

INTERNATIONAL HYDROGRAPHIC ORGANIZATION



MARINE RADIO SERVICES PRODUCT SPECIFICATION

IHO Publication S-123

Appendix E Data Validation Checks

Edition 1.0.0 – January 2019

Published by the
International Hydrographic Organization
4b quai Antoine 1^{er}
Principauté de Monaco
Tel: (377) 93.10.81.00
Fax: (377) 93.10.81.40
E-mail: info@iho.int
Web: www.iho.int

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1. References

IHO S-58 ENC VALIDATION CHECKS Edition 6.0.0 – 2016

2. Abbreviation

PS – Product Specification

DCEG – Data Capture and Encoding Guide

3. Production validation checks for S-123 Radio Services

The following checks are intended for production systems designed to produce S-123 Radio Services datasets. The checks can be administered at any time during the production phase. All checks should be considered as warnings, even though more severe classifications are available, due to the status of the development and lack of experience with system use of S-123 datasets, it is considered premature to classify any checks as error or critical error at this time. All operators and spatial expressions are defined in Annex A.

3.1 Check Classification

C	Critical Error	An error which would make a MRS dataset unusable in ECDIS through not loading or causing an ECDIS to crash or presenting data which is unsafe for navigation.
E	Error	An error which may degrade the quality of the MRS dataset through appearance or usability but which will not pose a significant danger when used to support navigation.
W	Warning	An error which may be duplication or an inconsistency which will not noticeably degrade the usability of an MRS dataset in ECDIS.

3.1.1 Check application

B	Base	Apply check to new dataset, new edition, and post-update dataset (after updates have been applied to the base).
U	Update	Apply check to update datasets in isolation.
S	Post-update	Apply check only to a post-update dataset, i.e., subsequent to application of all available updates.

Checks do not apply to dataset terminations or cancellations, except where the check description explicitly states it applies in case of a termination or cancellation.

3.2 Checks relating to MRS Product Specification

No	Check description	Check message	Check solution	Conformity to:	Apply to
100	For each feature object where its geometry is not COVERED_BY a DataCoverage	Objects fall outside the coverage object.	Ensure objects are not outside of the limits of the cell.	PS 10.9	B, S
101	If the cell file size is greater than 20 Megabytes.	The cell is larger than 20Mb in size.	Ensure that the cell is not larger than 20Mb.	PS 11.2	B, S?
102	For each feature record where the name is not unique WITHIN the dataset.	Duplicate FOIDS exist within the dataset.	Ensure that no duplicate FOIDS exist.	PS 10.8	B, U, S

103	If either QualityOfNonbathymetricData or DataCoverage meta objects do not exist within the data set.	Mandatory feature objects are missing.	Include mandatory meta feature objects QualityOfNonbathymetricData or DataCoverage	PS 10.9 and 10.11	B, S
104	If any mandatory attributes are not Present.	Mandatory attributes are not encoded	Populate mandatory attributes (If unknown encode attribute with empty value).	PS 10.5	B, U
105	For each feature object with an attribute of type Float or Integer where the value contains zeroes before the first numerical digit or after the last numerical digit.	Values have been padded with non-significant zeroes. E.g. : For a signal frequency of 156.8 MHZ, the value of SIGPER must be 156800000 and not 0156800000	Remove non-significant zeroes.	PS 10.3	B, U
106	For each feature object with an attribute value identical to a corresponding attribute of a meta object it is COVERED_BY.	An attribute value of a meta object is duplicated on a geo object.	Remove duplicate value from geo object.	Logical consistency	B, S
107	For each association between features instances, features instances and information instances, and between information instances that is not defined in the feature catalogue	Wrong association used	Use correct association type	Logical consistency	B, U
108	For each role name on associations that is not defined in the feature catalogue	Wrong role used	Use correct role name	Logical consistency	B, U
109	For each association that is not defined in the feature catalogue.	Unknown association is used.	Use association that is defined in the feature catalogue.	Logical consistency	B, U
110	For each role name that is not defined in the feature catalogue.	Unknown role name is used.	Use role name that is defined in the feature catalogue.	Logical consistency	B, U
111	For each association ensure associated classes are only those permitted by the feature catalogue.	Class is associated in an illegal association.	Ensure correct association is used between classes.	Logical consistency	B, U, S
112	For each role name ensure it is only used with permitted associations.	Role name is used on an illegal association.	Ensure correct role names are used on the association.	Logical consistency	B, U, S
113	Ensure dataset conformance to the GML schema	Dataset does not conform to the GML schema	Ensure conformance to the GML schema	PS 10.1.1 & 11.1	B, U
114	Ensure all text fields are encoded using UTF-8	Illegal character set used.	Change character encoding to UTF-8	PS 10.4	B, U
115	For each feature instance where more than one featureName is present, and the name subattribute of two or more featureName instances is equal.	Values name sub attribute are identical.	Ensure that name subattributes are populated with the correct values.	Logical consistency	B, U
116	For each feature instance where textContent attribute is present, and two or more information subAttributes are present, and the text subattributes are equal	Values for text sub attribute are identical.	Ensure that text subattributes are populated with the correct values.	Logical consistency	B, U

