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Partie 3: Spatial

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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. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

ISO/IEC 13249-3 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 32, *Data management and interchange*.

This fifth edition cancels and replaces the fourth edition (ISO/IEC 13249—3:2011), which has been technically revised.

ISO/IEC 13249 consists of the following parts, under the general title *Information technology — Database languages — SQL multimedia and application packages*:

— *Part 1: Framework*

— *Part 2: Full-Text*

— *Part 3: Spatial*

— *Part 5: Still Image*

— *Part 6: Data Mining*

— *Part 7: History*

Annexes A to E and the Bibliography of this part of ISO/IEC 13249 are for information only.

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Introduction

ISO/IEC 13249 defines multimedia and application-specific types and their associated routines using the features for the creation of user-defined types specified in ISO/IEC 9075, “Information technology - Database languages – SQL”.

The organization of this part of ISO/IEC 13249 is as follows:

Clause 1, "Scope", specifies the scope of this part of ISO/IEC 13249.

Clause 2, "Normative references", identifies additional standards that, through reference in this part of ISO/IEC 13249, constitute provisions of this part of ISO/IEC 13249.

Clause 3, "Terms and definitions, notations, and conventions", defines the notations and conventions used in this part of ISO/IEC 13249.

Clause 4, "Concepts", presents concepts used in the definition of this part of ISO/IEC 13249.

Clause 5, "Geometry Types", defines the geometry supertype.

Clause 6, "Point Types", defines primitive 0-dimensional geometry types.

Clause 7, "Curve Types", defines primitive 1-dimensional geometry types.

Clause 8, "Surface Types", defines primitive 2-dimensional geometry types.

Clause 9, "Solid Types", defines primitive 3-dimensional geometry types.

Clause 10, "Geometry Collection Types", defines the geometry collection types.

Clause 11, "Topology-Geometry", defines node, edge, and face topology-geometry primitives.

Clause 12, "Topology-Network", defines node and link topology-network primitives.

Clause 13, "General Routines", defines the routines to determine shortest path in directed or undirected graphs.

Clause 14, "Spatial Reference System Type", defines the user-defined type to manage spatial reference systems.

Clause 15, "Linear Referencing Types", defines user-defined types to manage linear referencing.

Clause 16, "Angle and Direction Types", defines the angles and direction types.

Clause 17, "Support Types", defines supporting types and routines used by this part of ISO/IEC 13249.

Clause 18, "Support Routines", defines supporting functions and procedures used by this part of ISO/IEC 13249.

Clause 19, "SQL/MM Spatial Information Schema" defines the SQL/MM Spatial Information Schema.

Clause 20, "SQL/MM Spatial Definition Schema" defines the SQL/MM Spatial Definition Schema.

Clause 21, "SQL/MM Linear Referencing Information and Definition Schemas" defines the SQL/MM Linear Referencing Information and Definition Schemas.

Clause 22, "Status Codes", defines the SQLSTATE codes used in this part of ISO/IEC 13249.

Clause 23, "Conformance", defines the criteria for conformance to this part of ISO/IEC 13249.

Annex A, "Implementation-defined elements", is an informative Annex. It lists those features for which the body of this part of ISO/IEC 13249 states that the syntax or meaning or effect on the database is partly or wholly implementation-defined, and describes the defining information that an implementer shall provide in each case.

Annex B, "Implementation-dependent elements", is an informative Annex. It lists those features for which the body of this part of ISO/IEC 13249 states explicitly that the meaning or effect on the database is implementation-dependent.

Annex C, "Deprecated features", is an informative Annex. It lists features that the responsible Technical Committee intend will not appear in a future revised version of this part of ISO/IEC 13249.

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Annex D, "Incompatibilities with ISO/IEC 13249-3:2006", is an informative Annex. It lists incompatibilities with the previous version of this part of ISO/IEC 13249-3.

Annex E, "Geometry Type Hierarchy", is an informative Annex. It visually describes the inheritance relationship between user-defined types in this part of ISO/IEC 13249.

