BS ISO 15926-2:2003

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

Part 2: Data model

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The UK participation in its preparation was entrusted to Technical Committee AMT/4, Industrial data and manufacturing interfaces.

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© The British Standards Institution 2023
Published by BSI Standards Limited 2023

ISBN 978 0 539 22152 7

ICS 25.040.40; 75.020

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 March 2023.

Amendments/corrigenda issued since publication

Date	Text affected

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INTERNATIONAL STANDARD

ISO 15926-2

First edition
2003-12-15

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

Part 2:
Data model

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 2: Modèle de données

Reference number
ISO 15926-2:2003(E)

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Published in Switzerland

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75% of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 15926-2 was prepared by Technical Committee ISO/TC 184, *Industrial automation systems and integration*, Subcommittee SC 4, *Industrial data*.

This International Standard is organized as a series of parts, each published separately. The structure of this International Standard is described in ISO 15926-1. A complete list of parts of ISO 15926 is available from the Internet:

<http://www.tc184-sc4.org/titles/15926_Titles.rtf>

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Introduction

ISO 15926 is an International Standard for the representation of process plant 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: standard instances that represent information common to a number of users, process plants, or both. The support for a specific life-cycle activity depends on the use of appropriate reference data in conjunction with the data model.

ISO 15926 is organized as a number of parts, each published separately. This part of ISO 15926 specifies a conceptual data model for computer representation of technical information about process plants.

The organization of this part of ISO 15926 is as follows:

— clause 1 specifies the scope and field of application of this part of ISO 15926;

— clause 2 identifies additional standards that, through references in this part of ISO 15926, constitute provisions of this part of ISO 15926;

— clause 3 defines terms used in this part of ISO 15926;

— clause 4 provides an overview of the fundamental concepts and assumptions that form the basis for the data model;

— clause 5 specifies the data model using the EXPRESS language (ISO 10303-11) and contains the EXPRESS-G diagrams that illustrate the structure of the model.

Readers of this part of ISO 15926 require knowledge of the information used by the designers, constructors and operators of process plants; an understanding of conceptual data models and the EPISTLE[1)] data modelling principles [5]; and knowledge of the EXPRESS language.

In this International Standard the same English language words may be used to refer to a real world thing or to an EXPRESS data type that represents the real world thing. These uses are distinguished by typographic convention. If a word or phrase occurs in the same typeface as the surrounding narrative text, the word or phrase refers to the real world thing. If the word or phrase occurs in bold typeface, it refers to the EXPRESS type. Names of EXPRESS schemas also occur in bold typeface.

In the definitions of entity data types declared in this document, the wording “A <entity data type name> is ...” is used as a synonymous phrase for “A member of the class represented by the <entity data type name> entity data type is ...”.

[1)] EPISTLE is the European Process Industry STEP Technical Liaison Executive.

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

Part 2:
Data model

1 Scope

This part of ISO 15926 specifies a conceptual data model for computer representation of technical information about process plants.

The following are within the scope of this part of ISO 15926:

— specification of requirements to produce, process, and transport process materials;

— specification of functions required to produce and process the required materials, including the following:

  — hydrocarbon process and conditioning systems,

  — injected gas and water conditioning and injection systems,

  — oil and gas product transport systems,

  — safety and control systems,

  — electricity generation and supply systems,

  — steam generation and supply systems,

  — structures,

  — buildings and accommodation;

— specification and selection of materials and equipment to provide the required production and processing functions, including information about market available materials and equipment;

— installation and commissioning of plant equipment;

— production and process operations, including process conditions and consumption, yields and quality of process material;

— maintenance and replacement of equipment.

The following are outside the scope of this part of ISO 15926:

— construction of buildings, production facilities and equipment.

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2 Normative references

The following referenced documents are indispensable for the application 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.

ISO 8601:2000, *Data elements and interchange formats — Information interchange — Representation of dates and times*

ISO/IEC 8824-1, *Information technology — Abstract Syntax Notation One (ASN.1) — Part 1: Specification of basic notation*

ISO 10303-1, *Industrial automation systems and integration — Product data representation and exchange — Part 1: Overview and fundamental principles*

ISO 10303-11:1994, *Industrial automation systems and integration — Product data representation and exchange — Part 11: Description methods: The EXPRESS language reference manual*

ISO 15926-1: –[2)], *Industrial automation systems and integration — Integration of life-cycle data for process plants including oil and gas production facilities — Part 1: Overview and fundamental principles*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply; those taken or adapted from other standards are repeated below for convenience.

NOTE Definitions copied verbatim from other standards are followed by a reference to the standard in brackets, such as "[ISO 10303-1]". In these cases the definition in the referenced document is normative; its repetition here is informative and in the case of any discrepancy the definition in the referenced document has precedence.

3.1.1

class
category or division of things based on one or more criterion for inclusion and exclusion

NOTE 1 A class need not have any known members (things that satisfy its criteria for membership).

NOTE 2 Because of the spatio-temporal paradigm is used to define individuals in this part of ISO 15926, all classes are non-well-founded sets. These are explained in D.2.4

[ISO 15926-1]

[2)] To be published.

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3.1.2

conceptual data model
data model in the three schema architecture defined by ISO/TR 9007 [2], in which the structure of data is represented in a form independent of any physical storage or external presentation format

[ISO 15926-1]

3.1.3

data
representation of information in a formal manner suitable for communication, interpretation, or processing by human beings or computers

[ISO 10303-1]

3.1.4

data store
computer system that allows data to be stored for future reference

[ISO 15926-1]

3.1.5

data warehouse
data store in which related data are merged to provide an integrated set of data containing no duplication or redundancy of information, and which supports many different application viewpoints

[ISO 15926-1]

3.1.6

individual
thing that exists in space and time

NOTE 1 In this context, existence could be within the world we live in, or some "possible" world that can be imagined. This therefore includes actual, hypothetical, planned, expected, or required individuals.

EXAMPLE A pump with serial number ABC123, Battersea Power Station, Sir Joseph Whitworth, and the Starship “Enterprise” are examples of individuals.

NOTE 2 See 4.6.2 and 4.7 for a detailed discussion of the concept of individual.

[ISO 15926-1]

3.1.7

information
facts, concepts, or instructions

[ISO 10303-1]

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3.1.8

process plant life-cycle data
data that represents, in computer processable form, information about one or more process plants in or throughout any phase or phases of a process plant's life-cycle, including design, engineering, construction, operation, maintenance, decommissioning and demolition

[ISO 15926-1]

3.1.9

reference data
process plant life-cycle data that represents information about classes or individuals which are common to many process plants or of interest to many users

[ISO 15926-1]

3.2 Abbreviations

For the purposes of this document, the following abbreviations apply.

UTC Coordinated Universal Time

4 Fundamental concepts and assumptions

4.1 Conceptual data model

The data model specified in clause 5 is a conceptual data model. Figure 1 shows its relationship to internal and external models (see ISO 15926-1:5.2).

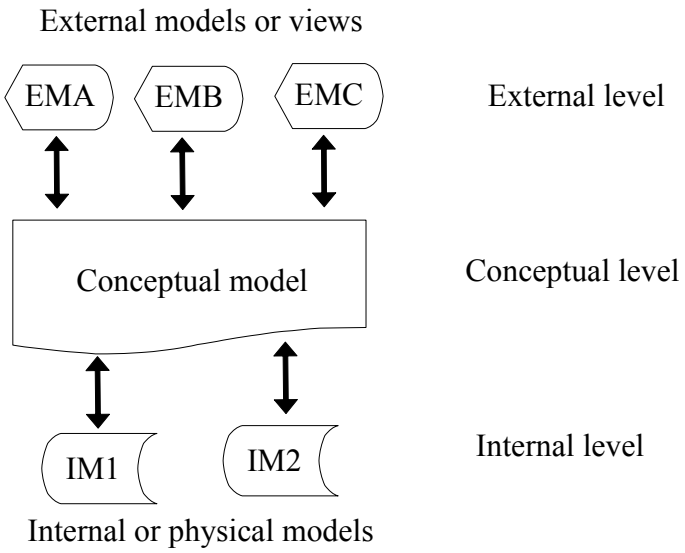

Figure 1 — Three level architecture

NOTE 1 The term conceptual data model is defined in ISO 15926-1 and is based on the three-schema architecture as described in ISO/TR 9007 [2].

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To enable integration of life-cycle process plant information the model excludes all information constraints that are appropriate only to particular applications within the scope.

NOTE 2 Data integration means combining information derived from several independent sources into one coherent set of data that represents what is known. Because the independent sources often have overlapping scopes, combining their data requires the common things to be recognized, duplicate information to be removed, and new information represented. To succeed in the role of integration, the data model must have a context that can include all the possible data that might be wanted or required.

4.2 Data model design

This data model is designed in accordance with data modelling principles [5] developed by the European Process Industries STEP Technical Liaison Executive (EPISTLE). These principles control the use of entity data types, attributes and relationships when defining a conceptual data model.

The effects of these principles are as follows.

— The model entity data types are part of a universal subtype/supertype hierarchy of entity data types.

— Entity data types are generic, representing and being named after the persistent nature of their members.

— Attribute information is usually expressed by references to entity data types.

— Attributes that are representations of numbers, text characters and binary patterns, are defined as EXPRESS simple types.

— Relationships and activities are represented by entity data types.

4.3 System identifiers

The data model includes an artificial, system defined, system identifier for each entity instance - **thing.id**. Each such identifier is a member of the EXPRESS string data type and is constrained to be unique within the set of identifiers managed by a given system. System identifiers are mandatory and shall remain consistent for the life of every entity instance managed by a given system.

EXAMPLE A database system that is used to manage information about the design and engineering of an offshore production platform provides the scope of uniqueness for system identifiers within that database.

Each system identifier shall be interpreted as the system reference to the **thing** it is identifying.

Other identifiers, external to the system, used for a particular **thing** are recorded using the **class_of_identification** entity data type.

4.4 Record management information

The data model makes provision for holding limited information about the computer records used to represent process plant information. The record management data is specified as attribute values that may be given for each entity instance. The scope of that information is as follows:

— for records that originate in another system, the date and time when this copy of the record was created in the current system;

— the date and time on which this record was first created in its originating system;

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— the person, organisation, or system that first created this record in the originating system;

— the date and time that this record was logically deleted;

— for logically deleted records, the reason why the record was logically deleted, where logical deletion means that whilst the record is still available in the system as a matter of historical record, it is now recognised as always being an invalid statement.

The definitions of the record management attributes are given in 5.2.1.2.

4.5 Documentation conventions

4.5.1 Entity and attribute definitions

Clause 4.6 introduces the concepts of the data model. The model is formally specified in clause 5. The introduction to 4.6 describes the model concepts and gives examples of their application. The descriptions in 4.6 complement the definitions and examples of clause 5, with clause 5 being the definitive description of the model.

4.5.2 Diagrams

This clause makes extensive use of diagrams to support the description of the fundamental concepts and assumptions.

Three types of diagrams are used:

— space-time maps;

— model diagrams, based on a subset of the EXPRESS G conventions;

— instance diagrams.

4.5.2.1 Space-time maps

Space-time maps are used to illustrate the use of space-time extensions to model tangible concrete objects that exist in space and time. Figure 2 is an example of a space-time map.

