the role in the connection attributes when connecting to the database, or specify it later using SET ROLE.

AUTO ADMIN MAPPING

Windows Administrators are not automatically granted RDB$ADMIN privileges when connecting to a database (if Win_Sspi is enabled, of course) The AUTO ADMIN MAPPING switch now determines whether Administrators have automatic RDB$ADMIN rights, on a database-by-database basis. By default, when a database is created, it is disabled.

If AUTO ADMIN MAPPING is enabled in the database, it will take effect whenever a Windows Administrator connects:

a. using Win_Sspi authentication, and
b. without specifying any role

After a successful “auto admin” connection, the current role is set to RDB$ADMIN.

If an explicit role was specified on connect, the RDB$ADMIN role can be assumed later in the session using SET TRUSTED ROLE.

Auto Admin Mapping in Regular Databases

To enable and disable automatic mapping in a regular database:

```
ALTER ROLE RDB$ADMIN
  SET AUTO ADMIN MAPPING;  -- enable it

ALTER ROLE RDB$ADMIN
  DROP AUTO ADMIN MAPPING; -- disable it
```

Either statement must be issued by a user with sufficient rights, that is:

- The database owner
- An administrator
- A user with the ALTER ANY ROLE privilege

The statement

```
ALTER ROLE RDB$ADMIN
  SET AUTO ADMIN MAPPING;
```

is a simplified form of a `CREATE MAPPING` statement to create a mapping of the predefined group `DOMAIN_ANY_RID_ADMINS` to the role of `RDB$ADMIN`:

```
CREATE MAPPING WIN_ADMINS
  USING PLUGIN WIN_SSPI
  FROM Predefined_Group DOMAIN_ANY_RID_ADMINS
  TO ROLE RDB$ADMIN;
```

Accordingly, the statement

```
ALTER ROLE RDB$ADMIN
  DROP AUTO ADMIN MAPPING
```

is equivalent to the statement

```
DROP MAPPING WIN_ADMINS;
```

For details, see Mapping of Users to Objects

In a regular database, the status of `AUTO ADMIN MAPPING` is checked only at connect time. If an Administrator has the `RDB$ADMIN` role because auto-mapping was on when they logged in, they will keep that role for the duration of the session, even if they or someone else turns off the mapping in the meantime.

Likewise, switching on `AUTO ADMIN MAPPING` will not change the current role to `RDB$ADMIN` for Administrators who were already connected.

Auto Admin Mapping in the Security Database

The `ALTER ROLE RDB$ADMIN` statement cannot enable or disable `AUTO ADMIN MAPPING` in the security database. However, you can create a global mapping for the predefined group `DOMAIN_ANY_RID_ADMINS` to the role `RDB$ADMIN` in the following way:

```
CREATE GLOBAL MAPPING WIN_ADMINS
  USING PLUGIN WIN_SSPI
  FROM Predefined_Group DOMAIN_ANY_RID_ADMINS
  TO ROLE RDB$ADMIN;
```

Additionally, you can use *gsec*:

```
gsec -mapping set

gsec -mapping drop
```

Depending on the administrative status of the current user, more parameters may be needed when invoking *gsec*, e.g. `-user` and `-pass`, or `-trusted`.

Only SYSDBA can enable `AUTO ADMIN MAPPING` if it is disabled, but any administrator can turn it off.

When turning off `AUTO ADMIN MAPPING` in *gsec*, the user turns off the mechanism itself which gave them access, and thus they would not be able to re-enable `AUTO ADMIN MAPPING`. Even in an interactive *gsec* session, the new flag setting takes effect immediately.

13.1.3. Administrators

As a general description, an administrator is a user that has sufficient rights to read, write to, create, alter or delete any object in a database to which that user's administrator status applies. The table summarises how "Superuser" privileges are enabled in the various Firebird security contexts.

Table 255. Administrator ("Superuser") Characteristics

User	RDB$ADMIN Role	Comments
`SYSDBA`	Auto	Exists automatically at server level. Has full privileges to all objects in all databases. Can create, alter and drop users, but has no direct remote access to the security database
root user on POSIX	Auto	Exactly like `SYSDBA`. Firebird Embedded only.
Superuser on POSIX	Auto	Exactly like `SYSDBA`. Firebird Embedded only.
Windows Administrator	Set as `CURRENT_ROLE` if login succeeds	Exactly like `SYSDBA` if all of the following are true: • In `firebird.conf` file, `AuthServer` includes `Win_Sspi`, and `Win_Sspi` is present in the client-side plugins (`AuthClient`) configuration • In databases where `AUTO ADMIN MAPPING` is enabled, or an equivalent mapping of the predefined group `DOMAIN_ANY_RID_ADMINS` for the role `RDB$ADMIN` exists • No role is specified at login
Database owner	Auto	Like `SYSDBA`, but only in the databases they own
Regular user	Must be previously granted; must be supplied at login	Like `SYSDBA`, but only in the databases where the role is granted

User	RDB$ADMIN Role	Comments
POSIX OS user	Must be previously granted; must be supplied at login	Like SYSDBA, but only in the databases where the role is granted. Firebird Embedded only.
Windows user	Must be previously granted; must be supplied at login	Like SYSDBA, but only in the databases where the role is granted. Only available if in `firebird.conf` file, `AuthServer` includes `Win_Sspi`, and `Win_Sspi` is present in the client-side plugins (`AuthClient`) configuration

13.1.4. Fine-grained System Privileges

In addition to granting users full administrative privileges, Firebird 4.0 introduced system privileges which makes it possible to grant regular users a subset of administrative privileges that have historically been limited to SYSDBA and administrators only. For example:

- Run utilities such as *gbak*, *gfix*, *nbackup* and so on
- Shut down a database and bring it online
- Trace other users' attachments
- Access the monitoring tables
- Run management statements

The implementation defines a set of *system privileges*, analogous to object privileges, from which lists of privileged tasks can be assigned to roles.

It is also possible to grant normal privileges to a system privilege, making the system privilege act like a special role type.

The system privileges are assigned through `CREATE ROLE` and `ALTER ROLE`.

Be aware that each system privilege provides a very thin level of control. For some tasks it may be necessary to give the user more than one privilege to perform some task. For example, add `IGNORE_DB_TRIGGERS` to `USE_GSTAT_UTILITY` because *gstat* needs to ignore database triggers.

List of Valid System Privileges

The following table lists the names of the valid system privileges that can be granted to and revoked from roles.

`USER_MANAGEMENT`	Manage users (given in the security database)
`READ_RAW_PAGES`	Read pages in raw format using `Attachment::getInfo()`
`CREATE_USER_TYPES`	Add/change/delete non-system records in `RDB$TYPES`

USE_NBACKUP_UTILITY	Use *nbackup* to create database copies
CHANGE_SHUTDOWN_MODE	Shut down database and bring online
TRACE_ANY_ATTACHMENT	Trace other users' attachments
MONITOR_ANY_ATTACHMENT	Monitor (tables MON$) other users' attachments
ACCESS_SHUTDOWN_DATABASE	Access database when it is shut down
CREATE_DATABASE	Create new databases (given in security.db)
DROP_DATABASE	Drop this database
USE_GBAK_UTILITY	Use *gbak* utility
USE_GSTAT_UTILITY	Use *gstat* utility
USE_GFIX_UTILITY	Use *gfix* utility
IGNORE_DB_TRIGGERS	Instruct engine not to run DB-level triggers
CHANGE_HEADER_SETTINGS	Modify parameters in DB header page
SELECT_ANY_OBJECT_IN_DATABASE	Use SELECT for any selectable object
ACCESS_ANY_OBJECT_IN_DATABASE	Access (in any possible way) any object
MODIFY_ANY_OBJECT_IN_DATABASE	Modify (up to drop) any object
CHANGE_MAPPING_RULES	Change authentication mappings
USE_GRANTED_BY_CLAUSE	Use GRANTED BY in GRANT and REVOKE statements
GRANT_REVOKE_ON_ANY_OBJECT	GRANT and REVOKE rights on any object in database
GRANT_REVOKE_ANY_DDL_RIGHT	GRANT and REVOKE any DDL rights
CREATE_PRIVILEGED_ROLES	Use SET SYSTEM PRIVILEGES in roles
MODIFY_EXT_CONN_POOL	Use command ALTER EXTERNAL CONNECTIONS POOL
REPLICATE_INTO_DATABASE	Use replication API to load change sets into database

13.2. SQL Statements for User Management

This section describes the SQL statements for creating, modifying and deleting Firebird user accounts. These statements can be executed by the following users:

- SYSDBA
- Any user with the RDB$ADMIN role in the security database
- When the AUTO ADMIN MAPPING flag is enabled in the security database (security4.fdb or

whatever is the security database configured for the current database in the `databases.conf`), any Windows Administrator - assuming `Win_Sspi` was used to connect without specifying roles.

- Any user with the system privilege `USER_MANAGEMENT` in the security database

For a Windows Administrator, `AUTO ADMIN MAPPING` enabled only in a regular database is not sufficient to permit management of other users. For instructions to enable it in the security database, see Auto Admin Mapping in the Security Database.

Non-privileged users can use only the `ALTER USER` statement, and then only to edit some data of their own account.

13.2.1. CREATE USER

Used for

Creating a Firebird user account

Available in

DSQL

Syntax

```
CREATE USER username
  <user_option> [<user_option> ...]
  [TAGS (<user_var> [, <user_var> ...]]

<user_option> ::=
    PASSWORD 'password'
  | FIRSTNAME 'firstname'
  | MIDDLENAME 'middlename'
  | LASTNAME 'lastname'
  | {GRANT | REVOKE} ADMIN ROLE
  | {ACTIVE | INACTIVE}
  | USING PLUGIN plugin_name

<user_var> ::=
    tag_name = 'tag_value'
  | DROP tag_name
```

Table 256. `CREATE USER` Statement Parameters

Parameter	Description
username	Username. The maximum length is 63 characters, following the rules for Firebird identifiers.
password	User password. Valid or effective password length depends on the user manager plugin. Case-sensitive.
firstname	Optional: User's first name. Maximum length 32 characters

Parameter	Description
middlename	Optional: User's middle name. Maximum length 32 characters
lastname	Optional: User's last name. Maximum length 32 characters.
plugin_name	Name of the user manager plugin.
tag_name	Name of a custom attribute. The maximum length is 63 characters, following the rules for Firebird regular identifiers.
tag_value	Value of the custom attribute. The maximum length is 255 characters.

The `CREATE USER` statement creates a new Firebird user account. If the user already exist in the Firebird security database for the specified user manager plugin, an appropriate error be raised. It is possible to create multiple users with the same name: one per user manager plugin.

The *username* argument must follow the rules for Firebird regular identifiers: see *Identifiers* in the *Structure* chapter. Usernames are case-sensitive when double-quoted (in other words, they follow the same rules as other delimited identifiers).

Usernames follow the general rules and syntax of identifiers. Thus, a user named `"Alex"` is distinct from a user named `"ALEX"`

```
CREATE USER ALEX PASSWORD 'bz23ds';

- this user is the same as the first one
CREATE USER Alex PASSWORD 'bz23ds';

- this user is the same as the first one
CREATE USER "ALEX" PASSWORD 'bz23ds';

- and this is a different user
CREATE USER "Alex" PASSWORD 'bz23ds';
```

The `PASSWORD` clause specifies the user's password, and is required. The valid or effective password length depends on the user manager plugin, see also User Authentication.

The optional `FIRSTNAME`, `MIDDLENAME` and `LASTNAME` clauses can be used to specify additional user properties, such as the person's first name, middle name and last name, respectively. They are just simple `VARCHAR(32)` fields and can be used to store anything you prefer.

If the `GRANT ADMIN ROLE` clause is specified, the new user account is created with the privileges of the `RDB$ADMIN` role in the security database (`security4.fdb` or database-specific). It allows the new user to manage user accounts from any regular database they log into, but it does not grant the user any special privileges on objects in those databases.

The `REVOKE ADMIN ROLE` clause is syntactically valid in a `CREATE USER` statement, but has no effect. It is not possible to specify `GRANT ADMIN ROLE` and `REVOKE ADMIN ROLE` in one statement.

The `ACTIVE` clause specifies the user is active and can log in, this is the default.

The INACTIVE clause specifies the user is inactive and cannot log in. It is not possible to specify ACTIVE and INACTIVE in one statement. The ACTIVE/INACTIVE option is not supported by the Legacy_UserManager and will be ignored.

The USING PLUGIN clause explicitly specifies the user manager plugin to use for creating the user. Only plugins listed in the UserManager configuration for this database (firebird.conf, or overridden in databases.conf) are valid. The default user manager (first in the UserManager configuration) is applied when this clause is not specified.

Users of the same name created using different user manager plugins are different objects. Therefore, the user created with one user manager plugin can only be altered or dropped by that same plugin.

From the perspective of ownership, and privileges and roles granted in a databases, different user objects with the same name are considered one and the same user.

The TAGS clause can be used to specify additional user attributes. Custom attributes are not supported (silently ignored) by the Legacy_UserManager. Custom attributes names follow the rules of Firebird identifiers, but are handled case-insensitive (for example, specifying both "A BC" and "a bc" will raise an error). The value of a custom attribute can be a string of maximum 255 characters. The DROP tag_name option is syntactically valid in CREATE USER, but behaves as if the property is not specified.

Users can view and alter their own custom attributes.

CREATE/ALTER/DROP USER are DDL statements, and only take effect at commit. Remember to COMMIT your work. In *isql*, the command SET AUTO ON will enable autocommit on DDL statements. In third-party tools and other user applications, this may not be the case.

Who Can Create a User

To create a user account, the current user must have

- administrator privileges in the security database
- the USER_MANAGEMENT system privilege in the security database. Users with the USER_MANAGEMENT system privilege can not grant or revoke the admin role.

CREATE USER Examples

1. Creating a user with the username bigshot:

```
CREATE USER bigshot PASSWORD 'buckshot';
```

2. Creating a user with the Legacy_UserManager user manager plugin

```
CREATE USER godzilla PASSWORD 'robot'
  USING PLUGIN Legacy_UserManager;
```

3. Creating the user `john` with custom attributes:

```
CREATE USER john PASSWORD 'fYe_3Ksw'
  FIRSTNAME 'John' LASTNAME 'Doe'
  TAGS (BIRTHYEAR='1970', CITY='New York');
```

4. Creating an inactive user:

```
CREATE USER john PASSWORD 'fYe_3Ksw'
  INACTIVE;
```

5. Creating the user `superuser` with user management privileges:

```
CREATE USER superuser PASSWORD 'kMn8Kjh'
GRANT ADMIN ROLE;
```

See also

`ALTER USER`, `CREATE OR ALTER USER`, `DROP USER`

13.2.2. ALTER USER

Used for

Modifying a Firebird user account

Available in

DSQL

Syntax

```
ALTER {USER username | CURRENT USER}
  [SET] [<user_option> [<user_option> ...]]
  [TAGS (<user_var> [, <user_var> ...]]

<user_option> ::=
    PASSWORD 'password'
  | FIRSTNAME 'firstname'
  | MIDDLENAME 'middlename'
  | LASTNAME 'lastname'
  | {GRANT | REVOKE} ADMIN ROLE
  | {ACTIVE | INACTIVE}
  | USING PLUGIN plugin_name
```

```
<user_var> ::=
    tag_name = 'tag_value'
  | DROP tag_name
```

See CREATE USER for details on the statement parameters.

The ALTER USER statement changes the details in the named Firebird user account. The ALTER USER statement must contain at least one of the optional clauses other than USING PLUGIN.

Any user can alter his or her own account, except that only an administrator may use GRANT/REVOKE ADMIN ROLE and ACTIVE/INACTIVE.

All clauses are optional, but at least one other than USING PLUGIN must be present:

- The PASSWORD parameter is for changing the password for the user
- FIRSTNAME, MIDDLENAME and LASTNAME update these optional user properties, such as the person's first name, middle name and last name respectively
- GRANT ADMIN ROLE grants the user the privileges of the RDB$ADMIN role in the security database (security4.fdb), enabling them to manage the accounts of other users. It does not grant the user any special privileges in regular databases.
- REVOKE ADMIN ROLE removes the user's administrator in the security database which, once the transaction is committed, will deny that user the ability to alter any user account except their own
- ACTIVE will enable a disabled account (not supported for Legacy_UserManager)
- INACTIVE will disable an account (not supported for Legacy_UserManager). This is convenient to temporarily disable an account without deleting it.
- USING PLUGIN specifies the user manager plugin to use
- TAGS can be used to add, update or remove (DROP) additional custom attributes (not supported for Legacy_UserManager). Attributes not listed will not be changed.

See CREATE USER for more details on the clauses.

If you need to change your own account, then instead of specifying the name of the current user, you can use the CURRENT USER clause.

The ALTER CURRENT USER statement follows the normal rules for selecting the user manager plugin. If the current user was created with a non-default user manager plugin, they will need to explicitly specify the user manager plugins with USING PLUGIN plugin_name, or they will receive an error that the user is not found. Or, if a user with the same name exists for the default user manager, they will alter that user instead.

Remember to commit your work if you are working in an application that does not auto-commit DDL.

Who Can Alter a User?

To modify the account of another user, the current user must have

- administrator privileges in the security database
- the USER_MANAGEMENT system privilege in the security database Users with the USER_MANAGEMENT system privilege can not grant or revoke the admin role.

Anyone can modify their own account, except for the GRANT/REVOKE ADMIN ROLE and ACTIVE/INACTIVE options, which require administrative privileges to change.

ALTER USER Examples

1. Changing the password for the user bobby and granting them user management privileges:

```
ALTER USER bobby PASSWORD '67-UiT_G8'
GRANT ADMIN ROLE;
```

2. Editing the optional properties (the first and last names) of the user dan:

```
ALTER USER dan
FIRSTNAME 'No_Jack'
LASTNAME 'Kennedy';
```

3. Revoking user management privileges from user dumbbell:

```
ALTER USER dumbbell
DROP ADMIN ROLE;
```

See also

CREATE USER, DROP USER

13.2.3. CREATE OR ALTER USER

Used for

Creating a new or modifying an existing Firebird user account

Available in

DSQL

Syntax

```
CREATE OR ALTER USER username
  [SET] [<user_option> [<user_option> ...]]
  [TAGS (<user_var> [, <user_var> ...]]

<user_option> ::=
```

```
    PASSWORD 'password'
  | FIRSTNAME 'firstname'
  | MIDDLENAME 'middlename'
  | LASTNAME 'lastname'
  | {GRANT | REVOKE} ADMIN ROLE
  | {ACTIVE | INACTIVE}
  | USING PLUGIN plugin_name

<user_var> ::=
    tag_name = 'tag_value'
  | DROP tag_name
```

See CREATE USER and ALTER USER for details on the statement parameters.

The CREATE OR ALTER USER statement creates a new or changes the details in the named Firebird user account. If the user does not exist, it will be created as if executing the CREATE USER statement. If the user already exists, it will be modified as if executing the ALTER USER statement. The CREATE OR ALTER USER statement must contain at least one of the optional clauses other than USING PLUGIN. If the user does not exist yet, the PASSWORD clause is required.

Remember to commit your work if you are working in an application that does not auto-commit DDL.

CREATE OR ALTER USER Examples

Creating or altering a user

```
CREATE OR ALTER USER john PASSWORD 'fYe_3Ksw'
FIRSTNAME 'John'
LASTNAME 'Doe'
INACTIVE;
```

See also

CREATE USER, ALTER USER, DROP USER

13.2.4. DROP USER

Used for

Deleting a Firebird user account

Available in

DSQL

Syntax

```
DROP USER username
  [USING PLUGIN plugin_name]
```

Table 257. DROP USER Statement Parameter

Parameter	Description
username	Username
plugin_name	Name of the user manager plugin

The DROP USER statement deletes a Firebird user account.

The optional USING PLUGIN clause explicitly specifies the user manager plugin to use for dropping the user. Only plugins listed in the UserManager configuration for this database (firebird.conf, or overridden in databases.conf) are valid. The default user manager (first in the UserManager configuration) is applied when this clause is not specified.

Users of the same name created using different user manager plugins are different objects. Therefore, the user created with one user manager plugin can only be dropped by that same plugin.

Remember to commit your work if you are working in an application that does not auto-commit DDL.

Who Can Drop a User?

To drop a user, the current user must have

- administrator privileges in the security database
- the USER_MANAGEMENT system privilege in the security database

DROP USER Example

1. Deleting the user bobby:

```
DROP USER bobby;
```

2. Removing a user created with the Legacy_UserManager plugin:

```
DROP USER Godzilla
  USING PLUGIN Legacy_UserManager;
```

See also

CREATE USER, ALTER USER

13.3. SQL Privileges

The second level of Firebird's security model is SQL privileges. Whilst a successful login — the first level — authorises a user's access to the server and to all databases under that server, it does not imply that the user has access to any objects in any databases. When an object is created, only the

user that created it (its owner) and administrators have access to it. The user needs *privileges* on each object they need to access. As a general rule, privileges must be *granted* explicitly to a user by the object owner or an administrator of the database.

A privilege comprises a DML access type (`SELECT`, `INSERT`, `UPDATE`, `DELETE`, `EXECUTE` and `REFERENCES`), the name of a database object (table, view, procedure, role) and the name of the grantee (user, procedure, trigger, role). Various means are available to grant multiple types of access on an object to multiple users in a single `GRANT` statement. Privileges may be revoked from a user with `REVOKE` statements.

An additional type of privileges, DDL privileges, provide rights to create, alter or drop specific types of metadata objects

Privileges are stored in the database to which they apply and are not applicable to any other database, except the `DATABASE` DDL privileges, which are stored in the security database.

13.3.1. The Object Owner

The user who created a database object becomes its owner. Only the owner of an object and users with administrator privileges in the database, including the database owner, can alter or drop the database object.

Administrators, the database owner or the object owner can grant privileges to and revoke them from other users, including privileges to grant privileges to other users. The process of granting and revoking SQL privileges is implemented with two statements, `GRANT` and `REVOKE`.

13.4. ROLE

A *role* is a database object that packages a set of privileges. Roles implement the concept of access control at a group level. Multiple privileges are granted to the role and then that role can be granted to or revoked from one or many users.

A user that is granted a role must supply that role in their login credentials in order to exercise the associated privileges. Any other privileges granted to the user directly are not affected by their login with the role. Logging in with multiple roles simultaneously is not supported.

In this section the tasks of creating and dropping roles are discussed.

13.4.1. CREATE ROLE

Used for

Creating a new `ROLE` object

Available in

DSQL, ESQL

Syntax

```
CREATE ROLE rolename
```

```
  [SET SYSTEM PRIVILEGES TO <sys_privileges>]

<sys_privileges> ::=
  <sys_privilege> [, <sys_privilege> ...]

<sys_privilege> ::=
    USER_MANAGEMENT | READ_RAW_PAGES
  | CREATE_USER_TYPES | USE_NBACKUP_UTILITY
  | CHANGE_SHUTDOWN_MODE | TRACE_ANY_ATTACHMENT
  | MONITOR_ANY_ATTACHMENT | ACCESS_SHUTDOWN_DATABASE
  | CREATE_DATABASE | DROP_DATABASE
  | USE_GBAK_UTILITY | USE_GSTAT_UTILITY
  | USE_GFIX_UTILITY | IGNORE_DB_TRIGGERS
  | CHANGE_HEADER_SETTINGS
  | SELECT_ANY_OBJECT_IN_DATABASE
  | ACCESS_ANY_OBJECT_IN_DATABASE
  | MODIFY_ANY_OBJECT_IN_DATABASE
  | CHANGE_MAPPING_RULES | USE_GRANTED_BY_CLAUSE
  | GRANT_REVOKE_ON_ANY_OBJECT
  | GRANT_REVOKE_ANY_DDL_RIGHT
  | CREATE_PRIVILEGED_ROLES | GET_DBCRYPT_INFO
  | MODIFY_EXT_CONN_POOL | REPLICATE_INTO_DATABASE
```

Table 258. `CREATE ROLE` Statement Parameter

Parameter	Description
rolename	Role name. The maximum length is 63 characters
sys_privilege	System privilege to grant

The statement `CREATE ROLE` creates a new role object, to which one or more privileges can be granted subsequently. The name of a role must be unique among the names of roles in the current database.

It is advisable to make the name of a role unique among usernames as well. The system will not prevent the creation of a role whose name clashes with an existing username but, if it happens, the user will be unable to connect to the database.

Who Can Create a Role

The `CREATE ROLE` statement can be executed by:

- Administrators
- Users with the `CREATE ROLE` privilege, with the following caveats
  - Setting system privileges also requires the system privilege `CREATE_PRIVILEGED_ROLES`

The user executing the `CREATE ROLE` statement becomes the owner of the role.

CREATE ROLE Examples

Creating a role named SELLERS

```
CREATE ROLE SELLERS;
```

Creating a role SELECT_ALL *with the system privilege to select from any selectable object*

```
CREATE ROLE SELECT_ALL
  SET SYSTEM PRIVILEGES TO SELECT_ANY_OBJECT_IN_DATABASE;
```

See also

ALTER ROLE, DROP ROLE, GRANT, REVOKE, Fine-grained System Privileges

13.4.2. ALTER ROLE

Used for

Altering a role

Available in

DSQL

Syntax

```
ALTER ROLE rolename
 { SET SYSTEM PRIVILEGES TO <sys_privileges>
 | DROP SYSTEM PRIVILEGES
 | {SET | DROP} AUTO ADMIN MAPPING }

<sys_privileges> ::=
  !! See CREATE ROLE !!
```

Table 259. ALTER ROLE *Statement Parameter*

Parameter	Description
rolename	Role name; specifying anything other than RDB$ADMIN will fail
sys_privilege	System privilege to grant

ALTER ROLE can be used to grant or revoke system privileges from a role, or enable and disable the capability for Windows Administrators to assume administrator privileges automatically when logging in.

This last capability can affect only one role: the system-generated role RDB$ADMIN that exists in every database of ODS 11.2 or higher.

For details on auto admin mapping, see AUTO ADMIN MAPPING.

It is not possible to selectively grant or revoke system privileges. Only the privileges listed in the SET

SYSTEM PRIVILEGES clause will be available to the role after commit, and DROP SYSTEM PRIVILEGES will remove all system privileges from this role.

Who Can Alter a Role

The ALTER ROLE statement can be executed by:

- Administrators
- Users with the ALTER ANY ROLE privilege, with the following caveats
  - Setting or dropping system privileges also requires the system privilege CREATE_PRIVILEGED_ROLES
  - Setting or dropping auto admin mapping also requires the system privilege CHANGE_MAPPING_RULES

ALTER ROLE Examples

Drop all system privileges from a role named SELECT_ALL

```
ALTER ROLE SELLERS
  DROP SYSTEM PRIVILEGES;
```

Grant a role SELECT_ALL *the system privilege to select from any selectable object*

```
ALTER ROLE SELECT_ALL
  SET SYSTEM PRIVILEGES TO SELECT_ANY_OBJECT_IN_DATABASE;
```

See also

CREATE ROLE, GRANT, REVOKE, Fine-grained System Privileges

13.4.3. DROP ROLE

Used for

Deleting a role

Available in

DSQL, ESQL

Syntax

```
DROP ROLE rolename
```

The statement DROP ROLE deletes an existing role. It takes just a single argument, the name of the role. Once the role is deleted, the entire set of privileges is revoked from all users and objects that were granted the role.

Who Can Drop a Role

The DROP ROLE statement can be executed by:

- Administrators
- The owner of the role
- Users with the DROP ANY ROLE privilege

DROP ROLE Examples

Deleting the role SELLERS

```
DROP ROLE SELLERS;
```

See also

CREATE ROLE, GRANT, REVOKE

13.5. Statements for Granting Privileges

A GRANT statement is used for granting privileges — including roles — to users and other database objects.

13.5.1. GRANT

Used for

Granting privileges and assigning roles

Available in

DSQL, ESQL

Syntax (granting privileges)

```
GRANT <privileges>
  TO <grantee_list>
  [WITH GRANT OPTION]
  [{GRANTED BY | AS} [USER] grantor]

<privileges> ::=
    <table_privileges> | <execute_privilege>
  | <usage_privilege>  | <ddl_privileges>
  | <db_ddl_privilege>

<table_privileges> ::=
  {ALL [PRIVILEGES] | <table_privilege_list> }
    ON [TABLE] {table_name | view_name}

<table_privilege_list> ::=
  <table_privilege> [, <tableprivilege> ...]
```

```
<table_privilege> ::=
    SELECT | DELETE | INSERT
  | UPDATE [(col [, col ...])]
  | REFERENCES [(col [, col ...)]

<execute_privilege> ::= EXECUTE ON
  { PROCEDURE proc_name | FUNCTION func_name
  | PACKAGE package_name }

<usage_privilege> ::= USAGE ON
  { EXCEPTION exception_name
  | {GENERATOR | SEQUENCE} sequence_name }

<ddl_privileges> ::=
  {ALL [PRIVILEGES] | <ddl_privilege_list>} <object_type>

<ddl_privilege_list> ::=
  <ddl_privilege> [, <ddl_privilege> ...]

<ddl_privilege> ::= CREATE | ALTER ANY | DROP ANY

<object_type> ::=
    CHARACTER SET | COLLATION | DOMAIN | EXCEPTION
  | FILTER | FUNCTION | GENERATOR | PACKAGE
  | PROCEDURE | ROLE | SEQUENCE | TABLE | VIEW

<db_ddl_privileges> ::=
  {ALL [PRIVILEGES] | <db_ddl_privilege_list>} {DATABASE | SCHEMA}

<db_ddl_privilege_list> ::=
  <db_ddl_privilege> [, <db_ddl_privilege> ...]

<db_ddl_privilege> ::= CREATE | ALTER | DROP

<grantee_list> ::= <grantee> [, <grantee> ...]

<grantee> ::=
    PROCEDURE proc_name  | FUNCTION func_name
  | PACKAGE package_name | TRIGGER trig_name
  | VIEW view_name       | ROLE role_name
  | [USER] username      | GROUP Unix_group
  | SYSTEM PRIVILEGE <sys_privilege>

<sys_privilege> ::=
 !! See CREATE ROLE !!
```

Syntax (granting roles)

```
GRANT <role_granted_list>
```

```
  TO <role_grantee_list>
  [WITH ADMIN OPTION]
  [{GRANTED BY | AS} [USER] grantor]

<role_granted_list> ::=
  <role_granted> [, <role_granted ...]

<role_granted> ::= [DEFAULT] role_name

<role_grantee_list> ::=
  <role_grantee> [, <role_grantee> ...]

<role_grantee> ::=
    user_or_role_name
  | USER username
  | ROLE role_name
```

Table 260. `GRANT` *Statement Parameters*

Parameter	Description
grantor	The user granting the privilege(s)
table_name	The name of a table
view_name	The name of a view
col	The name of table column
proc_name	The name of a stored procedure
func_name	The name of a stored function (or UDF)
package_name	The name of a package
exception_name	The name of an exception
sequence_name	The name of a sequence (generator)
object_type	The type of metadata object
trig_name	The name of a trigger
role_name	Role name
username	The username to which the privileges are granted to or to which the role is assigned. If the `USER` keyword is absent, it can also be a role.
Unix_group	The name of a user group in a POSIX operating system
sys_privilege	A system privilege
user_or_role_name	Name of a user or role

The `GRANT` statement grants one or more privileges on database objects to users, roles, or other database objects.

A regular, authenticated user has no privileges on any database object until they are explicitly granted to that individual user, to a role granted to the user as a default role, or to all users bundled

as the user PUBLIC. When an object is created, only its creator (the owner) and administrators have privileges to it, and can grant privileges to other users, roles, or objects.

Different sets of privileges apply to different types of metadata objects. The different types of privileges will be described separately later in this section.

SCHEMA is currently a synonym for DATABASE; this may change in a future version, so we recommend to always use DATABASE

The TO Clause

The TO clause specifies the users, roles, and other database objects that are to be granted the privileges enumerated in *privileges*. The clause is mandatory.

The optional USER keyword in the TO clause allow you to specify exactly who or what is granted the privilege. If a USER (or ROLE) keyword is not specified, the server first checks for a role with this name and, if there is no such role, the privileges are granted to the user with that name without further checking.

It is recommended to always explicitly specify USER and ROLE to avoid ambiguity. Future versions of Firebird may make USER mandatory.

- When a GRANT statement is executed, the security database is not checked for the existence of the grantee user. This is not a bug: SQL permissions are concerned with controlling data access for authenticated users, both native and trusted, and trusted operating system users are not stored in the security database.
- When granting a privilege to a database object other than user or role, such as a procedure, trigger or view, you must specify the object type.
- Although the USER keyword is optional, it is advisable to use it, in order to avoid ambiguity with roles.
- Privileges granted to a system privilege will be applied when the user is logged in with a role that has that system privilege.

Packaging Privileges in a ROLE Object

A role is a “container” object that can be used to package a collection of privileges. Use of the role is then granted to each user or role that requires those privileges. A role can also be granted to a list of users or roles.

The role must exist before privileges can be granted to it. See CREATE ROLE for the syntax and rules. The role is maintained by granting privileges to it and, when required, revoking privileges from it. When a role is dropped — see DROP ROLE — all users lose the privileges acquired through the role. Any privileges that were granted additionally to an affected user by way of a different grant statement are retained.

Unless the role is granted as a default role, a user that is granted a role must explicitly specify that

role, either with their login credentials or activating it using SET ROLE, in order to exercise the associated privileges. Any other privileges granted to the user or received through default roles are not affected by explicitly specifying a role.

More than one role can be granted to the same user. Although only one role can be explicitly specified, multiple roles can be active for a user, either as default roles, or as roles granted to the current role.

A role can be granted to a user or to another role.

Cumulative Roles

The ability to grant roles to other roles and default roles results in so-called cumulative roles. Multiple roles can be active for a user, and the user receives the cumulative privileges of all those roles.

When a role is explicitly specified on connect or using SET ROLE, the user will assume all privileges granted to that role, including those privileges granted to the secondary roles (including roles granted on that secondary role, etc). Or in other words, when the primary role is explicitly specified, the secondary roles are also activated. The function RDB$ROLE_IN_USE can be used to check if a role is currently active.

See also Default Roles for the effects of DEFAULT with cumulative roles, and The WITH ADMIN OPTION Clause for effects on granting.

Default Roles

A role can be granted as a *default* role by prefixing the role with DEFAULT in the GRANT statement. Granting roles as a default role to users simplifies management of privileges, as this makes it possible to group privileges on a role and granting that group of privileges to a user without requiring the user to explicitly specify the role. Users can receive multiple default roles, granting them all privileges of those default roles.

The effects of a default role depend on whether the role is granted to a user or to another role:

- When a role is granted to a user as a default role, the role will be activated automatically, and its privileges will be applied to the user without the need to explicitly specify the role.

  Roles that are active by default are not returned from CURRENT_ROLE, but the function RDB$ROLE_IN_USE can be used to check if a role is currently active.

- When a role is granted to another role as a default role, the rights of that role will only be automatically applied to the user if the primary role is granted as a default role to the user, otherwise the primary role needs to be specified explicitly (in other words, it behaves the same as when the secondary role was granted without the DEFAULT clause).

  For a string of granted roles, all roles need to be granted as a default role for them to be applied automatically. That is, for GRANT DEFAULT ROLEA TO ROLE ROLEB, GRANT ROLEB TO ROLE ROLEC, GRANT DEFAULT ROLEC TO USER USER1 only ROLEC is active by default for USER1. To assume the privileges of ROLEA and ROLEB, ROLEC needs to be explicitly specified, or ROLEB needs to be granted DEFAULT to ROLEC.

The User PUBLIC

Firebird has a predefined user named PUBLIC, that represents all users. Privileges for operations on a particular object that are granted to the user PUBLIC can be exercised by any authenticated user.

If privileges are granted to the user PUBLIC, they should be revoked from the user PUBLIC as well.

The WITH GRANT OPTION Clause

The optional WITH GRANT OPTION clause allows the users specified in the user list to grant the privileges specified in the privilege list to other users.

It is possible to assign this option to the user PUBLIC. Do not do this!

The GRANTED BY Clause

By default, when privileges are granted in a database, the current user is recorded as the grantor. The GRANTED BY clause enables the current user to grant those privileges as another user.

When using the REVOKE statement, it will fail if the current user is not the user that was named in the GRANTED BY clause.

The GRANTED BY (and AS) clause can be used only by the database owner and other administrators. The object owner cannot use GRANTED BY unless they also have administrator privileges.

Alternative Syntax Using AS username

The non-standard AS clause is supported as a synonym of the GRANTED BY clause to simplify migration from other database systems.

Privileges on Tables and Views

For tables and views, unlike other metadata objects, it is possible to grant several privileges at once.

List of Privileges on Tables

SELECT
: Permits the user or object to SELECT data from the table or view

INSERT
: Permits the user or object to INSERT rows into the table or view

DELETE
: Permits the user or object to DELETE rows from the table or view

UPDATE
: Permits the user or object to UPDATE rows in the table or view, optionally restricted to specific columns

`REFERENCES`

Permits the user or object to reference the table via a foreign key, optionally restricted to the specified columns. If the primary or unique key referenced by the foreign key of the other table is composite then all columns of the key must be specified.

`ALL [PRIVILEGES]`

Combines `SELECT`, `INSERT`, `UPDATE`, `DELETE` and `REFERENCES` privileges in a single package

Examples of `GRANT <privilege>` on Tables

1. `SELECT` and `INSERT` privileges to the user `ALEX`:

```
GRANT SELECT, INSERT ON TABLE SALES
  TO USER ALEX;
```

2. The `SELECT` privilege to the `MANAGER`, `ENGINEER` roles and to the user `IVAN`:

```
GRANT SELECT ON TABLE CUSTOMER
  TO ROLE MANAGER, ROLE ENGINEER, USER IVAN;
```

3. All privileges to the `ADMINISTRATOR` role, together with the authority to grant the same privileges to others:

```
GRANT ALL ON TABLE CUSTOMER
  TO ROLE ADMINISTRATOR
  WITH GRANT OPTION;
```

4. The `SELECT` and `REFERENCES` privileges on the `NAME` column to all users and objects:

```
GRANT SELECT, REFERENCES (NAME) ON TABLE COUNTRY
TO PUBLIC;
```

5. The `SELECT` privilege being granted to the user `IVAN` by the user `ALEX`:

```
GRANT SELECT ON TABLE EMPLOYEE
  TO USER IVAN
  GRANTED BY ALEX;
```

6. Granting the `UPDATE` privilege on the `FIRST_NAME`, `LAST_NAME` columns:

```
GRANT UPDATE (FIRST_NAME, LAST_NAME) ON TABLE EMPLOYEE
  TO USER IVAN;
```

7. Granting the INSERT privilege to the stored procedure ADD_EMP_PROJ:

```
GRANT INSERT ON EMPLOYEE_PROJECT
  TO PROCEDURE ADD_EMP_PROJ;
```

The EXECUTE Privilege

The EXECUTE privilege applies to stored procedures, stored functions (including UDFs), and packages. It allows the grantee to execute the specified object, and, if applicable, to retrieve its output.

In the case of selectable stored procedures, it acts somewhat like a SELECT privilege, insofar as this style of stored procedure is executed in response to a SELECT statement.

For packages, the EXECUTE privilege can only be granted for the package as a whole, ot for individual subroutines.

Examples of Granting the EXECUTE Privilege

1. Granting the EXECUTE privilege on a stored procedure to a role:

```
GRANT EXECUTE ON PROCEDURE ADD_EMP_PROJ
  TO ROLE MANAGER;
```

2. Granting the EXECUTE privilege on a stored function to a role:

```
GRANT EXECUTE ON FUNCTION GET_BEGIN_DATE
  TO ROLE MANAGER;
```

3. Granting the EXECUTE privilege on a package to user PUBLIC:

```
GRANT EXECUTE ON PACKAGE APP_VAR
  TO USER PUBLIC;
```

4. Granting the EXECUTE privilege on a function to a package:

```
GRANT EXECUTE ON FUNCTION GET_BEGIN_DATE
  TO PACKAGE APP_VAR;
```

The USAGE Privilege

To be able to use metadata objects other than tables, views, stored procedures or functions, triggers and packages, it is necessary to grant the user (or database object like trigger, procedure or function) the USAGE privilege on these objects.

Since Firebird executes stored procedures and functions, triggers, and package routines with the

privileges of the caller, it is necessary that either the user or otherwise the routine itself has been granted the USAGE privilege.

In Firebird 3.0 and Firebird 4.0, the USAGE privilege is only available for exceptions and sequences (in gen_id(gen_name, n) or `next value for gen_name`). Support for the USAGE privilege for other metadata objects may be added in future releases.

For sequences (generators), the USAGE privilege only grants the right to increment the sequence using the GEN_ID function or NEXT VALUE FOR. The SET GENERATOR statement is a synonym for ALTER SEQUENCE ⋯ RESTART WITH ⋯, and is considered a DDL statement. By default, only the owner of the sequence and administrators have the rights to such operations. The right to set the initial value of any sequence can be granted with GRANT ALTER ANY SEQUENCE, which is not recommend for general users.