Bibliography is the last informative Annex. It is a list of selective reading relating to this part of ISO/IEC 13249.

In the text of this part of ISO/IEC 13249, in Clause 5, "Geometry Types", through Clause 20, "SQL/MM Spatial Definition Schema", subclauses begin on a new page. Any resulting blank space is not significant.

The spatial user-defined types defined in this part adhere to the following:

— A spatial user-defined type is generic to spatial data handling. It addresses the need to store, manage and retrieve information based on aspects of spatial data such as geometry, location, and topology.

— A spatial user-defined type does not redefine the database language SQL directly or in combination with another spatial data type.

Implementations of this part of ISO/IEC 13249 may exist in environments that also support geographic information, decision support, data mining, and data warehousing systems.

Application areas addressed by implementations of this part of ISO/IEC 13249 include, but are not restricted to, automated mapping, desktop mapping, facilities management, geoengineering, graphics, linear referencing, location based services, multimedia, and resource management applications.

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Information technology — Database languages — SQL multimedia and application packages —

Part 3: Spatial

1 Scope

This part of ISO/IEC 13249:

a) defines concepts specific to this part of ISO/IEC 13249,

b) defines spatial user-defined types and their associated routines.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

ISO/IEC 9075-2, Information technology — Database languages — SQL — Part 1: Foundation (SQL/Foundation).

ISO/IEC 13249-1, Information technology — Database languages — SQL multimedia and application packages — Part 1: Framework.

ISO 19107, Geographic information — Spatial schema.

ISO 19111, Geographic information — Spatial referencing by coordinates.

ISO 19136, Geographic information — Geography Markup Language.

ISO 19136-2, Geographic information — Geography Markup Language - Extended schemas and encoding rules.

ISO 19148, Geographic information — Linear referencing

IEC 559:1989, Binary floating-point arithmetic for microprocessor systems.

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3 Terms and definitions, notations, and conventions

3.1 Terms and definitions

3.1.1 Terms and definitions provided in Part 1

For the purposes of this part of ISO/IEC 13249, the terms and definitions given in ISO/IEC 13249-1 apply.

3.1.2 Terms and definitions provided in Part 3

For the purposes of this part of ISO/IEC 13249, the following terms and definitions apply.

3.1.2.1
0-dimensional geometry
a geometry with a geometric dimension of 0 (zero)

3.1.2.2
1-dimensional geometry
a geometry with a geometric dimension of 1 (one)

3.1.2.3
2-dimensional geometry
a geometry with a geometric dimension of 2

3.1.2.4
3-dimensional geometry
a geometry with a geometric dimension of 3

3.1.2.5
angle
a measure of the inclination of two surfaces, or of two coplanar lines, with respect to each other

Note 1 to entry: The angle may be measured by the arc of a circle intercepted between the two lines forming the angle, the center of the circle being the point of intersection). The value of an angle can be expressed in degrees, in degrees, minutes, and seconds, in radians, or in gradians.

3.1.2.6
azimuth
the angle, measured clockwise, between a given direction and a reference direction

Note 1 to entry: The reference direction is usually true north (North Azimuth) or true south (South Azimuth), and the angle is positive and less than 360 degrees or the equivalent in other angle measures.

3.1.2.7
bearing
a representation of a geographic heading that is given by a rotation measured from True North or True South towards East or West

Note 1 to entry: A bearing is specified with three parts: the prefix is either 'N' or 'S' for North or South; an angle in the range of 0 (zero) to 90 degrees, 0 to π/2 radians, or 0 to 100 gradians; and a suffix of 'E' or 'W' for East or West. For example, a direction of Northeast is defined as the bearing N 45 E, where 45 is in degrees. A bearing of S 30 E is 30 degrees measured counterclockwise from due South and is equivalent to a North azimuth of 150 degrees.

3.1.2.8
boundary of a curve
if the curve is closed, then the empty set; otherwise the set consisting of the end points of the curve

3.1.2.9
boundary of a point
the empty set

3.1.2.10
boundary of a solid
the set of surfaces that delineate the edge of the solid, including interior and exterior shells

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3.1.2.11
boundary of a surface
the set of curves that delineate the edge of the surface, including interior and exterior rings

3.1.2.12
break void
void whose b*P03*-oundary elevations take precedence over existing surface elevations

3.1.2.13
breakline
discontinuity in the slope of a TIN surface

Note 1 to entry: When inserting a breakline into a surface, the elevations along the breakline take precedence over the original elevations on the surface.

3.1.2.14
closed curve
a curve such that its start point is equal to its end point

3.1.2.15
closed surface
a surface that is isomorphic to the surface of a sphere, or some torus

3.1.2.16
closure
a topological function to cause an open point-set to include its boundary making the point-set topologically closed

3.1.2.17
control contour
breakline having a constant elevation throughout its length

3.1.2.18
control point
position used in the construction of a geometry that partially controls its shape but does not necessarily lie on the geometry

Note 1 to entry: A center of an arc is a control point; poles in b-spline curves are control points.

3.1.2.19
data point
position used in the construction of a geometry that lies on the geometry

Note 1 to entry: The vertices in a line string are data points, the points used to construct a polynomial spline are data points. Data points can be used as control points, but are often derived after the geometry is constructed.

3.1.2.20
degree
a unit of measurement for angles such that there are 360 degrees in a circle

3.1.2.21
degrees, minutes, and seconds representation
a system of measurement for angles in which fractions of a degree can be expressed in terms of minutes and seconds

EXAMPLE *180 00 00.0 for an angle of π radians*

Note 1 to entry: For angles less than zero, only the degrees part is negative, however the positive minutes and seconds values are interpreted as increasing the negative-ness of the angle. An angle of –180 30 00.0 shall be interpreted to mean –(180 30 00.0).

3.1.2.22
dimension
geometric dimension

3.1.2.23
direction
the heading from one place to another

Note 1 to entry: The heading is usually given as an azimuth, but may be given as a bearing

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3.1.2.24
distance between two geometries
the minimum of the distances between all pairs of points composed of one point from each of the two geometries

let g_1 and g_2 be two geometries,
dist(g_1, g_2) = Min ({ distance between p and q | $p \in g_1 \wedge q \in g_2$ })

3.1.2.25
distance between two points
the minimum of the lengths of all curves connecting two points

3.1.2.26
drape void
void whose boundary elevations are ignored

Note 1 to entry: When inserting a drape void into a surface, the elevation of the surface takes precedence over any elevations which may have been included in the drape void boundary.

3.1.2.27
geometry
the shape and geographic location of a feature

3.1.2.28
GML
Geography Markup Language as defined in ISO 19136

3.1.2.29
GML representation
an XML element that is valid against an XML element definition in the Geometry Schemas as defined in ISO 19136

3.1.2.30
gradian
a unit of measurement for angles such that there are 400 gradians in a circle

3.1.2.31
heading
a geographic direction that is measured as a rotation from some reference direction

3.1.2.32
heal
topological operation which amalgamates two edges (or links) into one by deleting their common node or which amalgamates two faces into one by deleting their common edge

Note 1 to entry: Heal is the reverse operation of split. When healing two successive edges (or links), the connecting node is deleted and a single edge (or link) replaces the original two. When healing two adjacent faces, their common edge is deleted and a single face replaces the original two.

3.1.2.33
intersection
(of two geometries) the set of points that are common to both geometries

3.1.2.34
isolated edge
an edge which is not part of the boundary of any face and is not connected to any other edge

3.1.2.35
isolated link
a link which is not connected to any other link

3.1.2.36
linear ring
a linestring that is closed and simple

3.1.2.37
linestring
a curve with linear interpolation between control points

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3.1.2.38
link
one-dimensional topological primitive that represents a relationship between two nodes

3.1.2.39
logical network
a network which contains connectivity information but no geometric information

3.1.2.40
minute
a unit of measurement for angles such that there are 60 minutes in a degree

3.1.2.41
mod 2 union rule
operation on a multiset producing a resultant set consisting only of those elements occurring an odd number of times in the original multiset

Note 1 to entry: For example, by applying the mod 2 union rule to the multiset: A = { 10, 20, 20, 30, 30, 30, 40, 40, 40, 40 }, the result is the set: R = { 10, 30 }. In this example, R contains element 10 and 30 because these elements occur an odd number of times in A. Element 20 and 40 are not in R because they occur an even number of times in A.

3.1.2.42
network
set of nodes and links

3.1.2.43
non-closed curve
a curve such that its start point is not equal to its end point

3.1.2.44
non-universal face
any face other than the universal face

3.1.2.45
North azimuth
an azimuthal heading whose rotation is measured clockwise from True North

3.1.2.46
patch
planar component of a polyhedral surface

3.1.2.47
planar graph
graph that can be drawn in a plane without any of its edges crossing

3.1.2.48
point set
the representation of a geometry as a finite set or infinite set of points

Note 1 to entry: Mathematical set intersection (∩), set union (∪) and set difference (—) operations work on point sets.

3.1.2.49
polygon
a surface that is defined using linear rings to define its boundary

3.1.2.50
radian
a unit of measurement for angles such that there are 2pi radians in a circle

3.1.2.51
random point
point of known elevation from which a TIN surface can be generated

3.1.2.52
(regular) void
area within a TIN surface which signifies that the triangles within (or originally within) this area are voided

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Note 1 to entry: When inserting a (regular) void into a surface, the vertices of the void boundary are added to the other points in the surface and re-triangulation (perhaps only local to the boundary) occurs.

3.1.2.53
ring
a curve that is closed and simple

3.1.2.54
rotation
an angle with a specific sense, which may be either clockwise or counterclockwise

3.1.2.55
second
a unit of measurement for angles such that there are 60 seconds in a minute

3.1.2.56
slope
<line segment> ratio of (a) the absolute difference in z coordinate values of the two end points to (b) the distance between them, ignoring their z coordinates

3.1.2.57
slope
<triangle> maximal slope of any line segment in a triangle

3.1.2.58
soft break
surface discontinuity which behaves as a breakline except that contour lines may be smoothed where they cross a soft break

3.1.2.59
South azimuth
an azimuthal heading whose rotation is measured clockwise from True South

3.1.2.60
spatial network
a network which contains both connectivity and geometric information

3.1.2.61
spatially 2D equals
a 2D test for equivalence between geometry values

Note 1 to entry: Ignoring z and m coordinate values, if the point sets of two geometry values are equal, then the geometries are spatially 2D equal.

3.1.2.62
spatially 3D equals
a 3D test for equivalence between geometry values

Note 1 to entry: Considering their z (but not m) coordinate values, if the point sets of two geometry values are equal, then the geometries are spatially 3D equal.

3.1.2.63
split
topological operation which creates two edges (or links) from one by inserting a node or which creates two faces from one by inserting an edge.

Note 1 to entry: Split is the reverse operation of heal.

3.1.2.64
stop line
indicator of places where the contour lines of a TIN surface are irregular or not continuous

EXAMPLE *the slope from the top to the bottom of a cliff*

3.1.2.65
TIN
Triangular Irregular Network as defined in ISO 19107

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3.1.2.66
topologically closed
a characteristic of a geometry type that every value includes its own boundary

3.1.2.67
topology-geometry
a model assuming full planar topology, comprised of nodes, edges, and faces

3.1.2.68
topology-network
a model for linear applications including node and link topological primitives

3.1.2.69
True North
a geographic reference direction towards the Earth's geographic North pole

3.1.2.70
True South
a geographic reference direction towards the Earth's geographic South pole

3.1.2.71
unit of measure
defined quantity in which dimensioned parameters are expressed

3.1.2.72
universal face
a face containing everything else in a topology-geometry that is exterior to all other faces in that topology-geometry

3.1.2.73
voided area
within a TIN surface, a collection of contiguous triangles that remain in the surface but are designated as being void

Note 1 to entry: a voided area is bounded by a break void, drape void, or void.