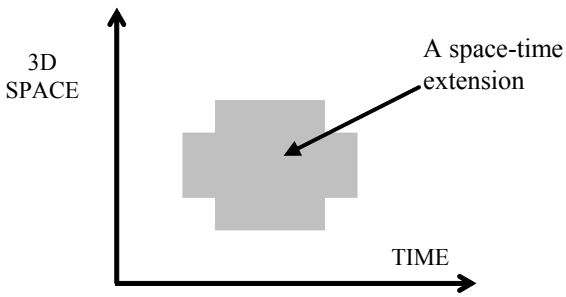

Figure 2 — Space-time map

A space-time map diagram consists of two perpendicular axes, the vertical axis for 3D space and the horizontal axis for time. Space-time extensions are plotted as bounded or shaded areas within these axes. The boundary to the left hand side of the extension indicates the start of the extension, and the boundary to the right hand side of the extension indicates the end of the extension. The change in boundaries at the top and bottom indicate changes in spatial extent.

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4.5.2.2 Model diagrams

Model diagrams are used to illustrate portions of the model to support its explanation and understanding. Model diagrams are restricted to show: EXPRESS entity types; EXPRESS subtyping; and EXPRESS relationships and use the appropriate EXPRESS G symbols.

EXAMPLE Figure 3 is an example of a model diagram.

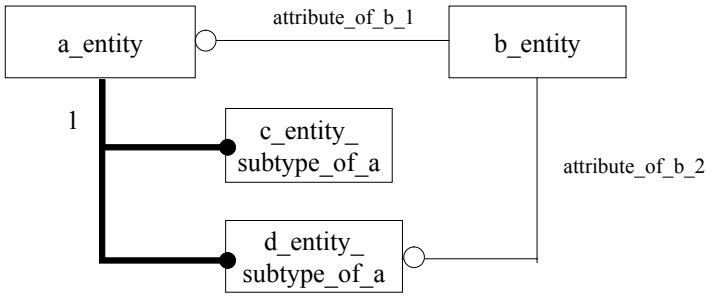

Figure 3 — Model diagram

A full set of EXPRESS G diagrams for the model is given in clause 5.

4.5.2.3 Instance diagrams

The meaning of the model entity types is illustrated using instance diagrams. The symbols used to construct instance diagrams are described in Figure 4.

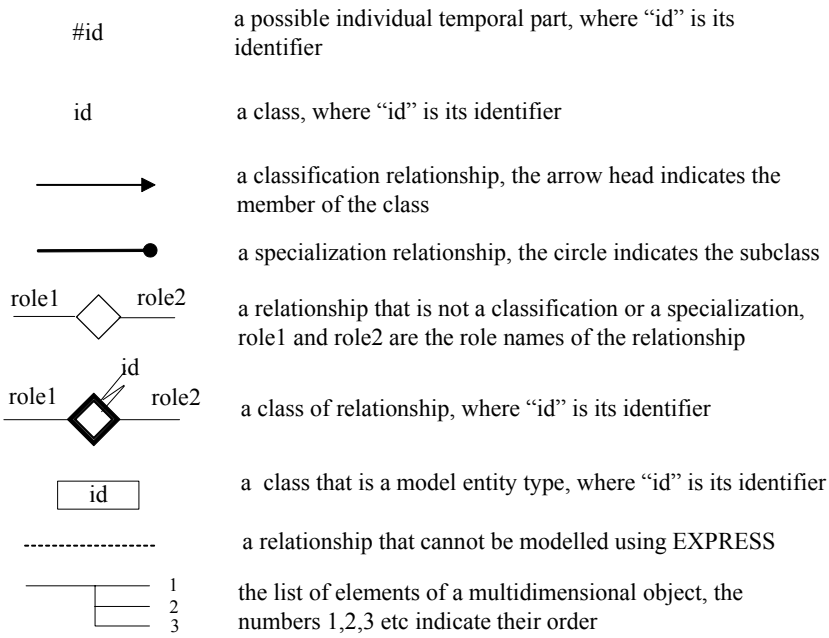

Figure 4 — Instance diagram notation

Figure 5 is an example instance diagram. It shows an object identified as #1234 that is a member of **thing**, and a member of pump. 'Pump'; is a member of **class**. Both **thing** and **class** are entity types of the model.

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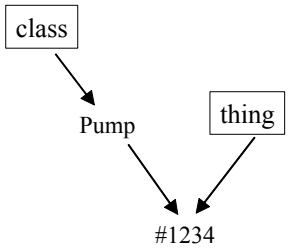

Figure 5 — Example diagram notation

NOTE 1 The symbols in Figure 4 enable examples of **thing**, entity data type, **classification**, **specialization**, **relationship**, and **class_of_relationship** to be represented in this part of ISO 15926.

NOTE 2 In this part of ISO 15926, the model entity data types defined in clause 5 are considered to be classes. Where such classes are used in illustrations, they are shown as a rectangular box.

NOTE 3 In this clause, the instance diagrams are considered complete when the objects shown are entity data types or are direct or indirect members of entity data types. The relationships between the model entity data types that are defined in the model are not shown.

NOTE 4 The instance diagrams in this clause are not intended to show how the model would be instantiated in practice. In particular, membership of the most specific model entity types may not be shown and some entity type memberships may be omitted altogether.

4.6 Data model concepts

4.6.1 Thing

The data model consists of a universal subtype/supertype entity type hierarchy.

There is one root supertype named **thing** that is the class of everything.

things are subdivided into

— either, **possible_individual**s;

— or, **abstract_object**s.

The topmost subdivisions of this hierarchy are shown in Figure 6 (see also 5.2.1 and Figure 177).

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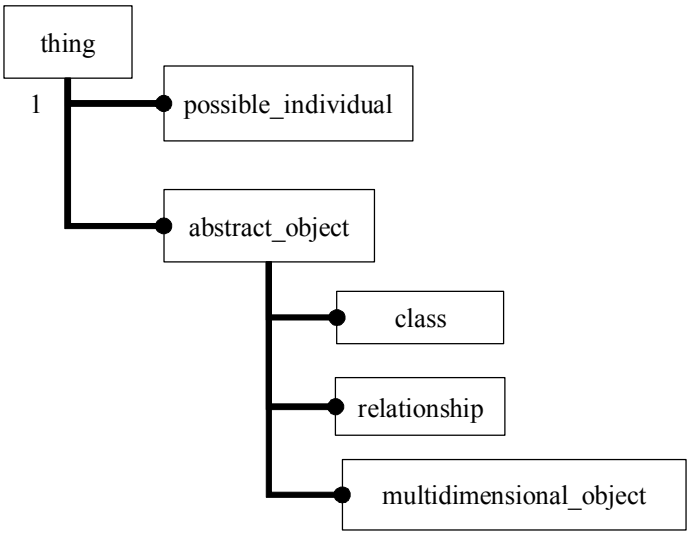

Figure 6 — Part of the model subtype/supertype hierarchy

4.6.2 Possible individual

A **possible_individual** is a **thing** that exists in space and time (see Figure 6 and 5.2.6). The identity of a **possible_individual** is its space-time extension. No two individuals have exactly the same space-time extension. Everyday physical things, often referred to as concrete objects, are **possible_individual**s.

EXAMPLE The pump known by the serial number #1234 is a **possible_individual**.

In contrast an **abstract_object** is a **thing** that does not exist in space-time. **class**, **relationship** and **multidimensional_object** are kinds of **abstract_object**.

4.6.3 Class

A **class** is an understanding of the nature of **thing**s; that divides **thing**s into **thing**s that are members of the **class** and **thing**s that are not, according to one or more criteria (see 5.2.2 and Figure 178). The identity of a **class** is its membership. No two **class**es have the same membership.

EXAMPLE 1 The concept known as pump is a **class**.

Classes are universal with no space-time extent. However, **class**es may involve time and space as criterion.

EXAMPLE 2 'Sales in June' is a **class**.

4.6.4 Relationship

A **relationship** is something that one **thing** has to do with another (see 5.2.11 and Figure 187). In this part of ISO 15926, a **relationship** is defined as the classification of an ordered pair. The pair is repeated to record another **relationship**. No two **relationship**s of the same classification have the same pair in the same order. The order enables roles to be assigned to the related **thing**s.

EXAMPLE 1 The pair consisting of 'pump' and '#1234' in the order where 'pump' acts as the **class** and '#1234' acts as the member is a **classification** relationship.

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This part of ISO 15926 defines some explicit subtypes of **relationship**, covering some commonly used relationships in the process industries.

EXAMPLE 2 Explicit subtypes of **relationship** include **classification**, **specialization**, **lifecycle_stage** and **approval**.

4.6.5 Multidimensional object

A **multidimensional_object** is an ordered list of **thing**s (see 5.2.4 and Figure 180). The **thing**s in the list can be **possible_individual**s, **class**es, **relationship**s or other **multidimensional_object**s.

EXAMPLE The list [2.0, 4.0, 5.7] is a **multidimensional_object**.

The order of the elements of a **multidimensional_object** is defined using the EXPRESS LIST aggregate type.

4.7 Possible individual

A **possible_individual** is a **thing** that could exist in space and time, often referred to as a concrete object (see 5.2.6 and Figure 182).

Possible_individual includes **thing**s that:

— actually exist, or have actually existed in the past;

— possibly have existed in the past, and may possibly exist in the future;

— are hypothetical having no existence in the past or future.

In this International Standard, a **possible_individual** corresponds to a particular extension in space and time. Things that have coincident space-time extensions are considered to be the same thing.

The general nature of a **possible_individual** is illustrated by the space-time map for the **possible_individual** '#1234' shown in Figure 7.

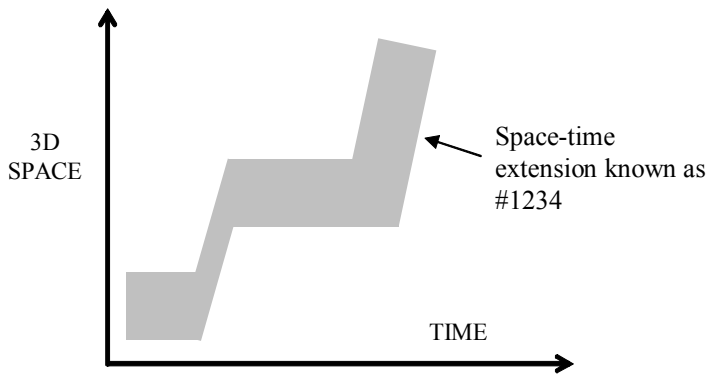

Figure 7 — Possible individual as a space-time extension

The instance diagram that represents the particular space-time extension in Figure 7 is shown in Figure 8.

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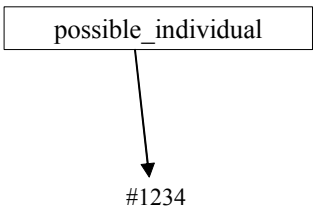

Figure 8 — Instance diagram for possible individual #1234

NOTE In this International Standard, "possible individual" and "individual" are terms used for space-time extension.

4.7.1 Composition of possible individual

A **possible_individual** may be part of other **possible_individual**s. Composition, or whole-part behaviour, distinguishes **possible_individual**s from **class**es. The concept of whole-part is represented by **composition_of_individual,** a subtype of **relationship** (see 5.2.6.5 and Figure 182). This is shown in Figure 9.

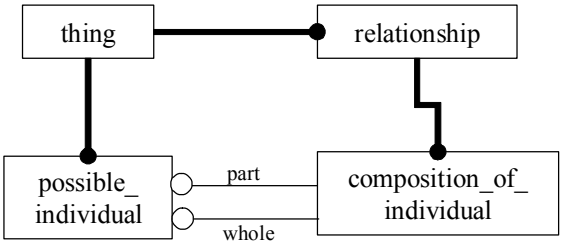

Figure 9 — Composition of individual relationships

EXAMPLE Consider the impeller of a centrifugal pump. The time in the life of the impeller that it is installed in the pump is a space-time extension that is part of both the pump and the impeller. This is illustrated in the space-time map shown in Figure 10. Extensions #1234 and #5678 represent the impeller and the pump respectively. Their intersection #9012 is where the impeller part is also part of the pump.