Examples of Granting the USAGE Privilege

1. Granting the USAGE privilege on a sequence to a role:

```
GRANT USAGE ON SEQUENCE GEN_AGE
  TO ROLE MANAGER;
```

2. Granting the USAGE privilege on a sequence to a trigger:

```
GRANT USAGE ON SEQUENCE GEN_AGE
  TO TRIGGER TR_AGE_BI;
```

3. Granting the USAGE privilege on an exception to a package:

```
GRANT USAGE ON EXCEPTION
  TO PACKAGE PKG_BILL;
```

DDL Privileges

By default, only administrators can create new metadata objects; altering or dropping these objects is restricted to the owner of the object (its creator) and administrators. DDL privileges can be used to grant privileges for these operations to other users.

Available DDL Privileges

`CREATE`

Allows creation of an object of the specified type

`ALTER ANY`

Allows modification of any object of the specified type

`DROP ANY`

Allows deletion of any object of the specified type

`ALL [PRIVILEGES]`

Combines the `CREATE`, `ALTER ANY` and `DROP ANY` privileges for the specified type

There are no separate DDL privileges for triggers and indexes. The necessary privileges are inherited from the table or view. Creating, altering or dropping a trigger or index requires the `ALTER ANY TABLE` or `ALTER ANY VIEW` privilege.

Examples of Granting DDL Privileges

1. Allow user `JOE` to create tables

```
GRANT CREATE TABLE
  TO USER Joe;
```

2. Allow user `JOE` to alter any procedure

```
GRANT ALTER ANY PROCEDURE
  TO USER Joe;
```

Database DDL Privileges

The syntax for granting privileges to create, alter or drop a database deviates from the normal syntax of granting DDL privileges for other object types.

Available Database DDL Privileges

`CREATE`

Allows creation of a database

`ALTER`

Allows modification of the current database

`DROP`

Allows deletion of the current database

`ALL [PRIVILEGES]`

Combines the `ALTER` and `DROP` privileges. `ALL` does not include the `CREATE` privilege.

The `ALTER DATABASE` and `DROP DATABASE` privileges apply only to the current database, whereas DDL privileges `ALTER ANY` and `DROP ANY` on other object types apply to all objects of the specified type in the current database. The privilege to alter or drop the current database can only be granted by administrators.

The `CREATE DATABASE` privilege is a special kind of privilege as it is saved in the security database. A list of users with the `CREATE DATABASE` privilege is available from the virtual table `SEC$DB_CREATORS`.

Only administrators in the security database can grant the privilege to create a new database.

SCHEMA is currently a synonym for DATABASE; this may change in a future version, so we recommend to always use DATABASE

Examples of Granting Database DDL Privileges

1. Granting SUPERUSER the privilege to create databases:

```
GRANT CREATE DATABASE
  TO USER Superuser;
```

2. Granting JOE the privilege to execute ALTER DATABASE for the current database:

```
GRANT ALTER DATABASE
  TO USER Joe;
```

3. Granting FEDOR the privilege to drop the current database:

```
GRANT DROP DATABASE
  TO USER Fedor;
```

Assigning Roles

Assigning a role is similar to granting a privilege. One or more roles can be assigned to one or more users, including the user PUBLIC, using one GRANT statement.

The WITH ADMIN OPTION Clause

The optional WITH ADMIN OPTION clause allows the users specified in the user list to grant the role(s) specified to other users or roles.

It is possible to assign this option to PUBLIC. Do not do this!

For cumulative roles, a user can only exercise the WITH ADMIN OPTION of a secondary role if all intermediate roles are also granted WITH ADMIN OPTION. That is, GRANT ROLEA TO ROLE ROLEB WITH ADMIN OPTION, GRANT ROLEB TO ROLE ROLEC, GRANT ROLEC TO USER USER1 WITH ADMIN OPTION only allows USER1 to grant ROLEC to other users or roles, while using GRANT ROLEB TO ROLE ROLEC WITH ADMIN OPTION allows USER1 to grant ROLEA, ROLEB and ROLEC to other users.

Examples of Role Assignment

1. Assigning the DIRECTOR and MANAGER roles to the user IVAN:

```
GRANT DIRECTOR, MANAGER
```

```
  TO USER IVAN;
```

2. Assigning the MANAGER role to the user ALEX with the authority to assign this role to other users:

```
GRANT MANAGER
  TO USER ALEX WITH ADMIN OPTION;
```

3. Assigning the DIRECTOR role to user ALEX as a default role:

```
GRANT DEFAULT DIRECTOR
  TO USER ALEX;
```

4. Assigning the MANAGER role to role DIRECTOR:

```
GRANT MANAGER
  TO ROLE DIRECTOR;
```

See also

REVOKE

13.6. Statements for Revoking Privileges

A REVOKE statement is used for revoking privileges — including roles — from users and other database objects.

13.6.1. REVOKE

Used for

Revoking privileges or role assignments

Available in

DSQL, ESQL

Syntax (revoking privileges)

```
REVOKE [GRANT OPTION FOR] <privileges>
  FROM <grantee_list>
  [{GRANTED BY | AS} [USER] grantor]

<privileges> ::=
  !! See GRANT syntax !!
```

Syntax (revoking roles)

```
REVOKE [ADMIN OPTION FOR] <role_granted_list>
```

```
  FROM <role_grantee_list>
  [{GRANTED BY | AS} [USER] grantor]

<role_granted_list> ::=
  !! See GRANT syntax !!

<role_grantee_list> ::=
  !! See GRANT syntax !!
```

Syntax (revoking all)

```
REVOKE ALL ON ALL FROM <grantee_list>

<grantee_list> ::=
  !! See GRANT syntax !!
```

Table 261. REVOKE Statement Parameters

Parameter	Description
grantor	The grantor user on whose behalf the privilege(s) are being revoked

The REVOKE statement revokes privileges that were granted using the GRANT statement from users, roles, and other database objects. See GRANT for detailed descriptions of the various types of privileges.

Only the user who granted the privilege can revoke it.

The DEFAULT Clause

When the DEFAULT clause is specified, the role itself is not revoked, only its DEFAULT property is removed without revoking the role itself.

The FROM Clause

The FROM clause specifies a list of users, roles and other database objects that will have the enumerated privileges revoked. The optional USER keyword in the FROM clause allow you to specify exactly which type is to have the privilege revoked. If a USER (or ROLE) keyword is not specified, the server first checks for a role with this name and, if there is no such role, the privileges are revoked from the user with that name without further checking.

- Although the USER keyword is optional, it is advisable to use them in order to avoid ambiguity with roles.
- The REVOKE statement does not check for the existence of the user from which the privileges are being revoked.
- When revoking a privilege from a database object other than USER or ROLE, you must specify its object type

Revoking Privileges from user PUBLIC

> Privileges that were granted to the special user named `PUBLIC` must be revoked from the user `PUBLIC`. User `PUBLIC` provides a way to grant privileges to all users at once, but it is not “a group of users”.

Revoking the `GRANT OPTION`

The optional `GRANT OPTION FOR` clause revokes the user’s privilege to grant the specified privileges to other users, roles, or database objects (as previously granted with the `WITH GRANT OPTION`). It does not revoke the specified privilege itself.

Removing the Privilege to One or More Roles

One usage of the `REVOKE` statement is to remove roles that were assigned to a user, or a group of users, by a `GRANT` statement. In the case of multiple roles and/or multiple grantees, the `REVOKE` verb is followed by the list of roles that will be removed from the list of users specified after the `FROM` clause.

The optional `ADMIN OPTION FOR` clause provides the means to revoke the grantee’s “administrator” privilege, the ability to assign the same role to other users, without revoking the grantee’s privilege to the role.

Multiple roles and grantees can be processed in a single statement.

Revoking Privileges That Were `GRANTED BY`

A privilege that has been granted using the `GRANTED BY` clause is internally attributed explicitly to the grantor designated by that original `GRANT` statement. Only that user can revoke the granted privilege. Using the `GRANTED BY` clause you can revoke privileges as if you are the specified user. To revoke a privilege with `GRANTED BY`, the current user must be logged in either with full administrative privileges, or as the user designated as *grantor* by that `GRANTED BY` clause.

> Not even the owner of a role can use `GRANTED BY` unless they have administrative privileges.

The non-standard `AS` clause is supported as a synonym of the `GRANTED BY` clause to simplify migration from other database systems.

Revoking `ALL ON ALL`

The `REVOKE ALL ON ALL` statement allows a user to revoke all privileges (including roles) on all object from one or more users, roles or other database objects. It is a quick way to “clear” privileges when access to the database must be blocked for a particular user or role.

When the current user is logged in with full administrator privileges in the database, the `REVOKE ALL ON ALL` will remove all privileges, no matter who granted them. Otherwise, only the privileges granted by the current user are removed.

> The `GRANTED BY` clause is not supported

Examples using REVOKE

1. Revoking the privileges for selecting and inserting into the table (or view) SALES

```
REVOKE SELECT, INSERT ON TABLE SALES
  FROM USER ALEX;
```

2. Revoking the privilege for slecting from the CUSTOMER table from the MANAGER and ENGINEER roles and from the user IVAN:

```
REVOKE SELECT ON TABLE CUSTOMER
  FROM ROLE MANAGER, ROLE ENGINEER, USER IVAN;
```

3. Revoking from the ADMINISTRATOR role the privilege to grant any privileges on the CUSTOMER table to other users or roles:

```
REVOKE GRANT OPTION FOR ALL ON TABLE CUSTOMER
  FROM ROLE ADMINISTRATOR;
```

4. Revoking the privilege for selecting from the COUNTRY table and the privilege to reference the NAME column of the COUNTRY table from any user, via the special user PUBLIC:

```
REVOKE SELECT, REFERENCES (NAME) ON TABLE COUNTRY
  FROM PUBLIC;
```

5. Revoking the privilege for selecting form the EMPLOYEE table from the user IVAN, that was granted by the user ALEX:

```
REVOKE SELECT ON TABLE EMPLOYEE
  FROM USER IVAN GRANTED BY ALEX;
```

6. Revoking the privilege for updating the FIRST_NAME and LAST_NAME columns of the EMPLOYEE table from the user IVAN:

```
REVOKE UPDATE (FIRST_NAME, LAST_NAME) ON TABLE EMPLOYEE
  FROM USER IVAN;
```

7. Revoking the privilege for inserting records into the EMPLOYEE_PROJECT table from the ADD_EMP_PROJ procedure:

```
REVOKE INSERT ON EMPLOYEE_PROJECT
  FROM PROCEDURE ADD_EMP_PROJ;
```

8. Revoking the privilege for executing the procedure ADD_EMP_PROJ from the MANAGER role:

```
REVOKE EXECUTE ON PROCEDURE ADD_EMP_PROJ
  FROM ROLE MANAGER;
```

9. Revoking the privilege to grant the EXECUTE privilege for the function GET_BEGIN_DATE to other users from the role MANAGER:

```
REVOKE GRANT OPTION FOR EXECUTE
  ON FUNCTION GET_BEGIN_DATE
  FROM ROLE MANAGER;
```

10. Revoking the EXECUTE privilege on the package DATE_UTILS from user ALEX:

```
REVOKE EXECUTE ON PACKAGE DATE_UTILS
  FROM USER ALEX;
```

11. Revoking the USAGE privilege on the sequence GEN_AGE from the role MANAGER:

```
REVOKE USAGE ON SEQUENCE GEN_AGE
  FROM ROLE MANAGER;
```

12. Revoking the USAGE privilege on the sequence GEN_AGE from the trigger TR_AGE_BI:

```
REVOKE USAGE ON SEQUENCE GEN_AGE
  FROM TRIGGER TR_AGE_BI;
```

13. Revoking the USAGE privilege on the exception E_ACCESS_DENIED from the package PKG_BILL:

```
REVOKE USAGE ON EXCEPTION E_ACCESS_DENIED
  FROM PACKAGE PKG_BILL;
```

14. Revoking the privilege to create tables from user JOE:

```
REVOKE CREATE TABLE
  FROM USER Joe;
```

15. Revoking the privilege to alter any procedure from user JOE:

```
REVOKE ALTER ANY PROCEDURE
  FROM USER Joe;
```

16. Revoking the privilege to create databases from user SUPERUSER:

```
REVOKE CREATE DATABASE
  FROM USER Superuser;
```

17. Revoking the DIRECTOR and MANAGER roles from the user IVAN:

```
REVOKE DIRECTOR, MANAGER FROM USER IVAN;
```

18. Revoke from the user ALEX the privilege to grant the MANAGER role to other users:

```
REVOKE ADMIN OPTION FOR MANAGER FROM USER ALEX;
```

19. Revoking all privileges (including roles) on all objects from the user IVAN:

```
REVOKE ALL ON ALL
  FROM USER IVAN;
```

    After this statement is executed by an administrator, the user IVAN will have no privileges whatsoever, except those granted through PUBLIC.

20. Revoking the DEFAULT property of the DIRECTOR role from user ALEX, while the role itself remains granted:

```
REVOKE DEFAULT DIRECTOR
  FROM USER ALEX;
```

See also

GRANT

13.7. Mapping of Users to Objects

With Firebird now supporting multiple security databases, some new problems arise that could not occur with a single, global security database. Clusters of databases using the same security database were efficiently separated. Mappings provide the means to achieve the same efficiency when multiple databases are using their own security databases. Some cases require control for limited interaction between such clusters. For example:

- when EXECUTE STATEMENT ON EXTERNAL DATA SOURCE requires some data exchange between clusters
- when server-wide SYSDBA access to databases is needed from other clusters, using services.
- comparable problems that have existed on Firebird 2.1 and 2.5 for Windows, due to support for Trusted User authentication: two separate lists of users — one in the security database and

another in Windows, with cases where it was necessary to relate them. An example is the demand for a `ROLE` granted to a Windows group to be assigned automatically to members of that group.

The single solution for all such cases is **mapping** the login information assigned to a user when it connects to a Firebird server to internal security objects in a database — `CURRENT_USER` and `CURRENT_ROLE`.

13.7.1. The Mapping Rule

The mapping rule consists of four pieces of information:

1. mapping scope — whether the mapping is local to the current database or whether its effect is to be global, affecting all databases in the cluster, including security databases
2. mapping name — an SQL identifier, since mappings are objects in a database, like any other
3. the object **FROM** which the mapping maps. It consists of four items:
   - The authentication source
     - plugin name **or**
     - the product of a mapping in another database **or**
     - use of server-wide authentication **or**
     - any method
   - The name of the database where authentication succeeded
   - The name of the object from which mapping is performed
   - The **type** of that name — username, role, or OS group — depending upon the plugin that added that name during authentication.

     Any item is accepted but only **type** is required.
4. the object **TO** which the mapping maps. It consists of two items:
   - The name of the object **TO** which mapping is performed
   - The **type**, for which only `USER` or `ROLE` is valid

13.7.2. `CREATE MAPPING`

Used for

Creating a mapping of a security object

Available in

DSQL

Syntax

```
CREATE [GLOBAL] MAPPING name
  USING
    { PLUGIN plugin_name [IN database]
```

```
    | ANY PLUGIN [IN database | SERVERWIDE]
    | MAPPING [IN database] | '*' [IN database] }
  FROM {ANY type | type from_name}
  TO {USER | ROLE} [to_name]
```

Table 262. CREATE MAPPING Statement Parameter

Parameter	Description
name	Mapping name The maximum length is 63 characters. Must be unique among all mapping names in the context (local or GLOBAL).
plugin_name	Authentication plugin name
database	Name of the database that authenticated against
type	The type of object to be mapped. Possible types are plugin-specific.
from_name	The name of the object to be mapped
to_name	The name of the user or role to map to

The CREATE MAPPING statement creates a mapping of security objects (e.g. users, groups, roles) of one or more authentication plugins to internal security objects - CURRENT_USER and CURRENT_ROLE.

If the GLOBAL clause is present, then the mapping will be applied not only for the current database, but for all databases in the same cluster, including security databases.

There can be global and local mappings with the same name. They are distinct objects.

Global mapping works best if a Firebird 3.0 or higher version database is used as the security database. If you plan to use another database for this purpose — using your own provider, for example — then you should create a table in it named RDB$MAP, with the same structure as RDB$MAP in a Firebird 3.0 or higher database and with SYSDBA-only write access.

The USING clause describes the mapping source. It has a very complex set of options:

- an explicit plugin name (PLUGIN plugin_name) means it applies only for that plugin
- it can use any available plugin (ANY PLUGIN); although not if the source is the product of a previous mapping
- it can be made to work only with server-wide plugins (SERVERWIDE)
- it can be made to work only with previous mapping results (MAPPING)
- you can omit to use of a specific method by using the asterisk (*) argument
- it can specify the name of the database that defined the mapping for the FROM object (IN database)

This argument is not valid for mapping server-wide authentication.

The FROM clause describes the object to map. The FROM clause has a mandatory argument, the *type* of the object named. It has the following options:

- When mapping names from plugins, *type* is defined by the plugin
- When mapping the product of a previous mapping, *type* can be only USER or ROLE
- If an explicit *from_name* is provided, it will be taken into account by this mapping
- Use the ANY keyword to work with any name of the given type.

The TO clause specifies the user or role that is the result of the mapping. The *to_name* is optional. If it is not specified, then the original name of the mapped object will be used.

For roles, the role defined by a mapping rule is only applied when the user does not explicitly specify a role on connect. The mapped role can be assumed later in the session using SET TRUSTED ROLE, even when the mapped role is not explicitly granted to the user.

Who Can Create a Mapping

The CREATE MAPPING statement can be executed by:

- Administrators
- The database owner — if the mapping is local

CREATE MAPPING examples

1. Enable use of Windows trusted authentication in all databases that use the current security database:

```
CREATE GLOBAL MAPPING TRUSTED_AUTH
  USING PLUGIN WIN_SSPI
  FROM ANY USER
  TO USER;
```

2. Enable RDB$ADMIN access for windows admins in the current database:

```
CREATE MAPPING WIN_ADMINS
  USING PLUGIN WIN_SSPI
  FROM Predefined_Group
  DOMAIN_ANY_RID_ADMINS
  TO ROLE RDB$ADMIN;
```

The group DOMAIN_ANY_RID_ADMINS does not exist in Windows, but such a name would be added by the Win_Sspi plugin to provide exact backwards compatibility.

3. Enable a particular user from another database to access the current database with another name:

```
CREATE MAPPING FROM_RT
  USING PLUGIN SRP IN "rt"
  FROM USER U1 TO USER U2;
```

Database names or aliases will need to be enclosed in double quotes on operating systems that have case-sensitive file names.

4. Enable the server's SYSDBA (from the main security database) to access the current database. (Assume that the database is using a non-default security database):

```
CREATE MAPPING DEF_SYSDBA
  USING PLUGIN SRP IN "security.db"
  FROM USER SYSDBA
  TO USER;
```

5. Ensure users who logged in using the legacy authentication plugin do not have too many privileges:

```
CREATE MAPPING LEGACY_2_GUEST
  USING PLUGIN legacy_auth
  FROM ANY USER
  TO USER GUEST;
```

See also

`ALTER MAPPING`, `CREATE OR ALTER MAPPING`, `DROP MAPPING`

13.7.3. ALTER MAPPING

Used for

Altering a mapping of a security object

Available in

DSQL

Syntax

```
ALTER [GLOBAL] MAPPING name
  USING
    { PLUGIN plugin_name [IN database]
    | ANY PLUGIN [IN database | SERVERWIDE]
    | MAPPING [IN database] | '*' [IN database] }
  FROM {ANY type | type from_name}
  TO {USER | ROLE} [to_name]
```

For details on the options, see `CREATE MAPPING`.

The ALTER MAPPING statement allows you to modify any of the existing mapping options, but a local mapping cannot be changed to GLOBAL or vice versa.

Global and local mappings of the same name are different objects.

Who Can Alter a Mapping

The ALTER MAPPING statement can be executed by:

- Administrators
- The database owner — if the mapping is local

ALTER MAPPING examples

Alter mapping

```
ALTER MAPPING FROM_RT
  USING PLUGIN SRP IN "rt"
  FROM USER U1 TO USER U3;
```

See also

CREATE MAPPING, CREATE OR ALTER MAPPING, DROP MAPPING

13.7.4. CREATE OR ALTER MAPPING

Used for

Creating a new or altering an existing mapping of a security object

Available in

DSQL

Syntax

```
CREATE OR ALTER [GLOBAL] MAPPING name
  USING
    { PLUGIN plugin_name [IN database]
    | ANY PLUGIN [IN database | SERVERWIDE]
    | MAPPING [IN database] | '*' [IN database] }
  FROM {ANY type | type from_name}
  TO {USER | ROLE} [to_name]
```

For details on the options, see CREATE MAPPING.

The CREATE OR ALTER MAPPING statement creates a new or modifies an existing mapping.

Global and local mappings of the same name are different objects.

`CREATE OR ALTER MAPPING` examples

Creating or altering a mapping

```
CREATE OR ALTER MAPPING FROM_RT
  USING PLUGIN SRP IN "rt"
  FROM USER U1 TO USER U4;
```

See also

`CREATE MAPPING`, `ALTER MAPPING`, `DROP MAPPING`

13.7.5. `DROP MAPPING`

Used for

Dropping (removing) a mapping of a security object

Available in

DSQL

Syntax

```
DROP [GLOBAL] MAPPING name
```

Table 263. `DROP MAPPING` Statement Parameter

Parameter	Description
name	Mapping name

The `DROP MAPPING` statement removes an existing mapping. If `GLOBAL` is specified, then a global mapping will be removed.

Global and local mappings of the same name are different objects.

Who Can Drop a Mapping

The `DROP MAPPING` statement can be executed by:

- Administrators
- The database owner — if the mapping is local

`DROP MAPPING` examples

Alter mapping

```
DROP MAPPING FROM_RT;
```

See also

`CREATE MAPPING`

13.8. Database Encryption

Firebird provides a plugin mechanism to encrypt the data stored in the database. This mechanism does not encrypt the entire database, but only data pages, index pages, and blob pages.

In order to make database encryption possible, you need to obtain or write a database encryption plugin.

Out of the box, Firebird does not include a database encryption plugin.

The encryption plugin example in `examples/dbcrypt` does not perform real encryption, it is only intended as an example how such a plugin can be written.

On Linux, an example plugin named `libDbCrypt_example.so` can be found in `plugins/`.

The main problem with database encryption is how to store the secret key. Firebird provides support for transferring the key from the client, but this does not mean that storing the key on the client is the best way; it is just one of the possible alternatives. However, keeping encryption keys on the same disk as the database is an insecure option.

For efficient separation of encryption and key access, the database encryption plugin data is divided into two parts, the encryption itself and the holder of the secret key. This can be an efficient approach when you want to use some good encryption algorithm, but you have your own custom method of storing the keys.

Once you have decided on the plugin and key holder, you can perform the encryption.

13.8.1. Encrypting a Database

Syntax

```
ALTER {DATABASE | SCHEMA}
  ENCRYPT WITH plugin_name [KEY key_name]
```

Table 264. `ALTER DATABASE ENCRYPT` Statement Parameters

Parameter	Description
plugin_name	The name of the encryption plugin
key_name	The name of the encryption key

Encrypts the database using the specified encryption plugin. Encryption starts immediately after this statement completes, and will be performed in the background. Normal operations of the database are not disturbed during encryption.

The optional `KEY` clause specifies the name of the key for the encryption plugin. The plugin decides what to do with this key name.

The encryption process can be monitored using the `MON$CRYPT_PAGE` field in the

MON$DATABASE virtual table, or viewed in the database header page using gstat -e. gstat -h will also provide limited information about the encryption status.

For example, the following query will display the progress of the encryption process as a percentage.

```
select MON$CRYPT_PAGE * 100 / MON$PAGES
  from MON$DATABASE;
```

SCHEMA is currently a synonym for DATABASE; this may change in a future version, so we recommend to always use DATABASE

See also

Decrypting a Database, ALTER DATABASE

13.8.2. Decrypting a Database

Syntax

```
ALTER {DATABASE | SCHEMA} DECRYPT
```

Decrypts the database using the configured plugin and key. Decryption starts immediately after this statement completes, and will be performed in the background. Normal operations of the database are not disturbed during decryption.

SCHEMA is currently a synonym for DATABASE; this may change in a future version, so we recommend to always use DATABASE

See also

Encrypting a Database, ALTER DATABASE

13.9. SQL Security

The SQL SECURITY clause of various DDL statements enables executable objects (triggers, stored procedures, stored functions) to be defined to run in a specific context of privileges.

The SQL Security feature has two contexts: INVOKER and DEFINER. The INVOKER context corresponds to the privileges available to the current user or the calling object, while DEFINER corresponds to those available to the owner of the object.

The SQL SECURITY property is an optional part of an object's definition that can be applied to the object with DDL statements. The property cannot be dropped, but it can be changed from INVOKER to DEFINER and vice versa.

This is not the same thing as SQL privileges, which are applied to users and some types of database objects to give them various types of access to other database objects. When an executable object in

Firebird needs access to a table, view or another executable object, the target object is not accessible if the invoker does not have the necessary privileges on that object. That has been the situation in previous Firebird versions and remains so in Firebird 4.0. That is, by default all executable objects have the `SQL SECURITY INVOKER` property, and any caller lacking the necessary privileges will be rejected. The default SQL Security behaviour of a database can be overridden using `ALTER DATABASE`.

If a routine has the `SQL SECURITY DEFINER` property applied, the invoking user or routine will be able to execute it if the required privileges have been granted to its owner, without the need for the caller to be granted those privileges as well.

In summary:

- If `INVOKER` is set, the access rights for executing the call to an executable object are determined by checking the current user's active set of privileges
- If `DEFINER` is set, the access rights of the object owner will be applied instead, regardless of the current user's active set of privileges.

Chapter 14. Management Statements

Since Firebird 3.0 a new class of DSQL statement has emerged in Firebird's SQL lexicon, usually for administering aspects of the client/server environment. Typically, such statements start with the verb `SET`.

The *isql* tool also has a collection of `SET` commands. Those commands are not part of Firebird's SQL lexicon. For information on *isql*s `SET` commands, see *Isql* Set Commands in *Firebird Interactive SQL Utility*.

Management statements can run anywhere DSQL can run but, typically, the developer will want to run a management statement in a database trigger. In past releases, management statements were treated in PSQL like DDL, precluding them from running directly inside a PSQL module. From Firebird 4.0 forward, a pre-determined set of them can be used directly in PSQL modules without the need to wrap them in an `EXECUTE STATEMENT` block. For more details of the current set, see Management Statements in PSQL in the PSQL chapter.

Most of the management statements affect the current connection (attachment, or "session") only, and do not require any authorization over and above the login privileges of the current user without elevated privileges.

Some management statements operate beyond the scope of the current session. Examples are the `ALTER DATABASE {BEGIN | END} BACKUP` statements to control *nBackup*, or the `ALTER EXTERNAL CONNECTIONS POOL` statements introduced in Firebird 4.0 to manage connection pooling. A new set of *system privileges*, analogous with SQL privileges granted for database objects, is provided to enable the required authority to run a specific management statement in this category.

Some statements of this class use the verb `ALTER`, although management statements should not be confused with DDL `ALTER` statements that modify database objects like tables, views, procedures, roles, et al.

Although some `ALTER DATABASE` clauses (`BEGIN BACKUP`) can be considered as management statements, they are documented in the *DDL* chapter.

14.1. Data Type Behaviour

14.1.1. `SET BIND` (Data Type Coercion Rules)

Used for

Configuring data type coercion rules

Available in

DSQL, PSQL

Syntax

```
SET BIND OF <type_from> TO <type_to>
```

```
<type_from> ::=
    <scalar_datatype>
  | <blob_datatype>
  | TIME ZONE
  | VARCHAR | {CHARACTER | CHAR} VARYING

<type_to> ::=
    <scalar_datatype>
  | <blob_datatype>
  | VARCHAR | {CHARACTER | CHAR} VARYING
  | LEGACY | NATIVE | EXTENDED
  | EXTENDED TIME WITH TIME ZONE
  | EXTENDED TIMESTAMP WITH TIME ZONE

<scalar_datatype> ::=
  !! See Scalar Data Types Syntax !!

<blob_datatype> ::=
  !! See BLOB Data Types Syntax !!
```

`SET BIND` configures data type coercion rules for the current session. This statement makes it possible to substitute one data type with another when performing client-server interactions. In other words, *type_from* returned by the engine is represented as *type_to* in the client API.

Only fields returned by the database engine in regular messages are substituted according to these rules. Variables returned as an array slice are not affected by the `SET BIND` statement.

When an incomplete type definition is used (i.e. simply `CHAR` instead of `CHAR(n)`) in *from_type*, the coercion is performed for all `CHAR` columns. The special incomplete type `TIME ZONE` stands for `TIME WITH TIME ZONE` and `TIMESTAMP WITH TIME ZONE`. When an incomplete type definition is used in *to_type*, the engine defines missing details about that type automatically based on source column.

Changing the binding of any `NUMERIC` or `DECIMAL` data type does not affect the underlying integer type. In contrast, changing the binding of an integer data type also affects appropriate NUMERICs/DECIMALs (e.g. `SET BIND OF INT128 TO DOUBLE PRECISION` will also map `NUMERIC` and `DECIMAL` with precision 19 or higher, as these types use `INT128` as their underlying type).

The special type `LEGACY` is used when a data type, missing in previous Firebird version, should be represented in a way, understandable by old client software (possibly with some data loss). The coercion rules applied in this case are shown in the table below.

Table 265. Native to `LEGACY` coercion rules

Native data type	Legacy data type
BOOLEAN	CHAR(5)
DECFLOAT	DOUBLE PRECISION

Native data type	Legacy data type
INT128	BIGINT
TIME WITH TIME ZONE	TIME WITHOUT TIME ZONE
TIMESTAMP WITH TIME ZONE	TIMESTAMP WITHOUT TIME ZONE

Using `EXTENDED` for *type_to* causes the engine to coerce to an extended form of the *type_from* data type. Currently, this works only for `TIME/TIMESTAMP WITH TIME ZONE`, they are coerced to `EXTENDED TIME/TIMESTAMP WITH TIME ZONE`. The `EXTENDED` type contains both the time zone name, and the corresponding GMT offset, so it remains usable if the client application cannot process named time zones properly (e.g. due to the missing ICU library).

Setting a binding to `NATIVE` resets the existing coercion rule for this data type and returns it in its native format.

The initial bind rules of a connection be configured through the DPB by providing a semi-colon separated list of `<type_from> TO <type_to>` options as the string value of *isc_dpb_set_bind*.

Execution of `ALTER SESSION RESET` will revert to the binding rules configured through the DPB, or otherwise the system default.

It is also possible to configure a default set of data type coercion rules for all clients through the `DataTypeCompatibility` configuration option, either as a global configuration in `firebird.conf` or per database in `databases.conf`.

`DataTypeCompatibility` currently has two possible values: `3.0` and `2.5`. The `3.0` option maps data types introduced after Firebird 3.0 — in particular `DECIMAL/NUMERIC` with precision 19 or higher, `DECFLOAT`, `TIME/TIMESTAMP WITH TIME ZONE` — to data types supported in Firebird 3.0. The `2.5` option also converts the `BOOLEAN` data type.

See the Native to `LEGACY` coercion rules for details. This setting allows legacy client applications to work with Firebird 4.0 without recompiling or otherwise adjusting them to understand the new data types.

`SET BIND` Examples

```
-- native
SELECT CAST('123.45' AS DECFLOAT(16)) FROM RDB$DATABASE;

                  CAST
=======================
                123.45

-- double
SET BIND OF DECFLOAT TO DOUBLE PRECISION;
SELECT CAST('123.45' AS DECFLOAT(16)) FROM RDB$DATABASE;

                  CAST
```

```
======================
      123.4500000000000

-- still double
SET BIND OF DECFLOAT(34) TO CHAR;
SELECT CAST('123.45' AS DECFLOAT(16)) FROM RDB$DATABASE;

                   CAST
======================
      123.4500000000000

-- text
SELECT CAST('123.45' AS DECFLOAT(34)) FROM RDB$DATABASE;

CAST
========================================
123.45
```

In the case of missing ICU on the client side:

```
SELECT CURRENT_TIMESTAMP FROM RDB$DATABASE;

                                      CURRENT_TIMESTAMP
=========================================================
2020-02-21 16:26:48.0230 GMT*

SET BIND OF TIME ZONE TO EXTENDED;
SELECT CURRENT_TIMESTAMP FROM RDB$DATABASE;

                                      CURRENT_TIMESTAMP
=========================================================
2020-02-21 19:26:55.6820 +03:00
```

14.1.2. SET DECFLOAT

Used for

Configuring DECFLOAT rounding and error behaviour

Available in

DSQL, PSQL

Syntax

```
SET DECFLOAT
  { ROUND <round_mode>
  | TRAPS TO [<trap_opt> [, <trap_opt> ...]] }

<round_mode> ::=
    CEILING | UP | HALF_UP | HALF_EVEN
```

```
  | HALF_DOWN | DOWN | FLOOR | REROUND

<trap_opt> ::=
    DIVISON_BY_ZERO | INEXACT | INVALID_OPERATION
  | OVERFLOW | UNDERFLOW
```

`SET DECFLOAT` configures the rounding and error behaviour of operations on `DECFLOAT` types in the current session.

SET DECFLOAT ROUND

`SET DECFLOAT ROUND` changes the rounding behaviour of operations on `DECFLOAT`. The default rounding mode is `HALF_UP`. The initial configuration of a connection can also be specified using the DPB tag `isc_dpb_decfloat_round` with the desired *round_mode* as string value.

The valid rounding modes are:

CEILING	towards +infinity
UP	away from 0
HALF_UP	to nearest, if equidistant, then up (default)
HALF_EVEN	to nearest, if equidistant, ensure last digit in the result will be even
HALF_DOWN	to nearest, if equidistant, then down
DOWN	towards 0
FLOOR	towards -infinity
REROUND	up if digit to be rounded is 0 or 5, down in other cases

Execution of `ALTER SESSION RESET` will revert to the value configured through the DPB, or otherwise the system default.

SET DECFLOAT TRAPS

`SET DECFLOAT TRAPS` changes the error behaviour of operations on `DECFLOAT`. The default traps are `DIVISION_BY_ZERO,INVALID_OPERATION,OVERFLOW`; this default matches the behaviour specified in the SQL:2016 standard for `DECFLOAT`. This statement controls whether certain exceptional conditions result in an error (“trap”) or alternative handling (for example, an underflow returns `0` when not set, or an overflow returns an infinity). The initial configuration of a connection can also be specified using the DPB tag `isc_dpb_decfloat_traps` with the desired comma-separated *trap_opt* values as a string value.

Valid trap options (exceptional conditions) are:

Division_by_zero	(set by default)
Inexact	—

`Invalid_operation`	(set by default)
`Overflow`	(set by default)
`Underflow`	—

Execution of `ALTER SESSION RESET` will revert to the value configured through the DPB, or otherwise the system default.

14.2. Connections Pool Management

Management statements to manage the external connections pool.

14.2.1. ALTER EXTERNAL CONNECTIONS POOL

Used for

Managing the external connections pool

Available in

DSQL

Syntax

```
ALTER EXTERNAL CONNECTIONS POOL
  { CLEAR ALL
  | CLEAR OLDEST
  | SET LIFETIME lifetime <time-unit>
  | SET SIZE size }

<time-unit> ::= SECOND | MINUTE | HOUR
```

Table 266. `ALTER EXTERNAL CONNECTIONS POOL` Statement Parameters

Parameter	Description
lifetime	Maximum lifetime of a connection in the pool. Minimum values is `1 SECOND`, maximum is `24 HOUR`.
size	Maximum size of the connection pool. Range 0 - 1000. Setting to `0` disables the external connections pool.

When prepared it is described like a DDL statement but its effect is immediate — it is executed immediately and completely, without waiting for transaction commit.

The statements can be issued from any connection, and changes are applied to the in-memory instance of the pool in the current Firebird process. If the process is a Classic one, a change submitted there does not affect other Classic processes.

Changes made with `ALTER EXTERNAL CONNECTIONS POOL` are not persistent: after a restart, Firebird will use the pool settings configured in `firebird.conf` by `ExtConnPoolSize` and `ExtConnPoolLifeTime`.

Clauses of `ALTER EXTERNAL CONNECTIONS POOL`

`CLEAR ALL`

Closes all idle connections and disassociates currently active connections so they are immediately closed when unused.

`CLEAR OLDEST`

Closes expired connections

`SET LIFETIME`

Configures the maximum lifetime of an idle connection in the pool. The default value (in seconds) is set using the parameter `ExtConnPoolLifetime` in `firebird.conf`.

`SET SIZE`

Configures the maximum number of idle connections in the pool. The default value is set using the parameter `ExtConnPoolSize` in `firebird.conf`.

How the Connection Pool Works

Every successful connection is associated with a pool, which maintains two lists — one for idle connections and one for active connections. When a connection in the "active" list has no active requests and no active transactions, it is assumed to be "unused". A reset of the unused connection is attempted using an `ALTER SESSION RESET` statement and,

- if the reset succeeds (no errors occur) the connection is moved into the "idle" list;
- if the reset fails, the connection is closed;
- if the pool has reached its maximum size, the oldest idle connection is closed.
- When the *lifetime* of an idle connection expires, it is deleted from the pool and closed.

New Connections

When the engine is asked to create a new external connection, the pool first looks for a candidate in the "idle" list. The search, which is case-sensitive, involves four parameters:

1. connection string
2. username
3. password
4. role

If suitable connection is found, it is tested to check that it is still alive.

- If it fails the check, it is deleted, and the search is repeated, without reporting any error to the client
- Otherwise, the live connection is moved from the "idle" list to the "active" list and returned to the caller
- If there are multiple suitable connections, the most recently used one is chosen

- If there is no suitable connection, a new one is created and added to the “active” list.

Who Can Alter the External Connections Pool

The ALTER EXTERNAL CONNECTIONS POOL statement can be executed by:

- Administrators
- Users with the MODIFY_EXT_CONN_POOL privilege

See also
RDB$GET_CONTEXT

14.3. Changing the Current Role

14.3.1. SET ROLE

Used for

Changing the role of the current session

Available in

DSQL

Syntax

```
SET ROLE {role_name | NONE}
```

Table 267. SET ROLE Statement Parameters

Parameter	Description
role_name	The name of the role to apply

The SET ROLE statement allows a user to assume a different role; it sets the CURRENT_ROLE context variable to *role_name*, if that role has been granted to the CURRENT_USER. For this session, the user receives the privileges granted by that role. Any rights granted to the previous role are removed from the session. Use NONE instead of *role_name* to clear the CURRENT_ROLE.

When the specified role does not exist or has not been explicitly granted to the user, the error “*Role **role_name** is invalid or unavailable*” is raised.

SET ROLE Examples

1. Change the current role to MANAGER

```
SET ROLE manager;
select current_role from rdb$database;

ROLE
========================
```

```
MANAGER
```

2. Clear the current role

```
SET ROLE NONE;
select current_role from rdb$database;

ROLE
========================
NONE
```

See also

`SET TRUSTED ROLE`, `GRANT`

14.3.2. SET TRUSTED ROLE

Used for

Changes role of the current session to the trusted role

Available in

DSQL

Syntax

```
SET TRUSTED ROLE
```

The `SET TRUSTED ROLE` statement makes it possible to assume the role assigned to the user through a mapping rule (see Mapping of Users to Objects). The role assigned through a mapping rule is assumed automatically on connect, if the user hasn't specified an explicit role. The `SET TRUSTED ROLE` statement makes it possible to assume the mapped (or "trusted") role at a later time, or to assume it again after the current role was changed using `SET ROLE`.

A trusted role is not a specific type of role, but can be any role that was created using `CREATE ROLE`, or a predefined system role such as `RDB$ADMIN`. An attachment (session) has a trusted role when the security objects mapping subsystem finds a match between the authentication result passed from the plugin and a local or global mapping to a role for the current database. The role may be one that is not granted explicitly to that user.

When a session has no trusted role, executing `SET TRUSTED ROLE` will raise error "*Your attachment has no trusted role*".

While the `CURRENT_ROLE` can be changed using `SET ROLE`, it is not always possible to revert to a trusted role using the same command, because `SET ROLE` checks if the role has been granted to the user. With `SET TRUSTED ROLE`, the trusted role can be assumed again even when `SET ROLE` fails.

SET TRUSTED ROLE Examples

1. Assuming a mapping rule that assigns the role ROLE1 to a user ALEX:

```
CONNECT 'employee' USER ALEX PASSWORD 'password';
SELECT CURRENT_ROLE FROM RDB$DATABASE;

ROLE
==============================
ROLE1

SET ROLE ROLE2;
SELECT CURRENT_ROLE FROM RDB$DATABASE;

ROLE
==============================
ROLE2

SET TRUSTED ROLE;
SELECT CURRENT_ROLE FROM RDB$DATABASE;

ROLE
==============================
ROLE1
```

See also

SET ROLE, Mapping of Users to Objects

14.4. Session Timeouts

Statements for management of timeouts of the current connection.

