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Industrial automation systems and integration — Integration of life-cycle data for process plants including oil and gas production facilities —

Part 12: Life-cycle integration ontology represented in Web Ontology Language (OWL)

Systèmes d'automatisation industrielle et intégration — Intégration de données de cycle de vie pour les industries de "process", y compris les usines de production de pétrole et de gaz —

Partie 12: Ontologie d'intégration de cycle de vie représentée dans le langage d'ontologie du Web (OWL)

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 ISO documents 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).

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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.

This document was prepared by Technical Committee ISO/TC 184, *Automation systems and integration*, Subcommittee SC 4, *Industrial data*.

A list of all parts in the ISO 15926 series can be found on the ISO website.

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.

Introduction

ISO 15926 is an International Standard for the representation of process industries facility life-cycle information. This representation is specified by a generic, conceptual data model that is suitable as the basis for implementation in a shared database or data warehouse. The data model is designed to be used in conjunction with reference data, i.e. standard instances that represent information common to a number of users, production facilities, or both. The support for a specific life-cycle activity depends on the use of appropriate reference data in conjunction with the data model.

This document specifies an ontology for the integration of industrial data throughout its life-cycle. The ontology implements capabilities defined by the life-cycle integration schema of ISO 15926-2, and is represented in Web Ontology Language (OWL).

This document is complementary to ISO/TS 15926-8, as follows:

— ISO/TS 15926-8 is a direct transposition of ISO 15926-2 into OWL, in which all relationships are reified. ISO/TS 15926-8 is intended an OWL implementation for the template methodology defined in ISO/TS 15926-7.

— This document is an implementation of ISO 15926-2 in OWL in which relationships are object properties, datatype properties or annotation properties. This document defines an ontology that is intended to be used with standard Resource Description Framework (RDF) and OWL tools. The ontology has a partition that is OWL DL and that can support reasoning.

Some of the content of ISO 15926-2 has not been included in this document, as follows:

— shape, which is within the scope of ISO/TS 15926-3;

— approval and status, which are covered by other ontologies and developments within W3C.

Industrial automation systems and integration — Integration of life-cycle data for process plants including oil and gas production facilities —

Part 12: Life-cycle integration ontology represented in Web Ontology Language (OWL)

1 Scope

This document specifies an ontology for the integration of industrial data throughout its life-cycle. The ontology is represented in Web Ontology Language (OWL).

NOTE 1 The ontology implements capabilities of the life-cycle integration schema of ISO 15926-2.

NOTE 2 OWL has a representation in RDF. Therefore, this document provides an ability to query life-cycle integration data using Simple Protocol and RDF Query Language (SPARQL).

The following are within the scope of this document:

— fundamental subclasses of an individual that exists in an actual or possible world, including physical object, activity and event;

— relationships between physical objects, activities and events, including the creation and destruction of physical objects;

— whole-part relationships between physical objects, including temporal part relationships that implement a 4-dimensional (4D) approach to change over time;

— points and periods in time;

— points and regions in space;

— the identification of points in time by text strings in the format defined by ISO 8601.

The following are outside the scope of this document:

— definitions of physical quantities and measurement scales;

— knowledge organization and document metadata specifications;

— approval and status;

— geometry and topology, including shape.

NOTE 3 Geometry and topology are covered by ISO/TS 15926-3.

2 Normative references

There are no normative references in this document.

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1.1
activity
individual (3.1.5) that is something happening or changing

3.1.2
event
individual (3.1.5) that has zero extent in time

3.1.3
ontology
formal statement of an understanding of the world

Note 1 to entry: An ontology can be represented in any language. It need not be represented in a language specifically designed for ontologies, such as OWL. An ontology can have different representations.

Note 2 to entry: An ontology does not specify what data need to be recorded about the world.

Note 3 to entry: The ontology defined by this document is principally concerned with the world outside a computer system.

3.1.4
physical object
individual (3.1.5) that is a distribution of energy, matter or both

3.1.5
individual
thing that exists in space and time

Note 1 to entry: An individual can exist in the actual world or in a possible world that is a prediction, plan or scenario.