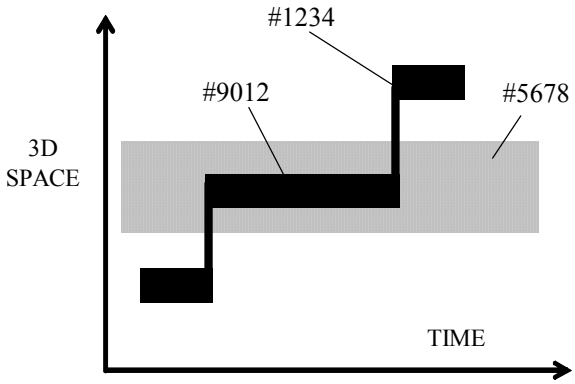

Figure 10 — Intersecting space-time extensions

The use of the model to represent the three space-time extensions is shown in Figure 11. The **possible_individual** #9012 is a part of both the **possible_individual**s #1234 and #5678.

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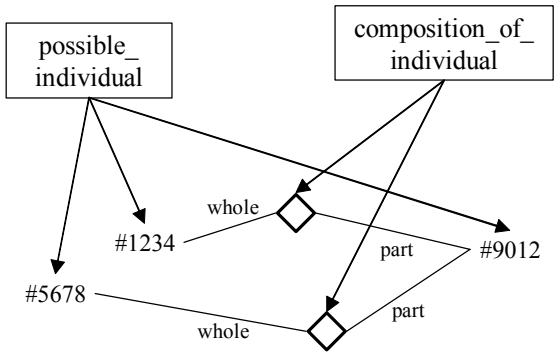

Figure 11 — Instance diagram for composition of individual

4.7.2 Temporal part of individual

In this part of ISO 15926, **possible_individual**s that correspond to the entire spatial extent for a period of time of another **possible_individual** are referred to as temporal parts (see 5.2.6.14 and Figure 182). The nature of a temporal part is illustrated in Figure 12.

NOTE State and substate are commonly used terms that are equivalent to temporal part.

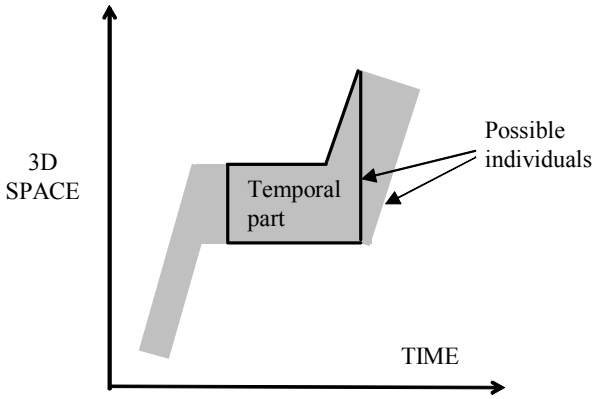

Figure 12 — Temporal part

The entity data type used to represent temporal parts is defined as a subtype of **composition_of_individual** as shown in Figure 13.

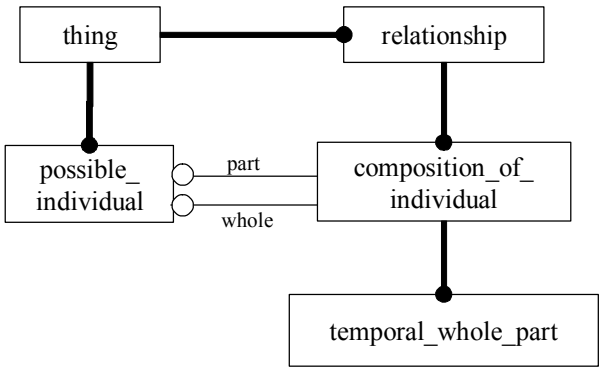

Figure 13 — Temporal whole part relationships

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EXAMPLE In Figure 14, #9012 is a temporal part of the impeller #1234. The **composition_of_individual** relationship can be specialised to be **temporal_whole_part**.

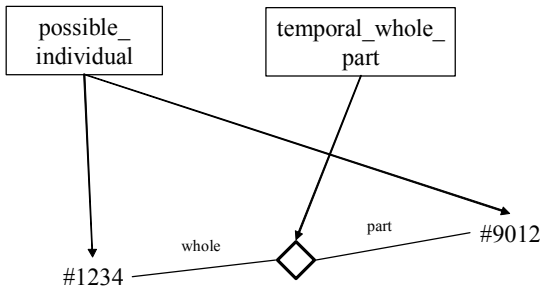

Figure 14 — Temporal part #9012 of #1234

With the exception of the concepts of wholeness and the nature of its temporal extent, all the characteristics of a **possible_individual** apply to all its temporal parts. However, the characteristics of a temporal part do not necessarily apply to the whole **possible_individual**.

4.7.3 Connection of individual

possible_individuals may be connected for their lifetime such that they can interact with each other (see 5.2.21 and Figure 197). The connection may be direct, that is they share a common space boundary; or it may be indirect via other **possible_individual**s. In the second case the intervening individuals will have a chain of direct connections that may not be recorded.

The space-time nature of a **direct_connection** is shown in Figure 15. The diagram shows two individuals that are in contact for a part of their lifetime. The temporal parts 'A' and 'B' of the two individuals have a common boundary in space for the duration of the connection. The boundary is shown as stationary with respect to time, though this not necessarily the case. 'A' and 'B' may also be considered to be parts of a third individual, 'W', not shown. The connection of 'A' and 'B' does not imply they are parts of a common whole, 'W'. This must be separately stated using **composition_of_individual** relationships. Similarly, being two parts of the same whole does not imply connection of the two parts.

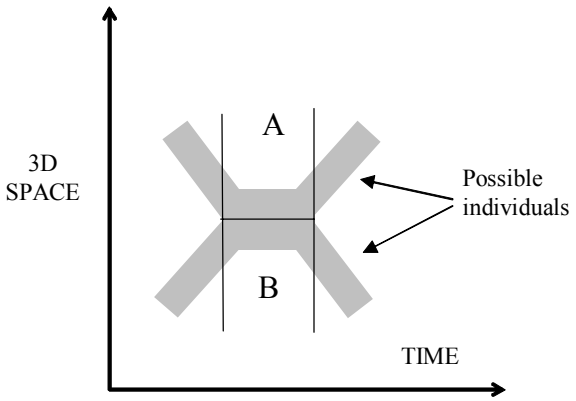

Figure 15 — Connected space-time extensions

The elements of the connection model are shown in Figure 16. **connection_of_individual** is a **relationship** with subtypes of **direct_connection** and **indirect_connection**. No order or direction is implied by the attribute names **side_1** and **side_2**. The names serve only to distinguish the individuals involved in the connection.

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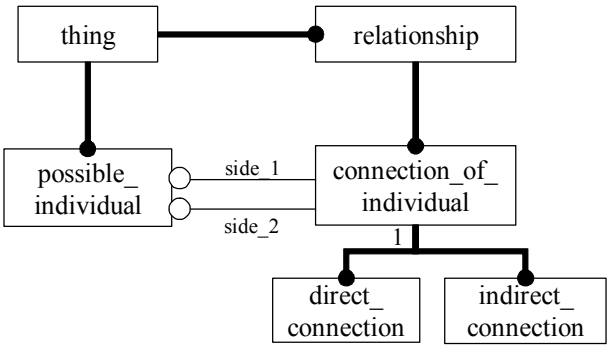

Figure 16 — Connection of individual

EXAMPLE 1 Figure 17 shows the connection between a particular engine shaft and a particular seal. The connection involves only temporal parts of the shaft and seal.

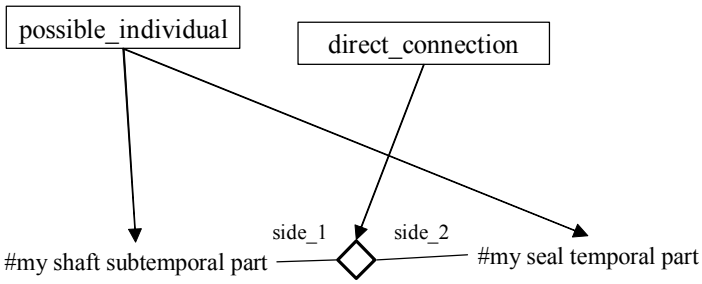

Figure 17 — Shaft seal direct connection

An **indirect_connection** is made via other individuals. Figure 18 shows the relationship **individual_used_in_connection**. This enables the other individuals involved in an **indirect_connection** to be recorded.

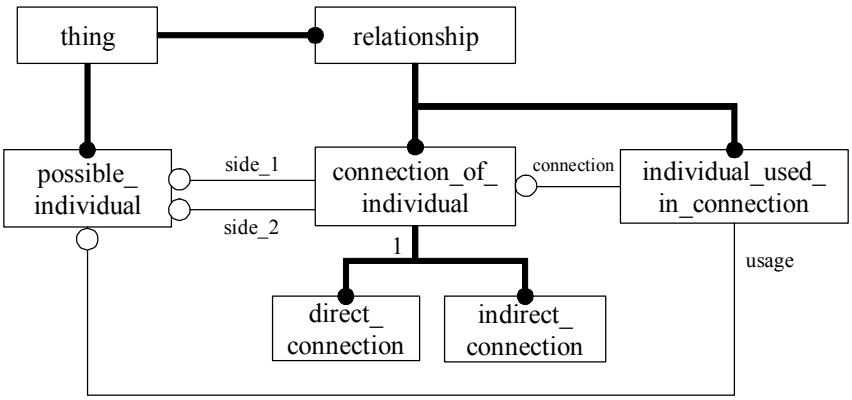

Figure 18 — Individual used in connection

EXAMPLE 2 Figure 19 shows an **indirect_connection** between the engine shaft and crankcase, where a bearing and seal is used to make the connection.

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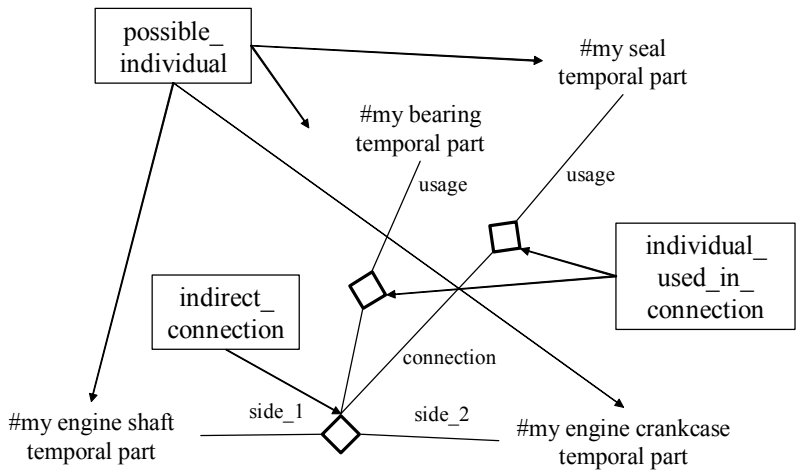

Figure 19 — Shaft crankcase indirect connection

4.7.4 Temporal sequence of individual

Space-time extensions may be ordered with respect to time, the entirety of one following the entirety of another. This is known as **temporal_sequence** in this part of ISO 15926 (see 5.2.22.6 and Figure 198) The space-time nature of **temporal_sequence** is shown in Figure 20. The figure shows individuals 'A' and 'B' which are sequenced in the time dimension where all of 'B' comes after all of 'A'.