14.4.1. SET SESSION IDLE TIMEOUT

Used for

Changing the session idle timeout

Available in

DSQL, PSQL

Syntax

```
SET SESSION IDLE TIMEOUT value [<time-unit>]

<time-unit> ::= MINUTE | HOUR | SECOND
```

Table 268. SET SESSION IDLE TIMEOUT Statement Parameters

Parameter	Description
value	The timeout duration expressed in *time-unit*. A value of `0` defers to connection idle timeout configured for the database.
time-unit	Time unit of the timeout. Defaults to `MINUTE`.

The `SET SESSION IDLE TIMEOUT` sets an idle timeout at connection level and takes effect immediately. The statement can run outside transaction control (without an active transaction).

Setting a *value* larger than configured for the database is allowed, but is effectively ignored, see also *Determining the Timeout that is In Effect*.

The current timeout set for the session can be retrieved through `RDB$GET_CONTEXT`, namespace `SYSTEM` and variable `SESSION_IDLE_TIMEOUT`. Information is also available from `MON$ATTACHMENTS`:

`MON$IDLE_TIMEOUT`
: Connection-level idle timeout in seconds; `0` if timeout is not set.

`MON$IDLE_TIMER`
: Idle timer expiration time; contains `NULL` if an idle timeout was not set, or if a timer is not running.

Both `RDB$GET_CONTEXT('SYSTEM', 'SESSION_IDLE_TIMEOUT')` and `MON$ATTACHMENTS.MON$IDLE_TIMEOUT` report the idle timeout configured for the connection; they do not report the effective idle timeout.

The session idle timeout is reset when `ALTER SESSION RESET` is executed.

Idle Session Timeouts

An idle session timeout allows a use connection to close automatically after a specified period of inactivity. A database administrator can use it to enforce closure of old connections that have become inactive, to reduce unnecessary consumption of resources. It can also be used by application and tools developers as an alternative to writing their own modules for controlling connection lifetime.

By default, the idle timeout is not enabled. No minimum or maximum limit is imposed, but a reasonably large period — such as a few hours — is recommended.

How the Idle Session Timeout Works

- When the user API call leaves the engine (returns to the calling connection) a special idle timer associated with the current connection is started
- When another user API call from that connection enters the engine, the idle timer is stopped and reset to zero
- If the maximum idle time is exceeded, the engine immediately closes the connection in the same way as with asynchronous connection cancellation:
  - all active statements and cursors are closed
  - all active transactions are rolled back

- The network connection remains open at this point, allowing the client application to get the exact error code on the next API call. The network connection will be closed on the server side, after an error is reported or in due course as a result of a network timeout from a client-side disconnection.

> Whenever a connection is cancelled, the next user API call returns the error `isc_att_shutdown` with a secondary error specifying the exact reason. Now, we have
>
> **`isc_att_shut_idle`**
> Idle timeout expired
>
> in addition to

> **`isc_att_shut_killed`**
> Killed by database administrator
>
> **`isc_att_shut_db_down`**
> Database is shut down
>
> **`isc_att_shut_engine`**
> Engine is shut down

Setting the Idle Session Timeout

The idle timer will not start if the timeout period is set to zero.

An idle session timeout can be set:

- At database level, the database administrator can set the configuration parameter `ConnectionIdleTimeout`, an integer value **in minutes**. The default value of zero means no timeout is set. It is configurable per-database, so it may be set globally in `firebird.conf` and overridden for individual databases in `databases.conf` as required.

  The scope of this method is all user connections, except system connections (garbage collector, cache writer, etc.).

- at connection level, the idle session timeout is supported by both the `SET SESSION IDLE TIMEOUT` statement and the API (`setIdleTimeout`). The scope of this method is specific to the supplied connection (attachment). Its value in the API is **in seconds**. In the SQL syntax it can be hours, minutes or seconds. Scope for this method is the connection to which it is applied.

For more information about the API calls, consult the *Firebird 4.0 Release Notes*.

Determining the Timeout that is In Effect

The effective idle timeout value is determined whenever a user API call leaves the engine, checking first at connection level and then at database level. A connection-level timeout can override the value of a database-level setting, as long as the period of time for the connection-level setting is no longer than any non-zero timeout that is applicable at database level.

Take note of the difference between the time units at each level. At database level, in the configuration files, the unit for `SessionTimeout` is minutes. In SQL, the default unit is minutes but can be expressed in hours or seconds explicitly. At the API level, the unit is seconds.

Absolute precision is not guaranteed in any case, especially when the system load is high, but timeouts are guaranteed not to expire earlier than the moment specified.

14.4.2. SET STATEMENT TIMEOUT

Used for

Changing the statement timeout for a connection

Available in

DSQL, PSQL

Syntax

```
SET STATEMENT TIMEOUT value [<time-unit>]

<time-unit> ::= SECOND | MILLISECOND | MINUTE | HOUR
```

Table 269. `SET STATEMENT TIMEOUT` *Statement Parameters*

Parameter	Description
value	The timeout duration expressed in *time-unit*. A value of `0` defers to statement timeout configured for the database.
time-unit	Time unit of the timeout. Defaults to `SECOND`.

The `SET STATEMENT TIMEOUT` sets a statement timeout at connection level and takes effect immediately. The statement can run outside transaction control (without an active transaction).

Setting a *value* larger than configured for the database is allowed, but is effectively ignored, see also *Determining the Statement Timeout that is In Effect*.

The current statement timeout set for the session can be retrieved through `RDB$GET_CONTEXT`, namespace `SYSTEM` and variable `STATEMENT_TIMEOUT`. Information is also available from `MON$ATTACHMENTS`:

`MON$STATEMENT_TIMEOUT`
: Connection-level statement timeout in milliseconds; `0` if timeout is not set.

In `MON$STATEMENTS`:

`MON$STATEMENT_TIMEOUT`
: Statement-level statement timeout in milliseconds; `0` if timeout is not set.

`MON$STATEMENT_TIMER`

Timeout timer expiration time; contains `NULL` if an idle timeout was not set, or if a timer is not running.

Both `RDB$GET_CONTEXT('SYSTEM', 'STATEMENT_TIMEOUT')` and `MON$ATTACHMENTS.MON$STATEMENT_TIMEOUT` report the statement timeout configured for the connection, and `MON$STATEMENTS.MON$STATEMENT_TIMEOUT` for the statement; they do not report the effective statement timeout.

The statement timeout is reset when `ALTER SESSION RESET` is executed.

Statement Timeouts

The statement timeout feature allows execution of a statement to be stopped automatically when it has been running longer than a given timeout period. It gives the database administrator an instrument for limiting excessive resource consumption from heavy queries.

Statement timeouts can also be useful to application developers when creating and debugging complex queries without advance knowledge of execution time. Testers and others could find them handy for detecting long-running queries and establishing finite run times for test suites.

How the Statement Timeout Works

When the statement starts execution, or a cursor is opened, the engine starts a special timer. It is stopped when the statement completes execution, or the last record has been fetched by the cursor.

A fetch does not reset this timer.

When the timeout point is reached:

- if statement execution is active, it stops at closest possible moment
- if statement is not active currently (between fetches, for example), it is marked as cancelled, and the next fetch will actually break execution and return an error

Statement types excluded from timeouts

Statement timeouts are not applicable to some types of statement and will simply be ignored:

- All DDL statements
- All internal queries issued by the engine itself

Setting a Statement Timeout

The timer will not start if the timeout period is set to zero.

A statement timeout can be set:

- at database level, by the database administrator, by setting the configuration parameter `StatementTimeout` in `firebird.conf` or `databases.conf`. `StatementTimeout` is an integer representing

the number of seconds after which statement execution will be cancelled automatically by the engine. Zero means no timeout is set. A non-zero setting will affect all statements in all connections.

- at connection level, using `SET STATEMENT TIMEOUT` or the API for setting a statement timeout (`setStatementTimeout`). A connection-level setting (via SQL or the API) affects all statements for the given connection; units for the timeout period at this level can be specified to any granularity from hours to milliseconds.
- at statement level, using the API, in milliseconds

Determining the Statement Timeout that is In Effect

The statement timeout value that is in effect is determined whenever a statement starts executing, or a cursor is opened. In searching out the timeout in effect, the engine goes up through the levels, from statement through to database and/or global levels until it finds a non-zero value. If the value in effect turns out to be zero then no statement timer is running and no timeout applies.

A statement-level or connection-level timeout can override the value of a database-level setting, as long as the period of time for the lower-level setting is no longer than any non-zero timeout that is applicable at database level.

Take note of the difference between the time units at each level. At database level, in the conf file, the unit for `StatementTimeout` is seconds. In SQL, the default unit is seconds but can be expressed in hours, minutes or milliseconds explicitly. At the API level, the unit is milliseconds.

Absolute precision is not guaranteed in any case, especially when the system load is high, but timeouts are guaranteed not to expire earlier than the moment specified.

Whenever a statement times out and is cancelled, the next user API call returns the error `isc_cancelled` with a secondary error specifying the exact reason, viz.,

`isc_cfg_stmt_timeout`
: Config level timeout expired

`isc_att_stmt_timeout`
: Attachment level timeout expired

`isc_req_stmt_timeout`
: Statement level timeout expired

Notes about Statement Timeouts

1. A client application could wait longer than the time set by the timeout value if the engine needs to undo a large number of actions as a result of the statement cancellation
2. When the engine runs an `EXECUTE STATEMENT` statement, it passes the remainder of the currently active timeout to the new statement. If the external (remote)

engine does not support statement timeouts, the local engine silently ignores any corresponding error.

3. When the engine acquires some lock from the lock manager, it tries to lower the value of the lock timeout using the remainder of the currently active statement timeout, if possible. Due to lock manager internals, any statement timeout remainder will be rounded up to whole seconds.

14.5. Time Zone Management

Statements for management of time zone features of the current connections.

14.5.1. SET TIME ZONE

Used for

Changing the session time zone

Available in

DSQL, PSQL

Syntax

```
SET TIME ZONE { time_zone_string | LOCAL }
```

Changes the session time zone to the specified time zone. Specifying `LOCAL` will revert to initial session time zone of the session (either the default or as specified through connection property `isc_dpb_session_time_zone`).

Executing `ALTER SESSION RESET` has the same effect on the session time zone as `SET TIME ZONE LOCAL`, but will also reset other session properties.

`SET TIME ZONE` Examples

```
set time zone '-02:00';
set time zone 'America/Sao_Paulo';
set time zone local;
```

14.6. Reset Session State

14.6.1. ALTER SESSION RESET

Used for

Resetting session state to its initial values

Available in

DSQL, PSQL

Syntax

```
ALTER SESSION RESET
```

`ALTER SESSION RESET` resets the current user session to its initial state. It can be useful for reusing the connection by a client application (for example, by a client-side connection pool). When this statement is executed, all user context variables are cleared, contents of global temporary tables are cleared, and all session-level settings are reset to their initial values.

It is possible to execute `ALTER SESSION RESET` without a transaction.

Execution of `ALTER SESSION RESET` performs the following steps:

- Error *isc_ses_reset_err* (`335545206`) is raised if any transaction is active in the current session other than the current transaction(the one executing `ALTER SESSION RESET`) and two-phase transactions in the prepared state.
- System variable `RESETTING` is set to TRUE.
- `ON DISCONNECT` database triggers are fired, if present and if database triggers are not disabled for the current connection.
- The current transaction (the one executing `ALTER SESSION RESET`), if present, is rolled back. A warning is reported if this transaction modified data before resetting the session.
- Session configuration is reset to their initial values. This includes, but is not limited to:
  - `DECFLOAT` parameters (`TRAP` and `ROUND`) and reset to the initial values defined using the DPB at connect time, or otherwise the system default.
  - Session and statement timeouts are reset to zero.
  - The current role is restored to the initial value defined using DPB at connect time, and — if the role changed — the security classes cache is cleared.
  - The session time zone is reset to the initial value defined using the DPB at connect time, or otherwise the system default.
  - The bind configuration is reset to the initial value defined using the DPB at connect time, or otherwise the database or system default.
  - In general, configuration values should revert to the values configured using DPB at connect time, or otherwise the database or system default.
- Context variables defined for the `USER_SESSION` namespace are removed.
- Global temporary tables defined as `ON COMMIT PRESERVE ROWS` are truncated (their contents is cleared).
- `ON CONNECT` database triggers are fired, if present and if database triggers are not disabled for the current connection.
- A new transaction is implicitly started with the same parameters as the transaction that was rolled back (if there was a transaction)
- System variable `RESETTING` is set to FALSE.

- The context variables `CURRENT_USER` and `CURRENT_CONNECTION` will not be changed.
- As *isql* starts multiple transactions for a single connection, `ALTER SESSION RESET` cannot be executed in *isql*.

Error Handling

Any error raised by `ON DISCONNECT` triggers aborts the session reset and leave the session state unchanged. Such errors are reported using primary error code *isc_session_reset_err* (`335545206`) and error text *"Cannot reset user session"*.

Any error raised after `ON DISCONNECT` triggers (including the ones raised by `ON CONNECT` triggers) aborts both the session reset and the connection itself. Such errors are reported using primary error code *isc_ses_reset_failed* (`335545272`) and error text *"Reset of user session failed. Connection is shut down."*. Subsequent operations on the connection (except detach) will fail with error *isc_att_shutdown* (`335544856`).

14.7. Debugging

14.7.1. SET DEBUG OPTION

Used for

Setting debug options

Available in

DSQL, PSQL

Introduced in

Firebird 4.0.1

Syntax

```
SET DEBUG OPTION option-name = value
```

Table 270. Supported options

Option name	Value Type	Description
`DSQL_KEEP_BLR`	`BOOLEAN`	Stores statement BLR for retrieval with `isc_info_sql_exec_path_blr_bytes` and `isc_info_sql_exec_path_blr_text`. Added in Firebird 4.0.1.

`SET DEBUG OPTION` configures debug information for the current connection.

Debug options are closely tied to engine internals and their usage is discouraged if you do not understand very well how these internals are subject to change between versions.

Appendix A: Supplementary Information

In this Appendix are topics that developers may wish to refer to, to enhance understanding of features or changes.

The RDB$VALID_BLR Field

The field RDB$VALID_BLR was added to the system tables RDB$PROCEDURES and RDB$TRIGGERS in Firebird 2.1. Its purpose is to signal possible invalidation of a PSQL module after alteration of a domain or table column on which the module depends. RDB$VALID_BLR is set to 0 for any procedure or trigger whose code is made invalid by such a change.

How Invalidation Works

In triggers and procedures, dependencies arise on the definitions of table columns accessed and also on any parameter or variable that has been defined in the module using the TYPE OF clause.

After the engine has altered any domain, including the implicit domains created internally behind column definitions and output parameters, the engine internally recompiles all of its dependencies.

In v2.x these comprise procedures and triggers but not blocks coded in DML statements for run-time execution with EXECUTE BLOCK. Firebird 3 will encompass more module types (stored functions, packages).

Any module that fails to recompile because of an incompatibility arising from a domain change is marked as invalid (“invalidated” by setting the RDB$VALID_BLR in its system record (in RDB$PROCEDURES or RDB$TRIGGERS, as appropriate) to zero.

Revalidation (setting RDB$VALID_BLR to 1) occurs when

1. the domain is altered again and the new definition is compatible with the previously invalidated module definition; OR
2. the previously invalidated module is altered to match the new domain definition

The following query will find the modules that depend on a specific domain and report the state of their RDB$VALID_BLR fields:

```
SELECT * FROM (
  SELECT
    'Procedure',
    rdb$procedure_name,
    rdb$valid_blr
  FROM rdb$procedures
  UNION ALL
  SELECT
    'Trigger',
    rdb$trigger_name,
    rdb$valid_blr
```

```
  FROM rdb$triggers
) (type, name, valid)
WHERE EXISTS
  (SELECT * from rdb$dependencies
   WHERE rdb$dependent_name = name
     AND rdb$depended_on_name = 'MYDOMAIN')

/* Replace MYDOMAIN with the actual domain name.
   Use all-caps if the domain was created
   case-insensitively. Otherwise, use the exact
   capitalisation. */
```

The following query will find the modules that depend on a specific table column and report the state of their RDB$VALID_BLR fields:

```
SELECT * FROM (
  SELECT
    'Procedure',
    rdb$procedure_name,
    rdb$valid_blr
  FROM rdb$procedures
  UNION ALL
  SELECT
    'Trigger',
    rdb$trigger_name,
    rdb$valid_blr
  FROM rdb$triggers) (type, name, valid)
WHERE EXISTS
  (SELECT *
   FROM rdb$dependencies
   WHERE rdb$dependent_name = name
     AND rdb$depended_on_name = 'MYTABLE'
     AND rdb$field_name = 'MYCOLUMN')
```

All PSQL invalidations caused by domain/column changes are reflected in the RDB$VALID_BLR field. However, other kinds of changes, such as the number of input or output parameters, called routines and so on, do not affect the validation field even though they potentially invalidate the module. A typical such scenario might be one of the following:

1. A procedure (B) is defined, that calls another procedure (A) and reads output parameters from it. In this case, a dependency is registered in RDB$DEPENDENCIES. Subsequently, the called procedure (A) is altered to change or remove one or more of those output parameters. The ALTER PROCEDURE A statement will fail with an error when commit is attempted.
2. A procedure (B) calls procedure A, supplying values for its input parameters. No dependency is registered in RDB$DEPENDENCIES. Subsequent modification of the input parameters in procedure A will be allowed. Failure will occur at run-

time, when B calls A with the mismatched input parameter set.

Other Notes

- For PSQL modules inherited from earlier Firebird versions (including a number of system triggers, even if the database was created under Firebird 2.1 or higher), `RDB$VALID_BLR` is NULL. This does not imply that their BLR is invalid.
- The *isql* commands `SHOW PROCEDURES` and `SHOW TRIGGERS` display an asterisk in the `RDB$VALID_BLR` column for any module for which the value is zero (i.e., invalid). However, `SHOW PROCEDURE <procname>` and `SHOW TRIGGER <trigname>`, which display individual PSQL modules, do not signal invalid BLR at all.

A Note on Equality

This note about equality and inequality operators applies everywhere in Firebird's SQL language.

The "=" operator, which is explicitly used in many conditions, only matches values to values. According to the SQL standard, `NULL` is not a value and hence two `NULL`s are neither equal nor unequal to one another. If you need `NULL`s to match each other in a condition, use the `IS NOT DISTINCT FROM` operator. This operator returns true if the operands have the same value *or* if they are both `NULL`.

```
select *
  from A join B
  on A.id is not distinct from B.code
```

Likewise, in cases where you want to test against `NULL` for a condition of *inequality*, use `IS DISTINCT FROM`, not "<>". If you want `NULL` to be considered different from any value and two `NULL`s to be considered equal:

```
select *
  from A join B
  on A.id is distinct from B.code
```

Appendix B: Exception Codes and Messages

This appendix includes:

- SQLSTATE Error Codes and Descriptions
- GDSCODE Error Codes, SQLCODEs and Descriptions

Custom Exceptions

Firebird DDL provides a simple syntax for creating custom exceptions for use in PSQL modules, with message text of up to 1,021 characters. For more information, see `CREATE EXCEPTION` in *DDL Statements* and, for usage, the statement `EXCEPTION` in *PSQL Statements*.

The Firebird `SQLCODE` error codes do not correlate with the standards-compliant `SQLSTATE` codes. `SQLCODE` has been used for many years and should be considered as deprecated now. Support for `SQLCODE` is likely to be dropped in a future version.

SQLSTATE Error Codes and Descriptions

This table provides the error codes and message texts for the `SQLSTATE` context variables.

The structure of an `SQLSTATE` error code is five characters comprising the SQL error class (2 characters) and the SQL subclass (3 characters).

Table 271. SQLSTATE Codes and Message Texts

SQLSTATE	Mapped Message
SQLCLASS 00 (Success)	
00000	Success
SQLCLASS 01 (Warning)	
01000	General warning
01001	Cursor operation conflict
01002	Disconnect error
01003	NULL value eliminated in set function
01004	String data, right-truncated
01005	Insufficient item descriptor areas
01006	Privilege not revoked
01007	Privilege not granted
01008	Implicit zero-bit padding
01100	Statement reset to unprepared
01101	Ongoing transaction has been committed

SQLSTATE	Mapped Message
01102	Ongoing transaction has been rolled back
SQLCLASS 02 (No Data)	
02000	No data found or no rows affected
SQLCLASS 07 (Dynamic SQL error)	
07000	Dynamic SQL error
07001	Wrong number of input parameters
07002	Wrong number of output parameters
07003	Cursor specification cannot be executed
07004	USING clause required for dynamic parameters
07005	Prepared statement not a cursor-specification
07006	Restricted data type attribute violation
07007	USING clause required for result fields
07008	Invalid descriptor count
07009	Invalid descriptor index
SQLCLASS 08 (Connection Exception)	
08001	Client unable to establish connection
08002	Connection name in use
08003	Connection does not exist
08004	Server rejected the connection
08006	Connection failure
08007	Transaction resolution unknown
SQLCLASS 0A (Feature Not Supported)	
0A000	Feature Not Supported
SQLCLASS 0B (Invalid Transaction Initiation)	
0B000	Invalid transaction initiation
SQLCLASS 0L (Invalid Grantor)	
0L000	Invalid grantor
SQLCLASS 0P (Invalid Role Specification)	
0P000	Invalid role specification
SQLCLASS 0U (Attempt to Assign to Non-Updatable Column)	
0U000	Attempt to assign to non-updatable column
SQLCLASS 0V (Attempt to Assign to Ordering Column)	
0V000	Attempt to assign to Ordering column

SQLSTATE	Mapped Message
SQLCLASS 20 (Case Not Found For Case Statement)	
20000	Case not found for case statement
SQLCLASS 21 (Cardinality Violation)	
21000	Cardinality violation
21S01	Insert value list does not match column list
21S02	Degree of derived table does not match column list
SQLCLASS 22 (Data Exception)	
22000	Data exception
22001	String data, right truncation
22002	Null value, no indicator parameter
22003	Numeric value out of range
22004	Null value not allowed
22005	Error in assignment
22006	Null value in field reference
22007	Invalid datetime format
22008	Datetime field overflow
22009	Invalid time zone displacement value
2200A	Null value in reference target
2200B	Escape character conflict
2200C	Invalid use of escape character
2200D	Invalid escape octet
2200E	Null value in array target
2200F	Zero-length character string
2200G	Most specific type mismatch
22010	Invalid indicator parameter value
22011	Substring error
22012	Division by zero
22014	Invalid update value
22015	Interval field overflow
22018	Invalid character value for cast
22019	Invalid escape character
2201B	Invalid regular expression
2201C	Null row not permitted in table

SQLSTATE	Mapped Message
22012	Division by zero
22020	Invalid limit value
22021	Character not in repertoire
22022	Indicator overflow
22023	Invalid parameter value
22024	Character string not properly terminated
22025	Invalid escape sequence
22026	String data, length mismatch
22027	Trim error
22028	Row already exists
2202D	Null instance used in mutator function
2202E	Array element error
2202F	Array data, right truncation
SQLCLASS 23 (Integrity Constraint Violation)	
23000	Integrity constraint violation
SQLCLASS 24 (Invalid Cursor State)	
24000	Invalid cursor state
24504	The cursor identified in the UPDATE, DELETE, SET, or GET statement is not positioned on a row
SQLCLASS 25 (Invalid Transaction State)	
25000	Invalid transaction state
25S01	Transaction state
25S02	Transaction is still active
25S03	Transaction is rolled back
SQLCLASS 26 (Invalid SQL Statement Name)	
26000	Invalid SQL statement name
SQLCLASS 27 (Triggered Data Change Violation)	
27000	Triggered data change violation
SQLCLASS 28 (Invalid Authorization Specification)	
28000	Invalid authorization specification
SQLCLASS 2B (Dependent Privilege Descriptors Still Exist)	
2B000	Dependent privilege descriptors still exist
SQLCLASS 2C (Invalid Character Set Name)	
2C000	Invalid character set name

SQLSTATE	Mapped Message
SQLCLASS 2D (Invalid Transaction Termination)	
2D000	Invalid transaction termination
SQLCLASS 2E (Invalid Connection Name)	
2E000	Invalid connection name
SQLCLASS 2F (SQL Routine Exception)	
2F000	SQL routine exception
2F002	Modifying SQL-data not permitted
2F003	Prohibited SQL-statement attempted
2F004	Reading SQL-data not permitted
2F005	Function executed no return statement
SQLCLASS 33 (Invalid SQL Descriptor Name)	
33000	Invalid SQL descriptor name
SQLCLASS 34 (Invalid Cursor Name)	
34000	Invalid cursor name
SQLCLASS 35 (Invalid Condition Number)	
35000	Invalid condition number
SQLCLASS 36 (Cursor Sensitivity Exception)	
36001	Request rejected
36002	Request failed
SQLCLASS 37 (Invalid Identifier)	
37000	Invalid identifier
37001	Identifier too long
SQLCLASS 38 (External Routine Exception)	
38000	External routine exception
SQLCLASS 39 (External Routine Invocation Exception)	
39000	External routine invocation exception
SQLCLASS 3B (Invalid Save Point)	
3B000	Invalid save point
SQLCLASS 3C (Ambiguous Cursor Name)	
3C000	Ambiguous cursor name
SQLCLASS 3D (Invalid Catalog Name)	
3D000	Invalid catalog name
3D001	Catalog name not found

SQLSTATE	Mapped Message
SQLCLASS 3F (Invalid Schema Name)	
3F000	Invalid schema name
SQLCLASS 40 (Transaction Rollback)	
40000	Ongoing transaction has been rolled back
40001	Serialization failure
40002	Transaction integrity constraint violation
40003	Statement completion unknown
SQLCLASS 42 (Syntax Error or Access Violation)	
42000	Syntax error or access violation
42702	Ambiguous column reference
42725	Ambiguous function reference
42818	The operands of an operator or function are not compatible
42S01	Base table or view already exists
42S02	Base table or view not found
42S11	Index already exists
42S12	Index not found
42S21	Column already exists
42S22	Column not found
SQLCLASS 44 (With Check Option Violation)	
44000	WITH CHECK OPTION Violation
SQLCLASS 45 (Unhandled User-defined Exception)	
45000	Unhandled user-defined exception
SQLCLASS 54 (Program Limit Exceeded)	
54000	Program limit exceeded
54001	Statement too complex
54011	Too many columns
54023	Too many arguments
SQLCLASS HY (CLI-specific Condition)	
HY000	CLI-specific condition
HY001	Memory allocation error
HY003	Invalid data type in application descriptor
HY004	Invalid data type
HY007	Associated statement is not prepared

SQLSTATE	Mapped Message
HY008	Operation canceled
HY009	Invalid use of null pointer
HY010	Function sequence error
HY011	Attribute cannot be set now
HY012	Invalid transaction operation code
HY013	Memory management error
HY014	Limit on the number of handles exceeded
HY015	No cursor name available
HY016	Cannot modify an implementation row descriptor
HY017	Invalid use of an automatically allocated descriptor handle
HY018	Server declined the cancellation request
HY019	Non-string data cannot be sent in pieces
HY020	Attempt to concatenate a null value
HY021	Inconsistent descriptor information
HY024	Invalid attribute value
HY055	Non-string data cannot be used with string routine
HY090	Invalid string length or buffer length
HY091	Invalid descriptor field identifier
HY092	Invalid attribute identifier
HY095	Invalid Function ID specified
HY096	Invalid information type
HY097	Column type out of range
HY098	Scope out of range
HY099	Nullable type out of range
HY100	Uniqueness option type out of range
HY101	Accuracy option type out of range
HY103	Invalid retrieval code
HY104	Invalid Length/Precision value
HY105	Invalid parameter type
HY106	Invalid fetch orientation
HY107	Row value out of range
HY109	Invalid cursor position
HY110	Invalid driver completion

SQLSTATE	Mapped Message
HY111	Invalid bookmark value
HYC00	Optional feature not implemented
HYT00	Timeout expired
HYT01	Connection timeout expired
SQLCLASS XX (Internal Error)	
XX000	Internal error
XX001	Data corrupted
XX002	Index corrupted

SQLCODE and GDSCODE Error Codes and Descriptions

The table provides the SQLCODE groupings, the numeric and symbolic values for the GDSCODE errors and the message texts.

`SQLCODE` has been used for many years and should be considered as deprecated now. Support for `SQLCODE` is likely to be dropped in a future version.

Table 272. SQLCODE and GDSCODE Error Codes and Message Texts

SQL-CODE	GDSCODE	Symbol	Message Text
501	335544802	dialect_reset_warning	Database dialect being changed from 3 to 1
304	335545266	truncate_warn	String truncated warning due to the following reason
304	335545267	truncate_monitor	Monitoring data does not fit into the field
304	335545268	truncate_context	Engine data does not fit into return value of system function
301	335544808	dtype_renamed	DATE data type is now called TIMESTAMP
301	336003076	dsql_dialect_warning_expr	Use of @1 expression that returns different results in dialect 1 and dialect 3
301	336003080	dsql_warning_number_ambiguous	WARNING: Numeric literal @1 is interpreted as a floating-point
301	336003081	dsql_warning_number_ambiguous 1	value in SQL dialect 1, but as an exact numeric value in SQL dialect 3.

SQL-CODE	GDSCODE	Symbol	Message Text
301	336003082	dsql_warn_precision_ambiguous	WARNING: NUMERIC and DECIMAL fields with precision 10 or greater are stored
301	336003083	dsql_warn_precision_ambiguous1	as approximate floating-point values in SQL dialect 1, but as 64-bit
301	336003084	dsql_warn_precision_ambiguous2	integers in SQL dialect 3.
300	335544807	sqlwarn	SQL warning code = @1
106	336068855	dyn_miss_priv_warning	Warning: @1 on @2 is not granted to @3.
101	335544366	segment	segment buffer length shorter than expected
100	335544338	from_no_match	no match for first value expression
100	335544354	no_record	invalid database key
100	335544367	segstr_eof	attempted retrieval of more segments than exist
0	335544875	bad_debug_format	Bad debug info format
0	335544931	montabexh	Monitoring table space exhausted
-84	335544554	nonsql_security_rel	object has non-SQL security class defined
-84	335544555	nonsql_security_fld	column has non-SQL security class defined
-84	335544668	dsql_procedure_use_err	procedure @1 does not return any values
-85	335544747	usrname_too_long	The username entered is too long. Maximum length is 31 bytes.
-85	335544748	password_too_long	The password specified is too long. Maximum length is 8 bytes.
-85	335544749	usrname_required	A username is required for this operation.
-85	335544750	password_required	A password is required for this operation
-85	335544751	bad_protocol	The network protocol specified is invalid
-85	335544752	dup_usrname_found	A duplicate user name was found in the security database
-85	335544753	usrname_not_found	The user name specified was not found in the security database

SQL-CODE	GDSCODE	Symbol	Message Text
-85	335544754	error_adding_sec_record	An error occurred while attempting to add the user.
-85	335544755	error_modifying_sec_record	An error occurred while attempting to modify the user record.
-85	335544756	error_deleting_sec_record	An error occurred while attempting to delete the user record.
-85	335544757	error_updating_sec_db	An error occurred while updating the security database.
-103	335544571	dsql_constant_err	Data type for constant unknown
-104	335544343	invalid_blr	invalid request BLR at offset @1
-104	335544390	syntaxerr	BLR syntax error: expected @1 at offset @2, encountered @3
-104	335544425	ctxinuse	context already in use (BLR error)
-104	335544426	ctxnotdef	context not defined (BLR error)
-104	335544429	badparnum	undefined parameter number
-104	335544440	bad_msg_vec	
-104	335544456	invalid_sdl	invalid slice description language at offset @1
-104	335544570	dsql_command_err	Invalid command
-104	335544579	dsql_internal_err	Internal error
-104	335544590	dsql_dup_option	Option specified more than once
-104	335544591	dsql_tran_err	Unknown transaction option
-104	335544592	dsql_invalid_array	Invalid array reference
-104	335544608	command_end_err	Unexpected end of command
-104	335544612	token_err	Token unknown
-104	335544634	dsql_token_unk_err	Token unknown - line @1, column @2
-104	335544709	dsql_agg_ref_err	Invalid aggregate reference
-104	335544714	invalid_array_id	invalid blob id
-104	335544730	cse_not_supported	Client/Server Express not supported in this release
-104	335544743	token_too_long	token size exceeds limit
-104	335544763	invalid_string_constant	a string constant is delimited by double quotes
-104	335544764	transitional_date	DATE must be changed to TIMESTAMP

SQL-CODE	GDSCODE	Symbol	Message Text
-104	335544796	sql_dialect_datatype_unsupport	Client SQL dialect @1 does not support reference to @2 datatype
-104	335544798	depend_on_uncommitted_rel	You created an indirect dependency on uncommitted metadata. You must roll back the current transaction.
-104	335544821	dsql_column_pos_err	Invalid column position used in the @1 clause
-104	335544822	dsql_agg_where_err	Cannot use an aggregate or window function in a WHERE clause, use HAVING (for aggregate only) instead
-104	335544823	dsql_agg_group_err	Cannot use an aggregate or window function in a GROUP BY clause
-104	335544824	dsql_agg_column_err	Invalid expression in the @1 (not contained in either an aggregate function or the GROUP BY clause)
-104	335544825	dsql_agg_having_err	Invalid expression in the @1 (neither an aggregate function nor a part of the GROUP BY clause)
-104	335544826	dsql_agg_nested_err	Nested aggregate and window functions are not allowed
-104	335544849	malformed_string	Malformed string
-104	335544851	command_end_err2	Unexpected end of command - line @1, column @2
-104	335544930	too_big_blr	BLR stream length @1 exceeds implementation limit @2
-104	335544980	internal_rejected_params	Incorrect parameters provided to internal function @1
-104	335545022	cannot_copy_stmt	Cannot copy statement @1
-104	335545023	invalid_boolean_usage	Invalid usage of boolean expression
-104	335545035	svc_no_stdin	No isc_info_svc_stdin in user request, but service thread requested stdin data
-104	335545037	svc_no_switches	All services except for getting server log require switches
-104	335545038	svc_bad_size	Size of stdin data is more than was requested from client
-104	335545039	no_crypt_plugin	Crypt plugin @1 failed to load
-104	335545040	cp_name_too_long	Length of crypt plugin name should not exceed @1 bytes

SQL-CODE	GDSCODE	Symbol	Message Text
-104	335545045	null_spb	NULL data with non-zero SPB length
-104	335545116	dsql_window_incompat_frames	If <window frame bound 1> specifies @1, then <window frame bound 2> shall not specify @2
-104	335545117	dsql_window_range_multi_key	RANGE based window with <expr> {PRECEDING | FOLLOWING} cannot have ORDER BY with more than one value
-104	335545118	dsql_window_range_inv_key_type	RANGE based window must have an ORDER BY key of numerical, date, time or timestamp types
-104	335545119	dsql_window_frame_value_inv_type	Window RANGE/ROWS PRECEDING/FOLLOWING value must be of a numerical type
-104	335545205	no_keyholder_plugin	Key holder plugin @1 failed to load
-104	336003075	dsql_transitional_numeric	Precision 10 to 18 changed from DOUBLE PRECISION in SQL dialect 1 to 64-bit scaled integer in SQL dialect 3
-104	336003077	sql_db_dialect_dtype_unsupport	Database SQL dialect @1 does not support reference to @2 datatype
-104	336003087	dsql_invalid_label	Label @1 @2 in the current scope
-104	336003088	dsql_datatypes_not_comparable	Datatypes @1are not comparable in expression @2
-104	336397215	dsql_max_sort_items	cannot sort on more than 255 items
-104	336397216	dsql_max_group_items	cannot group on more than 255 items
-104	336397217	dsql_conflicting_sort_field	Cannot include the same field (@1.@2) twice in the ORDER BY clause with conflicting sorting options
-104	336397218	dsql_derived_table_more_columns	column list from derived table @1 has more columns than the number of items in its SELECT statement
-104	336397219	dsql_derived_table_less_columns	column list from derived table @1 has less columns than the number of items in its SELECT statement
-104	336397220	dsql_derived_field_unnamed	no column name specified for column number @1 in derived table @2
-104	336397221	dsql_derived_field_dup_name	column @1 was specified multiple times for derived table @2

SQL-CODE	GDSCODE	Symbol	Message Text
-104	336397222	dsql_derived_alias_select	Internal dsql error: alias type expected by pass1_expand_select_node
-104	336397223	dsql_derived_alias_field	Internal dsql error: alias type expected by pass1_field
-104	336397224	dsql_auto_field_bad_pos	Internal dsql error: column position out of range in pass1_union_auto_cast
-104	336397225	dsql_cte_wrong_reference	Recursive CTE member (@1) can refer itself only in FROM clause
-104	336397226	dsql_cte_cycle	CTE '@1' has cyclic dependencies
-104	336397227	dsql_cte_outer_join	Recursive member of CTE can’t be member of an outer join
-104	336397228	dsql_cte_mult_references	Recursive member of CTE can’t reference itself more than once
-104	336397229	dsql_cte_not_a_union	Recursive CTE (@1) must be an UNION
-104	336397230	dsql_cte_nonrecurs_after_recurs	CTE '@1' defined non-recursive member after recursive
-104	336397231	dsql_cte_wrong_clause	Recursive member of CTE '@1' has @2 clause
-104	336397232	dsql_cte_union_all	Recursive members of CTE (@1) must be linked with another members via UNION ALL
-104	336397233	dsql_cte_miss_nonrecursive	Non-recursive member is missing in CTE '@1'
-104	336397234	dsql_cte_nested_with	WITH clause can’t be nested
-104	336397235	dsql_col_more_than_once_using	column @1 appears more than once in USING clause
-104	336397237	dsql_cte_not_used	CTE "@1" is not used in query
-104	336397238	dsql_col_more_than_once_view	column @1 appears more than once in ALTER VIEW
-104	336397257	dsql_max_distinct_items	Cannot have more than 255 items in DISTINCT / UNION DISTINCT list
-104	336397321	dsql_cte_recursive_aggregate	Recursive member of CTE cannot use aggregate or window function
-104	336397326	dsql_wlock_simple	WITH LOCK can be used only with a single physical table
-104	336397327	dsql_firstskip_rows	FIRST/SKIP cannot be used with OFFSET/FETCH or ROWS

SQL-CODE	GDSCODE	Symbol	Message Text
-104	336397328	dsql_wlock_aggregates	WITH LOCK cannot be used with aggregates
-104	336397329	dsql_wlock_conflict	WITH LOCK cannot be used with @1
-105	335544702	escape_invalid	Invalid ESCAPE sequence
-105	335544789	extract_input_mismatch	Specified EXTRACT part does not exist in input datatype
-105	335544884	invalid_similar_pattern	Invalid SIMILAR TO pattern
-150	335544360	read_only_rel	attempted update of read-only table
-150	335544362	read_only_view	cannot update read-only view @1
-150	335544446	non_updatable	not updatable
-150	335544546	constaint_on_view	Cannot define constraints on views
-151	335544359	read_only_field	attempted update of read-only column @1
-155	335544658	dsql_base_table	@1 is not a valid base table of the specified view
-157	335544598	specify_field_err	must specify column name for view select expression
-158	335544599	num_field_err	number of columns does not match select list
-162	335544685	no_dbkey	dbkey not available for multi-table views
-170	335544512	prcmismat	Input parameter mismatch for procedure @1
-170	335544619	extern_func_err	External functions cannot have more than 10 parameters
-170	335544850	prc_out_param_mismatch	Output parameter mismatch for procedure @1
-170	335545101	fun_param_mismatch	Input parameter mismatch for function @1
-171	335544439	funmismat	function @1 could not be matched
-171	335544458	invalid_dimension	column not array or invalid dimensions (expected @1, encountered @2)
-171	335544618	return_mode_err	Return mode by value not allowed for this data type
-171	335544873	array_max_dimensions	Array data type can use up to @1 dimensions

SQL-CODE	GDSCODE	Symbol	Message Text
-172	335544438	funnotdef	function @1 is not defined
-172	335544932	modnotfound	module name or entrypoint could not be found
-203	335544708	dyn_fld_ambiguous	Ambiguous column reference.
-204	335544463	gennotdef	generator @1 is not defined
-204	335544502	stream_not_defined	reference to invalid stream number
-204	335544509	charset_not_found	CHARACTER SET @1 is not defined
-204	335544511	prcnotdef	procedure @1 is not defined
-204	335544515	codnotdef	status code @1 unknown
-204	335544516	xcpnotdef	exception @1 not defined
-204	335544532	ref_cnstrnt_notfound	Name of Referential Constraint not defined in constraints table.
-204	335544551	grant_obj_notfound	could not find object for GRANT
-204	335544568	text_subtype	Implementation of text subtype @1 not located.
-204	335544573	dsql_datatype_err	Data type unknown
-204	335544580	dsql_relation_err	Table unknown
-204	335544581	dsql_procedure_err	Procedure unknown
-204	335544588	collation_not_found	COLLATION @1 for CHARACTER SET @2 is not defined
-204	335544589	collation_not_for_charset	COLLATION @1 is not valid for specified CHARACTER SET
-204	335544595	dsql_trigger_err	Trigger unknown
-204	335544620	alias_conflict_err	alias @1 conflicts with an alias in the same statement
-204	335544621	procedure_conflict_error	alias @1 conflicts with a procedure in the same statement
-204	335544622	relation_conflict_err	alias @1 conflicts with a table in the same statement
-204	335544635	dsql_no_relation_alias	there is no alias or table named @1 at this scope level
-204	335544636	indexname	there is no index @1 for table @2
-204	335544640	collation_requires_text	Invalid use of CHARACTER SET or COLLATE
-204	335544662	dsql_blob_type_unknown	BLOB SUB_TYPE @1 is not defined

SQL-CODE	GDSCODE	Symbol	Message Text
-204	335544759	bad_default_value	can not define a not null column with NULL as default value
-204	335544760	invalid_clause	invalid clause --- '@1'
-204	335544800	too_many_contexts	Too many Contexts of Relation/Procedure/Views. Maximum allowed is 256
-204	335544817	bad_limit_param	Invalid parameter to FETCH or FIRST. Only integers >= 0 are allowed.
-204	335544818	bad_skip_param	Invalid parameter to OFFSET or SKIP. Only integers >= 0 are allowed.
-204	335544837	bad_substring_offset	Invalid offset parameter @1 to SUBSTRING. Only positive integers are allowed.
-204	335544853	bad_substring_length	Invalid length parameter @1 to SUBSTRING. Negative integers are not allowed.
-204	335544854	charset_not_installed	CHARACTER SET @1 is not installed
-204	335544855	collation_not_installed	COLLATION @1 for CHARACTER SET @2 is not installed
-204	335544867	subtype_for_internal_use	Blob sub_types bigger than 1 (text) are for internal use only
-204	335545104	invalid_attachment_charset	CHARACTER SET @1 cannot be used as a attachment character set
-204	336003085	dsql_ambiguous_field_name	Ambiguous field name between @1 and @2
-205	335544396	fldnotdef	column @1 is not defined in table @2
-205	335544552	grant_fld_notfound	could not find column for GRANT
-205	335544883	fldnotdef2	column @1 is not defined in procedure @2
-206	335544578	dsql_field_err	Column unknown
-206	335544587	dsql_blob_err	Column is not a BLOB
-206	335544596	dsql_subselect_err	Subselect illegal in this context
-206	336397208	dsql_line_col_error	At line @1, column @2
-206	336397209	dsql_unknown_pos	At unknown line and column
-206	336397210	dsql_no_dup_name	Column @1 cannot be repeated in @2 statement
-208	335544617	order_by_err	invalid ORDER BY clause

SQL-CODE	GDSCODE	Symbol	Message Text
-219	335544395	relnotdef	table @1 is not defined
-219	335544872	domnotdef	domain @1 is not defined
-230	335544487	walw_err	WAL Writer error
-231	335544488	logh_small	Log file header of @1 too small
-232	335544489	logh_inv_version	Invalid version of log file @1
-233	335544490	logh_open_flag	Log file @1 not latest in the chain but open flag still set
-234	335544491	logh_open_flag2	Log file @1 not closed properly; database recovery may be required
-235	335544492	logh_diff_dbname	Database name in the log file @1 is different
-236	335544493	logf_unexpected_eof	Unexpected end of log file @1 at offset @2
-237	335544494	logr_incomplete	Incomplete log record at offset @1 in log file @2
-238	335544495	logr_header_small	Log record header too small at offset @1 in log file @2
-239	335544496	logb_small	Log block too small at offset @1 in log file @2
-239	335544691	cache_too_small	Insufficient memory to allocate page buffer cache
-239	335544693	log_too_small	Log size too small
-239	335544694	partition_too_small	Log partition size too small
-240	335544497	wal_illegal_attach	Illegal attempt to attach to an uninitialized WAL segment for @1
-241	335544498	wal_invalid_wpb	Invalid WAL parameter block option @1
-242	335544499	wal_err_rollover	Cannot roll over to the next log file @1
-243	335544500	no_wal	database does not use Write-ahead Log
-244	335544503	wal_subsys_error	WAL subsystem encountered error
-245	335544504	wal_subsys_corrupt	WAL subsystem corrupted
-246	335544513	wal_bugcheck	Database @1: WAL subsystem bug for pid @2 @3
-247	335544514	wal_cant_expand	Could not expand the WAL segment for database @1
-248	335544521	wal_err_rollover2	Unable to roll over please see Firebird log.

