INTERNATIONAL STANDARD

ISO/IEC 9075-2

Sixth edition
2023-06

Information technology — Database languages SQL —

Part 2: Foundation (SQL/Foundation)

Technologies de l'information — Langages de base de données SQL — Partie 2: Fondations (SQL/Fondations)

Reference number
ISO/IEC 9075-2:2023(E)

© ISO/IEC 2023



COPYRIGHT PROTECTED DOCUMENT

© ISO/IEC 2023

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

© ISO/IEC 2023 – All rights reserved

Contents

Page

Foreword . . . xix
Introduction . . . xxi
1 Scope . . . 1
2 Normative references . . . 2
3 Terms and definitions . . . 4
3.1 Definitions taken from ISO/IEC 10646:2020 . . . 4
3.2 Definitions taken from ISO/IEC 14651:2020 . . . 5
3.3 Definitions taken from ISO 8601-1:2019 . . . 5
3.4 Definitions taken from XQuery and XPath Functions and Operators 3.1 . . . 7
3.5 Definitions provided in this document . . . 7
4 Concepts . . . 15
4.1 Notations and conventions . . . 15
4.1.1 Notations . . . 15
4.1.2 Use of terms . . . 15
4.2 Data types . . . 16
4.2.1 General introduction to data types . . . 16
4.2.2 Naming of predefined types . . . 17
4.2.3 Host language data types . . . 18
4.2.4 Data type terminology . . . 18
4.2.5 Properties of distinct . . . 20
4.3 Character strings . . . 21
4.3.1 Introduction to character strings . . . 21
4.3.2 Comparison of character strings . . . 21
4.3.3 Operations involving character strings . . . 22
4.3.3.1 Regular expression syntaxes . . . 22
4.3.3.2 Operators that operate on character strings and return character strings . . . 22
4.3.3.3 Other operators involving character strings . . . 25
4.3.3.4 Operations involving large object character strings . . . 26
4.3.4 Character repertoires . . . 27
4.3.5 Character encoding forms . . . 28
4.3.6 Collations . . . 28
4.3.7 Character sets . . . 29
4.3.8 Universal character sets . . . 31
4.4 Binary strings . . . 31
4.4.1 Introduction to binary strings . . . 31
4.4.2 Binary string comparison . . . 31
4.4.3 Operations involving binary strings . . . 31
4.4.3.1 Operators that operate on binary strings and return binary strings . . . 31

© ISO/IEC 2023 – All rights reserved

4.4.3.2 Other operators involving binary strings. . . . 32
4.5 Numbers. . . . 32
4.5.1 Introduction to numbers. . . . 32
4.5.2 Characteristics of numbers. . . . 33
4.5.3 Operations involving numbers. . . . 34
4.6 Boolean types. . . . 35
4.6.1 Introduction to Boolean types. . . . 35
4.6.2 Comparison and assignment of Booleans. . . . 36
4.6.3 Operations involving Booleans. . . . 36
4.6.3.1 Operations on Booleans that return Booleans. . . . 36
4.6.3.2 Other operators involving Booleans. . . . 36
4.7 Datetimes and intervals. . . . 36
4.7.1 Introduction to datetimes and intervals. . . . 36
4.7.2 Datetimes. . . . 37
4.7.3 Intervals. . . . 39
4.7.4 Operations involving datetimes and intervals. . . . 41
4.8 JSON types. . . . 41
4.8.1 Introduction to JSON types. . . . 41
4.8.2 Comparison and assignment of JSON values. . . . 42
4.8.3 Operations involving JSON values. . . . 43
4.9 User-defined types. . . . 43
4.9.1 Introduction to user-defined types. . . . 43
4.9.2 Distinct types. . . . 44
4.9.3 Structured types. . . . 44
4.9.3.1 Introduction to structured types. . . . 44
4.9.3.2 Observer functions and mutator functions. . . . 44
4.9.3.3 Constructors. . . . 44
4.9.3.4 Subtypes and supertypes. . . . 45
4.9.4 Methods. . . . 46
4.9.5 User-defined type comparison and assignment. . . . 47
4.9.6 Transforms for user-defined types. . . . 48
4.9.7 User-defined type descriptor. . . . 48
4.10 Row types. . . . 50
4.11 Reference types. . . . 50
4.11.1 Introduction to reference types. . . . 50
4.11.2 Operations involving references. . . . 51
4.12 Collection types. . . . 51
4.12.1 Introduction to collection types. . . . 51
4.12.2 Arrays. . . . 52
4.12.3 Multisets. . . . 52
4.12.4 Collection comparison and assignment. . . . 52
4.12.5 Operations involving arrays. . . . 53
4.12.5.1 Operators that operate on array values and return array elements. . . . 53
4.12.5.2 Operators that operate on array values and return array values. . . . 53
4.12.5.3 Operators that operate on array values and return numbers. . . . 53
4.12.6 Operations involving multisets. . . . 53
4.12.6.1 Operators that operate on multisets and return multiset elements. . . . 53