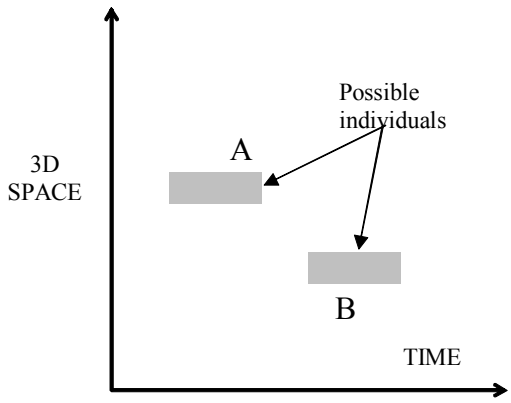

Figure 20 — Sequence of space-time extensions

The elements of the sequence model are shown in Figure 21. **temporal_sequence** is a type of **relationship** between a predecessor and successor **possible_individual** defining a sequence in time.

Sequence only records the case of what is. Rules concerning sequence, in the sense that the nature of a type of thing is that the members are in a sequence with another, are expressed using **class_of_temporal_sequence** (see section 4.8.4.7 and 5.2.22.3).

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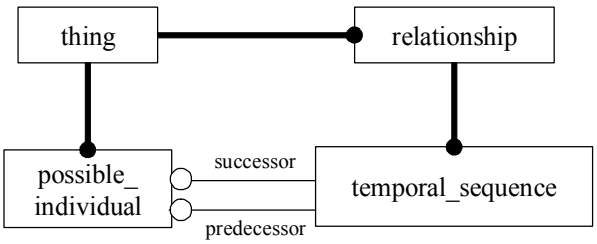

Figure 21 — Temporal sequence

EXAMPLE Figure 22 below shows the **possible_individual** known as James Watt came after the Battle of Hastings.

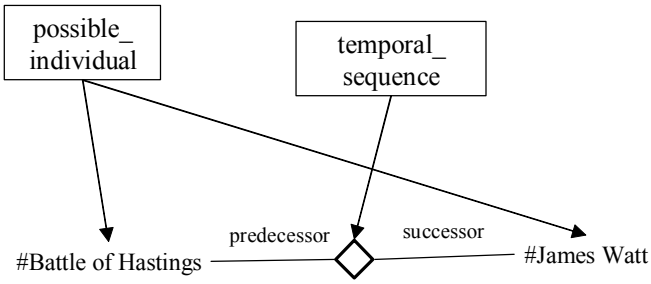

Figure 22 — James Watt and the Battle of Hastings

4.7.5 Subtypes of individual

The direct subtypes of **possible_individual** defined in the model are shown in Figure 23 (see also Figure 182).

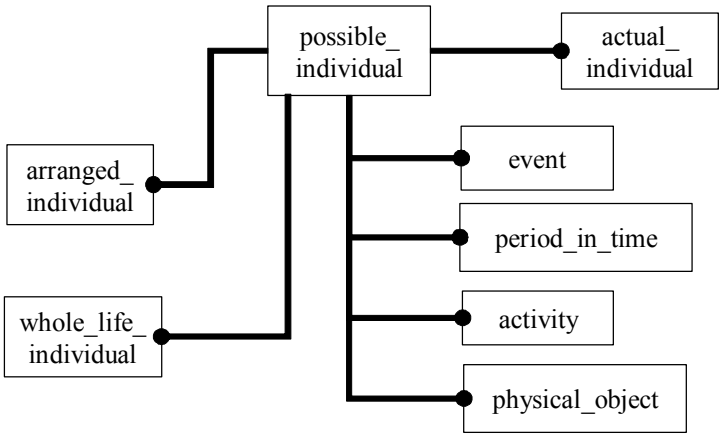

Figure 23 — Subtypes of possible_individual

4.7.6 Actual individual

actual_individuals are **possible_individual**s that actually exist in the real world (see 5.2.6.1). **thing**s that we may have planned in the past, or plan or expect in the future that never happen remain as just **possible_individual**s. Only those **possible_individual**s that come to pass are also **actual_individual**s.

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EXAMPLE The 25 gallon per minute pump that was required for the Omega production system from 21 March 1998 is a **possible_individual**. The pump manufactured in July of 1998 that has a capacity of 28 gallon per minute is an **actual_individual**. The extensions for the required 25 gpm pump and the actual 28 gpm pump are shown in Figure 24. Because they have different space-time boundaries, they are different extensions.

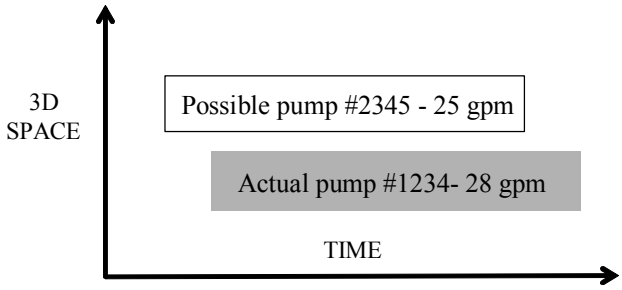

Figure 24 — Possible and actual individuals

Figure 25 shows the instance diagram for these extensions. Two **possible_individual**s are shown #2345 and #1234, each corresponding to a distinct extension. #1234 is a member of both the classes **actual_individual** and **possible_individual**.

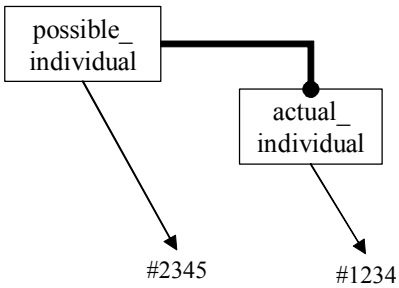

Figure 25 — Instance diagram of possible and actual individuals

4.7.7 Lifecycle stage of individual

Organisations and people often refer to **possible_individual**s using the lifecycle concepts such as proposed, planned or required. In this part of ISO 15926, **lifecycle_stage** is modelled as a relationship between two **possible_individual**s (see 5.2.23.4, 5.2.23.5 and Figure 199). This is shown in Figure 26.

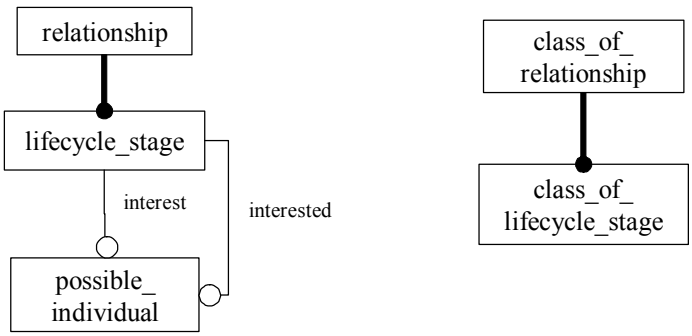

Figure 26 — Lifecycle relationship

There are no constraints on the relationship members of a **class_of_lifecycle_stage**.

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EXAMPLE Figure 27 shows the 25 gpm pump #2345 being required by the XYZ Company during the period 6 January to 27 September 2002. The same **possible_individual** could also be regarded as being required or planned by another organisation.

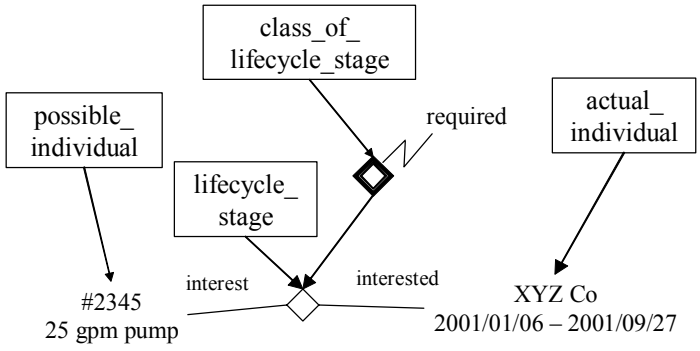

Figure 27 — The pump required by XYZ Co

4.7.8 Whole life individual

A **whole_life_individual** is a space-time extension that is not a temporal part of any other individual that is of the same class (see 5.2.6.15 and Figure 182). They are individuals whose identities are considered to be independent of other individuals.

EXAMPLE 1 The actual impeller with serial number #1234 is a **whole_life_individual**. It is not a temporal part of another impeller.

EXAMPLE 2 Consider a plastic blank, a cup formed from the blank, and some crushed plastic formed from the cup. They are temporal parts of the individual that is the plastic piece whose molecules are common to the blank, cup and crushed waste. Because the cup is not of the same class as the plastic piece, it is considered to be a **whole_life_individual**. For similar reasons the plastic blank and the crushed plastic are also **whole_life_individual**s. This is illustrated by Figure 28.

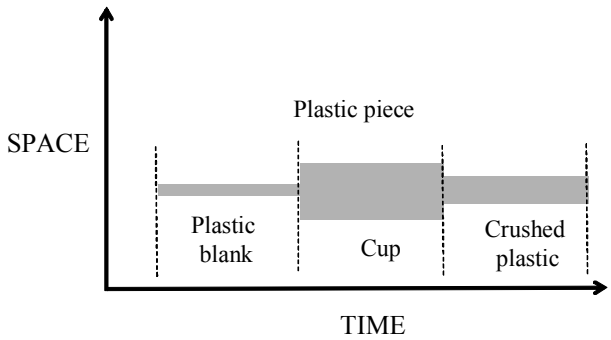

Figure 28 — Space-time map of a piece of plastic

EXAMPLE 3 Figure 29 shows the model instances necessary to represent the cup #X93 and the plastic piece #3A as **whole_life_individual**s, where the cup plays the role of part and the plastic piece the role of whole in the **temporal_whole_part** relationship.

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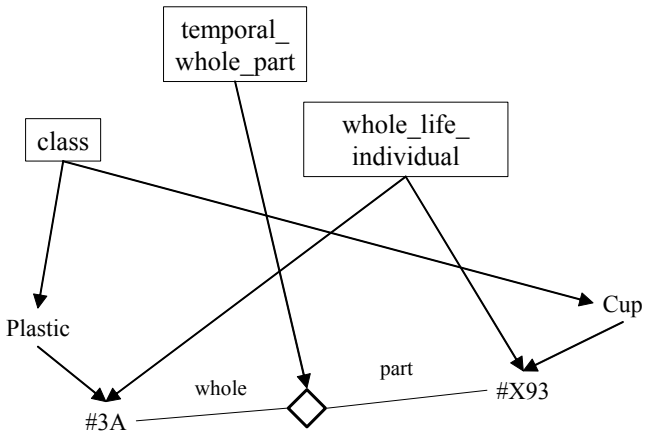

Figure 29 — Plastic piece and cup as whole life individuals

4.7.9 Arranged individual

possible_individuals are composed of other **possible_individual**s, referred to as parts. Those where the parts have a particular organization, or arrangement, are **arranged_individual**s (see 5.2.6.2 and Figure 182). The properties, characteristics and behaviours of an **arranged_individual** are different from those of its individual parts.

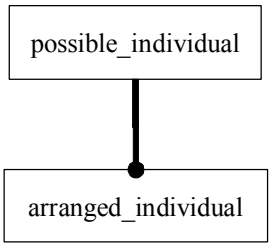

Figure 30 — Arranged individual

EXAMPLE 1 A particular pump with a manufacturer's serial number is a **arranged_individual**. The pumping capablity is its behaviour that is not present in any of its individual parts.