SQL-CODE	GDSCODE	Symbol	Message Text
-249	335544522	wal_err_logwrite	WAL I/O error. Please see Firebird log.
-250	335544523	wal_err_jrn_comm	WAL writer - Journal server communication error. Please see Firebird log.
-251	335544524	wal_err_expansion	WAL buffers cannot be increased. Please see Firebird log.
-252	335544525	wal_err_setup	WAL setup error. Please see Firebird log.
-253	335544526	wal_err_ww_sync	obsolete
-254	335544527	wal_err_ww_start	Cannot start WAL writer for the database @1
-255	335544556	wal_cache_err	Write-ahead Log without shared cache configuration not allowed
-257	335544566	start_cm_for_wal	WAL defined; Cache Manager must be started first
-258	335544567	wal_ovflow_log_required	Overflow log specification required for round-robin log
-259	335544629	wal_shadow_err	Write-ahead Log with shadowing configuration not allowed
-260	335544690	cache_redef	Cache redefined
-260	335544692	log_redef	Log redefined
-261	335544695	partition_not_supp	Partitions not supported in series of log file specification
-261	335544696	log_length_spec	Total length of a partitioned log must be specified
-281	335544637	no_stream_plan	table @1 is not referenced in plan
-282	335544638	stream_twice	table @1 is referenced more than once in plan; use aliases to distinguish
-282	335544643	dsql_self_join	the table @1 is referenced twice; use aliases to differentiate
-282	335544659	duplicate_base_table	table @1 is referenced twice in view; use an alias to distinguish
-282	335544660	view_alias	view @1 has more than one base table; use aliases to distinguish
-282	335544710	complex_view	navigational stream @1 references a view with more than one base table

SQL-CODE	GDSCODE	Symbol	Message Text
-283	335544639	stream_not_found	table @1 is referenced in the plan but not the from list
-284	335544642	index_unused	index @1 cannot be used in the specified plan
-291	335544531	primary_key_notnull	Column used in a PRIMARY constraint must be NOT NULL.
-291	335545103	domain_primary_key_notnull	Domain used in the PRIMARY KEY constraint of table @1 must be NOT NULL
-292	335544534	ref_cnstrnt_update	Cannot update constraints (RDB$REF_CONSTRAINTS).
-293	335544535	check_cnstrnt_update	Cannot update constraints (RDB$CHECK_CONSTRAINTS).
-294	335544536	check_cnstrnt_del	Cannot delete CHECK constraint entry (RDB$CHECK_CONSTRAINTS)
-295	335544545	rel_cnstrnt_update	Cannot update constraints (RDB$RELATION_CONSTRAINTS).
-296	335544547	invld_cnstrnt_type	internal Firebird consistency check (invalid RDB$CONSTRAINT_TYPE)
-297	335544558	check_constraint	Operation violates CHECK constraint @1 on view or table @2
-313	335544669	dsql_count_mismatch	count of column list and variable list do not match
-313	336003099	upd_ins_doesnt_match_pk	UPDATE OR INSERT field list does not match primary key of table @1
-313	336003100	upd_ins_doesnt_match_matching	UPDATE OR INSERT field list does not match MATCHING clause
-313	336003111	dsql_wrong_param_num	Wrong number of parameters (expected @1, got @2)
-313	336003113	upd_ins_cannot_default	UPDATE OR INSERT value for field @1, part of the implicit or explicit MATCHING clause, cannot be DEFAULT
-314	335544565	transliteration_failed	Cannot transliterate character between character sets
-315	336068815	dyn_dtype_invalid	Cannot change datatype for column @1. Changing datatype is not supported for BLOB or ARRAY columns.

SQL-CODE	GDSCODE	Symbol	Message Text
-383	336068814	dyn_dependency_exists	Column @1 from table @2 is referenced in @3
-401	335544647	invalid_operator	invalid comparison operator for find operation
-402	335544368	segstr_no_op	attempted invalid operation on a BLOB
-402	335544414	blobnotsup	BLOB and array data types are not supported for @1 operation
-402	335544427	datnotsup	data operation not supported
-402	335545262	cannot_update_old_blob	cannot update old BLOB
-402	335545263	cannot_read_new_blob	cannot read from new BLOB
-406	335544457	out_of_bounds	subscript out of bounds
-406	335545028	ss_out_of_bounds	Subscript @1 out of bounds [@2, @3]
-407	335544435	nullsegkey	null segment of UNIQUE KEY
-413	335544334	convert_error	conversion error from string "@1"
-413	335544454	nofilter	filter not found to convert type @1 to type @2
-413	335544860	blob_convert_error	Unsupported conversion to target type BLOB (subtype @1)
-413	335544861	array_convert_error	Unsupported conversion to target type ARRAY
-501	335544577	dsql_cursor_close_err	Attempt to reclose a closed cursor
-502	335544574	dsql_decl_err	Invalid cursor declaration
-502	335544576	dsql_cursor_open_err	Attempt to reopen an open cursor
-502	336003090	dsql_cursor_redefined	Statement already has a cursor @1 assigned
-502	336003091	dsql_cursor_not_found	Cursor @1 is not found in the current context
-502	336003092	dsql_cursor_exists	Cursor @1 already exists in the current context
-502	336003093	dsql_cursor_rel_ambiguous	Relation @1 is ambiguous in cursor @2
-502	336003094	dsql_cursor_rel_not_found	Relation @1 is not found in cursor @2
-502	336003095	dsql_cursor_not_open	Cursor is not open
-504	335544572	dsql_cursor_err	Invalid cursor reference
-504	336003089	dsql_cursor_invalid	Empty cursor name is not allowed
-508	335544348	no_cur_rec	no current record for fetch operation

SQL-CODE	GDSCODE	Symbol	Message Text
-510	335544575	dsql_cursor_update_err	Cursor @1 is not updatable
-518	335544582	dsql_request_err	Request unknown
-519	335544688	dsql_open_cursor_request	The prepare statement identifies a prepare statement with an open cursor
-530	335544466	foreign_key	violation of FOREIGN KEY constraint "@1" on table "@2"
-530	335544838	foreign_key_target_doesnt_exist	Foreign key reference target does not exist
-530	335544839	foreign_key_references_present	Foreign key references are present for the record
-531	335544597	dsql_crdb_prepare_err	Cannot prepare a CREATE DATABASE/SCHEMA statement
-532	335544469	trans_invalid	transaction marked invalid and cannot be committed
-532	335545002	attachment_in_use	Attachment is in use
-532	335545003	transaction_in_use	Transaction is in use
-532	335545017	async_active	Asynchronous call is already running for this attachment
-551	335544352	no_priv	no permission for @1 access to @2 @3
-551	335544790	insufficient_svc_privileges	Service @1 requires SYSDBA permissions. Reattach to the Service Manager using the SYSDBA account.
-551	335545033	trunc_limits	expected length @1, actual @2
-551	335545034	info_access	Wrong info requested in isc_svc_query() for anonymous service
-551	335545036	svc_start_failed	Start request for anonymous service is impossible
-551	335545254	effective_user	Effective user is @1
-552	335544550	not_rel_owner	only the owner of a table may reassign ownership
-552	335544553	grant_nopriv	user does not have GRANT privileges for operation
-552	335544707	grant_nopriv_on_base	user does not have GRANT privileges on base table/view for operation
-552	335545058	protect_ownership	Only the owner can change the ownership
-553	335544529	existing_priv_mod	cannot modify an existing user privilege

SQL-CODE	GDSCODE	Symbol	Message Text
-595	335544645	stream_crack	the current position is on a crack
-596	335544374	stream_eof	attempt to fetch past the last record in a record stream
-596	335544644	stream_bof	attempt to fetch before the first record in a record stream
-596	335545092	cursor_not_positioned	Cursor @1 is not positioned in a valid record
-597	335544632	dsql_file_length_err	Preceding file did not specify length, so @1 must include starting page number
-598	335544633	dsql_shadow_number_err	Shadow number must be a positive integer
-599	335544607	node_err	gen.c: node not supported
-599	335544625	node_name_err	A node name is not permitted in a secondary, shadow, cache or log file name
-600	335544680	crrp_data_err	sort error: corruption in data structure
-601	335544646	db_or_file_exists	database or file exists
-604	335544593	dsql_max_arr_dim_exceeded	Array declared with too many dimensions
-604	335544594	dsql_arr_range_error	Illegal array dimension range
-605	335544682	dsql_field_ref	Inappropriate self-reference of column
-607	335544351	no_meta_update	unsuccessful metadata update
-607	335544549	systrig_update	cannot modify or erase a system trigger
-607	335544657	dsql_no_blob_array	Array/BLOB/DATE data types not allowed in arithmetic
-607	335544746	reftable_requires_pk	"REFERENCES table" without "(column)" requires PRIMARY KEY on referenced table
-607	335544815	generator_name	GENERATOR @1
-607	335544816	udf_name	Function @1
-607	335544858	must_have_phys_field	Can’t have relation with only computed fields or constraints
-607	336003074	dsql_dbkey_from_non_table	Cannot SELECT RDB$DB_KEY from a stored procedure.
-607	336003086	dsql_udf_return_pos_err	External function should have return position between 1 and @1

SQL-CODE	GDSCODE	Symbol	Message Text
-607	336003096	dsql_type_not_supp_ext_tab	Data type @1 is not supported for EXTERNAL TABLES. Relation '@2', field '@3'
-607	336003104	dsql_record_version_table	To be used with RDB$RECORD_VERSION, @1 must be a table or a view of single table
-607	336068845	dyn_cannot_del_syscoll	Cannot delete system collation
-607	336068866	dyn_cannot_mod_sysproc	Cannot ALTER or DROP system procedure @1
-607	336068867	dyn_cannot_mod_systrig	Cannot ALTER or DROP system trigger @1
-607	336068868	dyn_cannot_mod_sysfunc	Cannot ALTER or DROP system function @1
-607	336068869	dyn_invalid_ddl_proc	Invalid DDL statement for procedure @1
-607	336068870	dyn_invalid_ddl_trig	Invalid DDL statement for trigger @1
-607	336068878	dyn_invalid_ddl_func	Invalid DDL statement for function @1
-607	336397206	dsql_table_not_found	Table @1 does not exist
-607	336397207	dsql_view_not_found	View @1 does not exist
-607	336397212	dsql_no_array_computed	Array and BLOB data types not allowed in computed field
-607	336397214	dsql_only_can_subscript_array	scalar operator used on field @1 which is not an array
-612	336068812	dyn_domain_name_exists	Cannot rename domain @1 to @2. A domain with that name already exists.
-612	336068813	dyn_field_name_exists	Cannot rename column @1 to @2. A column with that name already exists in table @3.
-615	335544475	relation_lock	lock on table @1 conflicts with existing lock
-615	335544476	record_lock	requested record lock conflicts with existing lock
-615	335544501	drop_wal	cannot drop log file when journaling is enabled
-615	335544507	range_in_use	refresh range number @1 already in use
-616	335544530	primary_key_ref	Cannot delete PRIMARY KEY being used in FOREIGN KEY definition.

SQL-CODE	GDSCODE	Symbol	Message Text
-616	335544539	integ_index_del	Cannot delete index used by an Integrity Constraint
-616	335544540	integ_index_mod	Cannot modify index used by an Integrity Constraint
-616	335544541	check_trig_del	Cannot delete trigger used by a CHECK Constraint
-616	335544543	cnstrnt_fld_del	Cannot delete column being used in an Integrity Constraint.
-616	335544630	dependency	there are @1 dependencies
-616	335544674	del_last_field	last column in a table cannot be deleted
-616	335544728	integ_index_deactivate	Cannot deactivate index used by an integrity constraint
-616	335544729	integ_deactivate_primary	Cannot deactivate index used by a PRIMARY/UNIQUE constraint
-617	335544542	check_trig_update	Cannot update trigger used by a CHECK Constraint
-617	335544544	cnstrnt_fld_rename	Cannot rename column being used in an Integrity Constraint.
-618	335544537	integ_index_seg_del	Cannot delete index segment used by an Integrity Constraint
-618	335544538	integ_index_seg_mod	Cannot update index segment used by an Integrity Constraint
-625	335544347	not_valid	validation error for column @1, value "@2"
-625	335544879	not_valid_for_var	validation error for variable @1, value "@2"
-625	335544880	not_valid_for	validation error for @1, value "@2"
-637	335544664	dsql_duplicate_spec	duplicate specification of @1 - not supported
-637	336397213	dsql_implicit_domain_name	Implicit domain name @1 not allowed in user created domain
-660	335544533	foreign_key_notfound	Non-existent PRIMARY or UNIQUE KEY specified for FOREIGN KEY.
-660	335544628	idx_create_err	cannot create index @1
-660	336003098	primary_key_required	Primary key required on table @1
-663	335544624	idx_seg_err	segment count of 0 defined for index @1
-663	335544631	idx_key_err	too many keys defined for index @1

SQL-CODE	GDSCODE	Symbol	Message Text
-663	335544672	key_field_err	too few key columns found for index @1 (incorrect column name?)
-664	335544434	keytoobig	key size exceeds implementation restriction for index "@1"
-677	335544445	ext_err	@1 extension error
-685	335544465	bad_segstr_type	invalid BLOB type for operation
-685	335544670	blob_idx_err	attempt to index BLOB column in index @1
-685	335544671	array_idx_err	attempt to index array column in index @1
-689	335544403	badpagtyp	page @1 is of wrong type (expected @2, found @3)
-689	335544650	page_type_err	wrong page type
-690	335544679	no_segments_err	segments not allowed in expression index @1
-691	335544681	rec_size_err	new record size of @1 bytes is too big
-692	335544477	max_idx	maximum indexes per table (@1) exceeded
-693	335544663	req_max_clones_exceeded	Too many concurrent executions of the same request
-694	335544684	no_field_access	cannot access column @1 in view @2
-802	335544321	arith_except	arithmetic exception, numeric overflow, or string truncation
-802	335544836	concat_overflow	Concatenation overflow. Resulting string cannot exceed 32765 bytes in length.
-802	335544914	string_truncation	string right truncation
-802	335544915	blob_truncation	blob truncation when converting to a string: length limit exceeded
-802	335544916	numeric_out_of_range	numeric value is out of range
-802	336003105	dsql_invalid_sqlda_version	SQLDA version expected between @1 and @2, found @3
-802	336003106	dsql_sqlvar_index	at SQLVAR index @1
-802	336003107	dsql_no_sqlind	empty pointer to NULL indicator variable
-802	336003108	dsql_no_sqldata	empty pointer to data

SQL-CODE	GDSCODE	Symbol	Message Text
-802	336003109	dsql_no_input_sqlda	No SQLDA for input values provided
-802	336003110	dsql_no_output_sqlda	No SQLDA for output values provided
-803	335544349	no_dup	attempt to store duplicate value (visible to active transactions) in unique index "@1"
-803	335544665	unique_key_violation	violation of PRIMARY or UNIQUE KEY constraint "@1" on table "@2"
-804	335544380	wronumarg	wrong number of arguments on call
-804	335544583	dsql_sqlda_err	SQLDA error
-804	335544584	dsql_var_count_err	Count of read-write columns does not equal count of values
-804	335544586	dsql_function_err	Function unknown
-804	335544713	dsql_sqlda_value_err	Incorrect values within SQLDA structure
-804	335545050	wrong_message_length	Message length passed from user application does not match set of columns
-804	335545051	no_output_format	Resultset is missing output format information
-804	335545052	item_finish	Message metadata not ready - item @1 is not finished
-804	335545100	interface_version_too_old	Interface @3 version too old: expected @1, found @2
-804	336003097	dsql_feature_not_supported_ods	Feature not supported on ODS version older than @1.@2
-804	336397205	dsql_too_old_ods	ODS versions before ODS@1 are not supported
-806	335544600	col_name_err	Only simple column names permitted for VIEW WITH CHECK OPTION
-807	335544601	where_err	No WHERE clause for VIEW WITH CHECK OPTION
-808	335544602	table_view_err	Only one table allowed for VIEW WITH CHECK OPTION
-809	335544603	distinct_err	DISTINCT, GROUP or HAVING not permitted for VIEW WITH CHECK OPTION
-810	335544605	subquery_err	No subqueries permitted for VIEW WITH CHECK OPTION

SQL-CODE	GDSCODE	Symbol	Message Text
-811	335544652	sing_select_err	multiple rows in singleton select
-811	335545269	merge_dup_update	Multiple source records cannot match the same target during MERGE
-816	335544651	ext_readonly_err	Cannot insert because the file is readonly or is on a read only medium.
-816	335544715	extfile_uns_op	Operation not supported for EXTERNAL FILE table @1
-817	335544361	read_only_trans	attempted update during read-only transaction
-817	335544371	segstr_no_write	attempted write to read-only BLOB
-817	335544444	read_only	operation not supported
-817	335544765	read_only_database	attempted update on read-only database
-817	335544766	must_be_dialect_2_and_up	SQL dialect @1 is not supported in this database
-817	335544793	ddl_not_allowed_by_db_sql_dial	Metadata update statement is not allowed by the current database SQL dialect @1
-817	336003079	sql_dialect_conflict_num	DB dialect @1 and client dialect @2 conflict with respect to numeric precision @3.
-817	336003101	upd_ins_with_complex_view	UPDATE OR INSERT without MATCHING could not be used with views based on more than one table
-817	336003102	dsql_incompatible_trigger_type	Incompatible trigger type
-817	336003103	dsql_db_trigger_type_cant_change	Database trigger type can’t be changed
-817	336003112	dsql_invalid_drop_ss_clause	Invalid DROP SQL SECURITY clause
-820	335544356	obsolete_metadata	metadata is obsolete
-820	335544379	wrong_ods	unsupported on-disk structure for file @1; found @2.@3, support @4.@5
-820	335544437	wrodynver	wrong DYN version
-820	335544467	high_minor	minor version too high found @1 expected @2
-820	335544881	need_difference	Difference file name should be set explicitly for database on raw device
-823	335544473	invalid_bookmark	invalid bookmark handle
-824	335544474	bad_lock_level	invalid lock level @1

SQL-CODE	GDSCODE	Symbol	Message Text
-825	335544519	bad_lock_handle	invalid lock handle
-826	335544585	dsql_stmt_handle	Invalid statement handle
-827	335544655	invalid_direction	invalid direction for find operation
-827	335544718	invalid_key	Invalid key for find operation
-828	335544678	inval_key_posn	invalid key position
-829	335544616	field_ref_err	invalid column reference
-829	336068816	dyn_char_fld_too_small	New size specified for column @1 must be at least @2 characters.
-829	336068817	dyn_invalid_dtype_conversion	Cannot change datatype for @1. Conversion from base type @2 to @3 is not supported.
-829	336068818	dyn_dtype_conv_invalid	Cannot change datatype for column @1 from a character type to a non-character type.
-829	336068829	max_coll_per_charset	Maximum number of collations per character set exceeded
-829	336068830	invalid_coll_attr	Invalid collation attributes
-829	336068852	dyn_scale_too_big	New scale specified for column @1 must be at most @2.
-829	336068853	dyn_precision_too_small	New precision specified for column @1 must be at least @2.
-829	336068857	dyn_cannot_addrem_computed	Cannot add or remove COMPUTED from column @1
-830	335544615	field_aggregate_err	column used with aggregate
-831	335544548	primary_key_exists	Attempt to define a second PRIMARY KEY for the same table
-832	335544604	key_field_count_err	FOREIGN KEY column count does not match PRIMARY KEY
-833	335544606	expression_eval_err	expression evaluation not supported
-833	335544810	date_range_exceeded	value exceeds the range for valid dates
-833	335544912	time_range_exceeded	value exceeds the range for a valid time
-833	335544913	datetime_range_exceeded	value exceeds the range for valid timestamps
-833	335544937	invalid_type_datetime_op	Invalid data type in DATE/TIME/TIMESTAMP addition or subtraction in add_datettime()

SQL-CODE	GDSCODE	Symbol	Message Text
-833	335544938	onlycan_add_timetodate	Only a TIME value can be added to a DATE value
-833	335544939	onlycan_add_datetotime	Only a DATE value can be added to a TIME value
-833	335544940	onlycansub_tstampfromtstamp	TIMESTAMP values can be subtracted only from another TIMESTAMP value
-833	335544941	onlyoneop_mustbe_tstamp	Only one operand can be of type TIMESTAMP
-833	335544942	invalid_extractpart_time	Only HOUR, MINUTE, SECOND and MILLISECOND can be extracted from TIME values
-833	335544943	invalid_extractpart_date	HOUR, MINUTE, SECOND and MILLISECOND cannot be extracted from DATE values
-833	335544944	invalidarg_extract	Invalid argument for EXTRACT() not being of DATE/TIME/TIMESTAMP type
-833	335544945	sysf_argmustbe_exact	Arguments for @1 must be integral types or NUMERIC/DECIMAL without scale
-833	335544946	sysf_argmustbe_exact_or_fp	First argument for @1 must be integral type or floating point type
-833	335544947	sysf_argviolates_uuidtype	Human readable UUID argument for @1 must be of string type
-833	335544948	sysf_argviolates_uuidlen	Human readable UUID argument for @2 must be of exact length @1
-833	335544949	sysf_argviolates_uuidfmt	Human readable UUID argument for @3 must have "-" at position @2 instead of "@1"
-833	335544950	sysf_argviolates_guidigits	Human readable UUID argument for @3 must have hex digit at position @2 instead of "@1"
-833	335544951	sysf_invalid_addpart_time	Only HOUR, MINUTE, SECOND and MILLISECOND can be added to TIME values in @1
-833	335544952	sysf_invalid_add_datetime	Invalid data type in addition of part to DATE/TIME/TIMESTAMP in @1
-833	335544953	sysf_invalid_addpart_dtime	Invalid part @1 to be added to a DATE/TIME/TIMESTAMP value in @2

SQL-CODE	GDSCODE	Symbol	Message Text
-833	335544954	sysf_invalid_add_dtime_rc	Expected DATE/TIME/TIMESTAMP type in evlDateAdd() result
-833	335544955	sysf_invalid_diff_dtime	Expected DATE/TIME/TIMESTAMP type as first and second argument to @1
-833	335544956	sysf_invalid_timediff	The result of TIME-<value> in @1 cannot be expressed in YEAR, MONTH, DAY or WEEK
-833	335544957	sysf_invalid_tstamptimediff	The result of TIME-TIMESTAMP or TIMESTAMP-TIME in @1 cannot be expressed in HOUR, MINUTE, SECOND or MILLISECOND
-833	335544958	sysf_invalid_datetimediff	The result of DATE-TIME or TIME-DATE in @1 cannot be expressed in HOUR, MINUTE, SECOND and MILLISECOND
-833	335544959	sysf_invalid_diffpart	Invalid part @1 to express the difference between two DATE/TIME/TIMESTAMP values in @2
-833	335544960	sysf_argmustbe_positive	Argument for @1 must be positive
-833	335544961	sysf_basemustbe_positive	Base for @1 must be positive
-833	335544962	sysf_argnmustbe_nonneg	Argument #@1 for @2 must be zero or positive
-833	335544963	sysf_argnmustbe_positive	Argument #@1 for @2 must be positive
-833	335544964	sysf_invalid_zeropowneg	Base for @1 cannot be zero if exponent is negative
-833	335544965	sysf_invalid_negpowfp	Base for @1 cannot be negative if exponent is not an integral value
-833	335544966	sysf_invalid_scale	The numeric scale must be between -128 and 127 in @1
-833	335544967	sysf_argmustbe_nonneg	Argument for @1 must be zero or positive
-833	335544968	sysf_binuuid_mustbe_str	Binary UUID argument for @1 must be of string type
-833	335544969	sysf_binuuid_wrongsize	Binary UUID argument for @2 must use @1 bytes
-833	335544976	sysf_argmustbe_nonzero	Argument for @1 must be different than zero
-833	335544977	sysf_argmustbe_range_inc1_1	Argument for @1 must be in the range [-1, 1]

SQL-CODE	GDSCODE	Symbol	Message Text
-833	335544978	sysf_argmustbe_gteq_one	Argument for @1 must be greater or equal than one
-833	335544979	sysf_argmustbe_range_exc1_1	Argument for @1 must be in the range]-1, 1[
-833	335544981	sysf_fp_overflow	Floating point overflow in built-in function @1
-833	335545009	sysf_invalid_trig_namespace	Invalid usage of context namespace DDL_TRIGGER
-833	335545024	sysf_argscant_both_be_zero	Arguments for @1 cannot both be zero
-833	335545046	max_args_exceeded	Maximum (@1) number of arguments exceeded for function @2
-833	335545120	window_frame_value_invalid	Invalid PRECEDING or FOLLOWING offset in window function: cannot be negative
-833	335545121	dsql_window_not_found	Window @1 not found
-833	335545122	dsql_window_cant_overr_part	Cannot use PARTITION BY clause while overriding the window @1
-833	335545123	dsql_window_cant_overr_order	Cannot use ORDER BY clause while overriding the window @1 which already has an ORDER BY clause
-833	335545124	dsql_window_cant_overr_frame	Cannot override the window @1 because it has a frame clause. Tip: it can be used without parenthesis in OVER
-833	335545125	dsql_window_duplicate	Duplicate window definition for @1
-833	335545156	sysf_invalid_first_last_part	Invalid part @1 to calculate the @1 of a DATE/TIMESTAMP
-833	335545157	sysf_invalid_date_timestamp	Expected DATE/TIMESTAMP value in @1
-833	336397240	dsql_eval_unknode	Unknown node type @1 in dsql/GEN_expr
-833	336397241	dsql_agg_wrongarg	Argument for @1 in dialect 1 must be string or numeric
-833	336397242	dsql_agg2_wrongarg	Argument for @1 in dialect 3 must be numeric
-833	336397243	dsql_nodateortime_pm_string	Strings cannot be added to or subtracted from DATE or TIME types
-833	336397244	dsql_invalid_datetime_subtract	Invalid data type for subtraction involving DATE, TIME or TIMESTAMP types

SQL-CODE	GDSCODE	Symbol	Message Text
-833	336397245	dsql_invalid_dateortime_add	Adding two DATE values or two TIME values is not allowed
-833	336397246	dsql_invalid_type_minus_date	DATE value cannot be subtracted from the provided data type
-833	336397247	dsql_nostring_addsub_dial3	Strings cannot be added or subtracted in dialect 3
-833	336397248	dsql_invalid_type_addsub_dial3	Invalid data type for addition or subtraction in dialect 3
-833	336397249	dsql_invalid_type_multip_dial1	Invalid data type for multiplication in dialect 1
-833	336397250	dsql_nostring_multip_dial3	Strings cannot be multiplied in dialect 3
-833	336397251	dsql_invalid_type_multip_dial3	Invalid data type for multiplication in dialect 3
-833	336397252	dsql_mustuse_numeric_div_dial1	Division in dialect 1 must be between numeric data types
-833	336397253	dsql_nostring_div_dial3	Strings cannot be divided in dialect 3
-833	336397254	dsql_invalid_type_div_dial3	Invalid data type for division in dialect 3
-833	336397255	dsql_nostring_neg_dial3	Strings cannot be negated (applied the minus operator) in dialect 3
-833	336397256	dsql_invalid_type_neg	Invalid data type for negation (minus operator)
-834	335544508	range_not_found	refresh range number @1 not found
-835	335544649	bad_checksum	bad checksum
-836	335544517	except	exception @1
-836	335544848	except2	exception @1
-836	335545016	formatted_exception	@1
-837	335544518	cache_restart	restart shared cache manager
-838	335544560	shutwarn	database @1 shutdown in @2 seconds
-839	335544686	jrn_format_err	journal file wrong format
-840	335544687	jrn_file_full	intermediate journal file full
-841	335544677	version_err	too many versions
-842	335544697	precision_err	Precision must be from 1 to 18
-842	335544698	scale_nogt	Scale must be between zero and precision
-842	335544699	expec_short	Short integer expected

SQL-CODE	GDSCODE	Symbol	Message Text
-842	335544700	expec_long	Long integer expected
-842	335544701	expec_ushort	Unsigned short integer expected
-842	335544712	expec_positive	Positive value expected
-842	335545138	decprecision_err	DecFloat precision must be 16 or 34
-842	335545158	precision_err2	Precision must be from @1 to @2
-901	335544322	bad_dbkey	invalid database key
-901	335544326	bad_dpb_form	unrecognized database parameter block
-901	335544327	bad_req_handle	invalid request handle
-901	335544328	bad_segstr_handle	invalid BLOB handle
-901	335544329	bad_segstr_id	invalid BLOB ID
-901	335544330	bad_tpb_content	invalid parameter in transaction parameter block
-901	335544331	bad_tpb_form	invalid format for transaction parameter block
-901	335544332	bad_trans_handle	invalid transaction handle (expecting explicit transaction start)
-901	335544337	excess_trans	attempt to start more than @1 transactions
-901	335544339	infinap	information type inappropriate for object specified
-901	335544340	infona	no information of this type available for object specified
-901	335544341	infunk	unknown information item
-901	335544342	integ_fail	action cancelled by trigger (@1) to preserve data integrity
-901	335544345	lock_conflict	lock conflict on no wait transaction
-901	335544350	no_finish	program attempted to exit without finishing database
-901	335544353	no_recon	transaction is not in limbo
-901	335544355	no_segstr_close	BLOB was not closed
-901	335544357	open_trans	cannot disconnect database with open transactions (@1 active)
-901	335544358	port_len	message length error (encountered @1, expected @2)
-901	335544363	req_no_trans	no transaction for request

SQL-CODE	GDSCODE	Symbol	Message Text
-901	335544364	req_sync	request synchronization error
-901	335544365	req_wrong_db	request referenced an unavailable database
-901	335544369	segstr_no_read	attempted read of a new, open BLOB
-901	335544370	segstr_no_trans	attempted action on BLOB outside transaction
-901	335544372	segstr_wrong_db	attempted reference to BLOB in unavailable database
-901	335544376	unres_rel	table @1 was omitted from the transaction reserving list
-901	335544377	uns_ext	request includes a DSRI extension not supported in this implementation
-901	335544378	wish_list	feature is not supported
-901	335544382	random	@1
-901	335544383	fatal_conflict	unrecoverable conflict with limbo transaction @1
-901	335544392	bdbincon	internal error
-901	335544407	dbbnotzer	database handle not zero
-901	335544408	tranotzer	transaction handle not zero
-901	335544418	trainlim	transaction in limbo
-901	335544419	notinlim	transaction not in limbo
-901	335544420	traoutsta	transaction outstanding
-901	335544428	badmsgnum	undefined message number
-901	335544431	blocking_signal	blocking signal has been received
-901	335544442	noargacc_read	database system cannot read argument @1
-901	335544443	noargacc_write	database system cannot write argument @1
-901	335544450	misc_interpreted	@1
-901	335544468	tra_state	transaction @1 is @2
-901	335544485	bad_stmt_handle	invalid statement handle
-901	335544510	lock_timeout	lock time-out on wait transaction
-901	335544559	bad_svc_handle	invalid service handle
-901	335544561	wrospbver	wrong version of service parameter block

SQL-CODE	GDSCODE	Symbol	Message Text
-901	335544562	bad_spb_form	unrecognized service parameter block
-901	335544563	svcnotdef	service @1 is not defined
-901	335544609	index_name	INDEX @1
-901	335544610	exception_name	EXCEPTION @1
-901	335544611	field_name	COLUMN @1
-901	335544613	union_err	union not supported
-901	335544614	dsql_construct_err	Unsupported DSQL construct
-901	335544623	dsql_domain_err	Illegal use of keyword VALUE
-901	335544626	table_name	TABLE @1
-901	335544627	proc_name	PROCEDURE @1
-901	335544641	dsql_domain_not_found	Specified domain or source column @1 does not exist
-901	335544656	dsql_var_conflict	variable @1 conflicts with parameter in same procedure
-901	335544666	srvr_version_too_old	server version too old to support all CREATE DATABASE options
-901	335544673	no_delete	cannot delete
-901	335544675	sort_err	sort error
-901	335544703	svcnoexe	service @1 does not have an associated executable
-901	335544704	net_lookup_err	Failed to locate host machine.
-901	335544705	service_unknown	Undefined service @1/@2.
-901	335544706	host_unknown	The specified name was not found in the hosts file or Domain Name Services.
-901	335544711	unprepared_stmt	Attempt to execute an unprepared dynamic SQL statement.
-901	335544716	svc_in_use	Service is currently busy: @1
-901	335544719	net_init_error	Error initializing the network software.
-901	335544720	loadlib_failure	Unable to load required library @1.
-901	335544731	tra_must_sweep	
-901	335544740	udf_exception	A fatal exception occurred during the execution of a user defined function.
-901	335544741	lost_db_connection	connection lost to database
-901	335544742	no_write_user_priv	User cannot write to RDB$USER_PRIVILEGES

SQL-CODE	GDSCODE	Symbol	Message Text
-901	335544767	blob_filter_exception	A fatal exception occurred during the execution of a blob filter.
-901	335544768	exception_access_violation	Access violation. The code attempted to access a virtual address without privilege to do so.
-901	335544769	exception_datatype_missalignment	Datatype misalignment. The attempted to read or write a value that was not stored on a memory boundary.
-901	335544770	exception_array_bounds_exceeded	Array bounds exceeded. The code attempted to access an array element that is out of bounds.
-901	335544771	exception_float_denormal_operand	Float denormal operand. One of the floating-point operands is too small to represent a standard float value.
-901	335544772	exception_float_divide_by_zero	Floating-point divide by zero. The code attempted to divide a floating-point value by zero.
-901	335544773	exception_float_inexact_result	Floating-point inexact result. The result of a floating-point operation cannot be represented as a decimal fraction.
-901	335544774	exception_float_invalid_operand	Floating-point invalid operand. An indeterminant error occurred during a floating-point operation.
-901	335544775	exception_float_overflow	Floating-point overflow. The exponent of a floating-point operation is greater than the magnitude allowed.
-901	335544776	exception_float_stack_check	Floating-point stack check. The stack overflowed or underflowed as the result of a floating-point operation.
-901	335544777	exception_float_underflow	Floating-point underflow. The exponent of a floating-point operation is less than the magnitude allowed.
-901	335544778	exception_integer_divide_by_zero	Integer divide by zero. The code attempted to divide an integer value by an integer divisor of zero.
-901	335544779	exception_integer_overflow	Integer overflow. The result of an integer operation caused the most significant bit of the result to carry.