117	For each feature instance where textContent attribute is present, and two or more information subAttributes are present, and the combination of fileReference and fileLocator subattributes are equal	Values for file reference and locator combinations are identical.	Ensure that national language attributes are populated with the correct values.	Logical consistency	B, U
118	For each featureName subattribute with language not equal to Eng, and where featureName subattributes with language equal to Eng is not present.	Name is encoded in national language only.	Populate text attribute with English text.	Logical consistency	B, U
119	For each information subattribute with language not equal to Eng, and where information subattribute with language equal to Eng is not present.	Text is encoded in national language only	Populate name attribute with English text.	Logical consistency	B, U
120	If the horizontalDatum reference and value attributes of DataSetDiscoveryMetadata are Not equal to EPSG:4326 (WGS 84).	horizontalDatum reference and value are not EPSG 4326	Set the horizontalDatum reference and value attributes to EPSG 4326	PS 8.1.1, 8.1.2 and 14.2	B, U
121	If the file names in an exchange set are not in accordance with the Product Specification.	File names are not in accordance with the Product Specification.	Amend file names.	PS 11.4, 11.5 and 11.6	B, U
122	For each feature instance that does not OVERLAP OR is WITHIN an area of dataCoverage	Object outside area of coverage.	Remove object or amend coverage.	PS 10.9 DCEG 2.6.3	B, S
123	For each feature instance, which does not have a valid feature class label/code as defined by the feature catalogue.	Object has invalid feature class code.	Amend object class code.	Logical consistency	B, U
124	For each attribute, which does not have a valid attribute label/code as defined by the feature catalogue.	Attribute has invalid attribute label/code.	Amend attribute label/code.	Logical consistency	B, U
125	For each feature object, which contains attributes outside the list of permissible attributes for the feature class (as defined in the feature catalogue).	Attribute not permitted on feature class.	Remove attribute.	Logical consistency	B, U
126	For each feature instance which is not COVERED_BY the combined coverage of QualityOfNonbathymetricData meta feature instance.	Feature instance not covered by an QualityOfNonbathymetricData instance.	Ensure full coverage of QualityOfNonbathymetricData instance	PS 10.11	B, S
127	If the order of the data in a dataset is not correct.	Incorrect data order.	Amend data order.	PS 10.7.1	B, U
128	For each attribute instance where the total number of instances exceed the permitted number of instances	Too many instances of attribute.	Ensure correct attribute encoding.	Logical consistency	B, U

129	For each feature instance where periodicDateRange subattributes dateEnd and dateStart are notNull AND their values are identical.	Object has identical values of periodicDateRange subattributes dateEnd and dateStart.	Ensure values of periodicDateRange subattributes dateEnd and dateStart are logical.	Logical consistency	B, U
130	For each feature instance where periodicDateRange subattribute dateStart is notNull AND dateEnd is Null OR not Present.	Object has dateStart without a value of dateEnd.	Populate dateEnd or remove dateStart .	Logical consistency	B, U
131	For each feature instance where periodicDateRange subattribute is notNull AND dateStart is Null OR not Present.	Object has dateEnd without a value of dateStart.	Populate dateStart or remove dateEnd.	Logical consistency	B, U
132	For each linear geometry, which contains vertices at a density Greater than 0.3mm at 1:10000.	Vertex density exceeds the allowable tolerance.	Generalise edge(s).	PS 6.1	B, U
133	For each instance of ServiceHours where an instance of scheduleByDoW attribute has temporal overlaps specified by tmIntervalByDoW attribute.	Time intervals within the same scheduleByDoW attribute overlap	Review time intervals and remove time overlap.	Logical consistency	B, U
134	For each instance of ServiceHours has more than one instance of scheduleByDoW, and where an instance of scheduleByDoW has a temporal overlap with another instance of scheduleByDoW.	Schedule overlaps	Review service hour intervals and remove time overlap.	Logical consistency	B, U
135	For each instance of a file referenced in the data, and it is not present in the exchange set	File referenced in the dataset is not present in the exchange set	Add file to exchange set or remove reference to file.	PS 11.4	B, S
136	For each instance of a dataset, present in the exchange set and that does not have dataset discovery metadata.	Dataset discovery metadata is missing for dataset	Add dataset discovery metadata	PS 14.2, 14.3	B, U
137	For each instance of a support file, present in the exchange set and that does not have support file discovery metadata.	Support file discovery metadata is missing for support file.	Support file discovery metadata	PS 14.3	B, U
138	For each file referenced by the catalogue file in the exchange set, and not present in the exchange set	File is missing from exchange set.	Add file to exchange set or remove reference to file.	PS 14.5, 14.6	B, U
139	For each feature instance, which CROSS the 180° meridian.	Data crossing the 180° meridian	Split the dataset along the 180° meridian.	DCEG 2.6.9	B, U
140	For each dataset discovery metadata file that does not correspond to the dataset discovery metadata content table.	Dataset discovery metadata file that does not correspond to the dataset discovery metadata content table.	Ensure correct encoding of the discovery metadata file	PS 14.2, 14.3	B, U