EXAMPLE 2 The stock of spare pump impellers is not an **arranged_individual**. They have no intended aggregate behaviour.

4.7.9.1 Arrangement of individual

arrangement_of_individual is defined as a subtype of **composition_of_individual**, constrained to refer to **arranged_individual**s as the **whole** (see Figure 31). An **arrangement_of_individual** indicates that the **part** is arranged with respect to other parts of the **whole** (see 5.2.6.3 and Figure 182).

EXAMPLE 1 Several aircraft flying in formation is an **arranged_individual**. **arrangement_of_individual** relationships indicate the temporal parts of each aircraft that are part of the formation. When the aircraft are on the ground, they are not part of the flying formation, hence the formation is composed of temporal parts of the aircraft.

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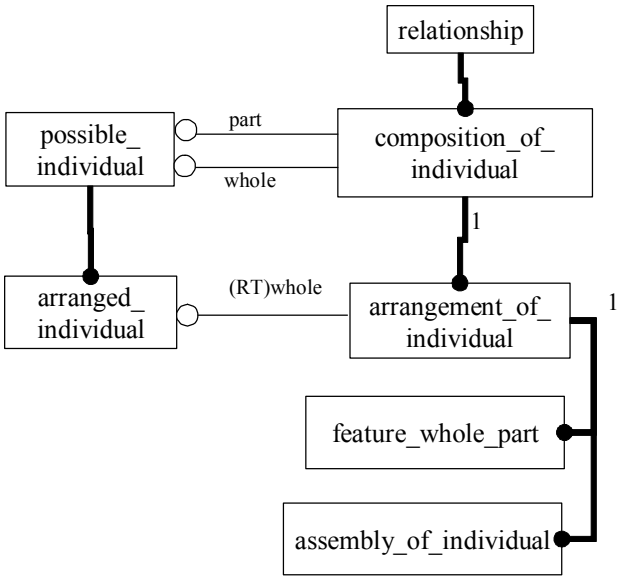

Figure 31 — Arrangement of individual

Two subtypes of **arrangement_of_individual** are defined to distinguish piece part assembly and feature parts of **arranged_individual**s.

assembly_of_individual relationships indicate that the parts of the whole are directly connected temporal parts of the components (see 5.2.6.4). The nature of the implied connection is that the part can be reasonably joined and separated from the whole particularly by mechanical means or by welding, gluing, and other forms of adhesion. This allows the parts to be replaced during the lifetime of the **arranged_individual** and for the parts to be parts of other **arranged_individual**s.

EXAMPLE 2 Figure 32 shows the **assembly_of_individual** relationships between two temporal parts of the impeller #I27C, designated as A and B, and the pumps, shown as #2345 and #2346, of which they are a part. #2345 and #2346 are temporal parts of two other whole individuals that would also be classified as pumps but are not shown here.

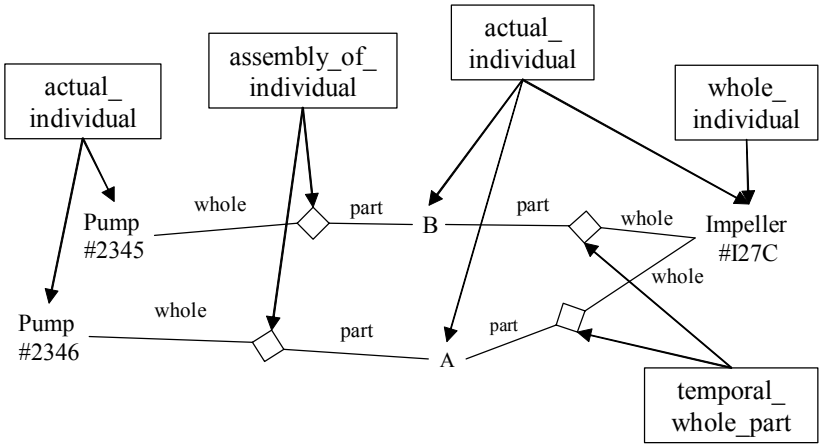

Figure 32 — Assembly of pump

In this part of ISO 15926, instances of **assembly_of_individual** are restricted to mesoscopic sized individuals, and therefore exclude composition of molecular and atomic sized individuals.

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feature_whole_part relations apply to parts of **arranged_individual**s that are non separable from the whole (see 5.2.6.6). The feature is such that it has no identification other than as a part of the individual of which it is a feature. In terms of this part of ISO 15926, a feature part is either a **whole_life_individual** or a part of a **whole_life_individual** that is a feature part of another **arranged_individual**.

EXAMPLE 3 Figure 33 shows the data for a corroded surface section of a pipeline. The surface section is a **whole_life_individual** that is a feature of the pipeline. The corroded section has individual parts that reflect the spatial extent and severity of the corrosion. The temporal part inherits the condition that it is a feature of the pipe. The development of corrosion can be tracked through time by identifying an appropriate whole life object and making the temporal parts that may be observed or measured from time to time, temporal parts of the **whole_life_individual**.

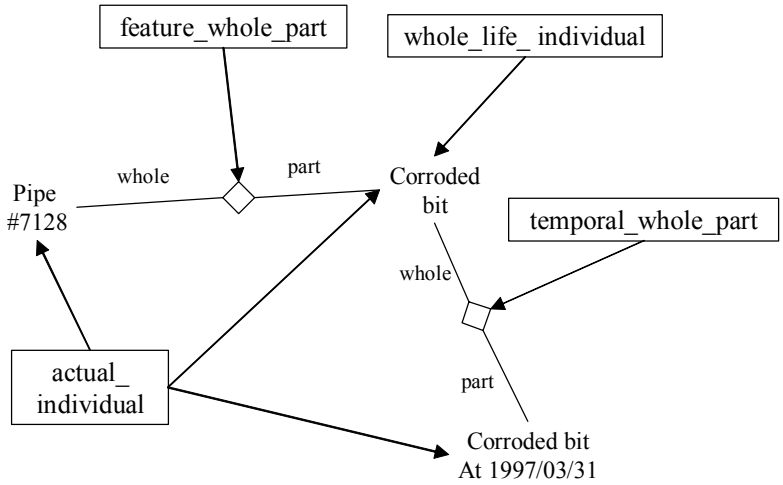

Figure 33 — Corrosion features

4.7.10 Event and point in time

In this part of ISO 15926, **event**s are defined as space-time extensions with zero time extension (see 5.2.9.5 and Figure 185). **event**s may be at one-time only, or may be continuous in time, or a combination of both. Figure 34 shows a space-time map for one-time and continuous **event**s. Both types satisfy the condition of zero time extension as every part has zero duration.

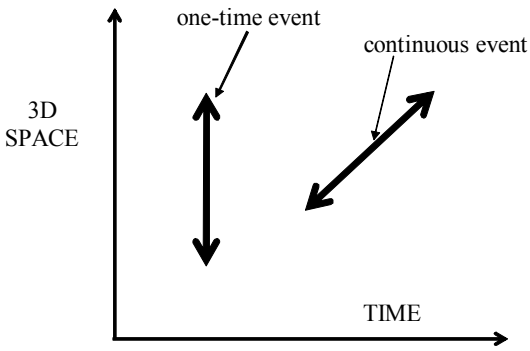

Figure 34 — Event space-time extensions

events mark the temporal boundaries of **possible_individual**s. Figure 35 shows the space-time map of an object that is moving, then at rest, and then moving. The one-time **event**s ‘A’ and ‘B’ delineate the stationary temporal part of the object. The continuous **event** ‘C’ marks the boundary of the leading

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edge of the moving object. **event** 'D' that has parts 'C' and 'B', is the beginning temporal boundary of the moving temporal part of the object.

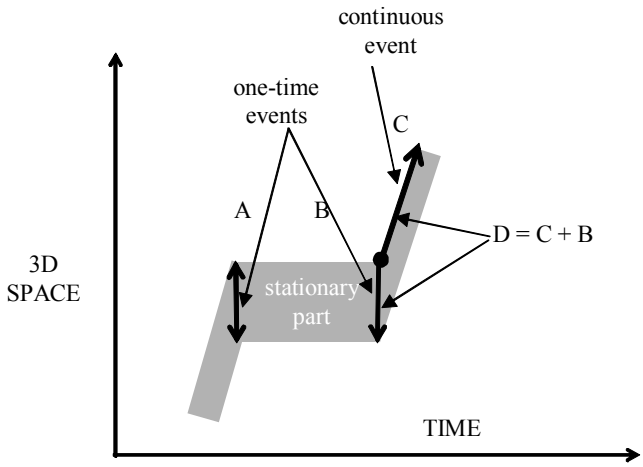

Figure 35 — Event boundary space-time map

The model of **event** is shown in Figure 36. **event** is a subtype of **possible_individual** and so can also be an **actual_individual**. An **event** is a temporal boundary of other space-time extensions. **temporal_bounding** is defined as a subtype of **composition_of_individual**, where the part is constrained to be an **event**. The subtypes **beginning** and **ending** indicate the **temporal_sequence** of the boundary relative to the bounded individual.

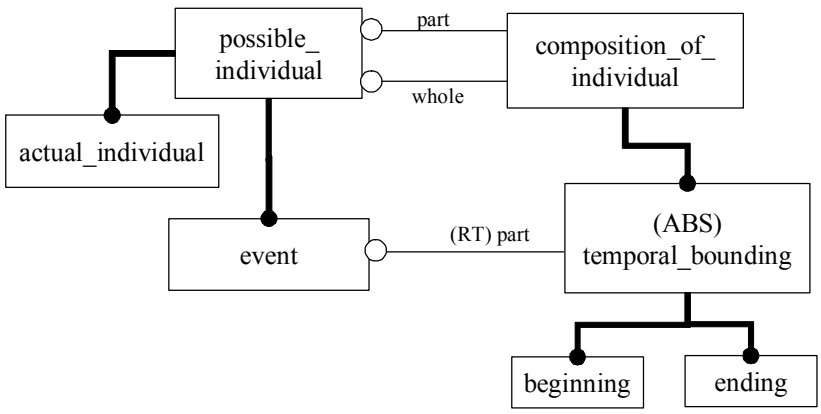

Figure 36 — Model diagram of event

EXAMPLE 1 A pipeline pig is brought to rest, parked for a period, before moving off again. The end of the pig's stationary state is a one time **event** and an **actual_individual**. The data for this is shown in Figure 37 below.

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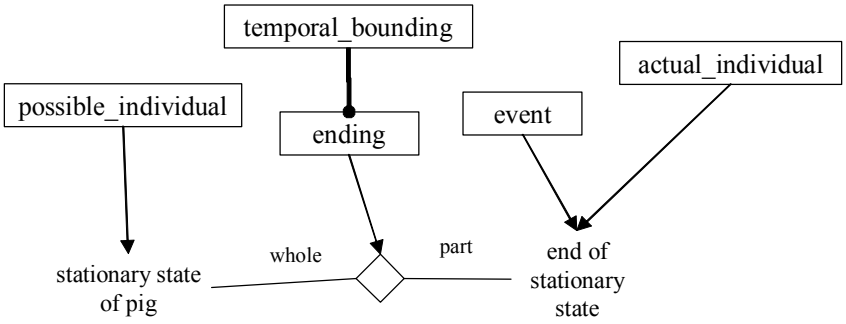

Figure 37 — Instance diagram of the ending of the stationary state

EXAMPLE 2 Figure 38 shows the space-time trajectory of the front edge of the pig for the period of motion. The start of the moving state is the end of the stationary state. Both are parts of the **beginning event** of the moving state.