SQL-CODE	GDSCODE	Symbol	Message Text
-901	335544780	exception_unknown	An exception occurred that does not have a description. Exception number @1.
-901	335544781	exception_stack_overflow	Stack overflow. The resource requirements of the runtime stack have exceeded the memory available to it.
-901	335544782	exception_sigsegv	Segmentation Fault. The code attempted to access memory without privileges.
-901	335544783	exception_sigill	Illegal Instruction. The Code attempted to perform an illegal operation.
-901	335544784	exception_sigbus	Bus Error. The Code caused a system bus error.
-901	335544785	exception_sigfpe	Floating Point Error. The Code caused an Arithmetic Exception or a floating point exception.
-901	335544786	ext_file_delete	Cannot delete rows from external files.
-901	335544787	ext_file_modify	Cannot update rows in external files.
-901	335544788	adm_task_denied	Unable to perform operation
-901	335544794	cancelled	operation was cancelled
-901	335544797	svcnouser	user name and password are required while attaching to the services manager
-901	335544801	datype_notsup	data type not supported for arithmetic
-901	335544803	dialect_not_changed	Database dialect not changed.
-901	335544804	database_create_failed	Unable to create database @1
-901	335544805	inv_dialect_specified	Database dialect @1 is not a valid dialect.
-901	335544806	valid_db_dialects	Valid database dialects are @1.
-901	335544811	inv_client_dialect_specified	passed client dialect @1 is not a valid dialect.
-901	335544812	valid_client_dialects	Valid client dialects are @1.
-901	335544814	service_not_supported	Services functionality will be supported in a later version of the product
-901	335544820	invalid_savepoint	Unable to find savepoint with name @1 in transaction context
-901	335544835	bad_shutdown_mode	Target shutdown mode is invalid for database "@1"
-901	335544840	no_update	cannot update

SQL-CODE	GDSCODE	Symbol	Message Text
-901	335544842	stack_trace	@1
-901	335544843	ctx_var_not_found	Context variable @1 is not found in namespace @2
-901	335544844	ctx_namespace_invalid	Invalid namespace name @1 passed to @2
-901	335544845	ctx_too_big	Too many context variables
-901	335544846	ctx_bad_argument	Invalid argument passed to @1
-901	335544847	identifier_too_long	BLR syntax error. Identifier @1... is too long
-901	335544859	invalid_time_precision	Time precision exceeds allowed range (0-@1)
-901	335544866	met_wrong_gtt_scope	@1 cannot depend on @2
-901	335544868	illegal_prc_type	Procedure @1 is not selectable (it does not contain a SUSPEND statement)
-901	335544869	invalid_sort_datatype	Datatype @1 is not supported for sorting operation
-901	335544870	collation_name	COLLATION @1
-901	335544871	domain_name	DOMAIN @1
-901	335544874	max_db_per_trans_allowed	A multi database transaction cannot span more than @1 databases
-901	335544876	bad_proc_BLR	Error while parsing procedure @1's BLR
-901	335544877	key_too_big	index key too big
-901	335544885	bad_teb_form	Invalid TEB format
-901	335544886	tpb_multiple_txn_isolation	Found more than one transaction isolation in TPB
-901	335544887	tpb_reserv_before_table	Table reservation lock type @1 requires table name before in TPB
-901	335544888	tpb_multiple_spec	Found more than one @1 specification in TPB
-901	335544889	tpb_option_without_rc	Option @1 requires READ COMMITTED isolation in TPB
-901	335544890	tpb_conflicting_options	Option @1 is not valid if @2 was used previously in TPB
-901	335544891	tpb_reserv_missing_tlen	Table name length missing after table reservation @1 in TPB

SQL-CODE	GDSCODE	Symbol	Message Text
-901	335544892	tpb_reserv_long_tlen	Table name length @1 is too long after table reservation @2 in TPB
-901	335544893	tpb_reserv_missing_tname	Table name length @1 without table name after table reservation @2 in TPB
-901	335544894	tpb_reserv_corrup_tlen	Table name length @1 goes beyond the remaining TPB size after table reservation @2
-901	335544895	tpb_reserv_null_tlen	Table name length is zero after table reservation @1 in TPB
-901	335544896	tpb_reserv_relnotfound	Table or view @1 not defined in system tables after table reservation @2 in TPB
-901	335544897	tpb_reserv_baserelnotfound	Base table or view @1 for view @2 not defined in system tables after table reservation @3 in TPB
-901	335544898	tpb_missing_len	Option length missing after option @1 in TPB
-901	335544899	tpb_missing_value	Option length @1 without value after option @2 in TPB
-901	335544900	tpb_corrupt_len	Option length @1 goes beyond the remaining TPB size after option @2
-901	335544901	tpb_null_len	Option length is zero after table reservation @1 in TPB
-901	335544902	tpb_overflow_len	Option length @1 exceeds the range for option @2 in TPB
-901	335544903	tpb_invalid_value	Option value @1 is invalid for the option @2 in TPB
-901	335544904	tpb_reserv_stronger_wng	Preserving previous table reservation @1 for table @2, stronger than new @3 in TPB
-901	335544905	tpb_reserv_stronger	Table reservation @1 for table @2 already specified and is stronger than new @3 in TPB
-901	335544906	tpb_reserv_max_recursion	Table reservation reached maximum recursion of @1 when expanding views in TPB
-901	335544907	tpb_reserv_virtualtbl	Table reservation in TPB cannot be applied to @1 because it’s a virtual table
-901	335544908	tpb_reserv_systbl	Table reservation in TPB cannot be applied to @1 because it’s a system table

SQL-CODE	GDSCODE	Symbol	Message Text
-901	335544909	tpb_reserv_temptbl	Table reservation @1 or @2 in TPB cannot be applied to @3 because it's a temporary table
-901	335544910	tpb_readtxn_after_writelock	Cannot set the transaction in read only mode after a table reservation isc_tpb_lock_write in TPB
-901	335544911	tpb_writelock_after_readtxn	Cannot take a table reservation isc_tpb_lock_write in TPB because the transaction is in read only mode
-901	335544917	shutdown_timeout	Firebird shutdown is still in progress after the specified timeout
-901	335544918	att_handle_busy	Attachment handle is busy
-901	335544919	bad_udf_freeit	Bad written UDF detected: pointer returned in FREE_IT function was not allocated by ib_util_malloc
-901	335544920	eds_provider_not_found	External Data Source provider '@1' not found
-901	335544921	eds_connection	Execute statement error at @1 : @2Data source : @3
-901	335544922	eds_preprocess	Execute statement preprocess SQL error
-901	335544923	eds_stmt_expected	Statement expected
-901	335544924	eds_prm_name_expected	Parameter name expected
-901	335544925	eds_unclosed_comment	Unclosed comment found near '@1'
-901	335544926	eds_statement	Execute statement error at @1 : @2Statement : @3 Data source : @4
-901	335544927	eds_input_prm_mismatch	Input parameters mismatch
-901	335544928	eds_output_prm_mismatch	Output parameters mismatch
-901	335544929	eds_input_prm_not_set	Input parameter '@1' have no value set
-901	335544933	nothing_to_cancel	nothing to cancel
-901	335544934	ibutil_not_loaded	ib_util library has not been loaded to deallocate memory returned by FREE_IT function
-901	335544973	bad_epb_form	Unrecognized events block
-901	335544982	udf_fp_overflow	Floating point overflow in result from UDF @1
-901	335544983	udf_fp_nan	Invalid floating point value returned by UDF @1

SQL-CODE	GDSCODE	Symbol	Message Text
-901	335544985	out_of_temp_space	No free space found in temporary directories
-901	335544986	eds_expl_tran_ctrl	Explicit transaction control is not allowed
-901	335544988	package_name	PACKAGE @1
-901	335544989	cannot_make_not_null	Cannot make field @1 of table @2 NOT NULL because there are NULLs present
-901	335544990	feature_removed	Feature @1 is not supported anymore
-901	335544991	view_name	VIEW @1
-901	335544993	invalid_fetch_option	Fetch option @1 is invalid for a non-scrollable cursor
-901	335544994	bad_fun_BLR	Error while parsing function @1's BLR
-901	335544995	func_pack_not_implemented	Cannot execute function @1 of the unimplemented package @2
-901	335544996	proc_pack_not_implemented	Cannot execute procedure @1 of the unimplemented package @2
-901	335544997	eem_func_not_returned	External function @1 not returned by the external engine plugin @2
-901	335544998	eem_proc_not_returned	External procedure @1 not returned by the external engine plugin @2
-901	335544999	eem_trig_not_returned	External trigger @1 not returned by the external engine plugin @2
-901	335545000	eem_bad_plugin_ver	Incompatible plugin version @1 for external engine @2
-901	335545001	eem_engine_notfound	External engine @1 not found
-901	335545004	pman_cannot_load_plugin	Error loading plugin @1
-901	335545005	pman_module_notfound	Loadable module @1 not found
-901	335545006	pman_entrypoint_notfound	Standard plugin entrypoint does not exist in module @1
-901	335545007	pman_module_bad	Module @1 exists but can not be loaded
-901	335545008	pman_plugin_notfound	Module @1 does not contain plugin @2 type @3
-901	335545010	unexpected_null	Value is NULL but isNull parameter was not informed
-901	335545011	type_notcompat_blob	Type @1 is incompatible with BLOB
-901	335545012	invalid_date_val	Invalid date

SQL-CODE	GDSCODE	Symbol	Message Text
-901	335545013	invalid_time_val	Invalid time
-901	335545014	invalid_timestamp_val	Invalid timestamp
-901	335545015	invalid_index_val	Invalid index @1 in function @2
-901	335545018	private_function	Function @1 is private to package @2
-901	335545019	private_procedure	Procedure @1 is private to package @2
-901	335545021	bad_events_handle	invalid events id (handle)
-901	335545025	spb_no_id	missing service ID in spb
-901	335545026	ee_blr_mismatch_null	External BLR message mismatch: invalid null descriptor at field @1
-901	335545027	ee_blr_mismatch_length	External BLR message mismatch: length = @1, expected @2
-901	335545031	libtommath_generic	Libtommath error code @1 in function @2
-901	335545041	cp_process_active	Crypt failed - already crypting database
-901	335545042	cp_already_crypted	Crypt failed - database is already in requested state
-901	335545047	ee_blr_mismatch_names_count	External BLR message mismatch: names count = @1, blr count = @2
-901	335545048	ee_blr_mismatch_name_not_found	External BLR message mismatch: name @1 not found
-901	335545049	bad_result_set	Invalid resultset interface
-901	335545059	badvarnum	undefined variable number
-901	335545071	info_unprepared_stmt	Attempt to get information about an unprepared dynamic SQL statement.
-901	335545072	idx_key_value	Problematic key value is @1
-901	335545073	forupdate_virtualtbl	Cannot select virtual table @1 for update WITH LOCK
-901	335545074	forupdate_systbl	Cannot select system table @1 for update WITH LOCK
-901	335545075	forupdate_temptbl	Cannot select temporary table @1 for update WITH LOCK
-901	335545076	cant_modify_sysobj	System @1 @2 cannot be modified
-901	335545077	server_misconfigured	Server misconfigured - contact administrator please

SQL-CODE	GDSCODE	Symbol	Message Text
-901	335545078	alter_role	Deprecated backward compatibility ALTER ROLE ... SET/DROP AUTO ADMIN mapping may be used only for RDB$ADMIN role
-901	335545079	map_already_exists	Mapping @1 already exists
-901	335545080	map_not_exists	Mapping @1 does not exist
-901	335545081	map_load	@1 failed when loading mapping cache
-901	335545082	map_aster	Invalid name <*> in authentication block
-901	335545083	map_multi	Multiple maps found for @1
-901	335545084	map_undefined	Undefined mapping result - more than one different results found
-901	335545088	map_nodb	Global mapping is not available when database @1 is not present
-901	335545089	map_notable	Global mapping is not available when table RDB$MAP is not present in database @1
-901	335545090	miss_trusted_role	Your attachment has no trusted role
-901	335545091	set_invalid_role	Role @1 is invalid or unavailable
-901	335545093	dup_attribute	Duplicated user attribute @1
-901	335545094	dyn_no_priv	There is no privilege for this operation
-901	335545095	dsql_cant_grant_option	Using GRANT OPTION on @1 not allowed
-901	335545097	crdb_load	@1 failed when working with CREATE DATABASE grants
-901	335545098	crdb_nodb	CREATE DATABASE grants check is not possible when database @1 is not present
-901	335545099	crdb_notable	CREATE DATABASE grants check is not possible when table RDB$DB_CREATORS is not present in database @1
-901	335545102	savepoint_backout_err	Error during savepoint backout - transaction invalidated
-901	335545105	map_down	Some database(s) were shutdown when trying to read mapping data
-901	335545109	encrypt_error	Page requires encryption but crypt plugin is missing

SQL-CODE	GDSCODE	Symbol	Message Text
-901	335545111	wrong_prvlg	System privilege @1 does not exist
-901	335545115	no_cursor	Cannot open cursor for non-SELECT statement
-901	335545127	cfg_stmt_timeout	Config level timeout expired.
-901	335545128	att_stmt_timeout	Attachment level timeout expired.
-901	335545129	req_stmt_timeout	Statement level timeout expired.
-901	335545139	decfloat_divide_by_zero	Decimal float divide by zero. The code attempted to divide a DECFLOAT value by zero.
-901	335545140	decfloat_inexact_result	Decimal float inexact result. The result of an operation cannot be represented as a decimal fraction.
-901	335545141	decfloat_invalid_operation	Decimal float invalid operation. An indeterminant error occurred during an operation.
-901	335545142	decfloat_overflow	Decimal float overflow. The exponent of a result is greater than the magnitude allowed.
-901	335545143	decfloat_underflow	Decimal float underflow. The exponent of a result is less than the magnitude allowed.
-901	335545144	subfunc_notdef	Sub-function @1 has not been defined
-901	335545145	subproc_notdef	Sub-procedure @1 has not been defined
-901	335545146	subfunc_signat	Sub-function @1 has a signature mismatch with its forward declaration
-901	335545147	subproc_signat	Sub-procedure @1 has a signature mismatch with its forward declaration
-901	335545148	subfunc_defvaldecl	Default values for parameters are not allowed in definition of the previously declared sub-function @1
-901	335545149	subproc_defvaldecl	Default values for parameters are not allowed in definition of the previously declared sub-procedure @1
-901	335545150	subfunc_not_impl	Sub-function @1 was declared but not implemented
-901	335545151	subproc_not_impl	Sub-procedure @1 was declared but not implemented
-901	335545152	sysf_invalid_hash_algorithm	Invalid HASH algorithm @1

SQL-CODE	GDSCODE	Symbol	Message Text
-901	335545153	expression_eval_index	Expression evaluation error for index "@1" on table "@2"
-901	335545154	invalid_decfloat_trap	Invalid decfloat trap state @1
-901	335545155	invalid_decfloat_round	Invalid decfloat rounding mode @1
-901	335545159	bad_batch_handle	invalid batch handle
-901	335545160	intl_char	Bad international character in tag @1
-901	335545161	null_block	Null data in parameters block with non-zero length
-901	335545162	mixed_info	Items working with running service and getting generic server information should not be mixed in single info block
-901	335545163	unknown_info	Unknown information item, code @1
-901	335545164	bpb_version	Wrong version of blob parameters block @1, should be @2
-901	335545165	user_manager	User management plugin is missing or failed to load
-901	335545168	metadata_name	Name @1 not found in system MetadataBuilder
-901	335545169	tokens_parse	Parse to tokens error
-901	335545171	batch_compl_range	Message @1 is out of range, only @2 messages in batch
-901	335545172	batch_compl_detail	Detailed error info for message @1 is missing in batch
-901	335545175	big_segment	Segment size (@1) should not exceed 65535 (64K - 1) when using segmented blob
-901	335545176	batch_policy	Invalid blob policy in the batch for @1() call
-901	335545177	batch_defbpb	Can’t change default BPB after adding any data to batch
-901	335545178	batch_align	Unexpected info buffer structure querying for default blob alignment
-901	335545179	multi_segment_dup	Duplicated segment @1 in multisegment connect block parameter
-901	335545181	message_format	Error parsing message format
-901	335545182	batch_param_version	Wrong version of batch parameters block @1, should be @2

SQL-CODE	GDSCODE	Symbol	Message Text
-901	335545183	batch_msg_long	Message size (@1) in batch exceeds internal buffer size (@2)
-901	335545184	batch_open	Batch already opened for this statement
-901	335545185	batch_type	Invalid type of statement used in batch
-901	335545186	batch_param	Statement used in batch must have parameters
-901	335545187	batch_blobs	There are no blobs in associated with batch statement
-901	335545188	batch_blob_append	appendBlobData() is used to append data to last blob but no such blob was added to the batch
-901	335545189	batch_stream_align	Portions of data, passed as blob stream, should have size multiple to the alignment required for blobs
-901	335545190	batch_rpt_blob	Repeated blob id @1 in registerBlob()
-901	335545191	batch_blob_buf	Blob buffer format error
-901	335545192	batch_small_data	Unusable (too small) data remained in @1 buffer
-901	335545193	batch_cont_bpb	Blob continuation should not contain BPB
-901	335545194	batch_big_bpb	Size of BPB (@1) greater than remaining data (@2)
-901	335545195	batch_big_segment	Size of segment (@1) greater than current BLOB data (@2)
-901	335545196	batch_big_seg2	Size of segment (@1) greater than available data (@2)
-901	335545197	batch_blob_id	Unknown blob ID @1 in the batch message
-901	335545198	batch_too_big	Internal buffer overflow - batch too big
-901	335545199	num_literal	Numeric literal too long
-901	335545202	hdr_overflow	Header page overflow - too many clumplets on it
-901	335545203	vld_plugins	No matching client/server authentication plugins configured for execute statement in embedded datasource
-901	335545206	ses_reset_err	Cannot reset user session

SQL-CODE	GDSCODE	Symbol	Message Text
-901	335545207	ses_reset_open_trans	There are open transactions (@1 active)
-901	335545208	ses_reset_warn	Session was reset with warning(s)
-901	335545209	ses_reset_tran_rollback	Transaction is rolled back due to session reset, all changes are lost
-901	335545210	plugin_name	Plugin @1:
-901	335545211	parameter_name	PARAMETER @1
-901	335545212	file_starting_page_err	Starting page number for file @1 must be @2 or greater
-901	335545213	invalid_timezone_offset	Invalid time zone offset: @1 - must use format +/-hours:minutes and be between -14:00 and +14:00
-901	335545214	invalid_timezone_region	Invalid time zone region: @1
-901	335545215	invalid_timezone_id	Invalid time zone ID: @1
-901	335545216	tom_decode64len	Wrong base64 text length @1, should be multiple of 4
-901	335545217	tom_strblob	Invalid first parameter datatype - need string or blob
-901	335545218	tom_reg	Error registering @1 - probably bad tomcrypt library
-901	335545219	tom_algorithm	Unknown crypt algorithm @1 in USING clause
-901	335545220	tom_mode_miss	Should specify mode parameter for symmetric cipher
-901	335545221	tom_mode_bad	Unknown symmetric crypt mode specified
-901	335545222	tom_no_mode	Mode parameter makes no sense for chosen cipher
-901	335545223	tom_iv_miss	Should specify initialization vector (IV) for chosen cipher and/or mode
-901	335545224	tom_no_iv	Initialization vector (IV) makes no sense for chosen cipher and/or mode
-901	335545225	tom_ctrtype_bad	Invalid counter endianess @1
-901	335545226	tom_no_ctrtype	Counter endianess parameter is not used in mode @1
-901	335545227	tom_ctr_big	Too big counter value @1, maximum @2 can be used

SQL-CODE	GDSCODE	Symbol	Message Text
-901	335545228	tom_no_ctr	Counter length/value parameter is not used with @1 @2
-901	335545229	tom_iv_length	Invalid initialization vector (IV) length @1, need @2
-901	335545230	tom_error	TomCrypt library error: @1
-901	335545231	tom_yarrow_start	Starting PRNG yarrow
-901	335545232	tom_yarrow_setup	Setting up PRNG yarrow
-901	335545233	tom_init_mode	Initializing @1 mode
-901	335545234	tom_crypt_mode	Encrypting in @1 mode
-901	335545235	tom_decrypt_mode	Decrypting in @1 mode
-901	335545236	tom_init_cip	Initializing cipher @1
-901	335545237	tom_crypt_cip	Encrypting using cipher @1
-901	335545238	tom_decrypt_cip	Decrypting using cipher @1
-901	335545239	tom_setup_cip	Setting initialization vector (IV) for @1
-901	335545240	tom_setup_chacha	Invalid initialization vector (IV) length @1, need 8 or 12
-901	335545241	tom_encode	Encoding @1
-901	335545242	tom_decode	Decoding @1
-901	335545243	tom_rsa_import	Importing RSA key
-901	335545244	tom_oaep	Invalid OAEP packet
-901	335545245	tom_hash_bad	Unknown hash algorithm @1
-901	335545246	tom_rsa_make	Making RSA key
-901	335545247	tom_rsa_export	Exporting @1 RSA key
-901	335545248	tom_rsa_sign	RSA-signing data
-901	335545249	tom_rsa_verify	Verifying RSA-signed data
-901	335545250	tom_chacha_key	Invalid key length @1, need 16 or 32
-901	335545251	bad_repl_handle	invalid replicator handle
-901	335545252	tra_snapshot_does_not_exist	Transaction’s base snapshot number does not exist
-901	335545253	eds_input_prm_not_used	Input parameter '@1' is not used in SQL query text
-901	335545255	invalid_time_zone_bind	Invalid time zone bind mode @1
-901	335545256	invalid_decfloat_bind	Invalid decfloat bind mode @1

SQL-CODE	GDSCODE	Symbol	Message Text
-901	335545257	odd_hex_len	Invalid hex text length @1, should be multiple of 2
-901	335545258	invalid_hex_digit	Invalid hex digit @1 at position @2
-901	335545261	bind_convert	Can not convert @1 to @2
-901	335545264	dyn_no_create_priv	No permission for CREATE @1 operation
-901	335545265	suspend_without_returns	SUSPEND could not be used without RETURNS clause in PROCEDURE or EXECUTE BLOCK
-901	335545274	tom_key_length	Invalid key length @1, need >@2
-901	336068645	dyn_filter_not_found	BLOB Filter @1 not found
-901	336068649	dyn_func_not_found	Function @1 not found
-901	336068656	dyn_index_not_found	Index not found
-901	336068662	dyn_view_not_found	View @1 not found
-901	336068697	dyn_domain_not_found	Domain not found
-901	336068717	dyn_cant_modify_auto_trig	Triggers created automatically cannot be modified
-901	336068740	dyn_dup_table	Table @1 already exists
-901	336068748	dyn_proc_not_found	Procedure @1 not found
-901	336068752	dyn_exception_not_found	Exception not found
-901	336068754	dyn_proc_param_not_found	Parameter @1 in procedure @2 not found
-901	336068755	dyn_trig_not_found	Trigger @1 not found
-901	336068759	dyn_charset_not_found	Character set @1 not found
-901	336068760	dyn_collation_not_found	Collation @1 not found
-901	336068763	dyn_role_not_found	Role @1 not found
-901	336068767	dyn_name_longer	Name longer than database column size
-901	336068784	dyn_column_does_not_exist	column @1 does not exist in table/view @2
-901	336068796	dyn_role_does_not_exist	SQL role @1 does not exist
-901	336068797	dyn_no_grant_admin_opt	user @1 has no grant admin option on SQL role @2
-901	336068798	dyn_user_not_role_member	user @1 is not a member of SQL role @2
-901	336068799	dyn_delete_role_failed	@1 is not the owner of SQL role @2
-901	336068800	dyn_grant_role_to_user	@1 is a SQL role and not a user

SQL-CODE	GDSCODE	Symbol	Message Text
-901	336068801	dyn_inv_sql_role_name	user name @1 could not be used for SQL role
-901	336068802	dyn_dup_sql_role	SQL role @1 already exists
-901	336068803	dyn_kywd_spec_for_role	keyword @1 can not be used as a SQL role name
-901	336068804	dyn_roles_not_supported	SQL roles are not supported in on older versions of the database. A backup and restore of the database is required.
-901	336068820	dyn_zero_len_id	Zero length identifiers are not allowed
-901	336068822	dyn_gen_not_found	Sequence @1 not found
-901	336068840	dyn_wrong_gtt_scope	@1 cannot reference @2
-901	336068843	dyn_coll_used_table	Collation @1 is used in table @2 (field name @3) and cannot be dropped
-901	336068844	dyn_coll_used_domain	Collation @1 is used in domain @2 and cannot be dropped
-901	336068846	dyn_cannot_del_def_coll	Cannot delete default collation of CHARACTER SET @1
-901	336068849	dyn_table_not_found	Table @1 not found
-901	336068851	dyn_coll_used_procedure	Collation @1 is used in procedure @2 (parameter name @3) and cannot be dropped
-901	336068856	dyn_ods_not_supp_feature	Feature '@1' is not supported in ODS @2.@3
-901	336068858	dyn_no_empty_pw	Password should not be empty string
-901	336068859	dyn_dup_index	Index @1 already exists
-901	336068864	dyn_package_not_found	Package @1 not found
-901	336068865	dyn_schema_not_found	Schema @1 not found
-901	336068871	dyn_funcnotdef_package	Function @1 has not been defined on the package body @2
-901	336068872	dyn_procnotdef_package	Procedure @1 has not been defined on the package body @2
-901	336068873	dyn_funcsignat_package	Function @1 has a signature mismatch on package body @2
-901	336068874	dyn_procsignat_package	Procedure @1 has a signature mismatch on package body @2

SQL-CODE	GDSCODE	Symbol	Message Text
-901	336068875	dyn_defvaldecl_package_proc	Default values for parameters are not allowed in the definition of a previously declared packaged procedure @1.@2
-901	336068877	dyn_package_body_exists	Package body @1 already exists
-901	336068879	dyn_newfc_oldsyntax	Cannot alter new style function @1 with ALTER EXTERNAL FUNCTION. Use ALTER FUNCTION instead.
-901	336068886	dyn_func_param_not_found	Parameter @1 in function @2 not found
-901	336068887	dyn_routine_param_not_found	Parameter @1 of routine @2 not found
-901	336068888	dyn_routine_param_ambiguous	Parameter @1 of routine @2 is ambiguous (found in both procedures and functions). Use a specifier keyword.
-901	336068889	dyn_coll_used_function	Collation @1 is used in function @2 (parameter name @3) and cannot be dropped
-901	336068890	dyn_domain_used_function	Domain @1 is used in function @2 (parameter name @3) and cannot be dropped
-901	336068891	dyn_alter_user_no_clause	ALTER USER requires at least one clause to be specified
-901	336068894	dyn_duplicate_package_item	Duplicate @1 @2
-901	336068895	dyn_cant_modify_sysobj	System @1 @2 cannot be modified
-901	336068896	dyn_cant_use_zero_increment	INCREMENT BY 0 is an illegal option for sequence @1
-901	336068897	dyn_cant_use_in_foreignkey	Can’t use @1 in FOREIGN KEY constraint
-901	336068898	dyn_defvaldecl_package_func	Default values for parameters are not allowed in the definition of a previously declared packaged function @1.@2
-901	336068900	dyn_cyclic_role	role @1 can not be granted to role @2
-901	336068904	dyn_cant_use_zero_inc_ident	INCREMENT BY 0 is an illegal option for identity column @1 of table @2
-901	336068907	dyn_no_ddl_grant_opt_priv	no @1 privilege with grant option on DDL @2
-901	336068908	dyn_no_grant_opt_priv	no @1 privilege with grant option on object @2
-901	336068909	dyn_func_not_exist	Function @1 does not exist
-901	336068910	dyn_proc_not_exist	Procedure @1 does not exist

SQL-CODE	GDSCODE	Symbol	Message Text
-901	336068911	dyn_pack_not_exist	Package @1 does not exist
-901	336068912	dyn_trig_not_exist	Trigger @1 does not exist
-901	336068913	dyn_view_not_exist	View @1 does not exist
-901	336068914	dyn_rel_not_exist	Table @1 does not exist
-901	336068915	dyn_exc_not_exist	Exception @1 does not exist
-901	336068916	dyn_gen_not_exist	Generator/Sequence @1 does not exist
-901	336068917	dyn_fld_not_exist	Field @1 of table @2 does not exist
-901	336397211	dsql_too_many_values	Too many values (more than @1) in member list to match against
-901	336397236	dsql_unsupp_feature_dialect	feature is not supported in dialect @1
-901	336397239	dsql_unsupported_in_auto_trans	@1 is not supported inside IN AUTONOMOUS TRANSACTION block
-901	336397258	dsql_alter_charset_failed	ALTER CHARACTER SET @1 failed
-901	336397259	dsql_comment_on_failed	COMMENT ON @1 failed
-901	336397260	dsql_create_func_failed	CREATE FUNCTION @1 failed
-901	336397261	dsql_alter_func_failed	ALTER FUNCTION @1 failed
-901	336397262	dsql_create_alter_func_failed	CREATE OR ALTER FUNCTION @1 failed
-901	336397263	dsql_drop_func_failed	DROP FUNCTION @1 failed
-901	336397264	dsql_recreate_func_failed	RECREATE FUNCTION @1 failed
-901	336397265	dsql_create_proc_failed	CREATE PROCEDURE @1 failed
-901	336397266	dsql_alter_proc_failed	ALTER PROCEDURE @1 failed
-901	336397267	dsql_create_alter_proc_failed	CREATE OR ALTER PROCEDURE @1 failed
-901	336397268	dsql_drop_proc_failed	DROP PROCEDURE @1 failed
-901	336397269	dsql_recreate_proc_failed	RECREATE PROCEDURE @1 failed
-901	336397270	dsql_create_trigger_failed	CREATE TRIGGER @1 failed
-901	336397271	dsql_alter_trigger_failed	ALTER TRIGGER @1 failed
-901	336397272	dsql_create_alter_trigger_failed	CREATE OR ALTER TRIGGER @1 failed
-901	336397273	dsql_drop_trigger_failed	DROP TRIGGER @1 failed
-901	336397274	dsql_recreate_trigger_failed	RECREATE TRIGGER @1 failed
-901	336397275	dsql_create_collation_failed	CREATE COLLATION @1 failed
-901	336397276	dsql_drop_collation_failed	DROP COLLATION @1 failed
-901	336397277	dsql_create_domain_failed	CREATE DOMAIN @1 failed

SQL-CODE	GDSCODE	Symbol	Message Text
-901	336397278	dsql_alter_domain_failed	ALTER DOMAIN @1 failed
-901	336397279	dsql_drop_domain_failed	DROP DOMAIN @1 failed
-901	336397280	dsql_create_except_failed	CREATE EXCEPTION @1 failed
-901	336397281	dsql_alter_except_failed	ALTER EXCEPTION @1 failed
-901	336397282	dsql_create_alter_except_failed	CREATE OR ALTER EXCEPTION @1 failed
-901	336397283	dsql_recreate_except_failed	RECREATE EXCEPTION @1 failed
-901	336397284	dsql_drop_except_failed	DROP EXCEPTION @1 failed
-901	336397285	dsql_create_sequence_failed	CREATE SEQUENCE @1 failed
-901	336397286	dsql_create_table_failed	CREATE TABLE @1 failed
-901	336397287	dsql_alter_table_failed	ALTER TABLE @1 failed
-901	336397288	dsql_drop_table_failed	DROP TABLE @1 failed
-901	336397289	dsql_recreate_table_failed	RECREATE TABLE @1 failed
-901	336397290	dsql_create_pack_failed	CREATE PACKAGE @1 failed
-901	336397291	dsql_alter_pack_failed	ALTER PACKAGE @1 failed
-901	336397292	dsql_create_alter_pack_failed	CREATE OR ALTER PACKAGE @1 failed
-901	336397293	dsql_drop_pack_failed	DROP PACKAGE @1 failed
-901	336397294	dsql_recreate_pack_failed	RECREATE PACKAGE @1 failed
-901	336397295	dsql_create_pack_body_failed	CREATE PACKAGE BODY @1 failed
-901	336397296	dsql_drop_pack_body_failed	DROP PACKAGE BODY @1 failed
-901	336397297	dsql_recreate_pack_body_failed	RECREATE PACKAGE BODY @1 failed
-901	336397298	dsql_create_view_failed	CREATE VIEW @1 failed
-901	336397299	dsql_alter_view_failed	ALTER VIEW @1 failed
-901	336397300	dsql_create_alter_view_failed	CREATE OR ALTER VIEW @1 failed
-901	336397301	dsql_recreate_view_failed	RECREATE VIEW @1 failed
-901	336397302	dsql_drop_view_failed	DROP VIEW @1 failed
-901	336397303	dsql_drop_sequence_failed	DROP SEQUENCE @1 failed
-901	336397304	dsql_recreate_sequence_failed	RECREATE SEQUENCE @1 failed
-901	336397305	dsql_drop_index_failed	DROP INDEX @1 failed
-901	336397306	dsql_drop_filter_failed	DROP FILTER @1 failed
-901	336397307	dsql_drop_shadow_failed	DROP SHADOW @1 failed
-901	336397308	dsql_drop_role_failed	DROP ROLE @1 failed
-901	336397309	dsql_drop_user_failed	DROP USER @1 failed

SQL-CODE	GDSCODE	Symbol	Message Text
-901	336397310	dsql_create_role_failed	CREATE ROLE @1 failed
-901	336397311	dsql_alter_role_failed	ALTER ROLE @1 failed
-901	336397312	dsql_alter_index_failed	ALTER INDEX @1 failed
-901	336397313	dsql_alter_database_failed	ALTER DATABASE failed
-901	336397314	dsql_create_shadow_failed	CREATE SHADOW @1 failed
-901	336397315	dsql_create_filter_failed	DECLARE FILTER @1 failed
-901	336397316	dsql_create_index_failed	CREATE INDEX @1 failed
-901	336397317	dsql_create_user_failed	CREATE USER @1 failed
-901	336397318	dsql_alter_user_failed	ALTER USER @1 failed
-901	336397319	dsql_grant_failed	GRANT failed
-901	336397320	dsql_revoke_failed	REVOKE failed
-901	336397322	dsql_mapping_failed	@2 MAPPING @1 failed
-901	336397323	dsql_alter_sequence_failed	ALTER SEQUENCE @1 failed
-901	336397324	dsql_create_generator_failed	CREATE GENERATOR @1 failed
-901	336397325	dsql_set_generator_failed	SET GENERATOR @1 failed
-901	336397330	dsql_max_exception_arguments	Number of arguments (@1) exceeds the maximum (@2) number of EXCEPTION USING arguments
-901	336397331	dsql_string_byte_length	String literal with @1 bytes exceeds the maximum length of @2 bytes
-901	336397332	dsql_string_char_length	String literal with @1 characters exceeds the maximum length of @2 characters for the @3 character set
-901	336397333	dsql_max_nesting	Too many BEGIN...END nesting. Maximum level is @1
-901	336397334	dsql_recreate_user_failed	RECREATE USER @1 failed
-902	335544333	bug_check	internal Firebird consistency check (@1)
-902	335544335	db_corrupt	database file appears corrupt (@1)
-902	335544344	io_error	I/O error during "@1" operation for file "@2"
-902	335544346	metadata_corrupt	corrupt system table
-902	335544373	sys_request	operating system directive @1 failed
-902	335544384	badblk	internal error
-902	335544385	invpoolcl	internal error

SQL-CODE	GDSCODE	Symbol	Message Text
-902	335544387	relbadblk	internal error
-902	335544388	blktoobig	block size exceeds implementation restriction
-902	335544394	badodsver	incompatible version of on-disk structure
-902	335544397	dirtypage	internal error
-902	335544398	waifortra	internal error
-902	335544399	doubleloc	internal error
-902	335544400	nodnotfnd	internal error
-902	335544401	dupnodfnd	internal error
-902	335544402	locnotmar	internal error
-902	335544404	corrupt	database corrupted
-902	335544405	badpage	checksum error on database page @1
-902	335544406	badindex	index is broken
-902	335544409	trareqmis	transaction—request mismatch (synchronization error)
-902	335544410	badhndcnt	bad handle count
-902	335544411	wrotpbver	wrong version of transaction parameter block
-902	335544412	wroblrver	unsupported BLR version (expected @1, encountered @2)
-902	335544413	wrodpbver	wrong version of database parameter block
-902	335544415	badrelation	database corrupted
-902	335544416	nodetach	internal error
-902	335544417	notremote	internal error
-902	335544422	dbfile	internal error
-902	335544423	orphan	internal error
-902	335544432	lockmanerr	lock manager error
-902	335544436	sqlerr	SQL error code = @1
-902	335544448	bad_sec_info	
-902	335544449	invalid_sec_info	
-902	335544470	buf_invalid	cache buffer for page @1 invalid
-902	335544471	indexnotdefined	there is no index in table @1 with id @2

SQL-CODE	GDSCODE	Symbol	Message Text
-902	335544472	login	Your user name and password are not defined. Ask your database administrator to set up a Firebird login.
-902	335544478	jrn_enable	enable journal for database before starting online dump
-902	335544479	old_failure	online dump failure. Retry dump
-902	335544480	old_in_progress	an online dump is already in progress
-902	335544481	old_no_space	no more disk/tape space. Cannot continue online dump
-902	335544482	no_wal_no_jrn	journaling allowed only if database has Write-ahead Log
-902	335544483	num_old_files	maximum number of online dump files that can be specified is 16
-902	335544484	wal_file_open	error in opening Write-ahead Log file during recovery
-902	335544486	wal_failure	Write-ahead log subsystem failure
-902	335544505	no_archive	must specify archive file when enabling long term journal for databases with round-robin log files
-902	335544506	shutinprog	database @1 shutdown in progress
-902	335544520	jrn_present	long-term journaling already enabled
-902	335544528	shutdown	database @1 shutdown
-902	335544557	shutfail	database shutdown unsuccessful
-902	335544564	no_jrn	long-term journaling not enabled
-902	335544569	dsql_error	Dynamic SQL Error
-902	335544653	psw_attach	cannot attach to password database
-902	335544654	psw_start_trans	cannot start transaction for password database
-902	335544717	err_stack_limit	stack size insufficent to execute current request
-902	335544721	network_error	Unable to complete network request to host "@1".
-902	335544722	net_connect_err	Failed to establish a connection.
-902	335544723	net_connect_listen_err	Error while listening for an incoming connection.