141	For each support file discovery metadata file, does not correspond to the support file discovery metadata content table.	Support file discovery metadata file, does not correspond to the support file discovery metadata content table.	Ensure correct encoding of the support file metadata file	PS 14.4	B, U
142	For each catalogue file discovery metadata file, does not correspond to the catalogue file discovery metadata content table.	Catalogue file discovery metadata file, does not correspond to the catalogue file discovery metadata content table.	Ensure correct encoding of the catalogue metadata file.	PS 14.5	B, U
143	For each fixedDateRange where dateEnd and dateStart are not Null and dateEnd is less than or equal to dateStart.	dateEnd less than dateStart	Amend values of dateEnd or dateStart accordingly.	Logical consistency	B, U
144	For each fixedDateRange where both dateEnd and dateStart are omitted or Null	FixedDateRange not Populated making the attribute meaningless.	Populate at least one of dateEnd or dateStart	Logical consistency	B, U
145	For each fixedDateRange where dateEnd or dateStart is not Null but the year component is not specified.	Year is required in fixedDateRange dates.	Populate year component of dateStart and dateEnd	Logical consistency	B, U
146	For each textContent attribute where both information and onlineResource are missing or null.	TextContent is not Populated with meaningful information.	Populate information or onlineResource.	Logical consistency	B, U
147	For each information attribute where both fileReference and text subattributes are missing or null	Information is not Populated with meaningful information.	Populate fileReference or text attribute.	Logical consistency	B, U
148	For each sourceIndication where the sub-attributes are missing or null	SourceIndication is not populated with meaningful information.	Populate source indication	Logical consistency	B, U
149	For each contactAddress with all sub-attributes either omitted or null	Contact address is not populated with meaningful information.	Populate at least one sub-attribute of contactAddress.	Logical consistency	B, U
150	For each frequencyPair with frequencyShoreStationTransmits or frequencyShoreStationReceives both sub-attributes either omitted or null	Frequency pair frequency attributes are not populated with meaningful information.	Populate at least one of frequencyShoreStation Transmits or frequencyShoreStation Receives	Logical consistency	B, U
151	For each Regulations, Restrictions, Recommendations, NauticalInformation with both graphic and textContent missing or null	Regulations, Restrictions, Recommendations, NauticalInformation not populated	Populate at least one of graphic and textContent	Logical consistency	B, U

152	For each Applicability without at least one of its attributes populated	Applicability is not populated with meaningful information.	Populate at least one attribute of Applicability	Logical consistency	B, U
153	For each NonStandardWorkingDay with all of dateFixed, dateVariable, and information missing or null	NonStandardWorkingDay not populated with meaningful information.	Populate at least one of dateFixed, dateVariable, and information	Logical consistency	B, U
154	For each ContactDetails without at least one non Null attribute	ContactDetails not populated with meaningful information.	Populate at least one attribute of ContactDetails	Logical consistency	B, U
155	For each association where the target is not in the dataset	Associated feature or information type not present.	Correct or remove the association, or add the missing feature or information type.	Logical consistency	B, S
156	For each RadioStation feature where categoryOfRadioStation or subattribute categoryOfMaritimeBroadcast under complex attribute radiocommunications is not encoded.	categoryOfRadioStation or subattribute categoryOfMaritimeBroadcast under complex attribute radiocommunications must be encoded.	Populate at least one of categoryOfRadioStation or subattribute categoryOfMaritimeBroadcast under complex attribute radiocommunications.	PS 6.2.1.3	B, U
158	For each radiocommunications attribute where transmissionContent and categoryOfMarineBroadcast are encoded	transmissionContent can only be encoded when categoryOfMarineBroadcast is not encoded.	Remove transmissionContent or add an additional radiocommunications attribute.	PS 6.2.1.3	B, U
159	For each ContactDetails where radiocommunications attribute is present and communicationChannel or frequencyPair is not present.	communicationChannel or frequencyPair should be encoded in radiocommunications.	Encode communicationChannel or frequencyPair in radiocommunications.	PS 6.2.1.4	B, U
160	For each ContactDetails where a radiocommunication attribute has an attribute populated, other than communicationChannel, categoryOfCommPref, categoryOfRadioMethods, contactInstructions, frequencyPair, timeIntervalsByDoW	Illegal attributes are populated.	Remove illegal attributes.	PS 6.2.1.4	B, U
161	For each IndeterminateZone that overlaps another IndeterminateZone associated to the same RadioServiceAreaAggregate or ForecastAreaAggregate.	IndeterminateZones within the same fuzzy area aggregate cannot overlap.	Resolve overlap.	PS 6.2.1.10	B, U, S
162	For each timesOfTransmission with sub-attributes transmissionTime, minutePastEveryHour, minutePastOddHours, minutePastEvenHours all omitted or null	Complex attribute timesOfTransmission must have at least one time field populated	Populate at least one of transmissionTime, minutePastEveryHour, minutePastOddHours, minutePastEvenHours	PS 6.2.1.3 DCEG 2.4.3	B, U