3.1.6
punning
assigning the same name to objects that are treated as different in OWL Direct Semantics

3.1.7
temporal part relationship
whole-part relationship (3.1.8) such that the part is all of the whole for a period of time

3.1.8
whole-part relationship
relationship between two *individuals* (3.1.5) such that 4D extent of one is part of the 4D extent of the other

3.2 Abbreviated terms

4D	4-dimensional
FPSO	Floating Production Storage and Offloading
IRI	Internationalized Resource Identifier
lci	Life-Cycle Integration
	NOTE This initialization is used in lower case as the TURTLE prefix for things in the life cycle integration ontology.
NORSOK	Norsk Sokkels Konkuranseposisjon
OWL	Web Ontology Language
PED	Pressurized Equipment Directive
RDF	Resource Description Framework
RDL	Reference Data Library
SPARQL	Simple Protocol and RDF Query Language
TURTLE	Terse RDF Triple Language

3.3 Symbols

This document contains examples with diagrams which show instantiations of ISO 15926. The concise notation is used for these diagrams as defined in Figure 1.

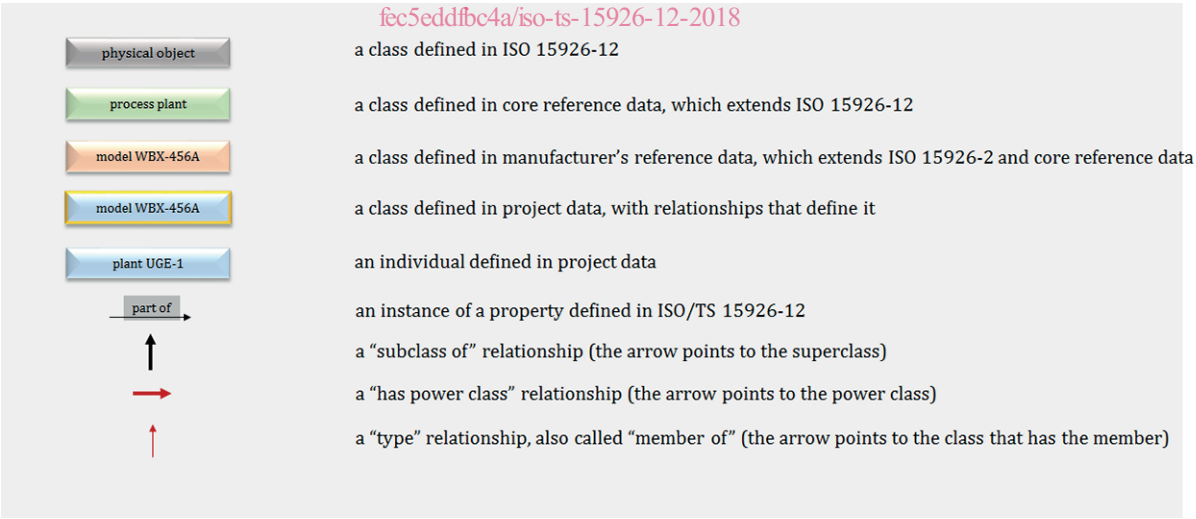

Figure 1 — Notation for the ISO 15926 instantiation examples

3.4 Identification of classes and properties and reference in text

The classes and properties defined by this document have natural language identifiers which are in lower case and which contain spaces where appropriate.

The classes and properties defined by this document have Internationalized Resource Identifiers (IRIs) with suffices derived from their natural language identifiers as follows:

— spaces are removed and encoded by camel-case;

— classes have an initial upper case letter;

— properties have an initial lower case letter.

The normative text of this document refers to a class or property in the following ways:

— if the class or property is defined by this document, then the text has the identifier of the class or property in bold font;

— otherwise, the text has the identifier of the class or property in normal font and in quotes and states the source.

The text of an example in this document has the identifier of an example class or property in normal font and in quotes.

4 Implementation of the life-cycle integration ontology

4.1 Data that conforms to the ontology

Implementation of the life-cycle ontology represented in OWL shall use the representation of the ontology in Annex A. Various examples are presented in Annex D, Annex F and Annex G.

Data that conforms to the life-cycle integration ontology shall consist of members of **thing** and statements that are relationships between them. A **thing** is either:

— **individual**: something that exists in space and time, and that has variation defined in 4D;

— **abstract object**: something that does not exist in space and time.

NOTE 1 An owl:Thing can be something other than an **individual** or **abstract object**. Therefore, **thing** is a subclass of owl:Thing.

NOTE 2 An **abstract object** can be:

— **class of individual**: class that has **individuals** as members;

— **class of class of individual**: class that has **classes of individual** as members;

or a higher order power class of **individual**.

There are very few things that are members of **abstract object** but not members of **class of individual** or **class of class of individual**. Most of these are:

— classes that have a mixture of individuals, classes of individual, and classes of class of individual as members;

  An example is the class that consists of all classes defined by this document.

— relationships that are recorded as **mappings**.