SQL-CODE	GDSCODE	Symbol	Message Text
-902	335544724	net_event_connect_err	Failed to establish a secondary connection for event processing.
-902	335544725	net_event_listen_err	Error while listening for an incoming event connection request.
-902	335544726	net_read_err	Error reading data from the connection.
-902	335544727	net_write_err	Error writing data to the connection.
-902	335544732	unsupported_network_drive	Access to databases on file servers is not supported.
-902	335544733	io_create_err	Error while trying to create file
-902	335544734	io_open_err	Error while trying to open file
-902	335544735	io_close_err	Error while trying to close file
-902	335544736	io_read_err	Error while trying to read from file
-902	335544737	io_write_err	Error while trying to write to file
-902	335544738	io_delete_err	Error while trying to delete file
-902	335544739	io_access_err	Error while trying to access file
-902	335544745	login_same_as_role_name	Your login @1 is same as one of the SQL role name. Ask your database administrator to set up a valid Firebird login.
-902	335544791	file_in_use	The file @1 is currently in use by another process. Try again later.
-902	335544795	unexp_spb_form	unexpected item in service parameter block, expected @1
-902	335544809	extern_func_dir_error	Function @1 is in @2, which is not in a permitted directory for external functions.
-902	335544819	io_32bit_exceeded_err	File exceeded maximum size of 2GB. Add another database file or use a 64 bit I/O version of Firebird.
-902	335544831	conf_access_denied	Use of @1 at location @2 is not allowed by server configuration
-902	335544834	cursor_not_open	Cursor is not open
-902	335544841	cursor_already_open	Cursor is already open
-902	335544856	att_shutdown	connection shutdown
-902	335544882	long_login	Login name too long (@1 characters, maximum allowed @2)

SQL-CODE	GDSCODE	Symbol	Message Text
-902	335544936	psw_db_error	Security database error
-902	335544970	missing_required_spb	Missing required item @1 in service parameter block
-902	335544971	net_server_shutdown	@1 server is shutdown
-902	335544974	no_threads	Could not start first worker thread - shutdown server
-902	335544975	net_event_connect_timeout	Timeout occurred while waiting for a secondary connection for event processing
-902	335544984	instance_conflict	Database is probably already opened by another engine instance in another Windows session
-902	335544987	no_trusted_spb	Use of TRUSTED switches in spb_command_line is prohibited
-902	335545029	missing_data_structures	Install incomplete. To complete security database initialization please CREATE USER. For details read doc/README.security_database.txt.
-902	335545030	protect_sys_tab	@1 operation is not allowed for system table @2
-902	335545032	wroblrver2	unsupported BLR version (expected between @1 and @2, encountered @3)
-902	335545043	decrypt_error	Missing crypt plugin, but page appears encrypted
-902	335545044	no_providers	No providers loaded
-902	335545053	miss_config	Missing configuration file: @1
-902	335545054	conf_line	@1: illegal line <@2>
-902	335545055	conf_include	Invalid include operator in @1 for <@2>
-902	335545056	include_depth	Include depth too big
-902	335545057	include_miss	File to include not found
-902	335545060	sec_context	Missing security context for @1
-902	335545061	multi_segment	Missing segment @1 in multisegment connect block parameter
-902	335545062	login_changed	Different logins in connect and attach packets - client library error
-902	335545063	auth_handshake_limit	Exceeded exchange limit during authentication handshake

SQL-CODE	GDSCODE	Symbol	Message Text
-902	335545064	wirecrypt_incompatible	Incompatible wire encryption levels requested on client and server
-902	335545065	miss_wirecrypt	Client attempted to attach unencrypted but wire encryption is required
-902	335545066	wirecrypt_key	Client attempted to start wire encryption using unknown key @1
-902	335545067	wirecrypt_plugin	Client attempted to start wire encryption using unsupported plugin @1
-902	335545068	secdb_name	Error getting security database name from configuration file
-902	335545069	auth_data	Client authentication plugin is missing required data from server
-902	335545070	auth_datalength	Client authentication plugin expected @2 bytes of @3 from server, got @1
-902	335545106	login_error	Error occurred during login, please check server firebird.log for details
-902	335545107	already_opened	Database already opened with engine instance, incompatible with current
-902	335545108	bad_crypt_key	Invalid crypt key @1
-902	335545112	miss_prvlg	System privilege @1 is missing
-902	335545113	crypt_checksum	Invalid or missing checksum of encrypted database
-902	335545114	not_dba	You must have SYSDBA rights at this server
-902	335545126	sql_too_long	SQL statement is too long. Maximum size is @1 bytes.
-902	335545130	att_shut_killed	Killed by database administrator.
-902	335545131	att_shut_idle	Idle timeout expired.
-902	335545132	att_shut_db_down	Database is shutdown.
-902	335545133	att_shut_engine	Engine is shutdown.
-902	335545134	overriding_without_identity	OVERRIDING clause can be used only when an identity column is present in the INSERT’s field list for table/view @1
-902	335545135	overriding_system_invalid	OVERRIDING SYSTEM VALUE can be used only for identity column defined as 'GENERATED ALWAYS' in INSERT for table/view @1

SQL-CODE	GDSCODE	Symbol	Message Text
-902	335545136	overriding_user_invalid	OVERRIDING USER VALUE can be used only for identity column defined as 'GENERATED BY DEFAULT' in INSERT for table/view @1
-902	335545137	overriding_system_missing	OVERRIDING SYSTEM VALUE should be used to override the value of an identity column defined as 'GENERATED ALWAYS' in table/view @1
-902	335545166	icu_entrypoint	Missing entrypoint @1 in ICU library
-902	335545167	icu_library	Could not find acceptable ICU library
-902	335545170	iconv_open	Error opening international conversion descriptor from @1 to @2
-902	335545173	deflate_init	Compression stream init error @1
-902	335545174	inflate_init	Decompression stream init error @1
-902	335545180	non_plugin_protocol	Plugin not supported by network protocol
-902	335545200	map_event	Error using events in mapping shared memory: @1
-902	335545201	map_overflow	Global mapping memory overflow
-902	335545204	db_crypt_key	Missing database encryption key for your attachment
-902	335545259	bind_err	Error processing isc_dpb_set_bind clumplet "@1"
-902	335545260	bind_statement	The following statement failed: @1
-902	335545270	wrong_page	RDB$PAGES written by non-system transaction, DB appears to be damaged
-902	335545271	repl_error	Replication error
-902	335545272	ses_reset_failed	Reset of user session failed. Connection is shut down.
-902	335545273	block_size	File size is less than expected
-904	335544324	bad_db_handle	invalid database handle (no active connection)
-904	335544375	unavailable	unavailable database
-904	335544381	imp_exc	Implementation limit exceeded
-904	335544386	nopoolids	too many requests
-904	335544389	bufexh	buffer exhausted

SQL-CODE	GDSCODE	Symbol	Message Text
-904	335544391	bufinuse	buffer in use
-904	335544393	reqinuse	request in use
-904	335544424	no_lock_mgr	no lock manager available
-904	335544430	virmemexh	unable to allocate memory from operating system
-904	335544451	update_conflict	update conflicts with concurrent update
-904	335544453	obj_in_use	object @1 is in use
-904	335544455	shadow_accessed	cannot attach active shadow file
-904	335544460	shadow_missing	a file in manual shadow @1 is unavailable
-904	335544661	index_root_page_full	cannot add index, index root page is full.
-904	335544676	sort_mem_err	sort error: not enough memory
-904	335544683	req_depth_exceeded	request depth exceeded. (Recursive definition?)
-904	335544758	sort_rec_size_err	sort record size of @1 bytes is too big
-904	335544761	too_many_handles	too many open handles to database
-904	335544762	optimizer_blk_exc	size of optimizer block exceeded
-904	335544792	service_att_err	Cannot attach to services manager
-904	335544799	svc_name_missing	The service name was not specified.
-904	335544813	optimizer_between_err	Unsupported field type specified in BETWEEN predicate.
-904	335544827	exec_sql_invalid_arg	Invalid argument in EXECUTE STATEMENT - cannot convert to string
-904	335544828	exec_sql_invalid_req	Wrong request type in EXECUTE STATEMENT '@1'
-904	335544829	exec_sql_invalid_var	Variable type (position @1) in EXECUTE STATEMENT '@2' INTO does not match returned column type
-904	335544830	exec_sql_max_call_exceeded	Too many recursion levels of EXECUTE STATEMENT
-904	335544832	wrong_backup_state	Cannot change difference file name while database is in backup mode
-904	335544833	wal_backup_err	Physical backup is not allowed while Write-Ahead Log is in use

SQL-CODE	GDSCODE	Symbol	Message Text
-904	335544852	partner_idx_incompat_type	partner index segment no @1 has incompatible data type
-904	335544857	blobtoobig	Maximum BLOB size exceeded
-904	335544862	record_lock_not_supp	Stream does not support record locking
-904	335544863	partner_idx_not_found	Cannot create foreign key constraint @1. Partner index does not exist or is inactive.
-904	335544864	tra_num_exc	Transactions count exceeded. Perform backup and restore to make database operable again
-904	335544865	field_disappeared	Column has been unexpectedly deleted
-904	335544878	concurrent_transaction	concurrent transaction number is @1
-904	335544935	circular_computed	Cannot have circular dependencies with computed fields
-904	335544992	lock_dir_access	Can not access lock files directory @1
-904	335545020	request_outdated	Request can’t access new records in relation @1 and should be recompiled
-904	335545096	read_conflict	read conflicts with concurrent update
-904	335545110	max_idx_depth	Maximum index depth (@1 levels) is reached
-906	335544452	unlicensed	product @1 is not licensed
-906	335544744	max_att_exceeded	Maximum user count exceeded. Contact your database administrator.
-909	335544667	drdb_completed_with_errs	drop database completed with errors
-911	335544459	rec_in_limbo	record from transaction @1 is stuck in limbo
-913	335544336	deadlock	deadlock
-922	335544323	bad_db_format	file @1 is not a valid database
-923	335544421	connect_reject	connection rejected by remote interface
-923	335544461	cant_validate	secondary server attachments cannot validate databases
-923	335544462	cant_start_journal	secondary server attachments cannot start journaling
-923	335544464	cant_start_logging	secondary server attachments cannot start logging

SQL-CODE	GDSCODE	Symbol	Message Text
-924	335544325	bad_dpb_content	bad parameters on attach or create database
-924	335544433	journerr	communication error with journal "@1"
-924	335544441	bad_detach	database detach completed with errors
-924	335544648	conn_lost	Connection lost to pipe server
-924	335544972	bad_conn_str	Invalid connection string
-924	335545085	baddpb_damaged_mode	Incompatible mode of attachment to damaged database
-924	335545086	baddpb_buffers_range	Attempt to set in database number of buffers which is out of acceptable range [@1:@2]
-924	335545087	baddpb_temp_buffers	Attempt to temporarily set number of buffers less than @1
-926	335544447	no_rollback	no rollback performed
-999	335544689	ib_error	Firebird error

Appendix C: Reserved Words and Keywords

Reserved words are part of the Firebird SQL language. They cannot be used as identifiers (e.g. as table or procedure names), except when enclosed in double quotes in Dialect 3. However, you should avoid this unless you have a compelling reason.

Keywords are also part of the language. They have a special meaning when used in the proper context, but they are not reserved for Firebird's own and exclusive use. You can use them as identifiers without double-quoting.

Reserved words

Full list of reserved words in Firebird 4.0:

ADD	ADMIN	ALL
ALTER	AND	ANY
AS	AT	AVG
BEGIN	BETWEEN	BIGINT
BINARY	BIT_LENGTH	BLOB
BOOLEAN	BOTH	BY
CASE	CAST	CHAR
CHARACTER	CHARACTER_LENGTH	CHAR_LENGTH
CHECK	CLOSE	COLLATE
COLUMN	COMMENT	COMMIT
CONNECT	CONSTRAINT	CORR
COUNT	COVAR_POP	COVAR_SAMP
CREATE	CROSS	CURRENT
CURRENT_CONNECTION	CURRENT_DATE	CURRENT_ROLE
CURRENT_TIME	CURRENT_TIMESTAMP	CURRENT_TRANSACTION
CURRENT_USER	CURSOR	DATE
DAY	DEC	DECFLOAT
DECIMAL	DECLARE	DEFAULT
DELETE	DELETING	DETERMINISTIC
DISCONNECT	DISTINCT	DOUBLE
DROP	ELSE	END
ESCAPE	EXECUTE	EXISTS
EXTERNAL	EXTRACT	FALSE
FETCH	FILTER	FLOAT
FOR	FOREIGN	FROM
FULL	FUNCTION	GDSCODE
GLOBAL	GRANT	GROUP

HAVING	HOUR	IN
INDEX	INNER	INSENSITIVE
INSERT	INSERTING	INT
INT128	INTEGER	INTO
IS	JOIN	LATERAL
LEADING	LEFT	LIKE
LOCAL	LOCALTIME	LOCALTIMESTAMP
LONG	LOWER	MAX
MERGE	MIN	MINUTE
MONTH	NATIONAL	NATURAL
NCHAR	NO	NOT
NULL	NUMERIC	OCTET_LENGTH
OF	OFFSET	ON
ONLY	OPEN	OR
ORDER	OUTER	OVER
PARAMETER	PLAN	POSITION
POST_EVENT	PRECISION	PRIMARY
PROCEDURE	PUBLICATION	RDB$DB_KEY
RDB$ERROR	RDB$GET_CONTEXT	RDB$GET_TRANSACTION_CN
RDB$RECORD_VERSION	RDB$ROLE_IN_USE	RDB$SET_CONTEXT
RDB$SYSTEM_PRIVILEGE	REAL	RECORD_VERSION
RECREATE	RECURSIVE	REFERENCES
REGR_AVGX	REGR_AVGY	REGR_COUNT
REGR_INTERCEPT	REGR_R2	REGR_SLOPE
REGR_SXX	REGR_SXY	REGR_SYY
RELEASE	RESETTING	RETURN
RETURNING_VALUES	RETURNS	REVOKE
RIGHT	ROLLBACK	ROW
ROWS	ROW_COUNT	SAVEPOINT
SCROLL	SECOND	SELECT
SENSITIVE	SET	SIMILAR
SMALLINT	SOME	SQLCODE
SQLSTATE	START	STDDEV_POP
STDDEV_SAMP	SUM	TABLE
THEN	TIME	TIMESTAMP
TIMEZONE_HOUR	TIMEZONE_MINUTE	TO
TRAILING	TRIGGER	TRIM
TRUE	UNBOUNDED	UNION
UNIQUE	UNKNOWN	UPDATE

UPDATING	UPPER	USER
USING	VALUE	VALUES
VARBINARY	VARCHAR	VARIABLE
VARYING	VAR_POP	VAR_SAMP
VIEW	WHEN	WHERE
WHILE	WINDOW	WITH
WITHOUT	YEAR	

Keywords

The following terms have a special meaning in Firebird 4.0 DSQL (as of 4.0.1). Some of them are also reserved words, others are not.

!<	^<	^=
^>	,	:=
!=	!>	(
)	<	⇐
<>	=	>
>=	||	~<
~=	~>	ABS
ABSOLUTE	ACCENT	ACOS
ACOSH	ACTION	ACTIVE
ADD	ADMIN	AFTER
ALL	ALTER	ALWAYS
AND	ANY	AS
ASC	ASCENDING	ASCII_CHAR
ASCII_VAL	ASIN	ASINH
AT	ATAN	ATAN2
ATANH	AUTO	AUTONOMOUS
AVG	BACKUP	BASE64_DECODE
BASE64_ENCODE	BEFORE	BEGIN
BETWEEN	BIGINT	BINARY
BIND	BIN_AND	BIN_NOT
BIN_OR	BIN_SHL	BIN_SHR
BIN_XOR	BIT_LENGTH	BLOB
BLOCK	BODY	BOOLEAN
BOTH	BREAK	BY
CALLER	CASCADE	CASE
CAST	CEIL	CEILING
CHAR	CHARACTER	CHARACTER_LENGTH

CHAR_LENGTH	CHAR_TO_UUID	CHECK
CLEAR	CLOSE	COALESCE
COLLATE	COLLATION	COLUMN
COMMENT	COMMIT	COMMITTED
COMMON	COMPARE_DECFLOAT	COMPUTED
CONDITIONAL	CONNECT	CONNECTIONS
CONSISTENCY	CONSTRAINT	CONTAINING
CONTINUE	CORR	COS
COSH	COT	COUNT
COUNTER	COVAR_POP	COVAR_SAMP
CREATE	CROSS	CRYPT_HASH
CSTRING	CTR_BIG_ENDIAN	CTR_LENGTH
CTR_LITTLE_ENDIAN	CUME_DIST	CURRENT
CURRENT_CONNECTION	CURRENT_DATE	CURRENT_ROLE
CURRENT_TIME	CURRENT_TIMESTAMP	CURRENT_TRANSACTION
CURRENT_USER	CURSOR	DATA
DATABASE	DATE	DATEADD
DATEDIFF	DAY	DDL
DEBUG	DEC	DECFLOAT
DECIMAL	DECLARE	DECODE
DECRYPT	DEFAULT	DEFINER
DELETE	DELETING	DENSE_RANK
DESC	DESCENDING	DESCRIPTOR
DETERMINISTIC	DIFFERENCE	DISABLE
DISCONNECT	DISTINCT	DO
DOMAIN	DOUBLE	DROP
ELSE	ENABLE	ENCRYPT
END	ENGINE	ENTRY_POINT
ESCAPE	EXCEPTION	EXCESS
EXCLUDE	EXECUTE	EXISTS
EXIT	EXP	EXTENDED
EXTERNAL	EXTRACT	FALSE
FETCH	FILE	FILTER
FIRST	FIRSTNAME	FIRST_DAY
FIRST_VALUE	FLOAT	FLOOR
FOLLOWING	FOR	FOREIGN
FREE_IT	FROM	FULL
FUNCTION	GDSCODE	GENERATED
GENERATOR	GEN_ID	GEN_UUID

GLOBAL	GRANT	GRANTED
GROUP	HASH	HAVING
HEX_DECODE	HEX_ENCODE	HOUR
IDENTITY	IDLE	IF
IGNORE	IIF	IN
INACTIVE	INCLUDE	INCREMENT
INDEX	INNER	INPUT_TYPE
INSENSITIVE	INSERT	INSERTING
INT	INT128	INTEGER
INTO	INVOKER	IS
ISOLATION	IV	JOIN
KEY	LAG	LAST
LASTNAME	LAST_DAY	LAST_VALUE
LATERAL	LEAD	LEADING
LEAVE	LEFT	LEGACY
LENGTH	LEVEL	LIFETIME
LIKE	LIMBO	LINGER
LIST	LN	LOCAL
LOCALTIME	LOCALTIMESTAMP	LOCK
LOG	LOG10	LONG
LOWER	LPAD	LPARAM
MAKE_DBKEY	MANUAL	MAPPING
MATCHED	MATCHING	MAX
MAXVALUE	MERGE	MESSAGE
MIDDLENAME	MILLISECOND	MIN
MINUTE	MINVALUE	MOD
MODE	MODULE_NAME	MONTH
NAME	NAMES	NATIONAL
NATIVE	NATURAL	NCHAR
NEXT	NO	NORMALIZE_DECFLOAT
NOT	NTH_VALUE	NTILE
NULL	NULLIF	NULLS
NUMBER	NUMERIC	OCTET_LENGTH
OF	OFFSET	OLDEST
ON	ONLY	OPEN
OPTION	OR	ORDER
OS_NAME	OTHERS	OUTER
OUTPUT_TYPE	OVER	OVERFLOW
OVERLAY	OVERRIDING	PACKAGE

PAD	PAGE	PAGES
PAGE_SIZE	PARAMETER	PARTITION
PASSWORD	PERCENT_RANK	PI
PKCS_1_5	PLACING	PLAN
PLUGIN	POOL	POSITION
POST_EVENT	POWER	PRECEDING
PRECISION	PRESERVE	PRIMARY
PRIOR	PRIVILEGE	PRIVILEGES
PROCEDURE	PROTECTED	PUBLICATION
QUANTIZE	RAND	RANGE
RANK	RDB$DB_KEY	RDB$ERROR
RDB$GET_CONTEXT	RDB$GET_TRANSACTION_CN	RDB$RECORD_VERSION
RDB$ROLE_IN_USE	RDB$SET_CONTEXT	RDB$SYSTEM_PRIVILEGE
READ	REAL	RECORD_VERSION
RECREATE	RECURSIVE	REFERENCES
REGR_AVGX	REGR_AVGY	REGR_COUNT
REGR_INTERCEPT	REGR_R2	REGR_SLOPE
REGR_SXX	REGR_SXY	REGR_SYY
RELATIVE	RELEASE	REPLACE
REQUESTS	RESERV	RESERVING
RESET	RESETTING	RESTART
RESTRICT	RETAIN	RETURN
RETURNING	RETURNING_VALUES	RETURNS
REVERSE	REVOKE	RIGHT
ROLE	ROLLBACK	ROUND
ROW	ROWS	ROW_COUNT
ROW_NUMBER	RPAD	RSA_DECRYPT
RSA_ENCRYPT	RSA_PRIVATE	RSA_PUBLIC
RSA_SIGN_HASH	RSA_VERIFY_HASH	SALT_LENGTH
SAVEPOINT	SCALAR_ARRAY	SCHEMA
SCROLL	SECOND	SECURITY
SEGMENT	SELECT	SENSITIVE
SEQUENCE	SERVERWIDE	SESSION
SET	SHADOW	SHARED
SIGN	SIGNATURE	SIMILAR
SIN	SINGULAR	SINH
SIZE	SKIP	SMALLINT
SNAPSHOT	SOME	SORT
SOURCE	SPACE	SQL

SQLCODE	SQLSTATE	SQRT
STABILITY	START	STARTING
STARTS	STATEMENT	STATISTICS
STDDEV_POP	STDDEV_SAMP	SUBSTRING
SUB_TYPE	SUM	SUSPEND
SYSTEM	TABLE	TAGS
TAN	TANH	TEMPORARY
THEN	TIES	TIME
TIMEOUT	TIMESTAMP	TIMEZONE_HOUR
TIMEZONE_MINUTE	TO	TOTALORDER
TRAILING	TRANSACTION	TRAPS
TRIGGER	TRIM	TRUE
TRUNC	TRUSTED	TWO_PHASE
TYPE	UNBOUNDED	UNCOMMITTED
UNDO	UNION	UNIQUE
UNKNOWN	UPDATE	UPDATING
UPPER	USAGE	USER
USING	UUID_TO_CHAR	VALUE
VALUES	VARBINARY	VARCHAR
VARIABLE	VARYING	VAR_POP
VAR_SAMP	VIEW	WAIT
WEEK	WEEKDAY	WHEN
WHERE	WHILE	WINDOW
WITH	WITHOUT	WORK
WRITE	YEAR	YEARDAY
ZONE		

Appendix D: System Tables

When you create a database, the Firebird engine creates a lot of system tables. Metadata — the descriptions and attributes of all database objects — are stored in these system tables.

System table identifiers all begin with the prefix `RDB$`.

List of System Tables

RDB$AUTH_MAPPING

Stores authentication and other security mappings

RDB$BACKUP_HISTORY

History of backups performed using *nBackup*

RDB$CHARACTER_SETS

Names and describes the character sets available in the database

RDB$CHECK_CONSTRAINTS

Cross-references between the names of constraints (`NOT NULL` constraints, `CHECK` constraints and `ON UPDATE` and `ON DELETE` clauses in foreign key constraints) and their associated system-generated triggers

RDB$COLLATIONS

Collation sequences for all character sets

RDB$CONFIG

Virtual table with configuration settings applied for the current database

RDB$DATABASE

Basic information about the database

RDB$DB_CREATORS

A list of users granted the `CREATE DATABASE` privilege when using the specified database as a security database

RDB$DEPENDENCIES

Information about dependencies between database objects

RDB$EXCEPTIONS

Custom database exceptions

RDB$FIELDS

Column and domain definitions, both system and custom

RDB$FIELD_DIMENSIONS

Dimensions of array columns

RDB$FILES

Information about secondary files and shadow files

RDB$FILTERS

Information about BLOB filters

RDB$FORMATS

Information about changes in the formats of tables

RDB$FUNCTIONS

Information about external functions

RDB$FUNCTION_ARGUMENTS

Attributes of the parameters of external functions

RDB$GENERATORS

Information about sequences (generators)

RDB$INDEX_SEGMENTS

Segments and index positions

RDB$INDICES

Definitions of all indexes in the database (system- or user-defined)

RDB$LOG_FILES

Not used in the current version

RDB$PACKAGES

Stores the definition (header and body) of SQL packages

RDB$PAGES

Information about database pages

RDB$PROCEDURES

Definitions of stored procedures

RDB$PROCEDURE_PARAMETERS

Parameters of stored procedures

RDB$REF_CONSTRAINTS

Definitions of referential constraints (foreign keys)

RDB$RELATIONS

Headers of tables and views

RDB$RELATION_CONSTRAINTS

Definitions of all table-level constraints

RDB$RELATION_FIELDS

Top-level definitions of table columns

RDB$ROLES

Role definitions

RDB$SECURITY_CLASSES

Access control lists

RDB$TIME_ZONES

Time zones

RDB$TRANSACTIONS

State of multi-database transactions

RDB$TRIGGERS

Trigger definitions

RDB$TRIGGER_MESSAGES

Trigger messages

RDB$TYPES

Definitions of enumerated data types

RDB$USER_PRIVILEGES

SQL privileges granted to system users

RDB$VIEW_RELATIONS

Tables that are referred to in view definitions: one record for each table in a view

RDB$AUTH_MAPPING

RDB$AUTH_MAPPING stores authentication and other security mappings.

Column Name	Data Type	Description
RDB$MAP_NAME	CHAR(63)	Name of the mapping
RDB$MAP_USING	CHAR(1)	Using definition: P - plugin (specific or any) S - any plugin serverwide M - mapping * - any method
RDB$MAP_PLUGIN	CHAR(63)	Mapping applies for authentication information from this specific plugin
RDB$MAP_DB	CHAR(63)	Mapping applies for authentication information from this specific database

Column Name	Data Type	Description
RDB$MAP_FROM_TYPE	CHAR(63)	The type of authentication object (defined by plugin) to map from, or * for any type
RDB$MAP_FROM	CHAR(255)	The name of the authentication object to map from
RDB$MAP_TO_TYPE	SMALLINT	The type to map to 0 - USER 1 - ROLE
RDB$MAP_TO	CHAR(63)	The name to map to
RDB$SYSTEM_FLAG	SMALLINT	Flag: 0 - user-defined 1 or higher - system-defined
RDB$DESCRIPTION	BLOB TEXT	Optional description of the mapping (comment)

RDB$BACKUP_HISTORY

RDB$BACKUP_HISTORY stores the history of backups performed using the *nBackup* utility.

Column Name	Data Type	Description
RDB$BACKUP_ID	INTEGER	The identifier assigned by the engine
RDB$TIMESTAMP	TIMESTAMP WITH TIME ZONE	Backup date and time
RDB$BACKUP_LEVEL	INTEGER	Backup level
RDB$GUID	CHAR(38)	Unique identifier
RDB$SCN	INTEGER	System (scan) number
RDB$FILE_NAME	VARCHAR(255)	Full path and file name of backup file

RDB$CHARACTER_SETS

RDB$CHARACTER_SETS names and describes the character sets available in the database.

Column Name	Data Type	Description
RDB$CHARACTER_SET_NAME	CHAR(63)	Character set name
RDB$FORM_OF_USE	CHAR(63)	Not used
RDB$NUMBER_OF_CHARACTERS	INTEGER	The number of characters in the set. Not used for existing character sets

Column Name	Data Type	Description
RDB$DEFAULT_COLLATE_NAME	CHAR(63)	The name of the default collation sequence for the character set
RDB$CHARACTER_SET_ID	SMALLINT	Unique character set identifier
RDB$SYSTEM_FLAG	SMALLINT	System flag: value is 1 if the character set is defined in the system when the database is created; value is 0 for a user-defined character set
RDB$DESCRIPTION	BLOB TEXT	Could store text description of the character set
RDB$FUNCTION_NAME	CHAR(63)	For a user-defined character set that is accessed via an external function, the name of the external function
RDB$BYTES_PER_CHARACTER	SMALLINT	The maximum number of bytes representing one character
RDB$SECURITY_CLASS	CHAR(63)	May reference a security class defined in the table RDB$SECURITY_CLASSES, in order to apply access control limits to all users of this character set
RDB$OWNER_NAME	CHAR(63)	The username of the user who created the character set originally

RDB$CHECK_CONSTRAINTS

RDB$CHECK_CONSTRAINTS provides the cross-references between the names of system-generated triggers for constraints and the names of the associated constraints (NOT NULL constraints, CHECK constraints and the ON UPDATE and ON DELETE clauses in foreign key constraints).

Column Name	Data Type	Description
RDB$CONSTRAINT_NAME	CHAR(63)	Constraint name, defined by the user or automatically generated by the system
RDB$TRIGGER_NAME	CHAR(63)	For CHECK constraints, the name of the trigger that enforces the constraint. For NOT NULL constraints, the name of the affected column. For foreign key constraints, the name of the trigger that enforces the ON UPDATE and ON DELETE clauses.

RDB$COLLATIONS

RDB$COLLATIONS stores collation sequences for all character sets.

Column Name	Data Type	Description
RDB$COLLATION_NAME	CHAR(63)	Collation sequence name
RDB$COLLATION_ID	SMALLINT	Collation sequence identifier. Together with the character set identifier, it is a unique collation sequence identifier
RDB$CHARACTER_SET_ID	SMALLINT	Character set identifier. Together with the collection sequence identifier, it is a unique identifier
RDB$COLLATION_ATTRIBUTES	SMALLINT	Collation attributes. It is a bit mask where the first bit shows whether trailing spaces should be taken into account in collations (0 - NO PAD; 1 - PAD SPACE); the second bit shows whether the collation is case-sensitive (0 - CASE SENSITIVE, 1 - CASE INSENSITIVE); the third bit shows whether the collation is accent-sensitive (0 - ACCENT SENSITIVE, 1 - ACCENT SENSITIVE). Thus, the value of 5 means that the collation does not take into account trailing spaces and is accent-insensitive
RDB$SYSTEM_FLAG	SMALLINT	Flag: the value of 0 means it is user-defined; the value of 1 means it is system-defined
RDB$DESCRIPTION	BLOB TEXT	Could store text description of the collation sequence
RDB$FUNCTION_NAME	CHAR(63)	Not currently used
RDB$BASE_COLLATION_NAME	CHAR(63)	The name of the base collation sequence for this collation sequence
RDB$SPECIFIC_ATTRIBUTES	BLOB TEXT	Describes specific attributes
RDB$SECURITY_CLASS	CHAR(63)	May reference a security class defined in the table RDB$SECURITY_CLASSES, in order to apply access control limits to all users of this collation
RDB$OWNER_NAME	CHAR(63)	The username of the user who created the collation originally

RDB$CONFIG

RDB$CONFIG is a virtual table showing the configuration settings of the current database for the current connection.

Table RDB$CONFIG is populated from in-memory structures upon request and its instance is preserved for the SQL query lifetime. For security reasons, access to this table is allowed for administrators only. Non-privileged users see no rows in this table (and no error is raised).

Column Name	Data Type	Description
RDB$CONFIG_ID	INTEGER	Unique row identifier, no special meaning
RDB$CONFIG_NAME	VARCHAR(63)	Setting name (e.g. TempCacheLimit)
RDB$CONFIG_VALUE	VARCHAR(255)	Actual value of setting
RDB$CONFIG_DEFAULT	VARCHAR(255)	Default value of setting (defined in the Firebird code)
RDB$CONFIG_IS_SET	BOOLEAN	TRUE if value is explicitly configured, FALSE when default
RDB$CONFIG_SOURCE	VARCHAR(255)	Name of the configuration file (relative to the Firebird root directory) where this setting was taken from, or special value DPB if the setting was specified by the client application via API.

RDB$DATABASE

RDB$DATABASE stores basic information about the database. It contains only one record.

Column Name	Data Type	Description
RDB$DESCRIPTION	BLOB TEXT	Database comment text
RDB$RELATION_ID	SMALLINT	A number that steps up by one each time a table or view is added to the database
RDB$SECURITY_CLASS	CHAR(63)	The security class defined in RDB$SECURITY_CLASSES in order to apply access control limits common to the entire database
RDB$CHARACTER_SET_NAME	CHAR(63)	The name of the default character set for the database set in the DEFAULT CHARACTER SET clause when the database is created. NULL for character set NONE.
RDB$LINGER	INTEGER	Number of seconds "delay" (established with the ALTER DATABASE SET LINGER statement) until the database file is closed after the last connection to this database is closed (in SuperServer). NULL if no delay is set.

Column Name	Data Type	Description
RDB$SQL_SECURITY	BOOLEAN	The default SQL SECURITY mode (DEFINER or INVOKER) applied to newly created objects: NULL - initial default (INVOKER) FALSE - INVOKER TRUE - DEFINER

RDB$DB_CREATORS

RDB$DB_CREATORS contains a list of users granted the CREATE DATABASE privilege when using the specified database as a security database.

Column Name	Data Type	Description
RDB$USER	CHAR(63)	User or role name
RDB$USER_TYPE	SMALLINT	Type of user 8 - user 13 - role

RDB$DEPENDENCIES

RDB$DEPENDENCIES stores the dependencies between database objects.

Column Name	Data Type	Description
RDB$DEPENDENT_NAME	CHAR(63)	The name of the view, procedure, trigger, CHECK constraint or computed column the dependency is defined for, i.e., the *dependent* object
RDB$DEPENDED_ON_NAME	CHAR(63)	The name of the object that the defined object — the table, view, procedure, trigger, CHECK constraint or computed column — depends on
RDB$FIELD_NAME	CHAR(63)	The column name in the depended-on object that is referred to by the dependent view, procedure, trigger, CHECK constraint or computed column

Column Name	Data Type	Description
RDB$DEPENDENT_TYPE	SMALLINT	Identifies the type of the dependent object: 0 - table 1 - view 2 - trigger 3 - computed column 4 - CHECK constraint 5 - procedure 6 - index expression 7 - exception 8 - user 9 - column 10 - index 15 - stored function 18 - package header 19 - package body
RDB$DEPENDED_ON_TYPE	SMALLINT	Identifies the type of the object depended on: 0 - table (or a column in it) 1 - view 2 - trigger 3 - computed column 4 - CHECK constraint 5 - procedure (or its parameter(s)) 6 - index expression 7 - exception 8 - user 9 - column 10 - index 14 - generator (sequence) 15 - UDF or stored function 17 - collation 18 - package header 19 - package body
RDB$PACKAGE_NAME	CHAR(63)	The package of a procedure or function for which this describes the dependency.

RDB$EXCEPTIONS

RDB$EXCEPTIONS stores custom database exceptions.

Column Name	Data Type	Description
RDB$EXCEPTION_NAME	CHAR(63)	Custom exception name

Column Name	Data Type	Description
RDB$EXCEPTION_NUMBER	INTEGER	The unique number of the exception assigned by the system
RDB$MESSAGE	VARCHAR(1021)	Exception message text
RDB$DESCRIPTION	BLOB TEXT	Could store text description of the exception
RDB$SYSTEM_FLAG	SMALLINT	Flag: 0 - user-defined 1 or higher - system-defined
RDB$SECURITY_CLASS	CHAR(63)	May reference a security class defined in the table RDB$SECURITY_CLASSES, in order to apply access control limits to all users of this exception
RDB$OWNER_NAME	CHAR(63)	The username of the user who created the exception originally

RDB$FIELDS

RDB$FIELDS stores definitions of columns and domains, both system and custom. This is where the detailed data attributes are stored for all columns.

The column RDB$FIELDS.RDB$FIELD_NAME links to RDB$RELATION_FIELDS.RDB$FIELD_SOURCE, not to RDB$RELATION_FIELDS.RDB$FIELD_NAME.

Column Name	Data Type	Description
RDB$FIELD_NAME	CHAR(63)	The unique name of the domain created by the user or of the domain automatically built for the table column by the system. System-created domain names start with the “RDB$” prefix
RDB$QUERY_NAME	CHAR(63)	Not used
RDB$VALIDATION_BLR	BLOB BLR	The binary language representation (BLR) of the SQL expression specifying the check of the CHECK value in the domain
RDB$VALIDATION_SOURCE	BLOB TEXT	The original source text in the SQL language specifying the check of the CHECK value
RDB$COMPUTED_BLR	BLOB BLR	The binary language representation (BLR) of the SQL expression the database server uses for evaluation when accessing a COMPUTED BY column

Column Name	Data Type	Description
RDB$COMPUTED_SOURCE	BLOB TEXT	The original source text of the expression that defines a COMPUTED BY column
RDB$DEFAULT_VALUE	BLOB BLR	The default value, if any, for the field or domain, in binary language representation (BLR)
RDB$DEFAULT_SOURCE	BLOB TEXT	The default value in the source code, as an SQL constant or expression
RDB$FIELD_LENGTH	SMALLINT	Column size in bytes. BOOLEAN occupies 1 byte. FLOAT, DATE, TIME, INTEGER occupy 4 bytes. DOUBLE PRECISION, BIGINT, TIMESTAMP, TIME WITH TIME ZONE, DECFLOAT(16) and BLOB identifiers occupy 8 bytes. TIMESTAMP WITH TIME ZONE occupies 12 bytes. INT128 and DECFLOAT(34) occupy 16 bytes. For the CHAR and VARCHAR data types, the column stores the maximum number of bytes specified when a string domain (column) is defined
RDB$FIELD_SCALE	SMALLINT	The negative number that specifies the scale for DECIMAL and NUMERIC columns — the number of digits after the decimal point

Column Name	Data Type	Description
RDB$FIELD_TYPE	SMALLINT	Data type code for the column: 7 - SMALLINT 8 - INTEGER 10 - FLOAT 12 - DATE 13 - TIME 14 - CHAR 16 - BIGINT 23 - BOOLEAN 24 - DECFLOAT(16) 25 - DECFLOAT(34) 26 - INT128 27 - DOUBLE PRECISION 28 - TIME WITH TIME ZONE 29 - TIMESTAMP WITH TIME ZONE 35 - TIMESTAMP 37 - VARCHAR 261 - BLOB Codes for DECIMAL and NUMERIC are the same as for the integer types used for storage.

Column Name	Data Type	Description
RDB$FIELD_SUB_TYPE	SMALLINT	Specifies the subtype for the BLOB data type: 0 - untyped (binary) 1 - text 2 - BLR 3 - access control list 4 - reserved for future use 5 - encoded table metadata description 6 - for storing the details of a cross-database transaction that ends abnormally 7 - external file description 8 - debug information (for PSQL) < 0 - user-defined Specifies for the CHAR data type: 0 - untyped data 1 - fixed binary data Specifies the particular data type for the integer data types (SMALLINT, INTEGER, BIGINT, INT128) and for fixed-point numbers (NUMERIC, DECIMAL): 0 or NULL - the data type matches the value in the RDB$FIELD_TYPE field 1 - NUMERIC 2 - DECIMAL
RDB$MISSING_VALUE	BLOB BLR	Not used
RDB$MISSING_SOURCE	BLOB TEXT	Not used
RDB$DESCRIPTION	BLOB TEXT	Any domain (table column) comment text
RDB$SYSTEM_FLAG	SMALLINT	Flag: the value of 1 means the domain is automatically created by the system, the value of 0 means that the domain is defined by the user
RDB$QUERY_HEADER	BLOB TEXT	Not used
RDB$SEGMENT_LENGTH	SMALLINT	Specifies the length of the BLOB buffer in bytes for BLOB columns. Stores NULL for all other data types
RDB$EDIT_STRING	VARCHAR(127)	Not used

Column Name	Data Type	Description
RDB$EXTERNAL_LENGTH	SMALLINT	The length of the column in bytes if it belongs to an external table. Always NULL for regular tables
RDB$EXTERNAL_SCALE	SMALLINT	The scale factor of an integer-type field in an external table; represents the power of 10 by which the integer is multiplied
RDB$EXTERNAL_TYPE	SMALLINT	The data type of the field as it is represented in an external table: 7 - SMALLINT 8 - INTEGER 10 - FLOAT 12 - DATE 13 - TIME 14 - CHAR 16 - BIGINT 23 - BOOLEAN 24 - DECFLOAT(16) 25 - DECFLOAT(34) 26 - INT128 27 - DOUBLE PRECISION 28 - TIME WITH TIME ZONE 29 - TIMESTAMP WITH TIME ZONE 35 - TIMESTAMP 37 - VARCHAR 261 - BLOB
RDB$DIMENSIONS	SMALLINT	Defines the number of dimensions in an array if the column is defined as an array. Always NULL for columns that are not arrays
RDB$NULL_FLAG	SMALLINT	Specifies whether the column can take an empty value (the field will contain NULL) or not (the field will contain the value of 1)
RDB$CHARACTER_LENGTH	SMALLINT	The length of CHAR or VARCHAR columns in characters (not in bytes)
RDB$COLLATION_ID	SMALLINT	The identifier of the collation sequence for a character column or domain. If it is not defined, the value of the field will be 0

Column Name	Data Type	Description
RDB$CHARACTER_SET_ID	SMALLINT	The identifier of the character set for a character column, BLOB TEXT column or domain
RDB$FIELD_PRECISION	SMALLINT	Specifies the total number of digits for the fixed-point numeric data type (DECIMAL and NUMERIC). The value is 0 for the integer data types, NULL is for other data types
RDB$SECURITY_CLASS	CHAR(63)	May reference a security class defined in the table RDB$SECURITY_CLASSES, in order to apply access control limits to all users of this domain
RDB$OWNER_NAME	CHAR(63)	The username of the user who created the domain originally

RDB$FIELD_DIMENSIONS

RDB$FIELD_DIMENSIONS stores the dimensions of array columns.

Column Name	Data Type	Description
RDB$FIELD_NAME	CHAR(63)	The name of the array column. It must be present in the RDB$FIELD_NAME field of the RDB$FIELDS table
RDB$DIMENSION	SMALLINT	Identifies one dimension in the array column. The numbering of dimensions starts with 0
RDB$LOWER_BOUND	INTEGER	The lower bound of this dimension
RDB$UPPER_BOUND	INTEGER	The upper bound of this dimension

RDB$FILES

RDB$FILES stores information about secondary files and shadow files.

Column Name	Data Type	Description
RDB$FILE_NAME	VARCHAR(255)	The full path to the file and the name of either • the database secondary file in a multi-file database, or • the shadow file

Column Name	Data Type	Description
RDB$FILE_SEQUENCE	SMALLINT	The sequential number of the secondary file in a sequence or of the shadow file in a shadow file set
RDB$FILE_START	INTEGER	The initial page number in the secondary file or shadow file
RDB$FILE_LENGTH	INTEGER	File length in database pages
RDB$FILE_FLAGS	SMALLINT	For internal use
RDB$SHADOW_NUMBER	SMALLINT	Shadow set number. If the row describes a database secondary file, the field will be NULL or its value will be 0

RDB$FILTERS

RDB$FILTERS stores information about BLOB filters.

Column Name	Data Type	Description
RDB$FUNCTION_NAME	CHAR(63)	The unique identifier of the BLOB filter
RDB$DESCRIPTION	BLOB TEXT	Documentation about the BLOB filter and the two subtypes it is used with, written by the user
RDB$MODULE_NAME	VARCHAR(255)	The name of the dynamic library or shared object where the code of the BLOB filter is located
RDB$ENTRYPOINT	CHAR(255)	The exported name of the BLOB filter in the filter library. Note, this is often not the same as RDB$FUNCTION_NAME, which is the identifier with which the BLOB filter is declared to the database
RDB$INPUT_SUB_TYPE	SMALLINT	The BLOB subtype of the data to be converted by the function
RDB$OUTPUT_SUB_TYPE	SMALLINT	The BLOB subtype of the converted data
RDB$SYSTEM_FLAG	SMALLINT	Flag indicating whether the filter is user-defined or internally defined: 0 - user-defined 1 or greater - internally defined
RDB$SECURITY_CLASS	CHAR(63)	May reference a security class defined in the table RDB$SECURITY_CLASSES, in order to apply access control limits to all users of this filter

Column Name	Data Type	Description
RDB$OWNER_NAME	CHAR(63)	The username of the user who created the filter originally

RDB$FORMATS

RDB$FORMATS stores information about changes in tables. Each time any metadata change to a table is committed, it gets a new format number. When the format number of any table reaches 255, or any view 32,000, the entire database becomes inoperable. To return to normal, the database must be backed up with the *gbak* utility and restored from that backup copy.

Column Name	Data Type	Description
RDB$RELATION_ID	SMALLINT	Table or view identifier
RDB$FORMAT	SMALLINT	Table format identifier — maximum 255 for tables, 32,000 for views. The critical time comes when this number approaches 255 for *any* table or 32,000 for *any* view
RDB$DESCRIPTOR	BLOB FORMAT	Stores column names and data attributes as BLOB, as they were at the time the format record was created

RDB$FUNCTIONS

RDB$FUNCTIONS stores the information needed by the engine about stored functions and external functions (user-defined functions, UDFs).