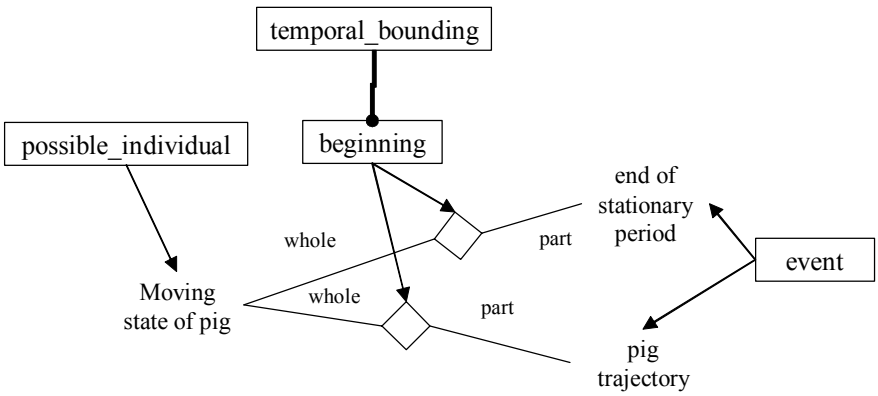

Figure 38 — Instance diagram of the pig space-time trajectory

Some one-time **event**s include the entire space extension; these are known as **point_in_time** (see 5.2.9.8 and Figure 185). One-time **event**s are always a part of a **point_in_time**. This is illustrated in Figure 39.

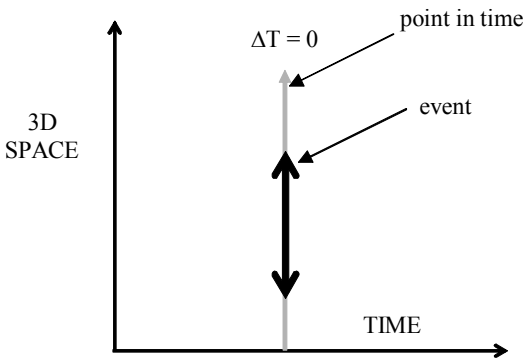

Figure 39 — Point in time extensions

The model of **event** and **point_in_time** is shown in Figure 40. As **event**s and **point_in_time** are **possible_individual**s, they may also be **actual_individual**s.

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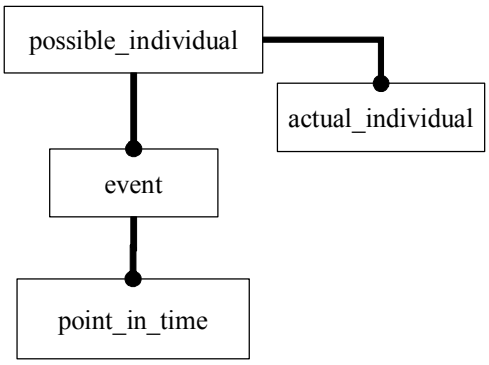

Figure 40 — Model diagram of Event

EXAMPLE 3 The time known as 10am 17 November 2002 UTC that has occured is a **point_in_time** and an **actual_individual** (see Figure 41).

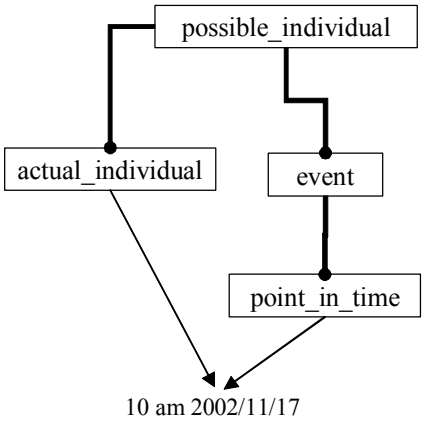

Figure 41 — Instance diagram of the actual point in time described as 10am 17 November 2002 UTC

events that are not points in time are spatial parts of a **point_in_time**, defining the time of the **event**. The **composition_of_individual** relationship is used to represent this.

EXAMPLE 4 Figure 42 shows the stationary state of the pipeline pig began its existence, at 10 am 2002/11/17 UTC.

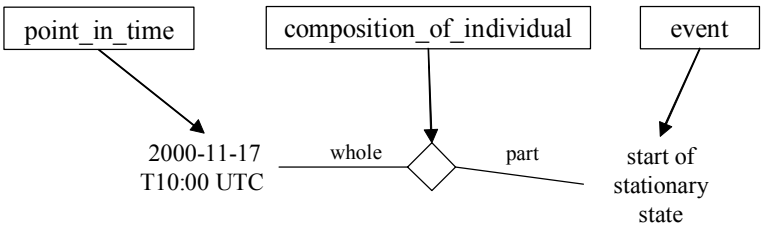

Figure 42 — Instance diagram of time of the stationary state

4.7.11 Period in time

A **period_in_time** is a **possible_individual** that is all space for part of time - a temporal part of the universe (see 5.2.6.9 and Figure 182). The space-time nature of **period_in_time** is illustrated in Figure 43.

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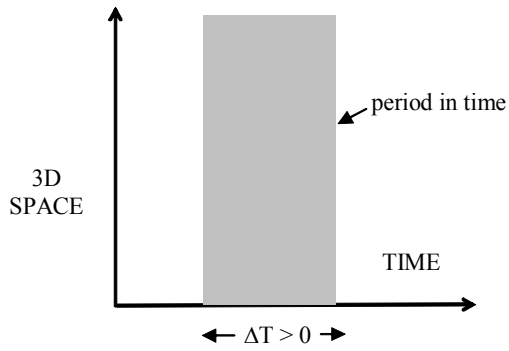

Figure 43 — Period in time space-time extension

The model for **period_in_time** is shown in Figure 44.

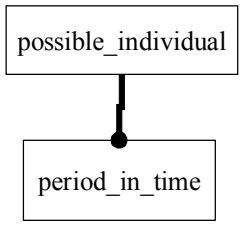

Figure 44 — Period in time entity type

Periods in time are bounded by a **beginning** and **ending** point in time as shown in Figure 45.

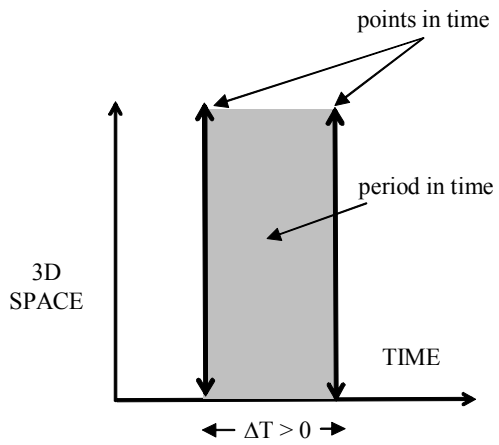

Figure 45 — Space-time map for a period of time and its bounding points in time

EXAMPLE In Figure 46, #EH26 is a **period_in_time**,with starting time 10:26 and ending time 11:09.

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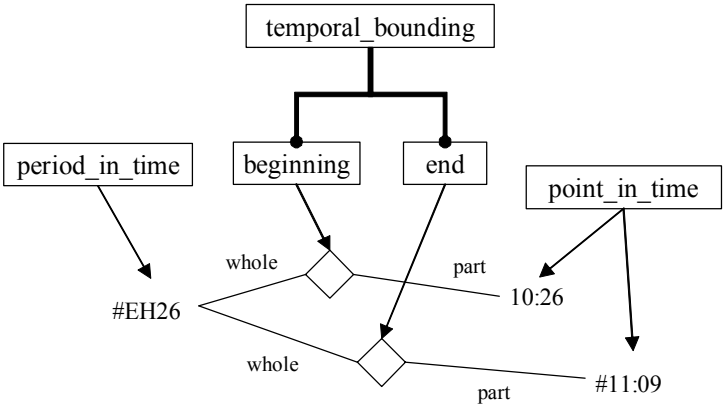

Figure 46 — Period in time 10:26 to 11:09

4.7.12 Physical object

In this part of ISO 15926, a **physical_object** is a distribution of matter and/or energy in time and space (see 5.2.6.10 and Figure 182). **physical_object**s are always a part of space and usually, though not necessarily, have a non-zero temporal extension.

physical_object and **activity** are not mutually exclusive. A **possible_individual** can be both.

EXAMPLE 'Radioactive materials', 'living organisms' and 'fire' are examples of **physical_object** and **activity**.

Four kinds of **physical_object** are recognized, discriminated on their basis of continuity. They are defined as subtypes of **physical_object** as shown in Figure 47:

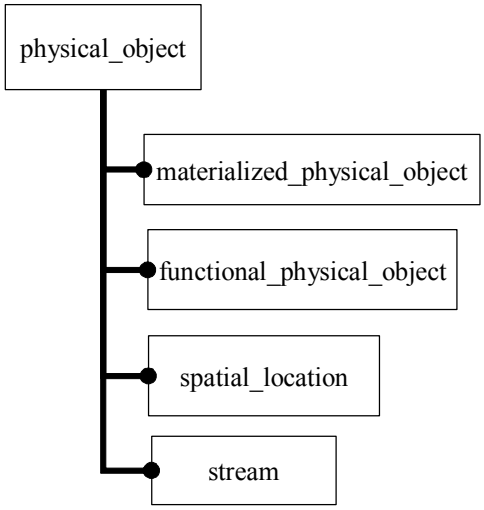

Figure 47 — Types of physical object

4.7.13 Materialised physical object

materialized_physical_objects are **physical_object**s that consist of the same or slowly changing material or energy during their existence (see 5.2.6.8 and Figure 182). This includes most of what are often described as concrete objects.

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EXAMPLE A mechanical pump bearing the manufacturer's serial number is a **materialized_physical_object**. It is regarded as the same thing even if all of its components are replaced during its life. Figure 48. shows a space-time map for a pump initially comprising two parts A & B. After some time, component A is replaced by a new component C. Later B is replaced by D. Material continuity is achieved as some material persists across each event boundary.

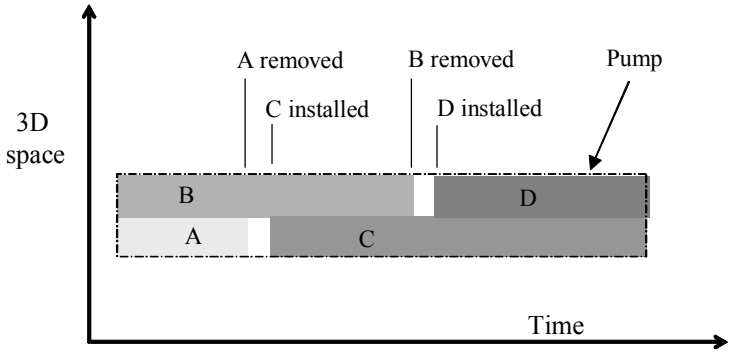

Figure 48 — Material continuity space-time map

The pump consists of a number of temporal parts each corresponding to the different component parts. This is illustrated in Figure 49.