 © ISO/IEC 2023 – All rights reserved

4.12.6.2 Operators that operate on multisets and return multisets. . . . 53
4.12.6.3 Operators that operate on multiset values and return numbers. . . . 54
4.13 Data conversions. . . . 54
4.14 Domains. . . . 55
4.15 Columns, fields, and attributes. . . . 55
4.16 Periods. . . . 57
4.16.1 Introduction to periods. . . . 57
4.16.2 Operations involving periods. . . . 58
4.17 Tables. . . . 58
4.17.1 Introduction to tables. . . . 58
4.17.2 Base tables. . . . 58
4.17.2.1 Introduction to base tables. . . . 58
4.17.2.2 Regular persistent base tables. . . . 59
4.17.2.3 System-versioned tables. . . . 59
4.17.2.4 Temporary tables. . . . 59
4.17.3 Derived tables. . . . 60
4.17.4 Transient tables. . . . 61
4.17.5 Unique identification of tables. . . . 61
4.17.6 Table updatability. . . . 61
4.17.7 Table descriptors. . . . 62
4.17.8 Syntactic analysis of derived tables and cursors. . . . 63
4.17.9 Referenceable tables, subtables, and supertables. . . . 65
4.17.10 Operations involving tables. . . . 66
4.17.11 Range variables. . . . 69
4.17.12 Identity columns. . . . 70
4.17.13 Base columns and generated columns. . . . 70
4.17.14 Grouped tables. . . . 70
4.17.15 Windowed tables. . . . 71
4.18 Data analysis operations. . . . 72
4.18.1 Introduction to data analysis operations. . . . 72
4.18.2 Group functions. . . . 72
4.18.3 Window functions. . . . 73
4.18.4 Aggregate functions. . . . 75
4.18.5 Row pattern measures. . . . 77
4.19 Row pattern matching. . . . 78
4.19.1 Introduction to row pattern matching. . . . 78
4.19.2 Matching rows with a pattern. . . . 78
4.19.3 Row pattern matching illustrated. . . . 79
4.19.4 Row pattern partitioning. . . . 83
4.19.5 Row ordering. . . . 83
4.19.6 Row pattern measure columns. . . . 83
4.19.7 Number of rows per match. . . . 83
4.19.8 Skipping rows after matching. . . . 84
4.20 Row patterns. . . . 84
4.21 Unions of row pattern variables. . . . 85
4.22 Defining Boolean conditions. . . . 85
4.23 Scalar expressions in row pattern matching. . . . 86

© ISO/IEC 2023 – All rights reserved

4.23.1 Introduction to scalars in row pattern matching. . . . 86
4.23.2 Running vs. final semantics. . . . 86
4.23.3 Row pattern navigation operations. . . . 87
4.23.4 Row pattern classifier function. . . . 87
4.23.5 Row pattern match number function. . . . 87
4.24 Determinism. . . . 87
4.25 Integrity constraints. . . . 88
4.25.1 Overview of integrity constraints. . . . 88
4.25.2 Checking of constraints. . . . 88
4.25.3 Table constraints. . . . 89
4.25.3.1 Introduction to table constraints. . . . 89
4.25.3.2 Unique constraints. . . . 89
4.25.3.3 Referential constraints. . . . 90
4.25.3.4 Table check constraints. . . . 93
4.25.4 Domain constraints. . . . 93
4.25.5 Assertions. . . . 93
4.26 Functional dependencies. . . . 94
4.26.1 Overview of functional dependency rules and notations. . . . 94
4.26.2 General rules and definitions. . . . 94
4.26.3 Known functional dependencies in a base table. . . . 95
4.26.4 Known functional dependencies in a viewed table. . . . 96
4.26.5 Known functional dependencies in a transition table. . . . 96
4.26.6 Known functional dependencies in <table value constructor>. . . . 96
4.26.7 Known functional dependencies in a <joined table>. . . . 96
4.26.8 Known functional dependencies in a <table primary>. . . . 98
4.26.9 Known functional dependencies in a <table factor>. . . . 99
4.26.10 Known functional dependencies in a <table reference>. . . . 99
4.26.11 Known functional dependencies in the result of a <from clause>. . . . 99
4.26.12 Known functional dependencies in the result of a <where clause>. . . . 99
4.26.13 Known functional dependencies in the result of a <group by clause>. . . . 100
4.26.14 Known functional dependencies in the result of a <having clause>. . . . 100
4.26.15 Known functional dependencies in a <query specification>. . . . 100
4.26.16 Known functional dependencies in a <query expression>. . . . 101
4.27 Candidate keys. . . . 101
4.28 SQL-schemas. . . . 102
4.29 Sequence generators. . . . 103
4.29.1 General description of sequence generators. . . . 103
4.29.2 Operations involving sequence generators. . . . 104
4.30 SQL-client modules. . . . 104
4.31 Embedded syntax. . . . 105
4.32 Dynamic SQL concepts. . . . 106
4.32.1 Introduction to dynamic SQL. . . . 106
4.32.2 Overview of dynamic SQL for constructed SQL-statements. . . . 106
4.32.3 Overview of dynamic SQL for polymorphic table functions. . . . 107
4.32.4 Dynamic SQL statements and descriptor areas. . . . 107
4.33 Direct invocation of SQL. . . . 109
4.34 Externally-invoked procedures. . . . 109

 © ISO/IEC 2023 – All rights reserved

4.35 SQL-invoked routines. . . . 109
4.35.1 Overview of SQL-invoked routines. . . . 109
4.35.2 Characteristics of SQL-invoked routines. . . . 111
4.35.3 Execution of conventional SQL-invoked routines. . . . 114
4.35.4 Invocation of polymorphic table functions. . . . 115
4.35.5 Routine descriptors. . . . 119
4.35.6 Result sets returned by SQL-invoked procedures. . . . 122
4.36 SQL-paths. . . . 123
4.37 Host parameters. . . . 123
4.37.1 Overview of host parameters. . . . 123
4.37.2 Status parameters. . . . 123
4.37.3 Data parameters. . . . 124
4.37.4 Indicator parameters. . . . 124
4.37.5 Locators. . . . 124
4.38 Diagnostics area. . . . 125
4.39 Host languages. . . . 126
4.40 Cursors. . . . 127
4.40.1 General description of cursors. . . . 127
4.40.2 Operations on and using cursors. . . . 131
4.41 SQL-statements. . . . 132
4.41.1 Classes of SQL-statements. . . . 132
4.41.2 SQL-statements classified by function. . . . 133
4.41.2.1 SQL-schema statements. . . . 133
4.41.2.2 SQL-data statements. . . . 134
4.41.2.3 SQL-data change statements. . . . 135
4.41.2.4 SQL-transaction statements. . . . 136
4.41.2.5 SQL-connection statements. . . . 136
4.41.2.6 SQL-control statements. . . . 136
4.41.2.7 SQL-session statements. . . . 136
4.41.2.8 SQL-diagnostics statements. . . . 137
4.41.2.9 SQL-dynamic statements. . . . 137
4.41.2.10 SQL embedded exception declaration. . . . 137
4.41.3 SQL-statements and SQL-data access indication. . . . 137
4.41.4 SQL-statements and transaction states. . . . 138
4.41.5 SQL-statement atomicity and statement execution contexts. . . . 140
4.41.6 Embeddable SQL-statements. . . . 141
4.41.7 Preparable and immediately executable SQL-statements. . . . 142
4.41.8 Directly executable SQL-statements. . . . 144
4.42 Basic security model. . . . 145
4.42.1 Authorization identifiers. . . . 145
4.42.1.1 Introduction to authorization identifiers. . . . 145
4.42.1.2 SQL-session authorization identifiers. . . . 145
4.42.1.3 SQL-client module authorization identifiers. . . . 146
4.42.1.4 SQL-schema authorization identifiers. . . . 146
4.42.2 Privileges. . . . 146
4.42.3 Roles. . . . 149
4.42.4 Security model definitions. . . . 149