163	For each RadioServiceArea attribute radiocommunications with communicationChannel, signalFrequency, categoryOfRadioMethods, categoryOfMaritimeBroadcast, selectiveCallNumber, transmissionContent, frequencyPair all omitted or null	RadioServiceArea attribute radiocommunications must have at least one communications attribute populated	Populate at least one of communicationChannel, signalFrequency, categoryOfRadioMethods, categoryOfMaritimeBroadcast, selectiveCallNumber, transmissionContent, frequencyPair	PS 6.2.1.3 DCEG 2.4.3	B, U
164	For each RadioStation attribute radiocommunications with communicationChannel, signalFrequency, categoryOfMaritimeBroadcast, transmissionContent all omitted or null	RadioStation attribute radiocommunications must have at least one communications attribute populated	Populate at least one of communicationChannel, signalFrequency, categoryOfMaritimeBroadcast, transmissionContent	PS 6.2.1.3 DCEG 2.4.3	B, U
165	For each RadioServiceAreaAggregate without exactly one RadioServiceArea and at least one IndeterminateZone associated with it	Fuzzy radio service area must have core feature and indeterminate zones	Associate at least one RadioServiceArea and IndeterminateZone feature to RadioServiceAreaAggregate	PS 6.2.1.10	B, U, S
166	For each ForecastAreaAggregate without exactly one WeatherForecastWarningArea and at least one IndeterminateZone associated with it	Fuzzy forecast area must have core feature and indeterminate zones	Associate at least one WeatherForecastWarningArea and IndeterminateZone feature to ForecastAreaAggregate	PS 6.2.1.10	B, U, S
167	If the update dataset file size is greater than 500KBytes	The update is larger than 500 KB in size.	Ensure that the cell is not larger than 500 KBytes	PS 11.2	U
168	For each update dataset, a base dataset of the same dataset name is not either present on the system, in the same exchange set, or in another exchange set in the collection of exchange sets.	Base dataset not present	Verify that the absence base dataset is not an error.	Logical consistency	U
169	For each update dataset with updateNumber N > 1, the base dataset is present and updates 1 to N-1 are not present on the system, in the exchange set, or in another exchange set on the system.	Preceding updates not present	Obtain and install preceding updates.	Logical consistency	U
170	For each update dataset, without a feature, information type, or support file	Empty update	Add the data or support file or correct the metadata.	Logical consistency	U
171	For each cancellation (termination) of a dataset that does not exist on the system or has already been cancelled	Terminated dataset is not present	Ignore the update	Logical consistency	U
172	For each cancellation (termination) of a dataset where the update exchange set contains a corresponding dataset file	Cancellations cannot contain data objects	Remove the dataset file from the exchange set or correct the metadata	Logical consistency	U

Annex A

1.0 Introduction

1.1 ISO 19125-1:2004 geometry.

This section defines ISO 19125-2004 geometric terms used in this Annex.

1.1.1 Definitions for ISO 19125-1:2004 geometry

Note that these definitions are for the primitives defined by ISO 19125-1:2004 which are single point, single Line and single area geometry objects.

- *Polygon* – A Polygon has a geometric dimension of 2. It consists of a boundary and it's interior, not just a boundary on its own. It is a simple planar surface defined by 1 exterior boundary and 0 or more interior boundaries. The geometry used by an S-57 Area feature is equivalent to a Polygon.
- *Polygon boundary* – A Polygon boundary has a geometric dimension of 1 and is equivalent to the outer and inner rings used by an S-57 Area feature.
- *LineString* – A LineString is a Curve with linear interpolation between Points. A LineString has a geometric dimension of 1. It is composed of one or more segments – each segment is defined by a pair of points. The geometry used by an S-57 Line feature is equivalent to a LineString.
- *Line* - An ISO 19125-1:2004 line is a LineString with exactly 2 points. Note that the geometry used by an S-57 Line feature is equivalent to a LineString, not a line in ISO 19125-1:2004 terms. In this document the term Line refers to an S-57 Line feature or a LineString which can have more than two points.
- *Point* – Points have a geometric dimension of 0. The geometry used by an S-57 Point feature is equivalent to an ISO 19125-1:2004 point.
- *Reciprocal* – inversely related or opposite

The following table matches 19125-1:2004 geometric terms to S-57 terms:

ISO 19125-1:2004	S-57
Polygon	Area feature geometry OR Area
Polygon boundary	outer and inner rings
LineString	Line feature geometry OR Line
Point	Point feature geometry OR Point

1.1.2 Definition of symbols used in ISO 19125-1:2004

I = interior of a geometric object

E = exterior of a geometric object

B = boundary of a geometric object

\cap = the set theoretic intersection

U = the set theoretic union

\wedge = AND

\vee = OR

\neq = not equal

\emptyset = the empty or null set

\mathbf{a} = first geometry, interior and boundary (the topological definition)

\mathbf{b} = second geometry, interior and boundary (the topological definition)

\dim = geometric dimension – 2 for Polygons, 1 for LineStrings and 0 for Points

$\text{Dim}(x)$ returns the maximum dimension (-1, 0, 1, or 2) of the geometric objects in x , with a numeric value of -1 corresponding to $\dim(\emptyset)$.

Note:

- Neither interior nor exterior include the boundary (i.e. I , E and B are mutually exclusive).
- The boundary of a Polygon includes its set of outer and inner rings.
- The boundary of a LineString is its end points except for a closed LineString, which has no boundary; the rest of the LineString is its interior.
- A Point does not have a boundary.

1.2 ISO 19125-1:2004 geometric operator relationships

In ISO 19125-1:2004 (see Reference [1]), the dimensionally extended nine-intersection model (DE-9IM) defines 5 mutually exclusive geometric relationships between two objects (Polygons, LineStrings and/or Points). One and only one relationship will be true for any two given objects (see Reference [2]):

1. WITHIN
2. CROSSES
3. TOUCHES
4. DISJOINT
5. OVERLAPS

There are others that help further define the relationship:

1. CONTAINS
 - the reciprocal of WITHIN
 - Within is the primary operator; however, if \mathbf{a} is not within \mathbf{b} then \mathbf{a} may contain \mathbf{b} so CONTAINS may be the unique relationship between the objects.
2. EQUAL
 - a special case of WITHIN / CONTAINS.
3. INTERSECTS
 - reciprocal of DISJOINT
 - have at least one point in common
4. COVERS and is COVERED_BY
 - reciprocal operators
 - extends CONTAINS and WITHIN respectively
5. COINCIDENT

Note that COVERS, COVERED_BY and COINCIDENT relational operators are not described in the ISO 19125-1:2004 document.