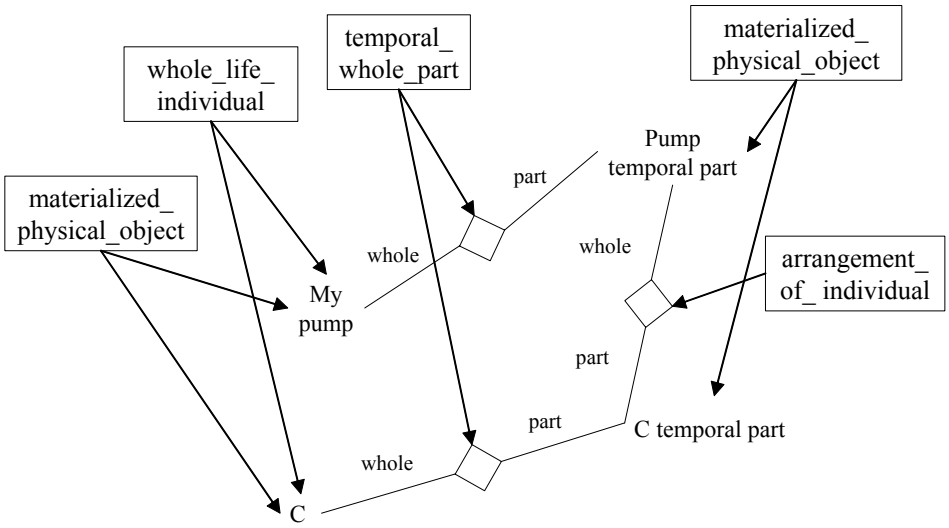

Figure 49 — Pump temporal parts

4.7.14 Functional physical object

functional_physical_objects are **physical_object**s based on continuity of intended function (see 5.2.6.7 and Figure 182). The material that makes up the object can be completely changed, provided the intended function of the individual remains the same.

temporal_whole_part relations are used to indicate which **materialized_physical_object** temporal parts are parts of a **functional_physical_object**.

EXAMPLE The pump known by the Tag 'P101', for which a succession of different pumping equipment items are installed, is a **functional_physical_object**. This is illustrated in Figure 50. pump 1 is installed and removed from Tag P101. Later pump 2 is installed and removed from Tag P101. There is no material continuity, but both pumps perform a similar function whilst installed. The instances required for pump 1 are shown in Figure 51.

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The **possible_individual** that is a temporal part of both the tag and of the pump is both a **materialized_physical_object** and **functional_physical_object**.

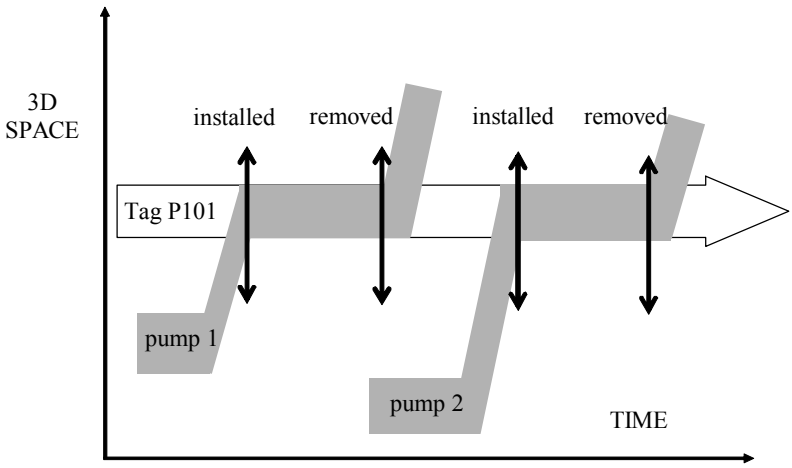

Figure 50 — Function physical object P101 space-time map

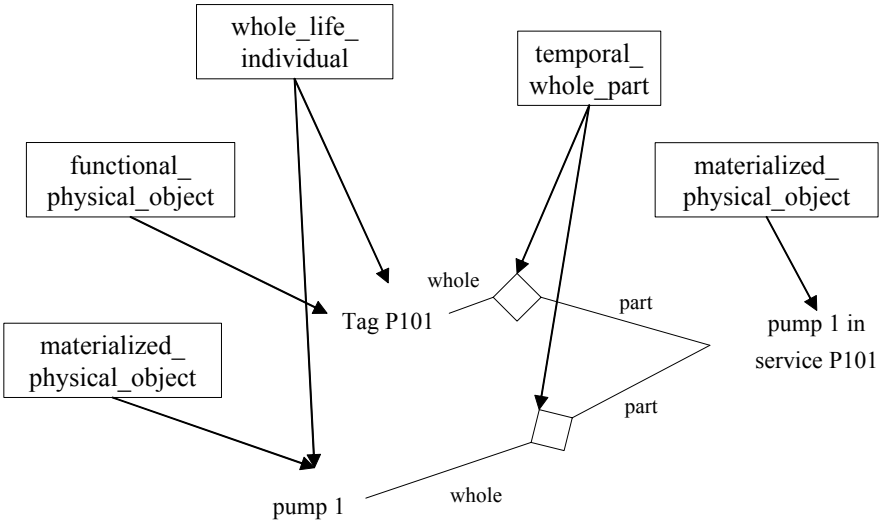

Figure 51 — Instance diagram for pump 1 installed as P101

4.7.15 Spatial location

spatial_locations are **physical_object**s where continuity of relative position is the basis of identity (see 5.2.6.12 and Figure 182).

EXAMPLE An offshore license area is a **spatial_location**.

4.7.16 Stream

streams are **physical_object**s where continuity of flow path is the basis of identity (see 5.2.6.13 and Figure 182).

EXAMPLE The moving contents of a hose is a **stream** and a **materialized_physical_object**.

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4.7.17 Activity

An **activity** is something happening or changing (see 5.2.9.1 and Figure 185). In this part of ISO 15926, activities are considered to be space-time extensions in which other individuals and **event**s participate. **participation** is defined as a type of **composition_of_individual** as shown in Figure 52 (see 5.2.9.7).

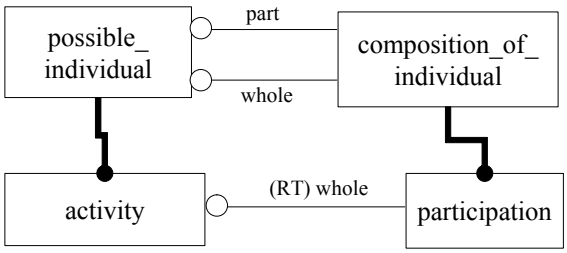

Figure 52 — Activity participation

EXAMPLE 1 Forming a plastic cup from a flat plastic blank using a hot moulding machine is an activity. The extent of the activity includes the plastic as its shape is changed and a temporal part of the machine being used. Figure 53 shows the spatio-temporal extent of the plastic involved in the "cup forming" activity. The forming activity causes the cup to come into existence and end the life of the plastic blank.

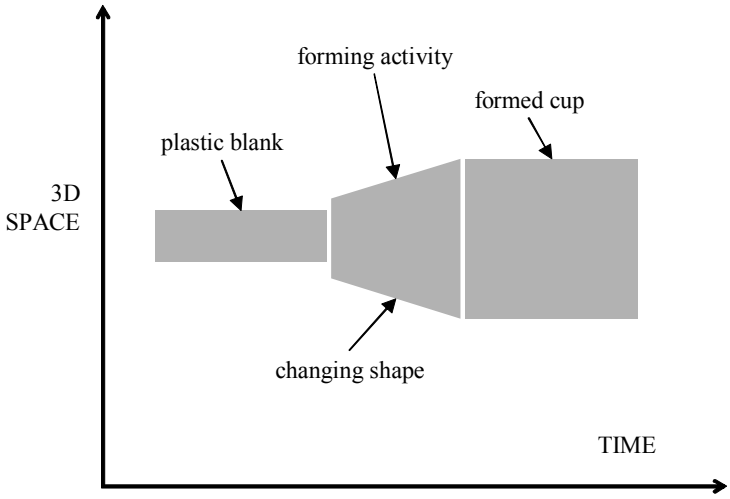

Figure 53 — Cup forming activity

The model instances necessary to show the participation of the molding machine, the plastic and a finished cup are shown in Figure 54.

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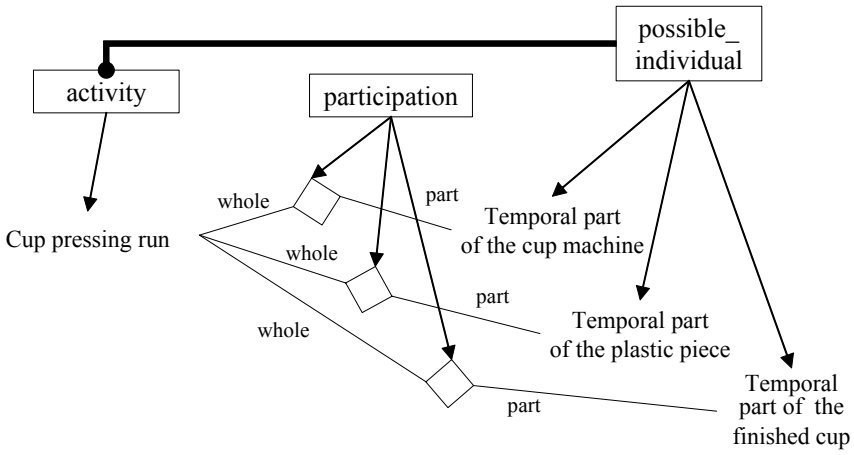

Figure 54 — Instance diagram of cup forming activity

Activities cause change that can be marked by **event**s (see 5.2.9.5). In Figure 53, two significant changes are shown: the start of the existence of the cup and the termination of the existence of the plastic blank. The model for cause is shown in Figure 55. **cause_of_event** is defined as a type of **relationship** (see 5.2.9.3).

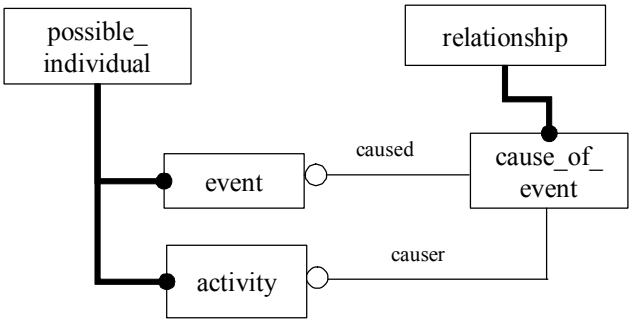

Figure 55 — Cause of event model

EXAMPLE 2 Figure 56 shows a particular cup pressing **activity** that causes the begin **event** of the cup and the ending of the plastic blank state.

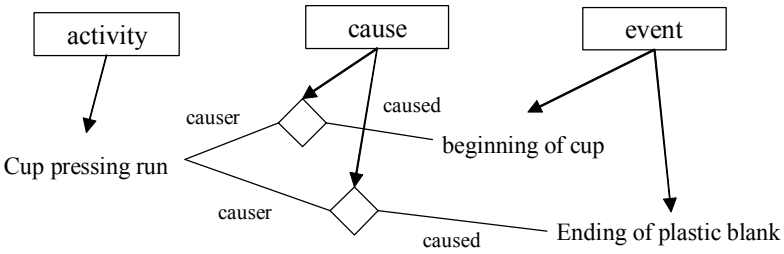

Figure 56 — Cup beginning caused by a cup pressing run

The model also allows **abstract_object**s and **possible_individual**s from the future or the past relative to the **activity** to be involved indirectly as shown in Figure 57 (see 5.2.9.6).