Column Name	Data Type	Description
RDB$FUNCTION_NAME	CHAR(63)	The unique (declared) name of the external function
RDB$FUNCTION_TYPE	SMALLINT	Not currently used
RDB$QUERY_NAME	CHAR(63)	Not currently used
RDB$DESCRIPTION	BLOB TEXT	Any text with comments related to the external function
RDB$MODULE_NAME	VARCHAR(255)	The name of the dynamic library or shared object where the code of the external function is located
RDB$ENTRYPOINT	CHAR(255)	The exported name of the external function in the function library. Note, this is often not the same as RDB$FUNCTION_NAME, which is the identifier with which the external function is declared to the database

Column Name	Data Type	Description
RDB$RETURN_ARGUMENT	SMALLINT	The position number of the returned argument in the list of parameters corresponding to input arguments
RDB$SYSTEM_FLAG	SMALLINT	Flag indicating whether the filter is user-defined or internally defined: 0 - user-defined 1 - internally defined
RDB$ENGINE_NAME	CHAR(63)	Engine for external functions. 'UDR' for UDR functions. NULL for legacy UDF or PSQL functions
RDB$PACKAGE_NAME	CHAR(63)	Package that contains this function (or NULL)
RDB$PRIVATE_FLAG	SMALLINT	NULL for normal (top-level) functions, 0 for package function defined in the header, 1 for package function only defined in the package body.
RDB$FUNCTION_SOURCE	BLOB TEXT	The PSQL sourcecode of the function
RDB$FUNCTION_ID	SMALLINT	Unique identifier of the function
RDB$FUNCTION_BLR	BLOB BLR	The binary language representation (BLR) of the function code (PSQL function only)
RDB$VALID_BLR	SMALLINT	Indicates whether the source PSQL of the stored procedure remains valid after the latest ALTER FUNCTION modification
RDB$DEBUG_INFO	BLOB DEBUG_INFORMATION	Contains debugging information about variables used in the function (PSQL function only)
RDB$SECURITY_CLASS	CHAR(63)	May reference a security class defined in the table RDB$SECURITY_CLASSES, in order to apply access control limits to all users of this function
RDB$OWNER_NAME	CHAR(63)	The username of the user who created the function originally
RDB$LEGACY_FLAG	SMALLINT	The legacy style attribute of the function. 1 - if the function is described in legacy style (DECLARE EXTERNAL FUNCTION), otherwise CREATE FUNCTION.
RDB$DETERMINISTIC_FLAG	SMALLINT	Deterministic flag. 1 - if function is deterministic

Column Name	Data Type	Description
RDB$SQL_SECURITY	BOOLEAN	The SQL SECURITY mode (DEFINER or INVOKER): NULL - initial default (INVOKER) FALSE - INVOKER TRUE - DEFINER

RDB$FUNCTION_ARGUMENTS

RDB$FUNCTION_ARGUMENTS stores the parameters of functions and their attributes.

Column Name	Data Type	Description
RDB$FUNCTION_NAME	CHAR(63)	The unique name (declared identifier) of the function
RDB$ARGUMENT_POSITION	SMALLINT	The position of the argument in the list of arguments
RDB$MECHANISM	SMALLINT	Flag: how this argument is passed: 0 - by value 1 - by reference 2 - by descriptor 3 - by BLOB descriptor 4 - by scalar array 5 - by reference with null Only for legacy external functions.

Column Name	Data Type	Description
RDB$FIELD_TYPE	SMALLINT	Data type code defined for the column: 7 - SMALLINT 8 - INTEGER 10 - FLOAT 12 - DATE 13 - TIME 14 - CHAR 16 - BIGINT 23 - BOOLEAN 24 - DECFLOAT(16) 25 - DECFLOAT(34) 26 - INT128 27 - DOUBLE PRECISION 28 - TIME WITH TIME ZONE 29 - TIMESTAMP WITH TIME ZONE 35 - TIMESTAMP 37 - VARCHAR 40 - CSTRING (null-terminated text) 45 - BLOB_ID 261 - BLOB Only for legacy external functions.
RDB$FIELD_SCALE	SMALLINT	The scale of an integer or a fixed-point argument. It is an exponent of 10. Only for legacy external functions.
RDB$FIELD_LENGTH	SMALLINT	Argument length in bytes: BOOLEAN = 1 SMALLINT = 2 INTEGER = 4 DATE = 4 TIME = 4 BIGINT = 8 DECFLOAT(16) = 8 DOUBLE PRECISION = 8 TIMESTAMP = 8 TIME WITH TIME ZONE = 8 BLOB_ID = 8 TIMESTAMP WITH TIME ZONE = 12 INT128 = 16 DECFLOAT(34) = 16 Only for legacy external functions.

Column Name	Data Type	Description
RDB$FIELD_SUB_TYPE	SMALLINT	Stores the BLOB subtype for an argument of a BLOB data type. Only for legacy external functions.
RDB$CHARACTER_SET_ID	SMALLINT	The identifier of the character set for a character argument. Only for legacy external functions.
RDB$FIELD_PRECISION	SMALLINT	The number of digits of precision available for the data type of the argument. Only for legacy external functions.
RDB$CHARACTER_LENGTH	SMALLINT	The length of a CHAR or VARCHAR argument in characters (not in bytes). Only for legacy external functions.
RDB$PACKAGE_NAME	CHAR(63)	Package name of the function (or NULL for a top-level function)
RDB$ARGUMENT_NAME	CHAR(63)	Parameter name
RDB$FIELD_SOURCE	CHAR(63)	The name of the user-created domain, when a domain is referenced instead of a data type. If the name starts with the prefix “RDB$”, it is the name of the domain automatically generated by the system for the parameter.
RDB$DEFAULT_VALUE	BLOB BLR	The default value for the parameter, in the binary language representation (BLR)
RDB$DEFAULT_SOURCE	BLOB TEXT	The default value for the parameter, in PSQL code
RDB$COLLATION_ID	SMALLINT	The identifier of the collation sequence used for a character parameter
RDB$NULL_FLAG	SMALLINT	The flag indicating whether NULL is allowable
RDB$ARGUMENT_MECHANISM	SMALLINT	Parameter passing mechanism for non-legacy functions: 0 - by value 1 - by reference 2 - through a descriptor 3 - via the BLOB descriptor

Column Name	Data Type	Description
RDB$FIELD_NAME	CHAR(63)	The name of the column the parameter references, if it was declared using TYPE OF COLUMN instead of a regular data type. Used in conjunction with RDB$RELATION_NAME (see next).
RDB$RELATION_NAME	CHAR(63)	The name of the table the parameter references, if it was declared using TYPE OF COLUMN instead of a regular data type
RDB$SYSTEM_FLAG	SMALLINT	Flag: 0 - user-defined 1 or higher - system-defined
RDB$DESCRIPTION	BLOB TEXT	Optional description of the function argument (comment)

RDB$GENERATORS

RDB$GENERATORS stores the metadata of sequences (generators).

Column Name	Data Type	Description
RDB$GENERATOR_NAME	CHAR(63)	The unique name of the sequence
RDB$GENERATOR_ID	SMALLINT	The unique identifier assigned to the sequence by the system
RDB$SYSTEM_FLAG	SMALLINT	Flag: 0 - user-defined 1 or greater - system-defined 6 - internal sequence for identity column
RDB$DESCRIPTION	BLOB TEXT	Optional description of the sequence (comment)
RDB$SECURITY_CLASS	CHAR(63)	May reference a security class defined in the table RDB$SECURITY_CLASSES, to apply access control limits to all users of this sequence
RDB$OWNER_NAME	CHAR(63)	The username of the user who created the sequence originally
RDB$INITIAL_VALUE	BIGINT	Stores the start value (START WITH value) of the sequence. The start value is the first value generated by NEXT VALUE FOR after a restart of the sequence.

Column Name	Data Type	Description
RDB$GENERATOR_INCREMENT	INTEGER	Stores the increment (INCREMENT BY value) of the sequence. The increment is used by NEXT VALUE FOR, but not by GEN_ID.

RDB$INDICES

RDB$INDICES stores definitions of both system- and user-defined indexes. The attributes of each column belonging to an index are stored in one row of the table RDB$INDEX_SEGMENTS.

Column Name	Data Type	Description
RDB$INDEX_NAME	CHAR(63)	The unique name of the index specified by the user or automatically generated by the system
RDB$RELATION_NAME	CHAR(63)	The name of the table to which the index belongs. It corresponds to an identifier in RDB$RELATION_NAME.RDB$RELATIONS
RDB$INDEX_ID	SMALLINT	The internal (system) identifier of the index
RDB$UNIQUE_FLAG	SMALLINT	Specifies whether the index is unique: 0 - not unique 1 - unique
RDB$DESCRIPTION	BLOB TEXT	Could store comments concerning the index
RDB$SEGMENT_COUNT	SMALLINT	The number of segments (columns) in the index
RDB$INDEX_INACTIVE	SMALLINT	Indicates whether the index is currently active: 0 - active 1 - inactive
RDB$INDEX_TYPE	SMALLINT	Distinguishes between an ascending (0 or NULL) and descending index (1). Not used in databases created before Firebird 2.0; hence, indexes in upgraded databases are more likely to store NULL in this column
RDB$FOREIGN_KEY	CHAR(63)	The name of the primary or unique key index referenced by the foreign key backed by this index; NULL if this index is not used by a foreign key.

Column Name	Data Type	Description
RDB$SYSTEM_FLAG	SMALLINT	Indicates whether the index is system-defined or user-defined: 0 - user-defined 1 or greater - system-defined
RDB$EXPRESSION_BLR	BLOB BLR	Expression for an expression index, written in the binary language representation (BLR), used for calculating the values for the index at runtime.
RDB$EXPRESSION_SOURCE	BLOB TEXT	The source code of the expression for an expression index
RDB$STATISTICS	DOUBLE PRECISION	Stores the last known selectivity of the entire index, calculated by execution of a SET STATISTICS statement over the index. It is also recalculated whenever the database is first opened by the server. The selectivity of each separate segment of the index is stored in RDB$INDEX_SEGMENTS.

RDB$INDEX_SEGMENTS

RDB$INDEX_SEGMENTS stores the segments (table columns) of indexes and their positions in the key. A separate row is stored for each column in an index.

Column Name	Data Type	Description
RDB$INDEX_NAME	CHAR(63)	The name of the index this segment is related to. The master record is RDB$INDICES.RDB$INDEX_NAME.
RDB$FIELD_NAME	CHAR(63)	The name of a column belonging to the index, corresponding to an identifier for the table and that column in RDB$RELATION_FIELDS.RDB$FIELD_NAME
RDB$FIELD_POSITION	SMALLINT	The column position in the index. Positions are numbered left-to-right, starting at zero
RDB$STATISTICS	DOUBLE PRECISION	The last known (calculated) selectivity of this column in the index. The higher the number, the lower the selectivity.

RDB$LOG_FILES

RDB$LOG_FILES is not currently used.

RDB$PACKAGES

RDB$PACKAGES stores the definition (header and body) of SQL packages.

Column Name	Data Type	Description
RDB$PACKAGE_NAME	CHAR(63)	Name of the package
RDB$PACKAGE_HEADER_SOURCE	BLOB TEXT	The PSQL sourcecode of the package header
RDB$PACKAGE_BODY_SOURCE	BLOB TEXT	The PSQL sourcecode of the package body
RDB$VALID_BODY_FLAG	SMALLINT	Indicates whether the body of the package is still valid. NULL or 0 indicates the body is not valid.
RDB$SECURITY_CLASS	CHAR(63)	May reference a security class defined in the table RDB$SECURITY_CLASSES, in order to apply access control limits to all users of this package
RDB$OWNER_NAME	CHAR(63)	The username of the user who created the package originally
RDB$SYSTEM_FLAG	SMALLINT	Flag: 0 - user-defined 1 or higher - system-defined
RDB$DESCRIPTION	BLOB TEXT	Optional description of the package (comment)
RDB$SQL_SECURITY	BOOLEAN	The SQL SECURITY mode (DEFINER or INVOKER): NULL - initial default (INVOKER) FALSE - INVOKER TRUE - DEFINER

RDB$PAGES

RDB$PAGES stores and maintains information about database pages and their usage.

Column Name	Data Type	Description
RDB$PAGE_NUMBER	INTEGER	The unique number of a physically created database page

Column Name	Data Type	Description
RDB$RELATION_ID	SMALLINT	The identifier of the table to which the page is allocated
RDB$PAGE_SEQUENCE	INTEGER	The number of the page in the sequence of all pages allocated to this table
RDB$PAGE_TYPE	SMALLINT	Indicates the page type (data, index, BLOB, etc.). For system use

RDB$PROCEDURES

RDB$PROCEDURES stores the definitions of stored procedures, including their PSQL source code and the binary language representation (BLR) of it. The next table, RDB$PROCEDURE_PARAMETERS, stores the definitions of input and output parameters.

Column Name	Data Type	Description
RDB$PROCEDURE_NAME	CHAR(63)	Stored procedure name (identifier)
RDB$PROCEDURE_ID	SMALLINT	The procedure's unique, system-generated identifier
RDB$PROCEDURE_INPUTS	SMALLINT	Indicates the number of input parameters. NULL if there are none
RDB$PROCEDURE_OUTPUTS	SMALLINT	Indicates the number of output parameters. NULL if there are none
RDB$DESCRIPTION	BLOB TEXT	Any text comments related to the procedure
RDB$PROCEDURE_SOURCE	BLOB TEXT	The PSQL source code of the procedure
RDB$PROCEDURE_BLR	BLOB BLR	The binary language representation (BLR) of the procedure code
RDB$SECURITY_CLASS	CHAR(63)	May point to the security class defined in the system table RDB$SECURITY_CLASSES in order to apply access control limits
RDB$OWNER_NAME	CHAR(63)	The username of the procedure's Owner — the user who was CURRENT_USER when the procedure was first created. It may or may not be the username of the author.
RDB$RUNTIME	BLOB	A metadata description of the procedure, used internally for optimization
RDB$SYSTEM_FLAG	SMALLINT	Indicates whether the procedure is defined by a user (value 0) or by the system (a value of 1 or greater)

Column Name	Data Type	Description
RDB$PROCEDURE_TYPE	SMALLINT	Procedure type: 1 - selectable stored procedure (contains a SUSPEND statement) 2 - executable stored procedure NULL - not known * * for procedures created before Firebird 1.5
RDB$VALID_BLR	SMALLINT	Indicates whether the source PSQL of the stored procedure remains valid after the latest ALTER PROCEDURE modification
RDB$DEBUG_INFO	BLOB DEBUG_INFORMATION	Contains debugging information about variables used in the stored procedure
RDB$ENGINE_NAME	CHAR(63)	Engine for external functions. 'UDR' for UDR procedures. NULL for PSQL stored procedures
RDB$ENTRYPOINT	CHAR(255)	The exported name of the external function in the procedure library. Note, this is often not the same as RDB$PROCEDURE_NAME, which is the identifier with which the external stored procedure is declared to the database
RDB$PACKAGE_NAME	CHAR(63)	Package name of the procedure (or NULL for a top-level stored procedure)
RDB$PRIVATE_FLAG	SMALLINT	NULL for normal (top-level) stored procedures, 0 for package procedures defined in the header, 1 for package procedures only defined in the package body.
RDB$SQL_SECURITY	BOOLEAN	The SQL SECURITY mode (DEFINER or INVOKER): NULL - initial default (INVOKER) FALSE - INVOKER TRUE - DEFINER

RDB$PROCEDURE_PARAMETERS

RDB$PROCEDURE_PARAMETERS stores the parameters of stored procedures and their attributes. It holds one row for each parameter.

Column Name	Data Type	Description
RDB$PARAMETER_NAME	CHAR(63)	Parameter name
RDB$PROCEDURE_NAME	CHAR(63)	The name of the procedure where the parameter is defined
RDB$PARAMETER_NUMBER	SMALLINT	The sequential number of the parameter
RDB$PARAMETER_TYPE	SMALLINT	Indicates whether the parameter is for input (value 0) or output (value 1)
RDB$FIELD_SOURCE	CHAR(63)	The name of the user-created domain, when a domain is referenced instead of a data type. If the name starts with the prefix “RDB$”, it is the name of the domain automatically generated by the system for the parameter.
RDB$DESCRIPTION	BLOB TEXT	Could store comments related to the parameter
RDB$SYSTEM_FLAG	SMALLINT	Indicates whether the parameter was defined by the system (value or greater) or by a user (value 0)
RDB$DEFAULT_VALUE	BLOB BLR	The default value for the parameter, in the binary language representation (BLR)
RDB$DEFAULT_SOURCE	BLOB TEXT	The default value for the parameter, in PSQL code
RDB$COLLATION_ID	SMALLINT	The identifier of the collation sequence used for a character parameter
RDB$NULL_FLAG	SMALLINT	The flag indicating whether NULL is allowable
RDB$PARAMETER_MECHANISM	SMALLINT	Flag: indicates how this parameter is passed: 0 - by value 1 - by reference 2 - by descriptor 3 - by BLOB descriptor
RDB$FIELD_NAME	CHAR(63)	The name of the column the parameter references, if it was declared using TYPE OF COLUMN instead of a regular data type. Used in conjunction with RDB$RELATION_NAME (see next).

Column Name	Data Type	Description
RDB$RELATION_NAME	CHAR(63)	The name of the table the parameter references, if it was declared using TYPE OF COLUMN instead of a regular data type
RDB$PACKAGE_NAME	CHAR(63)	Package name of the procedure (or NULL for a top-level stored procedure)

RDB$PUBLICATIONS

RDB$PUBLICATIONS stores the replication publications defined in the database.

Column Name	Data Type	Description
RDB$PUBLICATION_NAME	CHAR(63)	Publication name
RDB$OWNER_NAME	CHAR(63)	The username of the user who created the publication
RDB$SYSTEM_FLAG	SMALLINT	Flag: 0 - user-defined 1 or higher - system-defined
RDB$ACTIVE_FLAG	SMALLINT	Inactive (0) or active (1)
RDB$AUTO_ENABLE	SMALLINT	Automatically add new tables to publication: 0 - disabled 1 - enabled (tables are automatically added to this publication)

In Firebird 4.0 there is a single (pre-defined) publication named RDB$DEFAULT. User-defined publications will be available in future Firebird releases.

RDB$PUBLICATION_TABLES

RDB$PUBLICATION_TABLES stores the names of tables that are replicated as part of a publication.

Column Name	Data Type	Description
RDB$PUBLICATION_NAME	CHAR(63)	Publication name
RDB$TABLE_NAME	CHAR(63)	Table name

RDB$REF_CONSTRAINTS

RDB$REF_CONSTRAINTS stores the attributes of the referential constraints — Foreign Key relationships and referential actions.

Column Name	Data Type	Description
RDB$CONSTRAINT_NAME	CHAR(63)	Foreign key constraint name, defined by the user or automatically generated by the system
RDB$CONST_NAME_UQ	CHAR(63)	The name of the primary or unique key constraint linked by the REFERENCES clause in the constraint definition
RDB$MATCH_OPTION	CHAR(7)	Not used. The current value is FULL in all cases
RDB$UPDATE_RULE	CHAR(11)	Referential integrity actions applied to the foreign key record(s) when the primary (unique) key of the parent table is updated: RESTRICT, NO ACTION, CASCADE, SET NULL, SET DEFAULT
RDB$DELETE_RULE	CHAR(11)	Referential integrity actions applied to the foreign key record(s) when the primary (unique) key of the parent table is deleted: RESTRICT, NO ACTION, CASCADE, SET NULL, SET DEFAULT

RDB$RELATIONS

RDB$RELATIONS stores the top-level definitions and attributes of all tables and views in the system.

Column Name	Data Type	Description
RDB$VIEW_BLR	BLOB BLR	Stores the query specification for a view, in the binary language representation (BLR). The field stores NULL for a table
RDB$VIEW_SOURCE	BLOB TEXT	Contains the original source text of the query for a view, in SQL language. User comments are included. The field stores NULL for a table
RDB$DESCRIPTION	BLOB TEXT	Could store comments related to the table or view
RDB$RELATION_ID	SMALLINT	Internal identifier of the table or view
RDB$SYSTEM_FLAG	SMALLINT	indicates whether the table or view is user-defined (value 0) or system-defined (value 1 or greater)
RDB$DBKEY_LENGTH	SMALLINT	The total length of the database key. For a table: 8 bytes. For a view, the length is 8 multiplied by the number of tables referenced by the view

Column Name	Data Type	Description
RDB$FORMAT	SMALLINT	Internal use, points to the relation's record in RDB$FORMATS — do not modify
RDB$FIELD_ID	SMALLINT	The field ID for the next column to be added. The number is not decremented when a column is dropped.
RDB$RELATION_NAME	CHAR(63)	Table or view name
RDB$SECURITY_CLASS	CHAR(63)	May reference a security class defined in the table RDB$SECURITY_CLASSES, in order to apply access control limits to all users of this table or view
RDB$EXTERNAL_FILE	VARCHAR(255)	The full path to the external data file if the table is defined with the EXTERNAL FILE clause
RDB$RUNTIME	BLOB	Table metadata description, used internally for optimization
RDB$EXTERNAL_DESCRIPTION	BLOB	Could store comments related to the external file of an external table
RDB$OWNER_NAME	CHAR(63)	The username of the user who created the table or view originally
RDB$DEFAULT_CLASS	CHAR(63)	Default security class, used when a new column is added to the table
RDB$FLAGS	SMALLINT	Internal flags
RDB$RELATION_TYPE	SMALLINT	The type of the relation object being described: 0 - system or user-defined table 1 - view 2 - external table 3 - monitoring table 4 - connection-level GTT (PRESERVE ROWS) 5 - transaction-level GTT (DELETE ROWS)
RDB$SQL_SECURITY	BOOLEAN	The SQL SECURITY mode (DEFINER or INVOKER): NULL - initial default (INVOKER) FALSE - INVOKER TRUE - DEFINER

RDB$RELATION_CONSTRAINTS

RDB$RELATION_CONSTRAINTS stores the definitions of all table-level constraints: primary, unique, foreign key, CHECK, NOT NULL constraints.

Column Name	Data Type	Description
RDB$CONSTRAINT_NAME	CHAR(63)	The name of the table-level constraint defined by the user, or otherwise automatically generated by the system
RDB$CONSTRAINT_TYPE	CHAR(11)	The name of the constraint type: PRIMARY KEY, UNIQUE, FOREIGN KEY, CHECK or NOT NULL
RDB$RELATION_NAME	CHAR(63)	The name of the table this constraint applies to
RDB$DEFERRABLE	CHAR(3)	Currently NO in all cases: Firebird does not yet support deferrable constraints
RDB$INITIALLY_DEFERRED	CHAR(3)	Currently NO in all cases
RDB$INDEX_NAME	CHAR(63)	The name of the index that supports this constraint. For a CHECK or a NOT NULL constraint, it is NULL.

RDB$RELATION_FIELDS

RDB$RELATION_FIELDS stores the definitions of table and view columns.

Column Name	Data Type	Description
RDB$FIELD_NAME	CHAR(63)	Column name
RDB$RELATION_NAME	CHAR(63)	The name of the table or view that the column belongs to
RDB$FIELD_SOURCE	CHAR(63)	Domain name on which the column is based, either a user-defined one specified in the table definition or one created automatically by the system using the set of attributes defined. The attributes are in the table RDB$FIELDS: this column matches RDB$FIELDS.RDB$FIELD_NAME.
RDB$QUERY_NAME	CHAR(63)	Not currently used
RDB$BASE_FIELD	CHAR(63)	Only populated for a view, it is the name of the column from the base table
RDB$EDIT_STRING	VARCHAR(127)	Not used
RDB$FIELD_POSITION	SMALLINT	The zero-based ordinal position of the column in the table or view, numbering from left to right
RDB$QUERY_HEADER	BLOB TEXT	Not used

Column Name	Data Type	Description
RDB$UPDATE_FLAG	SMALLINT	Indicates whether the column is a regular one (value 1) or a computed one (value 0)
RDB$FIELD_ID	SMALLINT	An ID assigned from RDB$RELATIONS.RDB$FIELD_ID at the time the column was added to the table or view. It should always be treated as transient
RDB$VIEW_CONTEXT	SMALLINT	For a view column, the internal identifier of the base table from which this field derives
RDB$DESCRIPTION	BLOB TEXT	Comments related to the table or view column
RDB$DEFAULT_VALUE	BLOB BLR	The value stored for the DEFAULT clause for this column, if there is one, written in binary language representation (BLR)
RDB$SYSTEM_FLAG	SMALLINT	Indicates whether the column is user-defined (value 0) or system-defined (value 1 or greater)
RDB$SECURITY_CLASS	CHAR(63)	May reference a security class defined in RDB$SECURITY_CLASSES, in order to apply access control limits to all users of this column
RDB$COMPLEX_NAME	CHAR(63)	Not used
RDB$NULL_FLAG	SMALLINT	Indicates whether the column is nullable (NULL) non-nullable (value 1)
RDB$DEFAULT_SOURCE	BLOB TEXT	The source text of the DEFAULT clause, if any
RDB$COLLATION_ID	SMALLINT	The identifier of the collation sequence in the character set for the column, if it is not the default collation
RDB$GENERATOR_NAME	CHAR(63)	Internal generator name for generating an identity value for the column.
RDB$IDENTITY_TYPE	SMALLINT	The identity type of the column NULL - not an identity column 0 - identity column, GENERATED ALWAYS 1 - identity column, GENERATED BY DEFAULT

RDB$ROLES

RDB$ROLES stores the roles that have been defined in this database.

Column Name	Data Type	Description
RDB$ROLE_NAME	CHAR(63)	Role name
RDB$OWNER_NAME	CHAR(63)	The username of the role owner
RDB$DESCRIPTION	BLOB TEXT	Could store comments related to the role
RDB$SYSTEM_FLAG	SMALLINT	System flag
RDB$SECURITY_CLASS	CHAR(63)	May reference a security class defined in the table RDB$SECURITY_CLASSES, in order to apply access control limits to all users of this role
RDB$SYSTEM_PRIVILEGES	BINARY(8)	Bitset with the system privileges granted to a role, with the following bits 0 - unused 1 - USER_MANAGEMENT 2 - READ_RAW_PAGES 3 - CREATE_USER_TYPES 4 - USE_NBACKUP_UTILITY 5 - CHANGE_SHUTDOWN_MODE 6 - TRACE_ANY_ATTACHMENT 7 - MONITOR_ANY_ATTACHMENT 8 - ACCESS_SHUTDOWN_DATABASE 9 - CREATE_DATABASE 10 - DROP_DATABASE 11 - USE_GBAK_UTILITY 12 - USE_GSTAT_UTILITY 13 - USE_GFIX_UTILITY 14 - IGNORE_DB_TRIGGERS 15 - CHANGE_HEADER_SETTINGS 16 - SELECT_ANY_OBJECT_IN_DATABASE 17 - ACCESS_ANY_OBJECT_IN_DATABASE 18 - MODIFY_ANY_OBJECT_IN_DATABASE 19 - CHANGE_MAPPING_RULES 20 - USE_GRANTED_BY_CLAUSE 21 - GRANT_REVOKE_ON_ANY_OBJECT 22 - GRANT_REVOKE_ANY_DDL_RIGHT 23 - CREATE_PRIVILEGED_ROLES 24 - GET_DBCRYPT_INFO 25 - MODIFY_EXT_CONN_POOL 26 - REPLICATE_INTO_DATABASE

RDB$SECURITY_CLASSES

RDB$SECURITY_CLASSES stores the access control lists

Column Name	Data Type	Description
RDB$SECURITY_CLASS	CHAR(63)	Security class name
RDB$ACL	BLOB ACL	The access control list related to the security class. It enumerates users and their privileges
RDB$DESCRIPTION	BLOB TEXT	Could store comments related to the security class

RDB$TIME_ZONES

RDB$TIME_ZONES lists the named time zones supported by the engine. It is a virtual table that is populated using the current time zone database of the Firebird engine.

Column Name	Data Type	Description
RDB$TIME_ZONE_ID	INTEGER	The unique identifier of the time zone as used by Firebird. For example, this identifier is used in the `time_zone` field of the ISC_TIMESTAMP_TZ struct if the value has a named zone instead of an offset.
RDB$TIME_ZONE_NAME	CHAR(63)	Name of the time zone as specified by the time zone database

RDB$TRANSACTIONS

RDB$TRANSACTIONS stores the states of distributed transactions and other transactions that were prepared for two-phase commit with an explicit prepare message.

Column Name	Data Type	Description
RDB$TRANSACTION_ID	INTEGER	The unique identifier of the transaction being tracked
RDB$TRANSACTION_STATE	SMALLINT	Transaction state: 1 - in limbo 2 - committed 3 - rolled back
RDB$TIMESTAMP	TIMESTAMP WITH TIME ZONE	Not used

Column Name	Data Type	Description
RDB$TRANSACTION_DESCRIPTION	BLOB	Describes the prepared transaction and could be a custom message supplied to `isc_prepare_transaction2`, even if it is not a distributed transaction. It may be used when a lost connection cannot be restored

RDB$TRIGGERS

RDB$TRIGGERS stores the trigger definitions for all tables and views.

Column Name	Data Type	Description
RDB$TRIGGER_NAME	CHAR(63)	Trigger name
RDB$RELATION_NAME	CHAR(63)	The name of the table or view the trigger applies to. NULL if the trigger is applicable to a database event ("database trigger")
RDB$TRIGGER_SEQUENCE	SMALLINT	Position of this trigger in the sequence. Zero usually means that no sequence position is specified
RDB$TRIGGER_TYPE	BIGINT	The event the trigger fires on, see RDB$TRIGGER_TYPE Value
RDB$TRIGGER_SOURCE	BLOB TEXT	Stores the source code of the trigger in PSQL
RDB$TRIGGER_BLR	BLOB BLR	Stores the trigger in the binary language representation (BLR)
RDB$DESCRIPTION	BLOB TEXT	Trigger comment text
RDB$TRIGGER_INACTIVE	SMALLINT	Indicates whether the trigger is currently inactive (1) or active (0)
RDB$SYSTEM_FLAG	SMALLINT	Flag: indicates whether the trigger is user-defined (value 0) or system-defined (value 1 or greater)
RDB$FLAGS	SMALLINT	Internal use
RDB$VALID_BLR	SMALLINT	Indicates whether the text of the trigger remains valid after the latest modification by the `ALTER TRIGGER` statement
RDB$DEBUG_INFO	BLOB	Contains debugging information about variables used in the trigger
RDB$ENGINE_NAME	CHAR(63)	Engine for external triggers. `'UDR'` for UDR triggers. `NULL` for PSQL triggers

Column Name	Data Type	Description
RDB$ENTRYPOINT	CHAR(255)	The exported name of the external trigger in the trigger library. Note, this is often not the same as RDB$TRIGGER_NAME, which is the identifier with which the trigger is declared to the database
RDB$SQL_SECURITY	BOOLEAN	The SQL SECURITY mode (DEFINER or INVOKER): NULL - initial default (INVOKER) FALSE - INVOKER TRUE - DEFINER

RDB$TRIGGER_TYPE Value

The value of RDB$TRIGGER_TYPE is built from:

1	before insert
2	after insert
3	before update
4	after update
5	before delete
6	after delete
17	before insert or update
18	after insert or update
25	before insert or delete
26	after insert or delete
27	before update or delete
28	after update or delete
113	before insert or update or delete
114	after insert or update or delete
8192	on connect
8193	on disconnect
8194	on transaction start

8195 on transaction commit

8196 on transaction rollback

Identification of the exact RDB$TRIGGER_TYPE code is a little more complicated, since it is a bitmap, calculated according to which phase and events are covered and the order in which they are defined. For the curious, the calculation is explained in this code comment by Mark Rotteveel.

For DDL triggers, the trigger type is obtained by bitwise OR above the event phase (0 — BEFORE, 1 — AFTER) and all listed types events:

0x0000000000004002	CREATE TABLE
0x0000000000004004	ALTER TABLE
0x0000000000004008	DROP TABLE
0x0000000000004010	CREATE PROCEDURE
0x0000000000004020	ALTER PROCEDURE
0x0000000000004040	DROP PROCEDURE
0x0000000000004080	CREATE FUNCTION
0x0000000000004100	ALTER FUNCTION
0x0000000000004200	DROP FUNCTION
0x0000000000004400	CREATE TRIGGER
0x0000000000004800	ALTER TRIGGER
0x0000000000005000	DROP TRIGGER
0x0000000000014000	CREATE EXCEPTION
0x0000000000024000	ALTER EXCEPTION
0x0000000000044000	DROP EXCEPTION
0x0000000000084000	CREATE VIEW
0x0000000000104000	ALTER VIEW
0x0000000000204000	DROP VIEW
0x0000000000404000	CREATE DOMAIN
0x0000000000804000	ALTER DOMAIN
0x0000000001004000	DROP DOMAIN
0x0000000002004000	CREATE ROLE
0x0000000004004000	ALTER ROLE

0x0000000008004000	DROP ROLE
0x0000000010004000	CREATE INDEX
0x0000000020004000	ALTER INDEX
0x0000000040004000	DROP INDEX
0x0000000080004000	CREATE SEQUENCE
0x0000000100004000	ALTER SEQUENCE
0x0000000200004000	DROP SEQUENCE
0x0000000400004000	CREATE USER
0x0000000800004000	ALTER USER
0x0000001000004000	DROP USER
0x0000002000004000	CREATE COLLATION
0x0000004000004000	DROP COLLATION
0x0000008000004000	ALTER CHARACTER SET
0x0000010000004000	CREATE PACKAGE
0x0000020000004000	ALTER PACKAGE
0x0000040000004000	DROP PACKAGE
0x0000080000004000	CREATE PACKAGE BODY
0x0000100000004000	DROP PACKAGE BODY
0x0000200000004000	CREATE MAPPING
0x0000400000004000	ALTER MAPPING
0x0000800000004000	DROP MAPPING
0x7FFFFFFFFFFFDFFE	ANY DDL STATEMENT

For example a trigger with
`BEFORE CREATE PROCEDURE OR CREATE FUNCTION` will be of type `0x0000000000004090`,
`AFTER CREATE PROCEDURE OR CREATE FUNCTION` — `0x0000000000004091`,
`BEFORE DROP FUNCTION OR DROP EXCEPTION` — `0x0000000000044200`,
`AFTER DROP FUNCTION OR DROP EXCEPTION` — `0x0000000000044201`,
`BEFORE DROP TRIGGER OR DROP DOMAIN` — `0x0000000001005000`,
`AFTER DROP TRIGGER OR DROP DOMAIN` — `0x0000000001005001`.

RDB$TRIGGER_MESSAGES

`RDB$TRIGGER_MESSAGES` stores the trigger messages.

Column Name	Data Type	Description
RDB$TRIGGER_NAME	CHAR(63)	The name of the trigger the message is associated with
RDB$MESSAGE_NUMBER	SMALLINT	The number of the message within this trigger (from 1 to 32,767)
RDB$MESSAGE	VARCHAR(1023)	Text of the trigger message

RDB$TYPES

RDB$TYPES stores the defining sets of enumerated types used throughout the system.

Column Name	Data Type	Description
RDB$FIELD_NAME	CHAR(63)	Enumerated type name. Each type name masters its own set of types, e.g., object types, data types, character sets, trigger types, blob subtypes, etc.
RDB$TYPE	SMALLINT	The object type identifier. A unique series of numbers is used within each separate enumerated type. For example, in this selection from the set mastered under RDB$OBJECT_TYPE in RDB$FIELD_NAME, some object types are enumerated: 0 - TABLE 1 - VIEW 2 - TRIGGER 3 - COMPUTED_FIELD 4 - VALIDATION 5 - PROCEDURE ...
RDB$TYPE_NAME	CHAR(63)	The name of a member of an enumerated type, e.g., TABLE, VIEW, TRIGGER, etc. in the example above. In the RDB$CHARACTER_SET enumerated type, RDB$TYPE_NAME stores the names of the character sets.
RDB$DESCRIPTION	BLOB TEXT	Any text comments related to the enumerated type
RDB$SYSTEM_FLAG	SMALLINT	Flag: indicates whether the type-member is user-defined (value 0) or system-defined (value 1 or greater)

RDB$USER_PRIVILEGES

RDB$USER_PRIVILEGES stores the SQL access privileges for Firebird users and privileged objects.

Column Name	Data Type	Description
RDB$USER	CHAR(63)	The user or object that is granted this privilege
RDB$GRANTOR	CHAR(63)	The user who grants the privilege
RDB$PRIVILEGE	CHAR(6)	The privilege granted hereby: A - all (all privileges) S - select (selecting data) I - insert (inserting rows) D - delete (deleting rows) R - references (foreign key) U - update (updating data) X - executing (procedure) G - usage (of other object types) M - role membership C - DDL privilege create L - DDL privilege alter O - DDL privilege drop
RDB$GRANT_OPTION	SMALLINT	Whether the WITH GRANT OPTION / WITH ADMIN OPTION authority is included with the privilege: 0 - not included 1 - included WITH GRANT OPTION 2 - included WITH ADMIN OPTION
RDB$RELATION_NAME	CHAR(63)	The name of the object (table, view, procedure or role) the privilege is granted ON
RDB$FIELD_NAME	CHAR(63)	The name of the column the privilege is applicable to, for a column-level privilege (an UPDATE or REFERENCES privilege)
RDB$USER_TYPE	SMALLINT	Identifies the type of user the privilege is granted TO (a user, a procedure, a view, etc.)

Column Name	Data Type	Description
RDB$OBJECT_TYPE	SMALLINT	Identifies the type of the object the privilege is granted ON 0 - table 1 - view 2 - trigger 5 - procedure 7 - exception 8 - user 9 - domain 11 - character set 13 - role 14 - generator (sequence) 15 - function 16 - BLOB filter 17 - collation 18 - package

RDB$VIEW_RELATIONS

RDB$VIEW_RELATIONS stores the tables that are referred to in view definitions. There is one record for each table in a view.

Column Name	Data Type	Description
RDB$VIEW_NAME	CHAR(63)	View name
RDB$RELATION_NAME	CHAR(63)	The name of the table, view or stored procedure the view references
RDB$VIEW_CONTEXT	SMALLINT	The alias used to reference the view column in the BLR code of the query definition
RDB$CONTEXT_NAME	CHAR(255)	The text associated with the alias reported in the RDB$VIEW_CONTEXT column
RDB$CONTEXT_TYPE	SMALLINT	Context type: 0 - table 1 - view 2 - stored procedure
RDB$PACKAGE_NAME	CHAR(63)	Package name for a stored procedure in a package

Appendix E: Monitoring Tables

The Firebird engine can monitor activities in a database and make them available for user queries via the monitoring tables. The definitions of these tables are always present in the database, all named with the prefix `MON$`. The tables are virtual: they are populated with data only at the moment when the user queries them. That is also one good reason why it is no use trying to create triggers for them!

The key notion in understanding the monitoring feature is an *activity snapshot*. The activity snapshot represents the current state of the database at the start of the transaction in which the monitoring table query runs. It delivers a lot of information about the database itself, active connections, users, transactions prepared, running queries and more.

The snapshot is created when any monitoring table is queried for the first time. It is preserved until the end of the current transaction to maintain a stable, consistent view for queries across multiple tables, such as a master-detail query. In other words, monitoring tables always behave as though they were in `SNAPSHOT TABLE STABILITY` ("consistency") isolation, even if the current transaction is started with a lower isolation level.

To refresh the snapshot, the current transaction must be completed and the monitoring tables must be re-queried in a new transaction context.

Access Security

- SYSDBA and the database owner have full access to all information available from the monitoring tables
- Regular users can see information about their own connections; other connections are not visible to them

In a highly loaded environment, collecting information via the monitoring tables could have a negative impact on system performance.

List of Monitoring Tables

`MON$ATTACHMENTS`

Information about active attachments to the database

`MON$CALL_STACK`

Calls to the stack by active queries of stored procedures and triggers

`MON$CONTEXT_VARIABLES`

Information about custom context variables

MON$DATABASE

Information about the database to which the `CURRENT_CONNECTION` is attached

`MON$IO_STATS`

Input/output statistics

MON$MEMORY_USAGE

Memory usage statistics

MON$RECORD_STATS

Record-level statistics

MON$STATEMENTS

Statements prepared for execution

MON$TABLE_STATS

Table-level statistics

MON$TRANSACTIONS

Started transactions

MON$ATTACHMENTS

MON$ATTACHMENTS displays information about active attachments to the database.

Column Name	Data Type	Description
MON$ATTACHMENT_ID	BIGINT	Connection identifier
MON$SERVER_PID	INTEGER	Server process identifier
MON$STATE	SMALLINT	Connection state: 0 - idle 1 - active
MON$ATTACHMENT_NAME	VARCHAR(255)	Connection string — the file name and full path to the primary database file
MON$USER	CHAR(63)	The name of the user who is using this connection
MON$ROLE	CHAR(63)	The role name specified when the connection was established. If no role was specified when the connection was established, the field contains the text NONE
MON$REMOTE_PROTOCOL	VARCHAR(10)	Remote protocol name
MON$REMOTE_ADDRESS	VARCHAR(255)	Remote address (address and server name)
MON$REMOTE_PID	INTEGER	Remote client process identifier
MON$CHARACTER_SET_ID	SMALLINT	Connection character set identifier (see RDB$CHARACTER_SET in system table RDB$TYPES)
MON$TIMESTAMP	TIMESTAMP WITH TIME ZONE	The date and time when the connection was started

Column Name	Data Type	Description
MON$GARBAGE_COLLECTION	SMALLINT	Garbage collection flag (as specified in the attachment's DPB): 1=allowed, 0=not allowed
MON$REMOTE_PROCESS	VARCHAR(255)	The full file name and path to the executable file that established this connection
MON$STAT_ID	INTEGER	Statistics identifier
MON$CLIENT_VERSION	VARCHAR(255)	Client library version
MON$REMOTE_VERSION	VARCHAR(255)	Remote protocol version
MON$REMOTE_HOST	VARCHAR(255)	Name of the remote host
MON$REMOTE_OS_USER	VARCHAR(255)	Name of remote user
MON$AUTH_METHOD	VARCHAR(255)	Name of authentication plugin used to connect
MON$SYSTEM_FLAG	SMALLINT	Flag that indicates the type of connection: 0 - normal connection 1 - system connection
MON$IDLE_TIMEOUT	INTEGER	Connection-level idle timeout in seconds. When 0 is reported the database ConnectionIdleTimeout from databases.conf or firebird.conf applies.
MON$IDLE_TIMER	TIMESTAMP WITH TIME ZONE	Idle timer expiration time
MON$STATEMENT_TIMEOUT	INTEGER	Connection-level statement timeout in milliseconds. When 0 is reported the database StatementTimeout from databases.conf or firebird.conf applies.
MON$WIRE_COMPRESSED	BOOLEAN	Wire compression active (TRUE) or inactive (FALSE)
MON$WIRE_ENCRYPTED	BOOLEAN	Wire encryption active (TRUE) or inactive (FALSE)
MON$WIRE_CRYPT_PLUGIN	VARCHAR(63)	Name of the wire encryption plugin used

Retrieving information about client applications

```
SELECT MON$USER, MON$REMOTE_ADDRESS, MON$REMOTE_PID, MON$TIMESTAMP
FROM MON$ATTACHMENTS
WHERE MON$ATTACHMENT_ID <> CURRENT_CONNECTION
```

Using MON$ATTACHMENTS to Kill a Connection

Monitoring tables are read-only. However, the server has a built-in mechanism for deleting (and only deleting) records in the MON$ATTACHMENTS table, which makes it possible to close a connection to the database.

Notes

- All the current activity in the connection being deleted is immediately stopped and all active transactions are rolled back
- The closed connection will return an error with the isc_att_shutdown code to the application
- Subsequent attempts to use this connection (i.e., use its handle in API calls) will return errors
- Termination of system connections (MON$SYSTEM_FLAG = 1) is not possible. The server will skip system connections in a DELETE FROM MON$ATTACHMENTS.

Closing all connections except for your own (current):

```
DELETE FROM MON$ATTACHMENTS
WHERE MON$ATTACHMENT_ID <> CURRENT_CONNECTION
```

MON$CALL_STACK

MON$CALL_STACK displays calls to the stack from queries executing in stored procedures and triggers.

Column Name	Data Type	Description
MON$CALL_ID	BIGINT	Call identifier
MON$STATEMENT_ID	BIGINT	The identifier of the top-level SQL statement, the one that initiated the chain of calls. Use this identifier to find the records about the active statement in the MON$STATEMENTS table
MON$CALLER_ID	BIGINT	The identifier of the calling trigger or stored procedure
MON$OBJECT_NAME	CHAR(63)	PSQL object (module) name
MON$OBJECT_TYPE	SMALLINT	PSQL object type (trigger or stored procedure): 2 - trigger 5 - stored procedure 15 - stored function
MON$TIMESTAMP	TIMESTAMP WITH TIME ZONE	The date and time when the call was started

Column Name	Data Type	Description
MON$SOURCE_LINE	INTEGER	The number of the source line in the SQL statement being executed at the moment of the snapshot
MON$SOURCE_COLUMN	INTEGER	The number of the source column in the SQL statement being executed at the moment of the snapshot
MON$STAT_ID	INTEGER	Statistics identifier
MON$PACKAGE_NAME	CHAR(63)	Package name for stored procedures or functions in a package

Information about calls during the execution of the EXECUTE STATEMENT statement does not get into the call stack.

Get the call stack for all connections except your own

```
WITH RECURSIVE
  HEAD AS (
    SELECT
      CALL.MON$STATEMENT_ID, CALL.MON$CALL_ID,
      CALL.MON$OBJECT_NAME, CALL.MON$OBJECT_TYPE
    FROM MON$CALL_STACK CALL
    WHERE CALL.MON$CALLER_ID IS NULL
    UNION ALL
    SELECT
      CALL.MON$STATEMENT_ID, CALL.MON$CALL_ID,
      CALL.MON$OBJECT_NAME, CALL.MON$OBJECT_TYPE
    FROM MON$CALL_STACK CALL
      JOIN HEAD ON CALL.MON$CALLER_ID = HEAD.MON$CALL_ID
  )
SELECT MON$ATTACHMENT_ID, MON$OBJECT_NAME, MON$OBJECT_TYPE
FROM HEAD
  JOIN MON$STATEMENTS STMT ON STMT.MON$STATEMENT_ID = HEAD.MON$STATEMENT_ID
WHERE STMT.MON$ATTACHMENT_ID <> CURRENT_CONNECTION
```

MON$CONTEXT_VARIABLES

MON$CONTEXT_VARIABLES displays information about custom context variables.

Column Name	Data Type	Description
MON$ATTACHMENT_ID	BIGINT	Connection identifier. It contains a valid value only for a connection-level context variable. For transaction-level variables it is NULL.

Column Name	Data Type	Description
MON$TRANSACTION_ID	BIGINT	Transaction identifier. It contains a valid value only for transaction-level context variables. For connection-level variables it is NULL.
MON$VARIABLE_NAME	VARCHAR(80)	Context variable name
MON$VARIABLE_VALUE	VARCHAR(32765)	Context variable value

Retrieving all session context variables for the current connection

```
SELECT
  VAR.MON$VARIABLE_NAME,
  VAR.MON$VARIABLE_VALUE
FROM MON$CONTEXT_VARIABLES VAR
WHERE VAR.MON$ATTACHMENT_ID = CURRENT_CONNECTION
```

MON$DATABASE

MON$DATABASE displays the header information from the database the current user is connected to.

Column Name	Data Type	Description
MON$DATABASE_NAME	VARCHAR(255)	The file name and full path of the primary database file, or the database alias
MON$PAGE_SIZE	SMALLINT	Database page size in bytes
MON$ODS_MAJOR	SMALLINT	Major ODS version, e.g., 11
MON$ODS_MINOR	SMALLINT	Minor ODS version, e.g., 2
MON$OLDEST_TRANSACTION	BIGINT	The number of the oldest [interesting] transaction (OIT)
MON$OLDEST_ACTIVE	BIGINT	The number of the oldest active transaction (OAT)
MON$OLDEST_SNAPSHOT	BIGINT	The number of the transaction that was active at the moment when the OAT was started — oldest snapshot transaction (OST)
MON$NEXT_TRANSACTION	BIGINT	The number of the next transaction, as it stood when the monitoring snapshot was taken
MON$PAGE_BUFFERS	INTEGER	The number of pages allocated in RAM for the database page cache
MON$SQL_DIALECT	SMALLINT	Database SQL Dialect: 1 or 3

Column Name	Data Type	Description
MON$SHUTDOWN_MODE	SMALLINT	The current shutdown state of the database: 0 - the database is online 1 - multi-user shutdown 2 - single-user shutdown 3 - full shutdown
MON$SWEEP_INTERVAL	INTEGER	Sweep interval
MON$READ_ONLY	SMALLINT	Flag indicating whether the database is read-only (value 1) or read-write (value 0)
MON$FORCED_WRITES	SMALLINT	Indicates whether the write mode of the database is set for synchronous write (forced writes ON, value is 1) or asynchronous write (forced writes OFF, value is 0)
MON$RESERVE_SPACE	SMALLINT	The flag indicating reserve_space (value 1) or use_all_space (value 0) for filling database pages
MON$CREATION_DATE	TIMESTAMP WITH TIME ZONE	The date and time when the database was created or was last restored
MON$PAGES	BIGINT	The number of pages allocated for the database on an external device
MON$STAT_ID	INTEGER	Statistics identifier
MON$BACKUP_STATE	SMALLINT	Current physical backup (nBackup) state: 0 - normal 1 - stalled 2 - merge
MON$CRYPT_PAGE	BIGINT	Number of encrypted pages
MON$OWNER	CHAR(63)	Username of the database owner
MON$SEC_DATABASE	CHAR(7)	Displays what type of security database is used: Default - default security database, i.e. security4.fdb Self - current database is used as security database Other - another database is used as security database (not itself or security4.fdb)

Column Name	Data Type	Description
MON$CRYPT_STATE	SMALLINT	Current state of database encryption 0 - not encrypted 1 - encrypted 2 - decryption in progress 3 - encryption in progress
MON$GUID	CHAR(38)	Database GUID (persistent until restore/fixup)
MON$FILE_ID	VARCHAR(255)	Unique ID of the database file at the filesystem level
MON$NEXT_ATTACHMENT	BIGINT	Current value of the next attachment ID counter
MON$NEXT_STATEMENT	BIGINT	Current value of the next statement ID counter
MON$REPLICA_MODE	SMALLINT	Database replica mode 0 - not a replica 1 - read-only replica 2 - read-write replica

MON$IO_STATS

MON$IO_STATS displays input/output statistics. The counters are cumulative, by group, for each group of statistics.

Column Name	Data Type	Description
MON$STAT_ID	INTEGER	Statistics identifier
MON$STAT_GROUP	SMALLINT	Statistics group: 0 - database 1 - connection 2 - transaction 3 - statement 4 - call
MON$PAGE_READS	BIGINT	Count of database pages read
MON$PAGE_WRITES	BIGINT	Count of database pages written to
MON$PAGE_FETCHES	BIGINT	Count of database pages fetched
MON$PAGE_MARKS	BIGINT	Count of database pages marked

MON$MEMORY_USAGE

MON$MEMORY_USAGE displays memory usage statistics.

Column Name	Data Type	Description
MON$STAT_ID	INTEGER	Statistics identifier
MON$STAT_GROUP	SMALLINT	Statistics group: 0 - database 1 - connection 2 - transaction 3 - operator 4 - call
MON$MEMORY_USED	BIGINT	The amount of memory in use, in bytes. This data is about the high-level memory allocation performed by the server. It can be useful to track down memory leaks and excessive memory usage in connections, procedures, etc.
MON$MEMORY_ALLOCATED	BIGINT	The amount of memory allocated by the operating system, in bytes. This data is about the low-level memory allocation performed by the Firebird memory manager — the amount of memory allocated by the operating system — which can allow you to control the physical memory usage.
MON$MAX_MEMORY_USED	BIGINT	The maximum number of bytes used by this object
MON$MAX_MEMORY_ALLOCATED	BIGINT	The maximum number of bytes allocated for this object by the operating system

Counters associated with database-level records MON$DATABASE (MON$STAT_GROUP = 0), display memory allocation for all connections. In the Classic and SuperClassic zero values of the counters indicate that these architectures have no common cache.

Minor memory allocations are not accrued here but are added to the database memory pool instead.

Getting 10 requests consuming the most memory

```
SELECT
  STMT.MON$ATTACHMENT_ID,
  STMT.MON$SQL_TEXT,
  MEM.MON$MEMORY_USED
FROM MON$MEMORY_USAGE MEM
NATURAL JOIN MON$STATEMENTS STMT
ORDER BY MEM.MON$MEMORY_USED DESC
```

```
FETCH FIRST 10 ROWS ONLY
```

MON$RECORD_STATS

MON$RECORD_STATS displays record-level statistics. The counters are cumulative, by group, for each group of statistics.

Column Name	Data Type	Description
MON$STAT_ID	INTEGER	Statistics identifier
MON$STAT_GROUP	SMALLINT	Statistics group: 0 - database 1 - connection 2 - transaction 3 - statement 4 - call
MON$RECORD_SEQ_READS	BIGINT	Count of records read sequentially
MON$RECORD_IDX_READS	BIGINT	Count of records read via an index
MON$RECORD_INSERTS	BIGINT	Count of inserted records
MON$RECORD_UPDATES	BIGINT	Count of updated records
MON$RECORD_DELETES	BIGINT	Count of deleted records
MON$RECORD_BACKOUTS	BIGINT	Count of records backed out
MON$RECORD_PURGES	BIGINT	Count of records purged
MON$RECORD_EXPUNGES	BIGINT	Count of records expunged
MON$RECORD_LOCKS	BIGINT	Number of records locked
MON$RECORD_WAITS	BIGINT	Number of update, delete or lock attempts on records owned by other active transactions. Transaction is in WAIT mode.
MON$RECORD_CONFLICTS	BIGINT	Number of unsuccessful update, delete or lock attempts on records owned by other active transactions. These are reported as update conflicts.
MON$BACKVERSION_READS	BIGINT	Number of back-versions read to find visible records
MON$FRAGMENT_READS	BIGINT	Number of fragmented records read
MON$RECORD_RPT_READS	BIGINT	Number of repeated reads of records
MON$RECORD_IMGC	BIGINT	Number of records processed by the intermediate garbage collector

MON$STATEMENTS

MON$STATEMENTS displays statements prepared for execution.

Column Name	Data Type	Description
MON$STATEMENT_ID	BIGINT	Statement identifier
MON$ATTACHMENT_ID	BIGINT	Connection identifier
MON$TRANSACTION_ID	BIGINT	Transaction identifier
MON$STATE	SMALLINT	Statement state: 0 - idle 1 - active 2 - stalled
MON$TIMESTAMP	TIMESTAMP WITH TIME ZONE	The date and time when the statement was prepared
MON$SQL_TEXT	BLOB TEXT	Statement text in SQL
MON$STAT_ID	INTEGER	Statistics identifier
MON$EXPLAINED_PLAN	BLOB TEXT	Explained execution plan
MON$STATEMENT_TIMEOUT	INTEGER	Connection-level statement timeout in milliseconds. When 0 is reported the timeout of MON$ATTACHMENT.MON$STATEMENT_TIMEOUT for this connection applies.
MON$STATEMENT_TIMER	TIMESTAMP WITH TIME ZONE	Statement timer expiration time

The STALLED state indicates that, at the time of the snapshot, the statement had an open cursor and was waiting for the client to resume fetching rows.

Display active queries, excluding those running in your connection

```
SELECT
  ATT.MON$USER,
  ATT.MON$REMOTE_ADDRESS,
  STMT.MON$SQL_TEXT,
  STMT.MON$TIMESTAMP
FROM MON$ATTACHMENTS ATT
JOIN MON$STATEMENTS STMT ON ATT.MON$ATTACHMENT_ID = STMT.MON$ATTACHMENT_ID
WHERE ATT.MON$ATTACHMENT_ID <> CURRENT_CONNECTION
AND STMT.MON$STATE = 1
```

Using MON$STATEMENTS to Cancel a Query

Monitoring tables are read-only. However, the server has a built-in mechanism for deleting (and only deleting) records in the MON$STATEMENTS table, which makes it possible to cancel a running

query.

Notes

- If no statements are currently being executed in the connection, any attempt to cancel queries will not proceed
- After a query is cancelled, calling execute/fetch API functions will return an error with the `isc_cancelled` code
- Subsequent queries from this connection will proceed as normal
- Cancellation of the statement does not occur synchronously, it only marks the request for cancellation, and the cancellation itself is done asynchronously by the server

Example

Cancelling all active queries for the specified connection:

```
DELETE FROM MON$STATEMENTS
  WHERE MON$ATTACHMENT_ID = 32
```

MON$TABLE_STATS

`MON$TABLE_STATS` reports table-level statistics.

Column Name	Data Type	Description
`MON$STAT_ID`	`INTEGER`	Statistics identifier
`MON$STAT_GROUP`	`SMALLINT`	Statistics group: `0` - database `1` - connection `2` - transaction `3` - statement `4` - call
`MON$TABLE_NAME`	`CHAR(63)`	Name of the table
`MON$RECORD_STAT_ID`	`INTEGER`	Link to `MON$RECORD_STATS`

Getting statistics at the record level for each table for the current connection

```
SELECT
  t.mon$table_name,
  r.mon$record_inserts,
  r.mon$record_updates,
  r.mon$record_deletes,
  r.mon$record_backouts,
  r.mon$record_purges,
  r.mon$record_expunges,
```

```
  ------------------------
  r.mon$record_seq_reads,
  r.mon$record_idx_reads,
  r.mon$record_rpt_reads,
  r.mon$backversion_reads,
  r.mon$fragment_reads,
  ------------------------
  r.mon$record_locks,
  r.mon$record_waits,
  r.mon$record_conflicts,
  ------------------------
  a.mon$stat_id
FROM mon$record_stats r
JOIN mon$table_stats t ON r.mon$stat_id = t.mon$record_stat_id
JOIN mon$attachments a ON t.mon$stat_id = a.mon$stat_id
WHERE a.mon$attachment_id = CURRENT_CONNECTION
```

MON$TRANSACTIONS

MON$TRANSACTIONS reports started transactions.

Column Name	Data Type	Description
MON$TRANSACTION_ID	BIGINT	Transaction identifier (number)
MON$ATTACHMENT_ID	BIGINT	Connection identifier
MON$STATE	SMALLINT	Transaction state: 0 - idle 1 - active
MON$TIMESTAMP	TIMESTAMP WITH TIME ZONE	The date and time when the transaction was started
MON$TOP_TRANSACTION	BIGINT	Top-level transaction identifier (number)
MON$OLDEST_TRANSACTION	BIGINT	Transaction ID of the oldest [interesting] transaction (OIT)
MON$OLDEST_ACTIVE	BIGINT	Transaction ID of the oldest active transaction (OAT)
MON$ISOLATION_MODE	SMALLINT	Isolation mode (level): 0 - consistency (snapshot table stability) 1 - concurrency (snapshot) 2 - read committed record version 3 - read committed no record version 4 - read committed read consistency

Column Name	Data Type	Description
MON$LOCK_TIMEOUT	SMALLINT	Lock timeout: -1 - wait forever 0 - no waiting 1 or greater - lock timeout in seconds
MON$READ_ONLY	SMALLINT	Flag indicating whether the transaction is read-only (value 1) or read-write (value 0)
MON$AUTO_COMMIT	SMALLINT	Flag indicating whether automatic commit is used for the transaction (value 1) or not (value 0)
MON$AUTO_UNDO	SMALLINT	Flag indicating whether the logging mechanism *automatic undo* is used for the transaction (value 1) or not (value 0)
MON$STAT_ID	INTEGER	Statistics identifier

Getting all connections that started Read Write transactions with isolation level above Read Commited

```
SELECT DISTINCT a. *
FROM mon$attachments a
JOIN mon$transactions t ON a.mon$attachment_id = t.mon$attachment_id
WHERE NOT (t.mon$read_only = 1 AND t.mon$isolation_mode >= 2)
```

Appendix F: Security tables

The names of the security tables have SEC$ as prefix. They display data from the current security database. These tables are virtual in the sense that before access by the user, no data is recorded in them. They are filled with data at the time of user request. However, the descriptions of these tables are constantly present in the database. In this sense, these virtual tables are like tables of the MON$ -family used to monitor the server.

Security

- SYSDBA, users with the RDB$ADMIN role in the security database and the current database, and the owner of the security database have full access to all information provided by the security tables.
- Regular users can only see information on themselves, other users are not visible.

These features are highly dependent on the user management plugin. Keep in mind that some options are ignored when using a legacy control plugin users.

List of security tables

SEC$DB_CREATORS

Lists users and roles granted the CREATE DATABASE privilege

SEC$GLOBAL_AUTH_MAPPING

Information about global authentication mappings

SEC$USERS

Lists users in the current security database

SEC$USER_ATTRIBUTES

Additional attributes of users

SEC$DB_CREATORS

Lists users and roles granted the CREATE DATABASE privilege.

Column Name	Data Type	Description
SEC$USER	CHAR(63)	Name of the user or role
SEC$USER_TYPE	SMALLINT	Type of user: 8 - user 13 - role

SEC$GLOBAL_AUTH_MAPPING

Lists users and roles granted the CREATE DATABASE privilege.

Column Name	Data Type	Description
SEC$MAP_NAME	CHAR(63)	Name of the mapping
SEC$MAP_USING	CHAR(1)	Using definition: P - plugin (specific or any) S - any plugin serverwide M - mapping * - any method
SEC$MAP_PLUGIN	CHAR(63)	Mapping applies for authentication information from this specific plugin
SEC$MAP_DB	CHAR(63)	Mapping applies for authentication information from this specific database
SEC$MAP_FROM_TYPE	CHAR(63)	The type of authentication object (defined by plugin) to map from, or * for any type
SEC$MAP_FROM	CHAR(255)	The name of the authentication object to map from
SEC$MAP_TO_TYPE	SMALLINT Nullable	The type to map to 0 - USER 1 - ROLE
SEC$MAP_TO	CHAR(63)	The name to map to

SEC$USERS

Lists users in the current security database.

Column Name	Data Type	Description
SEC$USER_NAME	CHAR(63)	Username
SEC$FIRST_NAME	VARCHAR(32)	First name
SEC$MIDDLE_NAME	VARCHAR(32)	Middle name
SEC$LAST_NAME	VARCHAR(32)	Last name
SEC$ACTIVE	BOOLEAN	`true` - active, `false` - inactive
SEC$ADMIN	BOOLEAN	`true` - user has admin role in security database, `false` otherwise
SEC$DESCRIPTION	BLOB TEXT	Description (comment) on the user
SEC$PLUGIN	CHAR(63)	Authentication plugin name that manages this user

Multiple users can exist with the same username, each managed by a different authentication plugin.

SEC$USER_ATTRIBUTES

Additional attributes of users

Column Name	Data Type	Description
SEC$USER_NAME	CHAR(63)	Username
SEC$KEY	VARCHAR(63)	Attribute name
SEC$VALUE	VARCHAR(255)	Attribute value
SEC$PLUGIN	CHAR(63)	Authentication plugin name that manages this user

Displaying a list of users and their attributes

```
SELECT
  U.SEC$USER_NAME AS LOGIN,
  A.SEC$KEY AS TAG,
  A.SEC$VALUE AS "VALUE",
  U.SEC$PLUGIN AS "PLUGIN"
FROM SEC$USERS U
LEFT JOIN SEC$USER_ATTRIBUTES A
  ON U.SEC$USER_NAME = A.SEC$USER_NAME
    AND U.SEC$PLUGIN = A.SEC$PLUGIN;

LOGIN    TAG     VALUE   PLUGIN
======== ======= ======= ==================
SYSDBA   <null>  <null>  Srp
ALEX     B       x       Srp
ALEX     C       sample  Srp
SYSDBA   <null>  <null>  Legacy_UserManager
```

Appendix G: Character Sets and Collation Sequences

Table 273. Character Sets and Collation Sequences

Character Set	ID	Bytes per Char	Collation	Language
ASCII	2	1	ASCII	English
BIG_5	56	2	BIG_5	Chinese, Vietnamese, Korean
CP943C	68	2	CP943C	Japanese
//	//	//	CP943C_UNICODE	Japanese
CYRL	50	1	CYRL	Russian
//	//	//	DB_RUS	Russian dBase
//	//	//	PDOX_CYRL	Russian Paradox
DOS437	10	1	DOS437	U.S. English
//	//	//	DB_DEU437	German dBase
//	//	//	DB_ESP437	Spanish dBase
//	//	//	DB_FIN437	Finnish dBase
//	//	//	DB_FRA437	French dBase
//	//	//	DB_ITA437	Italian dBase
//	//	//	DB_NLD437	Dutch dBase
//	//	//	DB_SVE437	Swedish dBase
//	//	//	DB_UK437	English (Great Britain) dBase
//	//	//	DB_US437	U.S. English dBase
//	//	//	PDOX_ASCII	Code page Paradox-ASCII
//	//	//	PDOX_INTL	International English Paradox
//	//	//	PDOX_SWEDFIN	Swedish / Finnish Paradox
DOS737	9	1	DOS737	Greek
DOS775	15	1	DOS775	Baltic
DOS850	11	1	DOS850	Latin I (no Euro symbol)
//	//	//	DB_DEU850	German
//	//	//	DB_ESP850	Spanish
//	//	//	DB_FRA850	French
//	//	//	DB_FRC850	French-Canada
//	//	//	DB_ITA850	Italian

Character Set	ID	Bytes per Char	Collation	Language
//	//	//	DB_NLD850	Dutch
//	//	//	DB_PTB850	Portuguese-Brazil
//	//	//	DB_SVE850	Swedish
//	//	//	DB_UK850	English-Great Britain
//	//	//	DB_US850	U.S. English
DOS852	45	1	DOS852	Latin II
//	//	//	DB_CSY	Czech dBase
//	//	//	DB_PLK	Polish dBase
//	//	//	DB_SLO	Slovene dBase
//	//	//	PDOX_CSY	Czech Paradox
//	//	//	PDOX_HUN	Hungarian Paradox
//	//	//	PDOX_PLK	Polish Paradox
//	//	//	PDOX_SLO	Slovene Paradox
DOS857	46	1	DOS857	Turkish
//	//	//	DB_TRK	Turkish dBase
DOS858	16	1	DOS858	Latin I (with Euro symbol)
DOS860	13	1	DOS860	Portuguese
//	//	//	DB_PTG860	Portuguese dBase
DOS861	47	1	DOS861	Icelandic
//	//	//	PDOX_ISL	Icelandic Paradox
DOS862	17	1	DOS862	Hebrew
DOS863	14	1	DOS863	French-Canada
//	//	//	DB_FRC863	French dBase-Canada
DOS864	18	1	DOS864	Arabic
DOS865	12	1	DOS865	Scandinavian
//	//	//	DB_DAN865	Danish dBase
//	//	//	DB_NOR865	Norwegian dBase
//	//	//	PDOX_NORDAN4	Paradox Norway and Denmark
DOS866	48	1	DOS866	Russian
DOS869	49	1	DOS869	Modern Greek
EUCJ_0208	6	2	EUCJ_0208	Japanese EUC
GB18030	69	4	GB18030	Chinese

Character Set	ID	Bytes per Char	Collation	Language
//	//	//	GB18030_UNICODE	Chinese
GBK	67	2	GBK	Chinese
//	//	//	GBK_UNICODE	Chinese
GB_2312	57	2	GB_2312	Simplified Chinese (Hong Kong, Korea)
ISO8859_1	21	1	ISO8859_1	Latin I
//	//	//	DA_DA	Danish
//	//	//	DE_DE	German
//	//	//	DU_NL	Dutch
//	//	//	EN_UK	English-Great Britain
//	//	//	EN_US	U.S. English
//	//	//	ES_ES	Spanish
//	//	//	ES_ES_CI_AI	Spanish — case insensitive and + accent-insensitive
//	//	//	FI_FI	Finnish
//	//	//	FR_CA	French-Canada
//	//	//	FR_CA_CI_AI	French-Canada — case insensitive + accent insensitive
//	//	//	FR_FR	French
//	//	//	FR_FR_CI_AI	French — case insensitive + accent insensitive
//	//	//	IS_IS	Icelandic
//	//	//	IT_IT	Italian
//	//	//	NO_NO	Norwegian
//	//	//	PT_BR	Portuguese-Brazil
//	//	//	PT_PT	Portuguese
//	//	//	SV_SV	Swedish
ISO8859_2	22	1	ISO8859_2	Latin 2 — Central Europe (Croatian, Czech, Hungarian, Polish, Romanian, Serbian, Slovak, Slovenian)
//	//	//	CS_CZ	Czech
//	//	//	ISO_HUN	Hungarian — case insensitive, accent sensitive

Character Set	ID	Bytes per Char	Collation	Language
//	//	//	ISO_PLK	Polish
ISO8859_3	23	1	ISO8859_3	Latin 3 — Southern Europe (Malta, Esperanto)
ISO8859_4	34	1	ISO8859_4	Latin 4 — Northern Europe (Estonian, Latvian, Lithuanian, Greenlandic, Lappish)
ISO8859_5	35	1	ISO8859_5	Cyrillic (Russian)
ISO8859_6	36	1	ISO8859_6	Arabic
ISO8859_7	37	1	ISO8859_7	Greek
ISO8859_8	38	1	ISO8859_8	Hebrew
ISO8859_9	39	1	ISO8859_9	Latin 5
ISO8859_13	40	1	ISO8859_13	Latin 7 — Baltic
//	//	//	LT_LT	Lithuanian
KOI8R	63	1	KOI8R	Russian — dictionary ordering
//	//	//	KOI8R_RU	Russian
KOI8U	64	1	KOI8U	Ukrainian — dictionary ordering
//	//	//	KOI8U_UA	Ukrainian
KSC_5601	44	2	KSC_5601	Korean
//	//	//	KSC_DICTIONARY	Korean — dictionary sort order
NEXT	19	1	NEXT	Coding NeXTSTEP
//	//	//	NXT_DEU	German
//	//	//	NXT_ESP	Spanish
//	//	//	NXT_FRA	French
//	//	//	NXT_ITA	Italian
//	19	1	NXT_US	U.S. English
NONE	0	1	NONE	Neutral code page. Translation to upper case is performed only for code ASCII 97-122. Recommendation: avoid this character set
OCTETS	1	1	OCTETS	Binary character encoding
SJIS_0208	5	2	SJIS_0208	Japanese
TIS620	66	1	TIS620	Thai
//	//	//	TIS620_UNICODE	Thai

Character Set	ID	Bytes per Char	Collation	Language
UNICODE_FSS	3	3	UNICODE_FSS	All English
UTF8	4	4	UTF8	Any language that is supported in Unicode 4.0
//	//	//	UCS_BASIC	Any language that is supported in Unicode 4.0
//	//	//	UNICODE	Any language that is supported in Unicode 4.0
//	//	//	UNICODE_CI	Any language that is supported in Unicode 4.0 — Case insensitive
//	//	//	UNICODE_CI_AI	Any language that is supported in Unicode 4.0 — Case insensitive and accent insensitive
WIN1250	51	1	WIN1250	ANSI — Central Europe
//	//	//	BS_BA	Bosnian
//	//	//	PXW_CSY	Czech
//	//	//	PXW_HUN	Hungarian — case insensitive, accent sensitive
//	//	//	PXW_HUNDC	Hungarian — dictionary ordering
//	//	//	PXW_PLK	Polish
//	//	//	PXW_SLOV	Slovenian
//	//	//	WIN_CZ	Czech
//	//	//	WIN_CZ_CI_AI	Czech — Case insensitive and accent insensitive
WIN1251	52	1	WIN1251	ANSI Cyrillic
//	//	//	PXW_CYRL	Paradox Cyrillic (Russian)
//	//	//	WIN1251_UA	Ukrainian
WIN1252	53	1	WIN1252	ANSI — Latin I
//	//	//	PXW_INTL	English International
//	//	//	PXW_INTL850	Paradox multilingual Latin I
//	//	//	PXW_NORDAN4	Norwegian and Danish
//	//	//	PXW_SPAN	Paradox Spanish
//	//	//	PXW_SWEDFIN	Swedish and Finnish
//	//	//	WIN_PTBR	Portuguese — Brazil
WIN1253	54	1	WIN1253	ANSI Greek

Character Set	ID	Bytes per Char	Collation	Language
//	//	//	PXW_GREEK	Paradox Greek
WIN1254	55	1	WIN1254	ANSI Turkish
//	//	//	PXW_TURK	Paradox Turkish
WIN1255	58	1	WIN1255	ANSI Hebrew
WIN1256	59	1	WIN1256	ANSI Arabic
WIN1257	60	1	WIN1257	ANSI Baltic
//	//	//	WIN1257_EE	Estonian — Dictionary ordering
//	//	//	WIN1257_LT	Lithuanian — Dictionary ordering
//	//	//	WIN1257_LV	Latvian — Dictionary ordering
WIN1258	65	1	WIN1258	Vietnamese

Appendix H: License notice

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Appendix I: Document History

The exact file history is recorded in our *git* repository; see https://github.com/FirebirdSQL/firebird-documentation

Revision History

2.16	12 Jul 2025	*	• [MR] Corrected autonomous transaction isolation level for `READ CONSISTENCY` (#220) • [MR] Clarified section *Implicit Data Type Conversion* (#221) • [MR] Computed columns do not support domains (#222) • [MR] Documented that a compound index can have at most 16 columns (#223) • [DY] Corrected position of the `USING INDEX` clause in foreign key definitions • [DY] Documented `WITH ADMIN OPTION` value of `RDB$USER_PRIVILEGES.RDB$GRANT_OPTION`
2.15	03 Apr 2025	MR	• Added links to `CURRENT_DATE`, `CURRENT_TIME`, `CURRENT_TIMESTAMP`, `LOCALTIME`, and `LOCALTIMESTAMP` from chapter Built-in Scalar Functions • Added cross-reference between the datetime context variables • Fixed wrong nesting of sections in operators • `RDB$TRANSACTION_STATE` values were off by one (#217)
2.14	02 Oct 2024	MR	• Documented where to find time zone region names • Improved documentation of PSQL blocks to make clear `WHEN … DO` can only occur at the end of a block (#208) • Revised `SEQUENCE` DDL documentation regarding `START`/`RESTART` (#211) • Trigger order for the same position was documented as alphabetical by name; the actual order is undefined (#213)
2.13	20 Apr 2024	MR	Corrected description of `RDB$CHECK_CONSTRAINTS` (#206)
2.12	2 Apr 2024	MR	Protocol names are lowercase (#205)
2.11	17 Jan 2024	MR	• Removed `ALTER PACKAGE BODY` documentation, as this feature doesn't exist (#200)
2.10	15 Dec 2023	MR	• Added types 4 and 5 to `RDB$FUNCTION_ARGUMENTS.RDB$MECHANISM` (#192) • Fixed formatting of `RDB$FUNCTION_ARGUMENTS.RDB$FIELD_TYPE` (https://github.com/FirebirdSQL/firebird-documentation/issues/194)

Revision History

2.9	09 Nov 2023	MR	• Fixed typo in PSQL module syntax • Wrong link from `ALTER TRIGGER` to `CREATE TRIGGER` (#189) • Added TCPv6 to `NETWORK_PROTOCOL` for `SYSTEM` namespace (#170) • `CURRENT_DATE` is in the session time zone • Fixed description of `RDB$INDICES.RDB$FOREIGN_KEY` (#191)
2.8	05 Oct 2023	MR	• Added negative subtype to `RDB$FIELDS.RDB$FIELD_SUB_TYPE`, and fixed formatting • Fixed incorrect syntax documentation of forward declaration of subroutines (#188)
2.7	08 Aug 2023	MR	• Fixed incorrect "equivalent" for `REGR_COUNT` • Fixed incorrect references to idle timeout in `SET STATEMENT TIMEOUT` • Documented that since Firebird 4.0.3, `OVERRIDING USER VALUE` also works for `GENERATED ALWAYS` identity columns
2.6	20 Jun 2023	MR	• Computed columns can be indexed with expression indexes • Fixed wrong section levels for subsections of `SET DECFLOAT` • Replaced firebird-docs references with firebird-devel • Add caution about relying on ordered derived tables for `LIST()`
2.5	26 May 2023	MR	• Added missing context variable names for `RDB$GET_CONTEXT()` • Documented hex-literal support for `INT128` since 4.0.1 • `CURRENT_CONNECTION` returns `BIGINT` • Example for `RDB$ROLE_IN_USE()` should use `RDB$ROLES` (#184) • Removed section *Joins with stored procedures* as it no longer applies • Replaced mention that implicit join is deprecated and might get removed; its use is merely discouraged. • Added note in Encryption Algorithm Requirements about AES variants • Replaced incorrect `ROLE` keyword with `DEFAULT` in example in Granting the `RDB$ADMIN` Role in a Regular Database • Miscellaneous copy-editing
2.4	10 May 2023	MR	• Corrected column name `MON$IDLE_TIMER` to `MON$STATEMENT_TIMER` in `MON$STATEMENTS` • Removed incorrect `<common-table-expression>` production in SELECT syntax
2.3	30 Jan 2023	MR	Fixed typo in collation name `UCS_BASIC`
2.2	24 Jan 2023	MR	Added missing `[{WITHOUT | WITH} TIME ZONE]` to `TIME` and `TIMESTAMP` in Scalar Data Types Syntax and Array Data Types Syntax

Revision History

2.1	27 Oct 2022	MR	• Revise `BLOB_APPEND` documentation with known issues, and reduce mentions of result type being `BLOB SUB_TYPE TEXT` in favour of just `BLOB` • Description of behaviour of `SET BIND` mentioned “precision greater than 19” while “precision 19 or higher” should have been used • Removed sequence limitation with dialect 1 documented with datatype `BIGINT`, and updated/added result type of `GEN_ID` and `NEXT VALUE FOR` • Updated reference to details of literals in chapter *SQL Language Structure* • Fixed incorrect whitespace in table names • Added missing table name in `FROM` in Deterministic functions (#177)
2.0	11 Aug 2022	MR	Add documentation for `BLOB_APPEND` function introduced in Firebird 4.0.2
1.9	31 Jul 2022	MR	Move `RDB$TRIGGER_TYPE` description to separate section to prevent truncation of table cell in PDF
1.8	29 Jul 2022	MR	• Added `READ CONSISTENCY` to Isolation Level • Various copy-editing in *Transaction Control* chapter
1.7	18 Jul 2022	MR	Fix documentation for `RDB$INDICES.RDB$INDEX_TYPE` (#174)
1.6	13 Jul 2022	MR	`DATEDIFF` unit `MILLISECOND` returns `NUMERIC(18,1)` since Firebird 4.0.1 (#173)
1.5	12 Jul 2022	MR	• Corrected datatype of timestamp columns in system and monitoring tables (are `TIMESTAMP WITH TIME ZONE` since Firebird 4.0) (#172) • Nitpick: “user name” to “username” in “System Tables” appendix
1.4	03 Jan 2022	MR	Values for `RDB$RELATION_FIELDS.RDB$IDENTITY_TYPE` were swapped (#168)
1.3	24 Dec 2021	MR	• Documented `PKCS_1_5` option of `RSA_DECRYPT`, `RSA_ENCRYPT`, `RSA_SIGN_HASH`, `RSA_VERIFY_HASH` added in Firebird 4.0.1 • Documented collation attribute `DISABLE-COMPRESSIONS` since Firebird 4.0.1 is also supported for Unicode collations • Documented collation attribute `LOCALE` since Firebird 4.0.1 also supports ICU locale keywords and attributes • Documented result type determination of `AVG` as of Firebird 4.0.1 • Documented `SET DEBUG OPTION` added in Firebird 4.0.1 • Added `DEBUG` and `PKCS_1_5` to keywords list
1.2	04 Dec 2021	MR	• Added `LATERAL` join example contributed by Karol Bieniaszewski (#167) • Changed a `LATERAL` join example from implicit cross join to explicit `CROSS JOIN`

Revision History

1.1	16 Oct 2021	MR	`EXECUTE STATEMENT` named parameters are regular identifiers (#164)
1.0	29 Sep 2021	MR	Explicitly document transaction isolation level of `ON CONNECT`/`ON DISCONNECT` triggers (#163)
0.15	31 Jul 2021	MR	Fix behaviour documented for `SNAPSHOT TABLE STABILITY` (#158)
0.14	23 Jul 2021	MR	Remove extra `SELECT` in select syntax
0.13	18 Jul 2021	MR	Add missing isolation level code for read committed read consistency (4) to `MON$TRANSACTIONS` (#156)
0.12	13 Jun 2021	MR	Fixed wrong table title `NUMERIC` → `DECIMAL`
0.11	05 Jun 2021	MR	• Fixed rendering issues in `CRYPT_HASH` section • Fixed section level issue with examples of `HEX_ENCODE`/`HEX_DECODE` • Removed notice about `BASE64_ENCODE`/`BASE64_DECODE` and `HEX_ENCODE`/`HEX_DECODE` bugs fixed in Firebird 4.0.0 • Documented determination of result type of `SUM` • Documented — potential — bug with result type of `AVG` • Various copy-editing and corrections
0.10	03 Jun 2021	MR	• Fixed issue with some parts still referring to 18 as the max precision of `NUMERIC`/`DECIMAL` • Updated mapping of number literals to types with information for `DECFLOAT` and `INT128` • Added mention of increment of sequence to `NEXT VALUE FOR` • Various copy-editing and corrections
0.9	23 May 2021	MR	Changes: • Documented `USING PLUGIN` clause of `COMMENT ON USER` • Documented changes in start/restart behaviour of sequences • Removed some notes about Firebird 3.0 specific behaviour or bugs • Applied consistent version naming (e.g. Firebird 4.0, not Firebird 4) • Add missing links • Correct or clarify some issues previously annotated with TODO • Document key and block size of `ENCRYPT` algorithms • Fix section levels, and some reorganization of triggers

Revision History

0.8	22 May 2021	MR	Copied the *Firebird 3.0 Language Reference* as a starting point, and updated using the *Firebird 4.0 Release Notes Release Candidate 1* and further updates to the release notes as a guide.