The formulas given in this annex (e.g. $\mathbf{a}.\text{Disjoint}(\mathbf{b}) \Leftrightarrow \mathbf{a} \cap \mathbf{b} = \emptyset$) are the generalized ones given for ISO 19125-1, not the more specific DE-9IM formulas (i.e. DE-9IM predicates). The generalized formulas use topologically closed notation (i.e. geometry includes the interior and boundary unless otherwise stated), whereas the DE-9IM formulas refer to the interior and boundary of geometry separately. Note that different versions of documents describing 19125-1 give different generalized formulas – this annex is using the formulas that are the most consistent with the DE-9IM predicates. If a generalized formula

appears to contradict a DE-9IM predicate as defined in ISO 19125-1:2004, the DE-9IM predicate takes precedence. Software is expected to be consistent with DE-9IM predicates.

1.3 How the relationships apply to S-57 Features

Geometric relationships will be tested on an entire S-57 feature object as a single geometric entity. Note that S-57 Point, Line and Area feature geometry is equivalent in ISO 19125-1:2004 terms to Point, LineString and Polygon geometry respectively.

A Line feature in S-57 may be made up of several individual edges. The geometric relationship operators used with a Line feature will consider the sequence of edges as a single geometry(LineString).

A test on an Area feature will operate on the entire Polygon.

In an S-57 file a Line or Area feature may be split into pieces as a result of a cutting operation from a data source. In that case each feature record in the dataset is treated as a separate LineString or Polygon when testing geometric relationships.

If a test intends to operate only on a feature's specific components – Polygon boundary (all rings), Polygon outer ring, Polygon inner rings, edges, vertexes or nodes then it must make this explicit in the description of the test. When a specific linear portion is specified in a test (Polygon boundary, edge) then it is treated as a LineString while individual vertexes or points will be treated as points.

For example a test to look for cases where object class A OVERLAPS object class B would operate on the entire geometry. While a test to see if boundary of Area object class A OVERLAPS an edge of Line class B will be comparing Area boundaries to edges using Line to Line comparisons.

2.0 Geometric Operator Definitions

The ISO 19125-1 definitions referenced in this section, refer to section 6.1.14.3 entitled “Named spatial relationship predicates based on the DE-9IM” in the ISO 19125-1:2004 document.
(In the diagrams within this annex LineString corresponds to the S-57 Line geometric primitive)

EQUALS – Geometric object **a** is spatially equal to geometric object **b**.

The two geometric objects are the same. This is a special case of WITHIN.



Examples of the EQUALS relationship Note: ISO 19107:2003 describes equality more formally as:

Two different GM_Objects are equal if they return the same Boolean value for the operation `GM_Object::contains` for every tested `DirectPosition` within the valid range of the coordinate reference system associated to the object.

NOTE Since an infinite set of direct positions cannot be tested, the internal implementation of equal must test for equivalence between two, possibly quite different, representations. This test may be limited to the resolution of the coordinate system or the accuracy of the data. Application schemas may define a tolerance that returns true if the two GM_Objects have the same dimension and each direct position in this GM_Object is within a tolerance distance of a direct position in the passed GM_Object and vice versa.

For the purposes of S-58, a GM_Object is any spatial object as described in A.1.1 (Polygons, LineStrings, and Points). A spatial object is always equal to itself, i.e., **a EQUALS a** is always true.

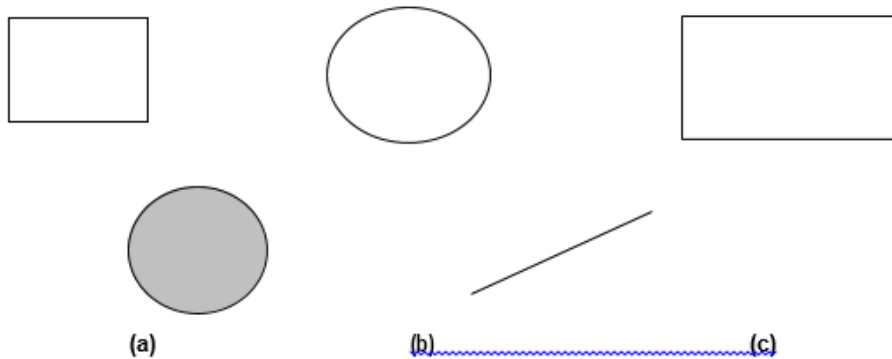
DISJOINT – Geometric object **a** and geometric object **b** do not intersect.

The two geometric objects have no common points.

The ISO 19125-1 definition of DISJOINT is:

$$\mathbf{a.Disjoint(b)} \Leftrightarrow \mathbf{a \cap b = \emptyset}$$

This translates to: **a** is disjoint from **b** if the intersection of **a** and **b** is the empty set.