© ISO/IEC 2023 – All rights reserved

4.43 SQL-transactions. . . . 149
4.43.1 General description of SQL-transactions. . . . 149
4.43.2 Savepoints. . . . 150
4.43.3 Properties of SQL-transactions. . . . 151
4.43.4 Isolation levels of SQL-transactions. . . . 151
4.43.5 Implicit rollbacks. . . . 152
4.43.6 Effects of SQL-statements in an SQL-transaction. . . . 153
4.43.7 Encompassing transactions. . . . 153
4.43.7.1 Encompassing transaction belonging to an external agent. . . . 153
4.43.7.2 Encompassing transaction belonging to the SQL-agent. . . . 153
4.44 SQL-connections. . . . 154
4.45 SQL-sessions. . . . 155
4.45.1 General description of SQL-sessions. . . . 155
4.45.2 SQL-session identification. . . . 156
4.45.3 SQL-session properties. . . . 156
4.45.4 SQL-session context management. . . . 159
4.45.5 Execution contexts. . . . 159
4.45.6 Routine execution context. . . . 159
4.46 Triggers. . . . 160
4.46.1 General description of triggers. . . . 160
4.46.2 Trigger execution. . . . 161
4.47 Client-server operation. . . . 163
4.48 JSON data handling in SQL. . . . 163
4.48.1 Introduction. . . . 163
4.48.2 Implied JSON data model. . . . 164
4.48.3 SQL/JSON data model. . . . 165
4.48.4 SQL/JSON functions. . . . 166
4.48.5 Overview of SQL/JSON path language. . . . 167
5 Lexical elements. . . . 169
5.1 <SQL terminal character>. . . . 169
5.2 <token> and <separator>. . . . 173
5.3 <literal>. . . . 183
5.4 Names and identifiers. . . . 194
6 Scalar expressions. . . . 206
6.1 <data type>. . . . 206
6.2 <field definition>. . . . 219
6.3 <value expression primary>. . . . 221
6.4 <value specification> and <target specification>. . . . 223
6.5 <contextually typed value specification>. . . . 228
6.6 <identifier chain>. . . . 230
6.7 <column reference>. . . . 234
6.8 <SQL parameter reference>. . . . 237
6.9 <set function specification>. . . . 238
6.10 <window function>. . . . 241
6.11 <nested window function>. . . . 247
6.12 <case expression>. . . . 250
6.13 <cast specification>. . . . 254

© ISO/IEC 2023 – All rights reserved

6.14 <next value expression>. . . . 271
6.15 <greatest or least function>. . . . 273
6.16 <field reference>. . . . 275
6.17 <subtype treatment>. . . . 276
6.18 <method invocation>. . . . 278
6.19 <static method invocation>. . . . 280
6.20 <new specification>. . . . 282
6.21 <attribute or method reference>. . . . 284
6.22 <dereference operation>. . . . 285
6.23 <method reference>. . . . 286
6.24 <reference resolution>. . . . 288
6.25 <array element reference>. . . . 290
6.26 <multiset element reference>. . . . 291
6.27 <row pattern navigation operation>. . . . 292
6.28 <JSON value function>. . . . 296
6.29 <value expression>. . . . 298
6.30 <numeric value expression>. . . . 300
6.31 <numeric value function>. . . . 302
6.32 <string value expression>. . . . 316
6.33 <string value function>. . . . 321
6.34 <JSON value constructor>. . . . 341
6.35 <JSON query>. . . . 348
6.36 <JSON simplified accessor>. . . . 351
6.37 <JSON serialize>. . . . 354
6.38 <JSON value expression>. . . . 355
6.39 <JSON typed value function>. . . . 356
6.40 <JSON parse>. . . . 357
6.41 <JSON scalar>. . . . 359
6.42 <datetime value expression>. . . . 360
6.43 <datetime value function>. . . . 363
6.44 <interval value expression>. . . . 365
6.45 <interval value function>. . . . 369
6.46 <boolean value expression>. . . . 370
6.47 <array value expression>. . . . 374
6.48 <array value function>. . . . 376
6.49 <array value constructor>. . . . 378
6.50 <multiset value expression>. . . . 380
6.51 <multiset value function>. . . . 383
6.52 <multiset value constructor>. . . . 384

7 Query expressions. . . . 386

7.1 <row value constructor>. . . . 386
7.2 <row value expression>. . . . 389
7.3 <table value constructor>. . . . 391
7.4 <table expression>. . . . 393
7.5 <from clause>. . . . 394
7.6 <table reference>. . . . 397
7.7 <row pattern recognition clause>. . . . 415