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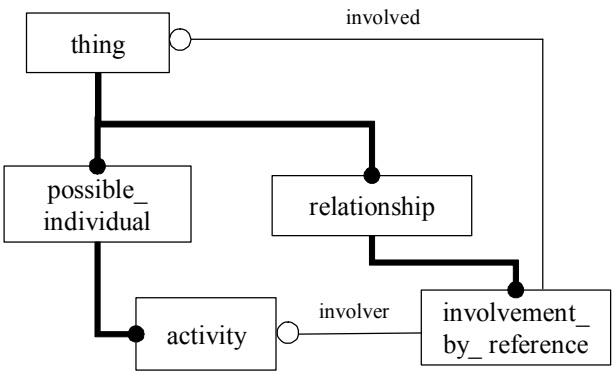

Figure 57 — Involvement by reference

EXAMPLE 3 A production **activity** may involve the specification for the individuals produced by the **activity**. The specification is a **class_of_individual** that has an **involvement_by_reference** relationship with the activity

Activities can also result in the recognition of abstract conditions (see 5.2.9.9). **recognition** is a relationship between an **activity** and a **thing** that indicates the **thing** has been recognised as a consequence of the **activity**. The elements of the model for **recognition** are shown in Figure 58 below.

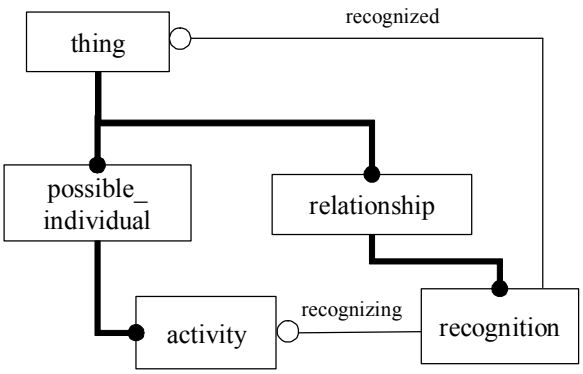

Figure 58 — Recognition by activity

EXAMPLE 4 Figure 59 shows a ship survey **activity** that recognizes that the ship has a 'Class A' classification.

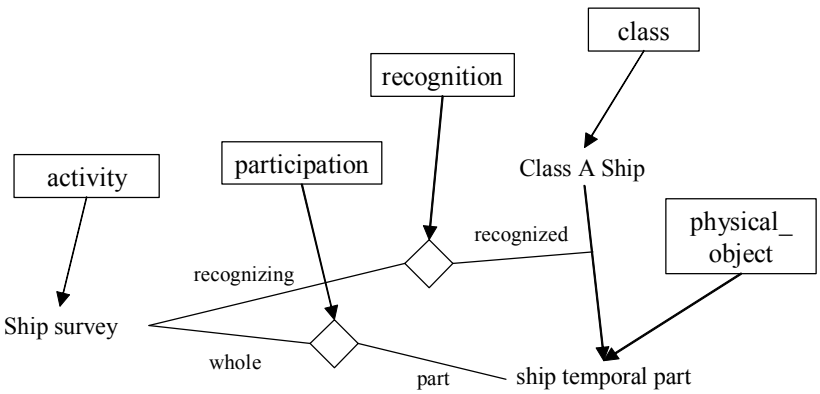

Figure 59 — Ship classification activity

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4.7.18 Approval

approval is a **relationship** linking a **possible_individual** that could be a person, organisation or machine that grants the **approval** to the thing that is approved (see 5.2.23.1 and Figure 199). In this part of ISO 15926, only **relationship**s can be approved as this gives a meaning to the **approval**. A **possible_individual** or a **class** is what it is, approving it is meaningless. It is approving its involvement with something else that has meaning.

The elements of the **approval** model are shown in Figure 60.

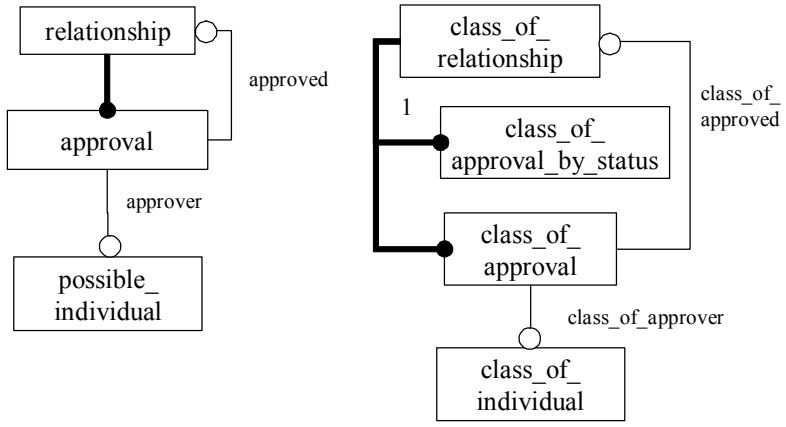

Figure 60 — Approval

The type of **approval** is given by classifying an **approval** relationship by a **class_of_approval_by_status** (see 5.2.23.3). **class_of_approval** enables rules on the classes of relationship that can be approved by types of individual (see 5.2.23.2).

EXAMPLE Figure 61 shows the **participation** of the raw plastic in the cup pressing **activity** being approved by the 'Production supervisor'. 'Approved' is a **class_of_approval_by_status**. 'Not approved' is also a **class_of_approval_by_status**.

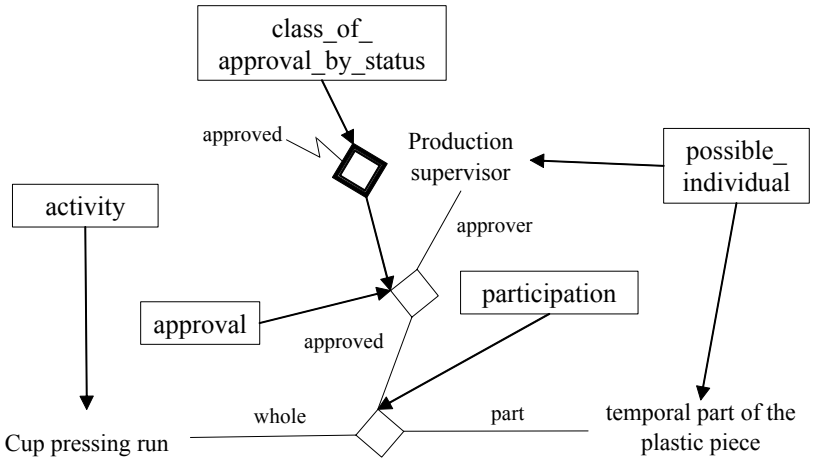

Figure 61 — Approval of cup raw material

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4.8 Class

A **class** is a category, sort or a division of **thing**s with some common nature (see 5.2.2 and Figure 178).

classes have a basis for inclusion and exclusion.

Within this International Standard,

— inclusion within a **class** is referred to as class membership;

— **class**es correspond to non-well-founded sets. The characteristics of non-well-founded sets are further described in Annex D;

— the basis for inclusion or exclusion for a **class** can be given by a textual definition and or by its relationships.

4.8.1 Classification

classification is a **relationship** that indicates membership of a **class** (see 5.2.2.3 and Figure 178). Class membership implies that the member satisfies the conditions for inclusion and exclusion. **classification** is modelled as an explicit subtype of **relationship** as shown in Figure 62.

possible_individuals, **class**es, **relationship**s and **multidimensional_object**s may be classified. Classification is not transitive. Members of a **class** are not necessarily members of any **class** of the **class**.

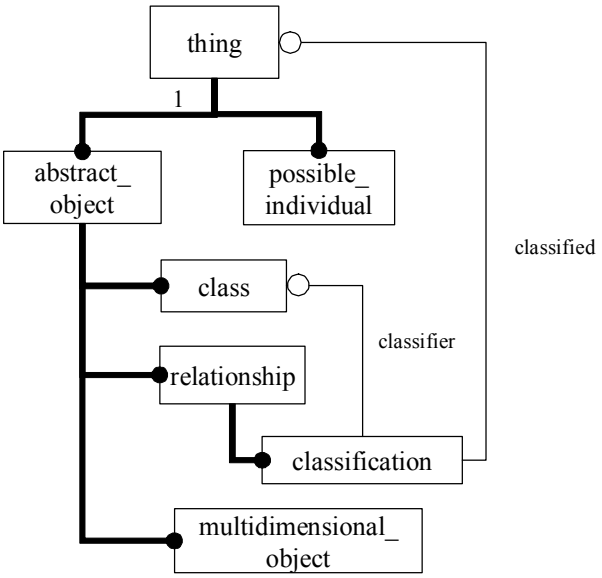

Figure 62 — Model of classification relationship

EXAMPLE 1 Figure 63 shows a category of **thing**s known as 'Pump' that is a **class**. Members of 'Pump' are **arranged_individual**s that enable pumping activity. The **arranged_individual** referred to as #1234 is a 'Pump'. The relationship that indicates #1234 is a member of 'Pump' **class** is a **classification**. In the case of the 'Pump' **class**, membership of it is not affected by whether or not the **arranged_individual** is a **whole_life_individual** or a temporal part of a **whole_life_indivdual**.

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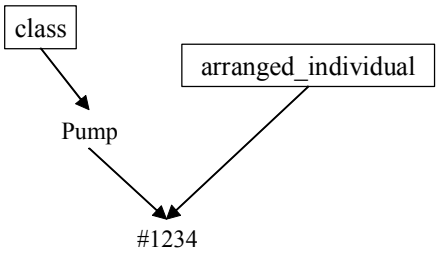

Figure 63 — Classification of pump

Classification allows something to be a member of many classes.

EXAMPLE 2 The **arranged_individual** referred to as #1234 is a 'Pump' and is also 'operating' as shown in Figure 64

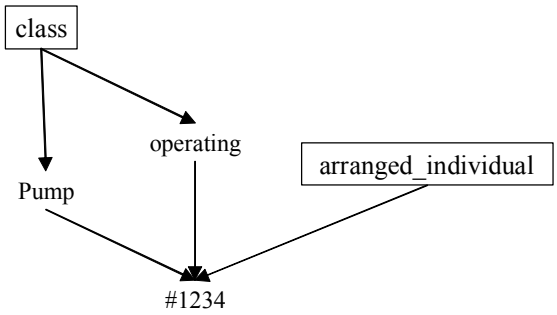

Figure 64 — Classification of operating pump

Many classifications that apply to a **whole_life_individual** also apply to all of the temporal parts of the **whole_life_individual** (a form of inheritance).

EXAMPLE 3 In Figure 65, #1234 is a temporal part of whole life 'pump' #PA01. The 'pump' classification rightly belongs to the **whole_life_individual** and is inherited by any and all of its temporal parts. However, if the **whole_life_individual** is not represented in the database, the classification can be recorded directly against the temporal part.

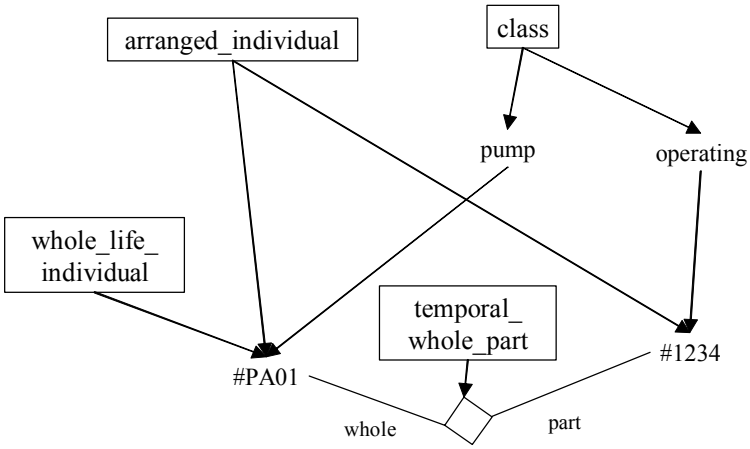

Figure 65 — Operating temporal part of a pump

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