Examples of the DISJOINT relationship

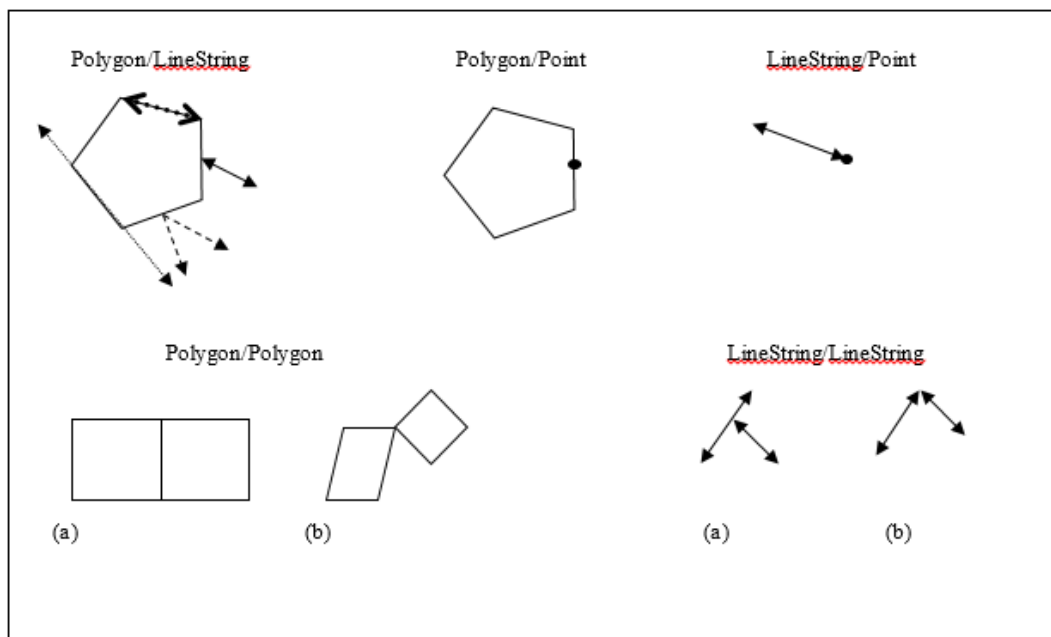
TOUCHES – Geometric object **a** intersects with geometric object **b** but they do not share interior points. Only the boundary of one geometry intersects with the boundary or interior of another geometry. The only thing the geometric objects have in common is contained in the union of their boundaries.

The ISO 19125-1 definition of TOUCHES is:

$$\mathbf{a.Touch(b)} \Leftrightarrow (I(\mathbf{a}) \cap I(\mathbf{b}) = \emptyset) \wedge (\mathbf{a} \cap \mathbf{b}) \neq \emptyset$$

This translates to: **a** touches **b** if the intersection of the interior of **a** and the interior of **b** is the empty set AND the intersection of **a** and **b** is not the empty set.

Note: This operator applies to the Area/Area, Line/Line, Line/Area, Point/Area and Point/Line relationships. It does not apply to a Point/Point relationship since points do not have a boundary.



Examples of the TOUCHES relationship.

Note the Polygon touches Polygon example (a) is also a case where the Polygon boundaries are COINCIDENT. In the Polygon/LineString example two of the LineStrings that share a linear portion of the Polygon boundary are also COINCIDENT with the Polygon boundary.

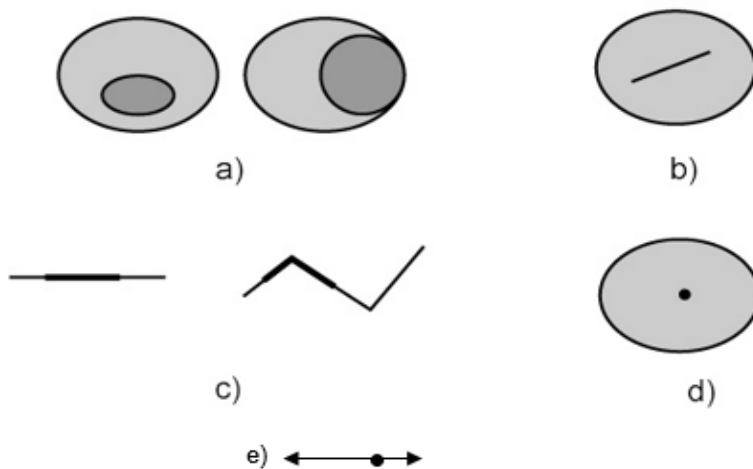
WITHIN — Geometric object **a** is completely contained in geometric object **b**.
WITHIN includes **EQUALS**.

The definition of **WITHIN** is:

$$\mathbf{a}.\text{Within}(\mathbf{b}) \Leftrightarrow (\mathbf{a} \cap \mathbf{b} = \mathbf{a}) \wedge (I(\mathbf{a}) \cap I(\mathbf{b}) \neq \emptyset)$$

This translates to: **a** is within **b** if the intersection of **a** and **b** equals **a** AND the intersection of the interior of **a** and the interior of **b** is not the empty set.

Note that this formula matches the one given in the **OpenGIS Simple Features Specification for SQL, Revision 1.1 (OpenGIS Project Document 99-049, Release Date: May 5, 1999)** which is the precursor to ISO 19125-1.



Examples of the **WITHIN**

relationship — Polygon/Polygon (a), Polygon/LineString (b), LineString/LineString (c), Polygon/Point (d), and LineString/Point (e)

Note that a Line that completely falls on a Polygon boundary is not **WITHIN** the Polygon, it **TOUCHES** it. In that case it would also be **COINCIDENT** with the Polygon boundary and **COVERED_BY** the Polygon.

OVERLAPS - The intersection of two geometric objects with the same dimension results in an object of the same dimension but is different from both of them.

For two Polygons or two LineStrings, part of each geometry, but not all, is shared with the other.

The **OVERLAPS** relationship is defined for Area/Area and Line/Line relationships. Points are either equal or disjoint.

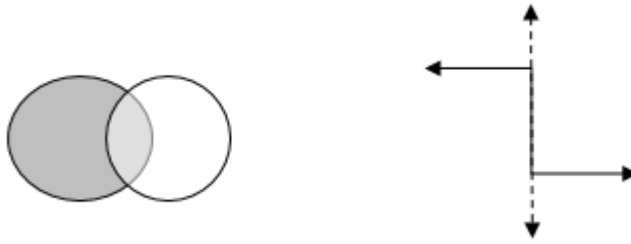
Note that this does not include lines that cross.

The ISO 19125-1 definition of **OVERLAPS** is:

$$\mathbf{a}.\text{Overlaps}(\mathbf{b}) \Leftrightarrow (\dim(I(\mathbf{a})) = \dim(I(\mathbf{b})) = \dim(I(\mathbf{a}) \cap I(\mathbf{b}))) \wedge (\mathbf{a} \cap \mathbf{b} \neq \mathbf{a}) \wedge (\mathbf{a} \cap \mathbf{b} \neq \mathbf{b})$$

This translates to: **a** **OVERLAPS** **b** if the geometric dimension of:

- (1) the interior of **a**
 - (2) the interior of **b**
 - (3) the intersection of the interiors of **a** and **b**
- are all equal AND the intersection of **a** and **b** does not equal either **a** or **b**.



Examples of the OVERLAPS relationship

Note Lines that OVERLAP are also COINCIDENT.

CROSSES – The intersection of geometric object **a** and geometric object **b** returns geometry with a dimension less than the largest dimension between **a** and **b** but is not the same as geometric object **a** or **b**.

Two LineStrings cross each other if they meet on an interior point. A LineString crosses a Polygon if the LineString is partly inside the Polygon and partly outside.

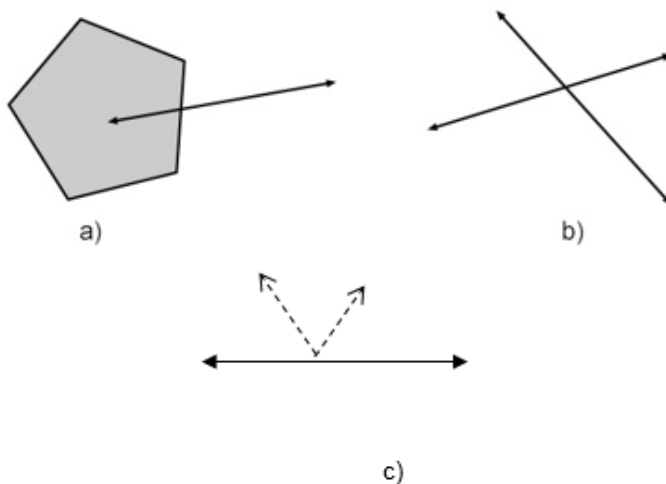
The definition of CROSSES is:

$$\mathbf{a.Cross(b)} \Leftrightarrow (I(\mathbf{a}) \cap I(\mathbf{b}) \neq \emptyset) \wedge (dim(I(\mathbf{a}) \cap I(\mathbf{b})) < \max(dim(I(\mathbf{a})), dim(I(\mathbf{b})))) \wedge (\mathbf{a} \cap \mathbf{b} \neq \mathbf{a}) \wedge (\mathbf{a} \cap \mathbf{b} \neq \mathbf{b})$$

This translates to: **a** crosses **b** if the intersection of the interiors of **a** and **b** is not the empty set AND the dimension of the result of the intersection of the interiors of **a** and **b** is less than the largest dimension between the interiors of **a** and **b** AND the intersection of **a** and **b** does not equal either **a** or **b**.

Note that “ $(I(\mathbf{a}) \cap I(\mathbf{b}) \neq \emptyset) \wedge$ ” was added to the beginning of the ISO 19125-1 formula so that it would not be true for disjoint geometry.

The CROSSES operator only applies Line/Line and Line/Area relationships.



Examples of the CROSSES relationship

Note that example c) shows one solid line and one dashed line – their interiors intersect. If any Line were split into two separate Line features at the intersection point then the relationship would be TOUCHES because a boundary would be involved.

INTERSECTS is the reciprocal of DISJOINT.

The two geometric objects cross, overlap or touch, or one is within (or is contained by) the other. They have at least one common point.

CONTAINS is the reciprocal of **WITHIN**.

Given two geometric objects, **a** and **b**, if **a** is within **b** then **b** must contain **a**.

COVERED_BY (not a standard ISO 19125-1 operator)

No point of geometry **a** is outside geometry **b**.

The definition of **COVERED_BY** is:

$$\mathbf{a. \text{ COVERED_BY } (b) \Leftrightarrow (a \cap b = a)}$$

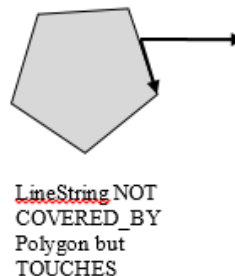
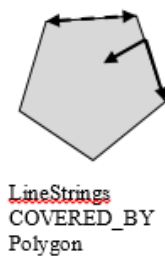
This translates to: **a** is **COVERED_BY** **b** if the intersection of **a** and **b** equals **a**.