3.1.2.74
XML element
an element as defined by ISO 19136

3.1.3 Terms and definitions taken from ISO 19107

For the purposes of this part of ISO/IEC 13249, the following terms defined in ISO 19107 apply.

a) boundary
b) buffer
c) computational topology
d) connected
e) connected node
f) convex hull of a geometric object
g) coordinate
h) coordinate dimension
i) coordinate reference system
j) coordinate system
k) curve
l) cycle
m) direct position
n) directed edge

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o) directed face
p) directed topological object
q) edge
r) end node
s) end point
t) exterior
u) face
v) geometric complex
w) geometric dimension
x) geometric object
y) geometric primitive
z) homomorphism
aa) interior
ab) isolated node
ac) isomorphism
ad) node
ae) point
af) shell
ag) solid
ah) start node
ai) start point
aj) surface
ak) topological complex
al) topological object
am) topological primitive

3.1.4 Terms and definitions taken from ISO 19111

For the purposes of this part of ISO/IEC 13249, the following terms defined in ISO 19111 apply.

a) datum
b) ellipsoid
c) flattening
d) geodetic coordinate system, ellipsoidal coordinate system
e) height
f) meridian
g) prime meridian, zero meridian
h) projected coordinate system
i) semi-major axis
j) semi-minor axis

3.1.5 Terms and definitions taken from ISO 19148

For the purposes of this document, the following terms defined in ISO 19148 apply.

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a) attribute event
b) attributed feature
c) feature
d) feature event
e) linear element
f) linear referencing
g) Linear Referencing Method
h) Linear Referencing System
i) linear segment
j) linearly located
k) linearly located event
l) linearly referenced location
m) located feature
n) locating feature
o) spatial position

3.2 Notations

3.2.1 Notations provided in Part 1

For the purposes of this part of ISO/IEC 13249, the notations given in ISO/IEC 13249-1 apply.

3.2.2 Notations provided in Part 3

This part of ISO/IEC 13249 uses the prefix 'ST_' for user-defined type, attribute, SQL-invoked routine table and view names.

This part of ISO/IEC 13249 uses the prefix 'ST_Private' for names of certain attributes. The use of 'ST_Private' indicates that the attribute is not for public use.

The real number mathematical constant that represents the circumference of a circle with unit diameter is notated as “π”. This number is transcendental and cannot be represented exactly in any algebraic form, so the precision is implementation-defined.

This part of ISO/IEC 13249 uses the symbols in Table 1 — Symbols.

Table 1 — Symbols

Symbols	Meaning
∅	empty set
∩	Intersection
∪	union
—	difference
∈	is a member of
∉	is not a member of
⊂	is a proper subset of
⊆	is a subset of
⇔	if and only if
⇒	implies
∀	for all
{ *x* | ... }	set of all *x* such that ...
∧	and
∨	or
¬	not

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3.3 Conventions

For the purposes of this part of ISO/IEC 13249, the conventions given in ISO/IEC 13249-1 apply.

3.4 Extended BNF notation for WKT and WKB

For defining Well-Known Text and Well-Known Binary strings, the conventions given in ISO/IEC 9075-1, Subclause 6.2 “Notation provided in this International Standard” shall apply. The following Clauses in this standard define well-known text:

geometry: 5.1.67 “<well-known text representation>”

spatial reference system: 14.1.9 “<spatial reference system>”

linear referencing: 15.14 “Linear Referencing Well-Known Text”

angle: 16.1.21 “<angle text representation>”

direction: 16.2.23 “<direction text representation>”

vector: 17.2.22 “<well-known text representation>”

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