  An example is the **mapping** "identification by UK vehicle registration number", which is shown in Annex D. The **mapping** "identification by UK vehicle registration number" has a **representation space assigned by** relationship with the "UK Driver and Vehicle Licencing Authority". Using OWL punning, the mapping is also an owl:ObjectProperty, an owl:FunctionalProperty and an owl:InverseFunctionalProperty.

A statement of the relationship between **things** shall not be qualified in any way. If a statement is true for a particular **period in time**, then temporal parts of the related **individuals** shall be defined. If a

statement is true for a particular scenario, or "possible world", then **individuals** that exist only within that possible world shall be defined.

4.2 Extensions to the ontology

The life-cycle integration ontology may be extended by creating new classes that are subclasses of **individual**, **abstract object**, **class of individual**, and **class of class of individual**.

NOTE There are likely to be few subclasses of **abstract object** that are not subclasses of **class of individual** or **class of class of individual**, outside the realm of mathematics.

4.3 Choice of OWL version

This document defines an ontology that is represented using the W3C OWL 2 Web Ontology Language. The approach of the OWL implementation is described in Annex B, while a representation of the ontology as diagrams is presented in Annex E. The relationship between the life-cycle integration ontology and the EXPRESS entities in ISO 15926-2 is described in Annex C.

The ontology complies with the Direct Semantics of OWL 2. However, compliance has been achieved by using punning and by implementing relationships between classes as OWL annotation properties. Industrial experience using an OWL Direct Semantics representation that enables efficient support for automated reasoning is described in Annex H. The ontology has been partitioned into:

— a part concerned with individuals and their relationships — this part supports OWL DL reasoners;

— an extension containing subclasses of class and of class of class and their relationships — this part supports the full capability of ISO 15926-2; use of this part results in data that complies with OWL 2 RDF-based semantics.

NOTE An objective of this document is to enable the recording of all engineering data as precisely as possible, and to support direct querying using languages such as SPARQL.

4.4 Punning

ISO 15926-2 makes statements about relationships between classes and classification of classes. These statements are implemented by making the classes **class of individual** and **class of class of individual** subclasses of the OWL class "Thing", instead of the OWL class "Class".

This is an implementation of punning as defined in W3C, OWL 2 Web Ontology Language New Features and Rationale.

4.5 Thing and class

ISO 15926-2 contains the classes **thing** and **class**. These classes are not identical to the classes "Thing" and "Class" in OWL. The differences are as follows:

thing: In ISO 15926-2, the class **thing** is defined as the disjoint union of **individual**, which has a 4D spatio-temporal extent, and **abstract object** which does not have a spatio-temporal extent. All classes in ISO 15926-2 are subclasses of either **individual** or **abstract object**. Members of **thing** are defined with respect to the 4D paradigm or are independent of space and time.

In other ontologies, the OWL class "Thing" has members that are not within the 4D paradigm.

class: In ISO 15926-2, the class **class** has all sets as members. The members of **class** are not necessarily regarded as classes by an OWL implementation. There is also a difference in approach. An ISO 15926 class is the set of members, but an OWL class "Class" is a definition of a class that has an extension. Two members of OWL "Class" are equivalent if they have the same extension. Two members of an ISO 15926 **class** are either the same or different.

5 Time and time duration

5.1 Time duration

The class **time duration** is a measure of how long an individual lasts. It is a subclass of **quantity** and a member of **quantity kind**.

NOTE **Time duration** is important for many practical implementations of ISO 15926. This document extends ISO 15926-2 by including this class within the ontology.

5.2 ISO 8601 identification of point in time

ISO 8601 identification of point in time is a sub-property of **identified by litera**l, where the domain is **point in time** and the range is a text string defined by ISO 8601.

NOTE The representation of a **point in time** according to ISO 8601 is useful for many practical implementations of ISO 15926. This document extends ISO 15926-2 by providing an identification of a **point in time** using a text string defined in ISO 8601.

EXAMPLE The text string "2007-04-05T12:30-02:00" is an ISO 8601 identifier of the **point in time** that is 12:30 in a time zone 2 h ahead of UTC on 2007-04-05.

5.3 ISO 8601 identification of period in time

ISO 8601 identification of period in time is a sub-property of **identified by litera**l, where the domain is **period in time** and the range is a text string defined by ISO 8601.

NOTE The representation of a **period in time** according to ISO 8601 is useful for many practical implementations of ISO 15926. This document extends to capabilities in ISO 15926-2 by providing an identification of a **period in time** using a text string defined in ISO 8601.