The following expressions are equivalent to **a** is **COVERED_BY** **b**:

1. Polygon (**a**) is **COVERED_BY** Polygon (**b**): Polygon **a** is **WITHIN** a polygon **b** (**WITHIN** includes **EQUALS**)
2. Point (**a**) is **COVERED_BY** Polygon (**b**): Point **a** is **WITHIN** or **TOUCHES** polygon **b**
3. Line (**a**) is **COVERED_BY** Polygon (**b**): Line **a** is **WITHIN** polygon **b** or **WITHIN** the boundary of Polygon **b**
4. Line (**a**) is **COVERED_BY** Line (**b**): Line **a** is **WITHIN** Line **b** (**WITHIN** includes **EQUALS**)
5. Point (**a**) is **COVERED_BY** Line (**b**): Point **a** is **WITHIN** or **TOUCHES** Line **b**
6. Point (**a**) is **COVERED_BY** Point (**b**): Point **a** **EQUALS** Point **b**

Note that the figure below on the left is an example of Lines that are **COVERED_BY** a polygon.

The figure on the right is NOT an example of a Line that is covered by a Polygon – it is an example of a Line that **TOUCHES** a Polygon. In both cases the Lines are **COINCIDENT** with the Polygon boundary.



COVERS (not a standard ISO 19125-1 operator)

COVERS is the reciprocal of **COVERED_BY**.

Given two geometric objects, **a** and **b**, if **a** is **COVERED_BY** **b** then **b** must cover **a**.

COINCIDENT (not an ISO 19125-1 operator)

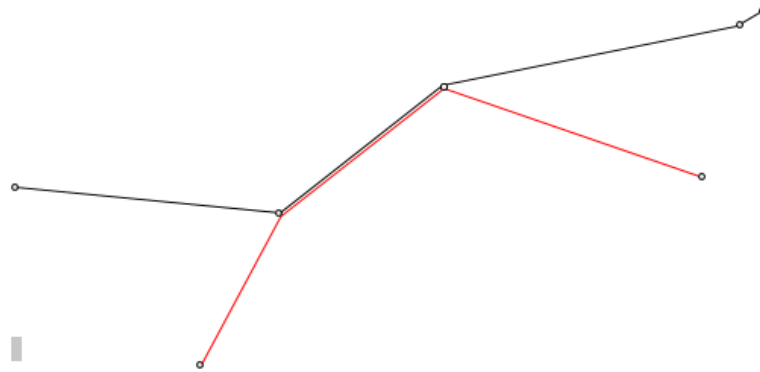
Two geometric Lines **OVERLAP** or one geometric Line is **WITHIN** the other. Note that **EQUAL** Lines are also **COINCIDENT** by this definition.

The intersection of two geometric Lines results in one or more Lines.

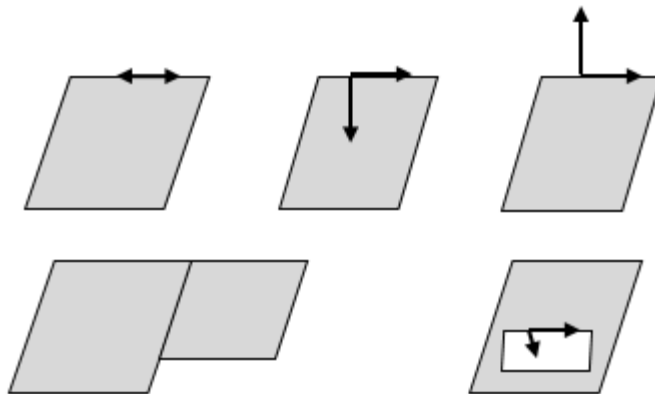
This operator is only to be used to compare a Line with another Line. Note that normally the boundary of a Polygon is not the same as a Line but for this operation the boundary of a Polygon, exterior and interior rings, is treated as Lines for the **COINCIDENT** test.

The following expressions are equivalent to **a** is **COINCIDENT** with **b**:

1. Polygon (**a**) is **COINCIDENT** with Polygon (**b**): The boundary of Polygon **a** **OVERLAPS** or is **WITHIN** the boundary of Polygon **b**.
2. Line (**a**) is **COINCIDENT WITH** Polygon (**b**) : Line **a** **OVERLAPS** or is **WITHIN** the boundary of Polygon **b**.
3. Line (**a**) is **COINCIDENT WITH** Line (**b**): Line **a** **OVERLAPS** or is **WITHIN** Line **b**



The case above is an example of two **COINCIDENT** geometric Lines.



Above are other examples of objects **COINCIDENT** with the boundary of a Polygon. LineStrings following a portion of a Polygon boundary or Polygons sharing a boundaryportion.

*Note that by definition a Line can be **COINCIDENT** with an interior boundary of a Polygon.*

*Note that other relationships may also be true such as **COVERED_BY** or **TOUCHES** since **COINCIDENT** is not mutually exclusive.*

Bibliography

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- [3] ISO 19107:2003, *Geographic information | Spatial schema*
- [4] OpenGIS Simple Features Specification for SQL, Revision 1.1 (*OpenGIS Project Document 99-049, Release Date: May 5, 1999*)