© ISO/IEC 2023 – All rights reserved

7.8 <row pattern measures>. . . . 420
7.9 <row pattern common syntax>. . . . 422
7.10 <joined table>. . . . 427
7.11 <JSON table>. . . . 437
7.12 <where clause>. . . . 451
7.13 <group by clause>. . . . 452
7.14 <having clause>. . . . 461
7.15 <window clause>. . . . 463
7.16 <query specification>. . . . 478
7.17 <query expression>. . . . 486
7.18 <search or cycle clause>. . . . 503
7.19 <subquery>. . . . 507
8 Predicates. . . . 509
8.1 <predicate>. . . . 509
8.2 <comparison predicate>. . . . 511
8.3 <between predicate>. . . . 519
8.4 <in predicate>. . . . 520
8.5 <like predicate>. . . . 522
8.6 <similar predicate>. . . . 528
8.7 <regex like predicate>. . . . 534
8.8 <null predicate>. . . . 536
8.9 <quantified comparison predicate>. . . . 538
8.10 <exists predicate>. . . . 540
8.11 <unique predicate>. . . . 541
8.12 <normalized predicate>. . . . 543
8.13 <match predicate>. . . . 545
8.14 <overlaps predicate>. . . . 548
8.15 <distinct predicate>. . . . 550
8.16 <member predicate>. . . . 553
8.17 <submultiset predicate>. . . . 555
8.18 <set predicate>. . . . 557
8.19 <type predicate>. . . . 558
8.20 <period predicate>. . . . 560
8.21 <search condition>. . . . 565
8.22 <JSON predicate>. . . . 566
8.23 <JSON exists predicate>. . . . 568
9 Additional common rules. . . . 570
9.1 Retrieval assignment. . . . 570
9.2 Store assignment. . . . 576
9.3 Passing a value from a host language to the SQL-server. . . . 582
9.4 Passing a value from the SQL-server to a host language. . . . 586
9.5 Result of data type combinations. . . . 590
9.6 Subject routine determination. . . . 594
9.7 Type precedence list determination. . . . 596
9.8 Host parameter mode determination. . . . 600
9.9 Type name determination. . . . 602
9.10 Determination of identical values. . . . 604

 © ISO/IEC 2023 – All rights reserved

9.11 Equality operations. . . . 606
9.12 Grouping operations. . . . 608
9.13 Multiset element grouping operations. . . . 610
9.14 Ordering operations. . . . 612
9.15 Collation determination. . . . 614
9.16 Potential sources of non-determinism. . . . 616
9.17 Executing an <SQL procedure statement>. . . . 620
9.18 Invoking an SQL-invoked routine. . . . 625
9.19 Processing a method invocation. . . . 655
9.20 Transformation of query specifications. . . . 657
9.21 Execution of array-returning external functions. . . . 660
9.22 Execution of multiset-returning external functions. . . . 664
9.23 Evaluation and transformation of <window function>. . . . 665
9.24 Compilation of an invocation of a polymorphic table function. . . . 669
9.25 Execution of an invocation of a polymorphic table function. . . . 674
9.26 Signatures of PTF component procedures. . . . 685
9.27 Invocation of a PTF component procedure. . . . 688
9.28 XQuery regular expression matching. . . . 691
9.29 XQuery regular expression replacement. . . . 694
9.30 Data type identity. . . . 696
9.31 Determination of a from-sql function. . . . 698
9.32 Determination of a from-sql function for an overriding method. . . . 699
9.33 Determination of a to-sql function. . . . 700
9.34 Determination of a to-sql function for an overriding method. . . . 701
9.35 Generation of the next value of a sequence generator. . . . 702
9.36 Creation of a sequence generator. . . . 704
9.37 Altering a sequence generator. . . . 707
9.38 Generation of the hierarchical <query expression> of a view. . . . 710
9.39 Determination of view privileges. . . . 711
9.40 Determination of view component privileges. . . . 713
9.41 Row pattern recognition in a sequence of rows. . . . 717
9.42 Parsing JSON text. . . . 721
9.43 Serializing an SQL/JSON item. . . . 724
9.44 Converting an SQL/JSON sequence to an SQL/JSON item. . . . 726
9.45 SQL/JSON path language: lexical elements. . . . 729
9.46 SQL/JSON path language: syntax and semantics. . . . 733
9.47 Processing <JSON API common syntax>. . . . 764
9.48 Casting an SQL/JSON sequence to an SQL type. . . . 765
9.49 Serializing an SQL/JSON sequence to an SQL string type. . . . 768
9.50 Converting a datetime to a formatted character string. . . . 772
9.51 Converting a formatted character string to a datetime. . . . 776
9.52 Datetime templates. . . . 784
10 Additional common elements. . . . 788
10.1 <interval qualifier>. . . . 788
10.2 <language clause>. . . . 792
10.3 <path specification>. . . . 794
10.4 <routine invocation>. . . . 795