EXAMPLE The text string "2007-04-05T12:30-02:00/2007-04-05T13:30-02:00" is an ISO 8601 identifier of the **period in time** that is 12:30 to 13:30 in a time zone 2 h ahead of UTC on 2007-04-05.

5.4 ISO 8601 identification of duration

ISO 8601 identification of duration is a sub-property of **identified by litera**l, where the domain is **point in time** and the range is a text string defined by ISO 8601.

NOTE 1 The representation of a **time duration** according to ISO 8601 is useful for many practical implementations of ISO 15926. This document extends to capabilities in ISO 15926-2 by providing an identification of a **duration** using a text string defined in ISO 8601.

NOTE 2 A time duration can also be represented using members of **scale,** such as second, minute, hour, day, which are defined in ISO/TS 15926-4.

EXAMPLE The text string "P1DT12H" is an ISO 8601 identifier of the **time duration** that is 1 day and 12 h, which is usually 36 h except when daylight saving time begins or ends during the period.

Annex A
(normative)

Ontology for life-cycle integration

A.1 Full ontology

This document defines an ontology for life-cycle integration.

NOTE 1 This ontology is intended for OWL 2 RDF-based semantics.

The following copyright statement applies to the ontology and is included within the representation of the ontology.

The life-cycle integration ontology defined by this document has the IRI:

http://standards.iso.org/iso/ts/15926/-12/ed-1/en/tech/ontology

The version of the ontology that is defined by this edition of this document is represented by the TURTLE files listed in Table A.1. The files can be obtained by dereferencing the IRIs with the prefix:

http://standards.iso.org/iso/ts/15926/-12/ed-1/en/tech/ontology/<file>.ttl

NOTE 2 TURTLE is a W3C recommendation and is much more readable than the XML serialization of RDF.

Table A.1 — Representation of the ontology for life-cycle integration

File	File content
abstract-object-v-1.0	**abstract object**, **mapping** and subclasses of **class of individual** and **class of class of individual**
annotation-lci-v-1.0	Annotation of the ontology using annotation properties defined in this document
annotation-skos-v-1.0	Annotation of the ontology using annotation properties defined in SKOS
arranged-individual-v-1.0	Subclasses of **physical object**
class-of-arranged-individual-v-1.0	Subclasses of **class of physical object**
collector-v-1.0	Collector of all the ontologies except the annotation and the inferred statements
document-v-1.0	Classes relevant to information and documents
individual-v-1.0	Subclasses of **individual**
inferred-domains-and-ranges-v-1.0	Domains, ranges, and inverse statements that could be inferred
inverse-occurrance-relationship-v-1.0	Inverses of relationships between **classes of individual**
inverse-relationship-v-1.0	Inverses of relationships between **individuals**
maths-v-1.0	Simple mathematical classes and relationships
occurrence-relationship-v-1.0	Relationships between **classes of individual**
quantity-v-1.0	Classes and relationships about quantities and properties
relationship-v-1.0	Relationships between **individuals**

The annotation files in the ontology are informative copies of the normative definitions contained in the following HTML file:

http://standards.iso.org/iso/ts/15926/-12/ed-1/en/tech/iso_ts_15926-12_definitions.htm

The import graph for the ontology files is shown in Figure A.1.