© ISO/IEC 2023 – All rights reserved

10.5 <character set specification>. . . . 799
10.6 <specific routine designator>. . . . 801
10.7 <collate clause>. . . . 804
10.8 <constraint name definition> and <constraint characteristics>. . . . 805
10.9 <aggregate function>. . . . 807
10.10 <sort specification list>. . . . 823
10.11 <JSON aggregate function>. . . . 825
10.12 <JSON input expression>. . . . 831
10.13 <JSON output clause>. . . . 833
10.14 <JSON API common syntax>. . . . 835
11 Schema definition and manipulation. . . . 837
11.1 <schema definition>. . . . 837
11.2 <drop schema statement>. . . . 840
11.3 <table definition>. . . . 843
11.4 <column definition>. . . . 855
11.5 <default clause>. . . . 861
11.6 <table constraint definition>. . . . 865
11.7 <unique constraint definition>. . . . 867
11.8 <referential constraint definition>. . . . 870
11.9 <check constraint definition>. . . . 876
11.10 <alter table statement>. . . . 878
11.11 <add column definition>. . . . 879
11.12 <alter column definition>. . . . 881
11.13 <set column default clause>. . . . 883
11.14 <drop column default clause>. . . . 884
11.15 <set column not null clause>. . . . 885
11.16 <drop column not null clause>. . . . 886
11.17 <add column scope clause>. . . . 887
11.18 <drop column scope clause>. . . . 888
11.19 <alter column data type clause>. . . . 890
11.20 <alter identity column specification>. . . . 894
11.21 <drop identity property clause>. . . . 896
11.22 <drop column generation expression clause>. . . . 897
11.23 <drop column definition>. . . . 898
11.24 <add table constraint definition>. . . . 900
11.25 <alter table constraint definition>. . . . 901
11.26 <drop table constraint definition>. . . . 902
11.27 <add table period definition>. . . . 905
11.28 <drop table period definition>. . . . 908
11.29 <add system versioning clause>. . . . 913
11.30 <drop system versioning clause>. . . . 914
11.31 <drop table statement>. . . . 916
11.32 <view definition>. . . . 919
11.33 <drop view statement>. . . . 930
11.34 <domain definition>. . . . 933
11.35 <alter domain statement>. . . . 935
11.36 <set domain default clause>. . . . 936

 © ISO/IEC 2023 – All rights reserved

11.37 <drop domain default clause> . . . 937
11.38 <add domain constraint definition> . . . 938
11.39 <drop domain constraint definition> . . . 939
11.40 <drop domain statement> . . . 940
11.41 <character set definition> . . . 942
11.42 <drop character set statement> . . . 944
11.43 <collation definition> . . . 946
11.44 <drop collation statement> . . . 948
11.45 <transliteration definition> . . . 950
11.46 <drop transliteration statement> . . . 952
11.47 <assertion definition> . . . 954
11.48 <drop assertion statement> . . . 956
11.49 <trigger definition> . . . 959
11.50 <drop trigger statement> . . . 965
11.51 <user-defined type definition> . . . 968
11.52 <attribute definition> . . . 984
11.53 <alter type statement> . . . 986
11.54 <add attribute definition> . . . 987
11.55 <drop attribute definition> . . . 989
11.56 <add original method specification> . . . 991
11.57 <add overriding method specification> . . . 996
11.58 <drop method specification> . . . 1001
11.59 <drop data type statement> . . . 1005
11.60 <SQL-invoked routine> . . . 1008
11.61 <alter routine statement> . . . 1037
11.62 <drop routine statement> . . . 1040
11.63 <user-defined cast definition> . . . 1042
11.64 <drop user-defined cast statement> . . . 1044
11.65 <user-defined ordering definition> . . . 1047
11.66 <drop user-defined ordering statement> . . . 1050
11.67 <transform definition> . . . 1053
11.68 <alter transform statement> . . . 1056
11.69 <add transform element list> . . . 1057
11.70 <drop transform element list> . . . 1059
11.71 <drop transform statement> . . . 1061
11.72 <sequence generator definition> . . . 1064
11.73 <alter sequence generator statement> . . . 1066
11.74 <drop sequence generator statement> . . . 1067

12 Access control . . . 1068

12.1 <grant statement> . . . 1068
12.2 <grant privilege statement> . . . 1073
12.3 <privileges> . . . 1076
12.4 <role definition> . . . 1080
12.5 <grant role statement> . . . 1081
12.6 <drop role statement> . . . 1083
12.7 <revoke statement> . . . 1084
12.8 Grantor determination . . . 1103

© ISO/IEC 2023 – All rights reserved

13 SQL-client modules. 1105
13.1 <SQL-client module definition>. 1105
13.2 <module name clause>. 1109
13.3 <externally-invoked procedure>. 1110
13.4 <SQL procedure statement>. 1125
13.5 Data type correspondences. 1128
14 Data manipulation. 1139
14.1 <declare cursor>. 1139
14.2 <cursor properties>. 1141
14.3 <cursor specification>. 1143
14.4 <open statement>. 1146
14.5 <fetch statement>. 1147
14.6 <close statement>. 1151
14.7 <select statement: single row>. 1152
14.8 <delete statement: positioned>. 1156
14.9 <delete statement: searched>. 1158
14.10 <truncate table statement>. 1162
14.11 <insert statement>. 1164
14.12 <merge statement>. 1169
14.13 <update statement: positioned>. 1179
14.14 <update statement: searched>. 1181
14.15 <set clause list>. 1185
14.16 <temporary table declaration>. 1189
14.17 <free locator statement>. 1191
14.18 <hold locator statement>. 1192
15 Additional data manipulation rules. 1193
15.1 Effect of opening a cursor. 1193
15.2 Effect of receiving a result set. 1196
15.3 Determination of the current row of a cursor. 1197
15.4 Effect of closing a cursor. 1199
15.5 Evaluating a <set clause list>. 1201
15.6 Effect of a positioned delete. 1203
15.7 Effect of a positioned update. 1205
15.8 Effect of deleting rows from base tables. 1208
15.9 Effect of deleting some rows from a derived table. 1211
15.10 Effect of deleting some rows from a viewed table. 1213
15.11 Effect of inserting tables into base tables. 1215
15.12 Effect of inserting a table into a derived table. 1218
15.13 Effect of inserting a table into a viewed table. 1220
15.14 Effect of replacing rows in base tables. 1222
15.15 Effect of replacing some rows in a derived table. 1226
15.16 Effect of replacing some rows in a viewed table. 1229
15.17 Checking of views that specify CHECK OPTION. 1231
15.18 Execution of referential actions. 1234
15.19 Execution of BEFORE triggers. 1240
15.20 Execution of AFTER triggers. 1241
15.21 Execution of triggers. 1242

 © ISO/IEC 2023 – All rights reserved

16 Control statements. 1245
16.1 <call statement>. 1245
16.2 <return statement>. 1246
17 Transaction management. 1247
17.1 <start transaction statement>. 1247
17.2 <set transaction statement>. 1249
17.3 <transaction characteristics>. 1251
17.4 <set constraints mode statement>. 1253
17.5 <savepoint statement>. 1255
17.6 <release savepoint statement>. 1256
17.7 <commit statement>. 1257
17.8 <rollback statement>. 1259
18 Connection management. 1261
18.1 <connect statement>. 1261
18.2 <set connection statement>. 1264
18.3 <disconnect statement>. 1266
19 Session management. 1268
19.1 <set session characteristics statement>. 1268
19.2 <set session user identifier statement>. 1270
19.3 <set role statement>. 1271
19.4 <set local time zone statement>. 1272
19.5 <set catalog statement>. 1273
19.6 <set schema statement>. 1274
19.7 <set names statement>. 1275
19.8 <set path statement>. 1276
19.9 <set transform group statement>. 1277
19.10 <set session collation statement>. 1278
20 Dynamic SQL. 1280
20.1 Description of SQL descriptor areas. 1280
20.2 <allocate descriptor statement>. 1290
20.3 <deallocate descriptor statement>. 1292
20.4 <get descriptor statement>. 1293
20.5 <set descriptor statement>. 1297
20.6 <copy descriptor statement>. 1302
20.7 <prepare statement>. 1305
20.8 <cursor attributes>. 1316
20.9 <deallocate prepared statement>. 1317
20.10 <describe statement>. 1318
20.11 <input using clause>. 1324
20.12 <output using clause>. 1328
20.13 <execute statement>. 1333
20.14 <execute immediate statement>. 1335
20.15 <dynamic declare cursor>. 1336
20.16 <descriptor value constructor>. 1337
20.17 <allocate extended dynamic cursor statement>. 1339
20.18 <allocate received cursor statement>. 1341

© ISO/IEC 2023 – All rights reserved

20.19 <dynamic open statement>. . . . 1343
20.20 <dynamic fetch statement>. . . . 1345
20.21 <dynamic single row select statement>. . . . 1346
20.22 <dynamic close statement>. . . . 1347
20.23 <dynamic delete statement: positioned>. . . . 1348
20.24 <dynamic update statement: positioned>. . . . 1349
20.25 <preparable dynamic delete statement: positioned>. . . . 1351
20.26 <preparable dynamic cursor name>. . . . 1353
20.27 <preparable dynamic update statement: positioned>. . . . 1355
20.28 <pipe row statement>. . . . 1357
21 Embedded SQL. . . . 1359
21.1 <embedded SQL host program>. . . . 1359
21.2 <embedded exception declaration>. . . . 1370
21.3 <embedded SQL Ada program>. . . . 1374
21.4 <embedded SQL C program>. . . . 1382
21.5 <embedded SQL COBOL program>. . . . 1391
21.6 <embedded SQL Fortran program>. . . . 1398
21.7 <embedded SQL MUMPS program>. . . . 1405
21.8 <embedded SQL Pascal program>. . . . 1409
21.9 <embedded SQL PL/I program>. . . . 1415
22 Direct invocation of SQL. . . . 1422
22.1 <direct SQL statement>. . . . 1422
22.2 <direct select statement: multiple rows>. . . . 1425
23 Diagnostics management. . . . 1426
23.1 <get diagnostics statement>. . . . 1426
23.2 Pushing and popping the diagnostics area stack. . . . 1442
24 Status codes. . . . 1443
24.1 SQLSTATE. . . . 1443
24.2 Remote Database Access SQLSTATE Subclasses. . . . 1453
25 Conformance. . . . 1454
25.1 Claims of conformance to SQL/Foundation. . . . 1454
25.2 Additional conformance requirements for SQL/Foundation. . . . 1455
25.3 Implied feature relationships of SQL/Foundation. . . . 1455
Annex A (informative) **SQL conformance summary. . . . 1466**
Annex B (informative) **Implementation-defined elements. . . . 1555**
Annex C (informative) **Implementation-dependent elements. . . . 1606**
Annex D (informative) **SQL optional feature taxonomy. . . . 1624**
Annex E (informative) **Deprecated features. . . . 1640**
Annex F (informative) **Incompatibilities with ISO/IEC 9075:2016. . . . 1641**
Annex G (informative) **Defect Reports not addressed in this edition of this document. . . . 1642**
Annex H (informative) **SQL mandatory feature taxonomy. . . . 1643**
Bibliography. . . . 1660
Index. . . . 1662

 © ISO/IEC 2023 – All rights reserved

Tables

Table

Page

1 Overview of character sets. . . . 30
2 Fields in datetime values. . . . 37
3 Datetime data type conversions. . . . 38
4 Fields in year-month INTERVAL values. . . . 39
5 Fields in day-time INTERVAL values. . . . 40
6 Valid values for fields in INTERVAL values. . . . 40
7 Valid operators involving datetimes and intervals. . . . 41
8 Result with ONE ROW PER MATCH. . . . 81
9 Result with ALL ROWS PER MATCH. . . . 82
10 Schematic diagram of effective parameter lists of PTF component procedures. . . . 118
11 SQL-transaction isolation levels and the three phenomena. . . . 152
12 Interpretation of datetime components. . . . 189
13 Valid values for datetime fields. . . . 214
14 Valid absolute values for interval fields. . . . 215
15 Truth table for the AND Boolean operator. . . . 373
16 Truth table for the OR Boolean operator. . . . 373
17 Truth table for the IS Boolean operator. . . . 373
18 <null predicate> semantics. . . . 537
19 SQL/JSON and ECMAScript correspondences. . . . 731
20 Standard programming languages. . . . 792
21 Data type correspondences for Ada. . . . 1128
22 Data type correspondences for C. . . . 1130
23 Data type correspondences for COBOL. . . . 1131
24 Data type correspondences for Fortran. . . . 1133
25 Data type correspondences for M. . . . 1134
26 Data type correspondences for Pascal. . . . 1136
27 Data type correspondences for PL/I. . . . 1137
28 Data types of <key word>s used in the header of SQL descriptor areas. . . . 1284
29 Data types of <key word>s used in SQL item descriptor areas. . . . 1284
30 Codes used for SQL data types in Dynamic SQL. . . . 1286
31 Codes associated with datetime data types in Dynamic SQL. . . . 1287
32 Codes used for <interval qualifier>s in Dynamic SQL. . . . 1288
33 Codes used for input/output SQL parameter modes in Dynamic SQL. . . . 1288
34 Codes associated with user-defined types in Dynamic SQL. . . . 1289
35 Codes associated with sort direction. . . . 1289
36 Codes associated with null ordering. . . . 1289
37 Data types of <statement information item name>s. . . . 1428
38 Data types of <condition information item name>s. . . . 1428
39 SQL-statement codes. . . . 1430
40 SQLSTATE class and subclass codes. . . . 1444
41 SQLSTATE class codes for RDA. . . . 1453
42 Implied feature relationships of SQL/Foundation. . . . 1455
A.1 Feature definitions outside of Conformance Rules. . . . 1466
D.1 Feature taxonomy for optional features. . . . 1624
H.1 Feature taxonomy and definition for mandatory features. . . . 1643

© ISO/IEC 2023 – All rights reserved

Figures

Figure

Page

1 Operation of <regular expression substring function>. 24
2 Illustration of WIDTH_BUCKET Semantics. 35
3 Illustration of important concepts in example query. 81
4 Taxonomy of SQL-invoked routines. 110
5 Flow of information during the invocation of a polymorphic table function. 117
6 Architecture of SQL/JSON path language usage. 167
7 Diagram of COLTREE. 443
8 Diagram of a plan tree. 444

© ISO/IEC 2023 – All rights reserved

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives or www.iec.ch/members_experts/refdocs).

ISO and IEC draw attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO and IEC take no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO and IEC have not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents and https://patents.iec.ch. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html. In the IEC, see www.iec.ch/understanding-standards.

This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 32, *Data management and interchange*.

This sixth edition cancels and replaces the fifth edition (ISO/IEC 9075-2:2016), which has been technically revised. It also incorporates the Technical Corrigenda ISO/IEC 9075-2:2016/Cor.1:2019 and ISO/IEC 9075-2:2016/Cor.2:2022.

The main changes are as follows:

— native JSON datatype;

— more types of numeric literals;

— additional SQL functions:

  — ANY_VALUE,
  — BTRIM,
  — GREATEST,
  — JSON_SCALAR,
  — JSON_SERIALIZE,

© ISO/IEC 2023 – All rights reserved

  - LEAST,
  - LPAD,
  - LTRIM,
  - RPAD,
  - RTRIM;

- improve the presentation and accuracy of the summaries of implementation-defined and implementation-dependent aspects of this document;

- introduction of several digital artifacts;

- alignment with updated ISO house style and other guidelines for creating standards.

This sixth edition of ISO/IEC 9075-2 is designed to be used in conjunction with the following editions of other parts of the ISO/IEC 9075 series, all published 2023:

- ISO/IEC 9075-1, sixth edition;

- ISO/IEC 9075-3, sixth edition;

- ISO/IEC 9075-4, seventh edition;

- ISO/IEC 9075-9, fifth edition;

- ISO/IEC 9075-10, fifth edition;

- ISO/IEC 9075-11, fifth edition;

- ISO/IEC 9075-13, fifth edition;

- ISO/IEC 9075-14, sixth edition;

- ISO/IEC 9075-15, second edition;

- ISO/IEC 9075-16, first edition.

A list of all parts in the ISO/IEC 9075 series can be found on the ISO and IEC websites.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html and www.iec.ch/national-committees.

© ISO/IEC 2023 – All rights reserved

Introduction

The organization of this document is as follows:

1) Clause 1, "Scope", specifies the scope of this document.
2) Clause 2, "Normative references", identifies additional standards that, through reference in this document, constitute provisions of this document.
3) Clause 3, "Terms and definitions", defines the terms and definitions used in this document.
4) Clause 4, "Concepts", presents concepts used in the definition of SQL.
5) Clause 5, "Lexical elements", defines the lexical elements of the language.
6) Clause 6, "Scalar expressions", defines the elements of the language that produce scalar values.
7) Clause 7, "Query expressions", defines the elements of the language that produce rows and tables of data.
8) Clause 8, "Predicates", defines the predicates of the language.
9) Clause 9, "Additional common rules", specifies the rules for assignments that retrieve data from or store data into SQL-data, and formation rules for set operations.
10) Clause 10, "Additional common elements", defines additional language elements that are used in various parts of the language.
11) Clause 11, "Schema definition and manipulation", defines facilities for creating and managing a schema.
12) Clause 12, "Access control", defines facilities for controlling access to SQL-data.
13) Clause 13, "SQL-client modules", defines SQL-client modules and externally-invoked procedures.
14) Clause 14, "Data manipulation", defines the data manipulation statements.
15) Clause 15, "Additional data manipulation rules", defines additional rules for data manipulation.
16) Clause 16, "Control statements", defines the SQL-control statements.
17) Clause 17, "Transaction management", defines the SQL-transaction management statements.
18) Clause 18, "Connection management", defines the SQL-connection management statements.
19) Clause 19, "Session management", defines the SQL-session management statements.
20) Clause 20, "Dynamic SQL", defines the SQL dynamic statements.
21) Clause 21, "Embedded SQL", defines the host language embeddings.
22) Clause 22, "Direct invocation of SQL", defines direct invocation of SQL language.
23) Clause 23, "Diagnostics management", defines the diagnostics management facilities.
24) Clause 24, "Status codes", defines values that identify the status of the execution of SQL-statements and the mechanisms by which those values are returned.
25) Clause 25, "Conformance", defines the criteria for conformance to this document.
26) Annex A, "SQL conformance summary", is an informative Annex. It summarizes the conformance requirements of the SQL language.

© ISO/IEC 2023 – All rights reserved

27) Annex B, "Implementation-defined elements", is an informative Annex. It lists those features for which the body of this document states that the syntax, the meaning, the returned results, the effect on SQL-data and/or schemas, or other aspect is partly or wholly implementation-defined.

28) Annex C, "Implementation-dependent elements", is an informative Annex. It lists those features for which the body of this document states that the syntax, the meaning, the returned results, the effect on SQL-data and/or schemas, or other aspect is partly or wholly implementation-dependent.

29) Annex D, "SQL optional feature taxonomy", is an informative Annex. It identifies the optional features of the SQL language specified in this document by an identifier and a short descriptive name. This taxonomy is used to specify conformance.

30) Annex E, "Deprecated features", is an informative Annex. It lists features that the responsible Technical Committee intends not to include in a future edition of this document.

31) Annex F, "Incompatibilities with ISO/IEC 9075:2016", is an informative Annex. It lists incompatibilities with the previous edition of this document.

32) Annex G, "Defect Reports not addressed in this edition of this document", is an informative Annex. It describes the Defect Reports that were known at the time of publication of this document. Each of these problems is a problem carried forward from the previous edition of the ISO/IEC 9075 series. No new problems have been created in the drafting of this edition of this document.

33) Annex H, "SQL mandatory feature taxonomy", is an informative Annex. It identifies mandatory features and subfeatures of the SQL language specified in this document by an identifier and a short descriptive name. This taxonomy is used to specify conformance to Core SQL.

In the text of this document, in Clause 5, "Lexical elements", through Clause 24, "Status codes", Subclauses begin new pages. Any resulting blank space is not significant.

© ISO/IEC 2023 – All rights reserved

Information technology — Database language SQL —

Part 2:
Foundation (SQL/Foundation)

1 Scope

This document defines the data structures and basic operations on SQL-data. It provides functional capabilities for creating, accessing, maintaining, controlling, and protecting SQL-data.

This document specifies the syntax and semantics of a database language:

— for specifying and modifying the structure and the integrity constraints of SQL-data;

— for declaring and invoking operations on SQL-data and cursors;

— for declaring database language procedures;

— for embedding SQL-statements in a compilation unit that is otherwise written in a particular programming language (host language);

— for deriving an equivalent compilation unit in the host language. In that equivalent compilation unit, each embedded SQL-statement has been replaced by one or more statements in the host language, some of which invoke an SQL externally-invoked procedure that, when executed, has an effect equivalent to executing the SQL-statement;

— for direct invocation of SQL-statements;

— to support dynamic preparation and execution of SQL-statements.

This document provides a vehicle for portability of data definitions and compilation units between SQL-implementations.

This document provides a vehicle for interconnection of SQL-implementations.

Implementations of this document can exist in environments that also support application programming languages, end-user query languages, report generator systems, data dictionary systems, program library systems, and distributed communication systems, as well as various tools for database design, data administration, and performance optimization.

© ISO/IEC 2023 – All rights reserved

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies. [1]

ISO/IEC 646, *Information technology — ISO 7-bit coded character set for information interchange*

ISO/IEC 1539-1:2018, *Information technology — Programming languages — Fortran — Part 1: Base language*

ISO 1989:2014, *Information technology — Programming languages — COBOL*

ISO 6160:1979, *Programming languages — PL/I (Endorsement of ANSI X3.53-1976)*

ISO/IEC 6429, *Information technology — Control functions for coded character sets*

ISO 7185:1990, *Information technology — Programming languages — Pascal*

ISO 8601-1:2019, *Date and time — Representations for information interchange — Part 1: Basic rules*

ISO/IEC 8652:2012, *Information technology — Programming languages — Ada*

ISO/IEC 8652:2012/Cor.1:2016, *Information technology — Programming languages — Ada — Technical Corrigendum 1*

ISO/IEC 8859-1, *Information technology — 8-bit single-byte coded graphic character sets — Part 1: Latin alphabet No. 1*

ISO/IEC 9075-1, *Information technology — Database languages — SQL — Part 1: Framework (SQL/Framework)*

ISO/IEC 9075-11, *Information technology — Database languages — SQL — Part 11: Information and Definition Schemas (SQL/Schemata)*

ISO/IEC 9579, *Information technology — Remote database access for SQL with security enhancement*

ISO/IEC 9899:2018, *Information technology — Programming languages — C*

ISO/IEC 10206:1991, *Information technology — Programming languages — Extended Pascal*

ISO/IEC 10646:2020, *Information technology — Universal Multi-Octet Coded Character Set (UCS)*

ISO/IEC 11756:1999, *Information technology — Programming languages — M*

ISO/IEC 14651:2020, *Information technology — International string ordering and comparison — Method for comparing character strings and description of the common template tailorable ordering*

ECMA International. *ECMA-262 — ECMAScript® Language Specification 5.1 Edition* [online]. [Place of publication unknown]: Available at `https://262.ecma-international.org/5.1/-ECMA-262.pdf`

1 In this document, ECMAScript Language Specification 5.1 Edition is referenced for the purpose of defining the lexical elements of the SQL/JSON path language specified in Subclause 9.45, "SQL/JSON path language: lexical elements", and Subclause 9.46, "SQL/JSON path language: syntax and semantics". There are no intentions to update this reference to a newer edition of ECMA-262.

© ISO/IEC 2023 – All rights reserved