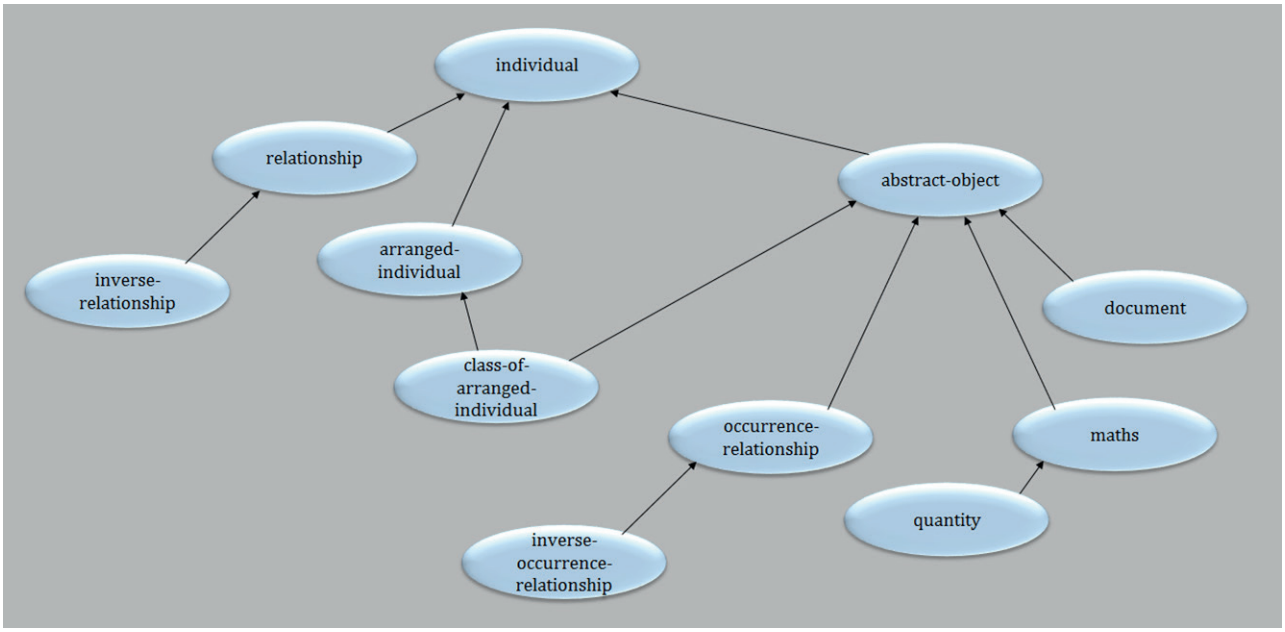

Figure A.1 — Import hierarchy

The annotation and the inferred domains, ranges and inverse statements can be added to the collector as shown in Figure A.2.

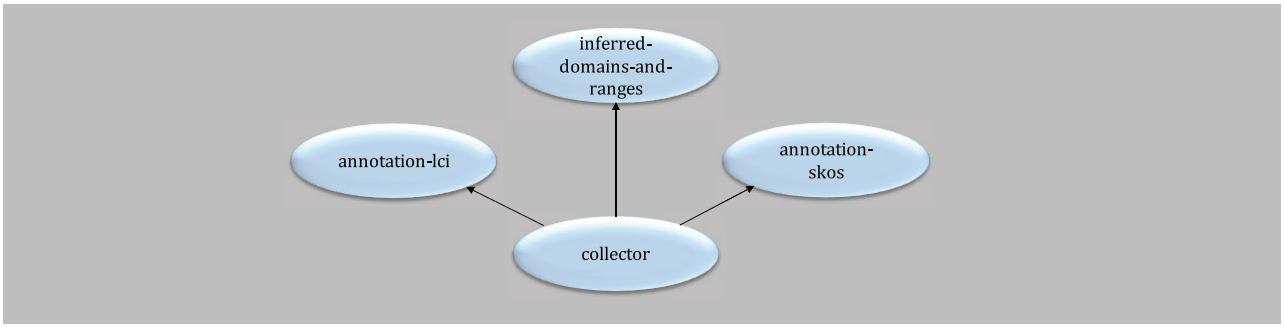

Figure A.2 — Annotation and inferred statements

The annotation in SKOS is provided by the SKOS vocabulary shown in Table A.2.

Table A.2 — SKOS annotation

SKOS term	Definition	Equivalent in this document
prefLabel	The preferred lexical label for a resource, in a given language	**identificationByLiteral**
definition	A statement or formal explanation of the meaning of a concept	**definitionByLiteral**
scopeNote	A note that helps to clarify the meaning and/or the use of a concept	**noteByLiteral**
example	An example of the use of a concept	**descriptionOfExampleByLiteral**

A.2 Individual subset ontology

A subset of the full ontology that is concerned only with individuals and their properties is defined.

NOTE 1 This ontology is intended for OWL 2 direct semantics.

The "individual subset" ontology imports the ontologies "individual", "relationship" and "inverse relationship". The ontology also contains the classes in "abstract object" and "quantity" that are useful for the representation of physical quantities.

http://standards.iso.org/iso/ts/15926/-12/ed-1/en/tech/ontology/individual-subset-v-1.0.ttl

NOTE 2 The ontology is also represented in the OWL Functional Syntax. This representation was used to check the validity of the OWL in the ontologies. This representation is informative. The files can be obtained by dereferencing the IRIs of the form:

http://standards.iso.org/iso/ts/15926/-12/ed-1/en/tech/ontology/individual-subset-v-1.0.ofn

The imported ontologies "individual", "relationship" and "inverse relationship" are also available in the OWL Functional Syntax in the files:

http://standards.iso.org/iso/ts/15926/-12/ed-1/en/tech/<file>.ofn

where the name <file> is as specified in Table A.1.

An informative extract of the normative definitions, which are appropriate for the individual subset, is contained in the file: