BS EN 62264-4:2016

BSI Standards Publication

Enterprise-control system integration

Part 4: Object model attributes for manufacturing operations management integration

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National foreword

This British Standard is the UK implementation of EN 62264-4:2016. It is identical to IEC 62264-4:2015.

The UK participation in its preparation was entrusted to Technical Committee AMT/7, Industrial communications: process measurement and control, including fieldbus.

A list of organizations represented on this committee can be obtained on request to its secretary.

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English Version

Enterprise-control system integration - Part 4: Object model attributes for manufacturing operations management integration (IEC 62264-4:2015)

Intégration des systèmes entreprise-contrôle - Partie 4: Attributs des modèles d'objets pour l'intégration de la gestion des opérations de fabrication (IEC 62264-4:2015)

Integration von Unternehmensführungs- und Leitsystemen - Teil 4: Attribute des Objektmodells für die Integration des operativen Produktionsmanagements (IEC 62264-4:2015)

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Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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European foreword

The text of document 65E/479/FDIS, future edition 1 of IEC 62264-4, prepared by SC 65E "Devices and integration in enterprise systems", of IEC/TC 65 "Industrial-process measurement, control and automation" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 62264-4:2016.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2016-10-20
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2019-01-20

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In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 61512 (series)	NOTE	Harmonized as EN 61512 (series).
IEC 62541 (series)	NOTE	Harmonized as EN 62541 (series).

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

Publication	Year	Title	EN/HD	Year
IEC 61511-1	-	Functional safety - Safety instrumented systems for the process industry sector - Normative (uon) -- Part 1: Framework, definitions, system, hardware and software requirements	-	-
IEC 61512-4	2009	Batch control -- Part 4: Batch production records	EN 61512-4	2010
IEC 62264-1	2013	Enterprise-control system integration -- Part 1: Models and terminology	EN 62264-1	2013
IEC 62264-2	2013	Enterprise-control system integration -- Part 2: Object and attributes for enterprise-control system integration	EN 62264-2	2013
IEC 62264-3	-	Enterprise-control system integration -- Part 3 Activity models of manufacturing operations management	EN 62264-3	-
IEC 62682	-	Management of Alarm Systems for the Process Industries	EN 62682	-
ISO 8601	-	Data elements and interchange formats -- Information interchange - Representation of dates and times		-
ISO/IEC 19501	-	Information technology - Open Distributed Processing - Unified Modeling Language (UML) Version 1.4.2	-	-
ISO/IEC 19505-1	-	Information technology - Object Management Group Unified Modeling Language (OMG UML) - Part 1: Infrastructure	-	-
ISO/IEC 19505-2	-	Information technology - Object Management Group Unified Modeling Language (OMG UML) – Part 2: Superstructure	-	-

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ENTERPRISE-CONTROL SYSTEM INTEGRATION –

Part 4: Object model attributes for manufacturing operations management integration

FOREWORD

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The text of this standard is based on the following documents:

FDIS	Report on voting
65E/479/FDIS	65E/488/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62264 series, published under the general title *Enterprise-control system integration*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

This part of IEC 62264 defines the interfaces between enterprise activities and control activities and is to be used in conjunction with IEC 62264-3.

The scope of this part of IEC 62264 is limited to defining the details of the information content of interfaces within manufacturing operations management. The scope is limited to the definition of object models and attributes for the information defined in IEC 62264-3. The goal is to reduce the effort, cost, and errors associated with implementing these interfaces.

The standard may be used to reduce the effort associated with implementing new product offerings. The goal is to have enterprise systems and control systems that interoperate and easily integrate.

This part of IEC 62264 further defines the object models and attributes involved in data exchange between activities of manufacturing operations management defined in 62264-3. The models and terminology defined in IEC 62264-3 and this part of IEC 6226

a) emphasize good manufacturing operations management integration practices during the entire life cycle of the systems;
b) can be used to improve existing integration capability of manufacturing operations management systems; and
c) can be applied regardless of the degree of automation.

Specifically, IEC 62264-3 and this part of IEC 62264 provide a standard terminology and a consistent set of concepts and models for integrating manufacturing operations management systems that will improve communications between all parties involved. Benefits produced will

d) reduce the user’s time to reach full production levels for new products;
e) enable vendors to supply appropriate tools for implementing integration of manufacturing operations management systems;
f) enable users to better identify their needs;
g) reduce the cost of automating manufacturing processes;
h) optimize supply chains; and
i) reduce life-cycle engineering efforts.

IEC 62264-3 and this part of IEC 62264 may be used to reduce the effort associated with implementing new product offerings. The goal is to have manufacturing operations management systems that interoperate and easily integrate.

It is not the intent of the standards to

1) suggest that there is only one way of implementing integration of manufacturing operations management systems;
2) force users to abandon their current way of handling integration; or
3) restrict development in the area of integration of manufacturing operations management systems.

ENTERPRISE-CONTROL SYSTEM INTEGRATION –

Part 4: Object model attributes for manufacturing operations management integration

1 Scope

This part defines object models and attributes exchanged between Level 3 manufacturing operations management activities defined in IEC 62264-3.

2 Normative references

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

IEC 62264-1:2013, *Enterprise-control system integration – Part 1: Models and terminology*

IEC 62264-2:2013, *Enterprise-control system integration – Part 2: Object and attributes for enterprise-control system integration*

IEC 62264-3, *Enterprise-control system integration – Part 3: Activity models of manufacturing operations management*

IEC 61512-1, *Batch control – Part 1: Models and terminology*

IEC 61512-4:2009, *Batch control – Part 4: Batch production records*

IEC 62682, *Management of alarm systems for the process industries*

ISO/IEC 19501, *Information technology – Open Distributed Processing – Unified Modeling Language (UML) Version 1.4.2*

ISO/IEC 19505-1, *Information technology – Object Management Group Unified Modeling Language (OMG UML) – Part 1: Infrastructure*

ISO/IEC 19505-2, *Information technology – Object Management Group Unified Modeling Language (OMG UML) – Part 2: Superstructure*

ISO 8601, *Data elements and interchange formats – Information interchange – Representation of dates and times*

3 Terms, definitions, abbreviations and conventions

3.1 Terms and definitions

For the purposes of this document the terms and definitions given in IEC 62264-1 as well as the following apply.

3.1.1
batch production record
BPR
subset of the execution and business information that is retained based upon business requirements identified by the batch production record specification

Note 1 to entry: This note applies to the French language only.

[SOURCE: IEC 61512-4:2009, 3.2]

3.1.2
job list
collection of job orders for one or more work centers and/or resources for a specific time frame

3.1.3
job order

unit of scheduled work that is dispatched for execution

3.1.4
job response
information on the result of execution of a job order

3.1.5
job response list
collection of job responses for one or more work centers and/or resources for a specific time frame

3.1.6
resource relationship network
one or more expressions of a relationship between two or more resources

3.1.7
work alert
notification of a Level 3 event that does not require acknowledgement

3.1.8
work calendar
collection of work calendar entries

3.1.9
work calendar entry
information about a specific time period

3.1.10
work capability
collection of information about the resources for work for selected future and past times

3.1.11
work definition
collection of information about resources and workflow specification associated with job orders

3.1.12
work directive
type of work definition derived from a work master and used to perform a specific job order

3.1.13
work KPI
key performance indicator related to Level 3 activities

3.1.14
work master
type of work definition that is a template for work to be performed for a job order

3.1.15
work performance
collection of work responses

Note 1 to entry: This note applies to the French language only.

3.1.16
work master capability
collection of information about the resources for selected future and past times for a specific work master

3.1.17
work record
subset of the execution and business information that is retained based upon business requirements

3.1.18
work request
collection of job orders

3.1.19
work response
collection of job responses

3.1.20
work schedule
detailed schedule of MOM activities as a collection of work requests

3.1.21
workflow specification
information representing work as a pattern of activities used to orchestrate the execution of procedures

EXAMPLE A repeatable sequence of procedures, enabled by an organization of resources with defined roles corresponding to flows of mass, energy or information.

3.2 Symbols and abbreviations

BPMN Business Process Model and Notation
BPR Batch production record
ERP Enterprise resource planning
ID Identifier
KPI Key performance indicator
MES Manufacturing execution system
MOM Manufacturing operations management
SOP Standard operating procedures
UML Unified Modeling Language
UTC Coordinated Universal Time

3.3 Conventions

Italics are used, beyond the use defined in ISO/IEC Directives Part2, to emphasize the 62264 specific meaning of terminology. They are used for the following cases:

– Names of objects used in exchanged data

4 Information exchange between manufacturing operations

4.1 Activity information exchange network

A set of models are used to represent the information exchanged between activities defined in IEC 62264-3. This is illustrated in Figure 1 with each information model represented as black rounded rectangles. This part of IEC 62264 defines models of information which can be exchanged between Level 3 activities (represented as ellipses in the figure) within an operational category or across operational categories. IEC 62264-2 defines models of information that may be exchanged between Level 4 activities and Level 3 activities and are represented as yellow rounded rectangles. Other information (represented as hashed elements) shown in Figure 1 is defined in other standards, such as IEC 61512 and IEC 62541.

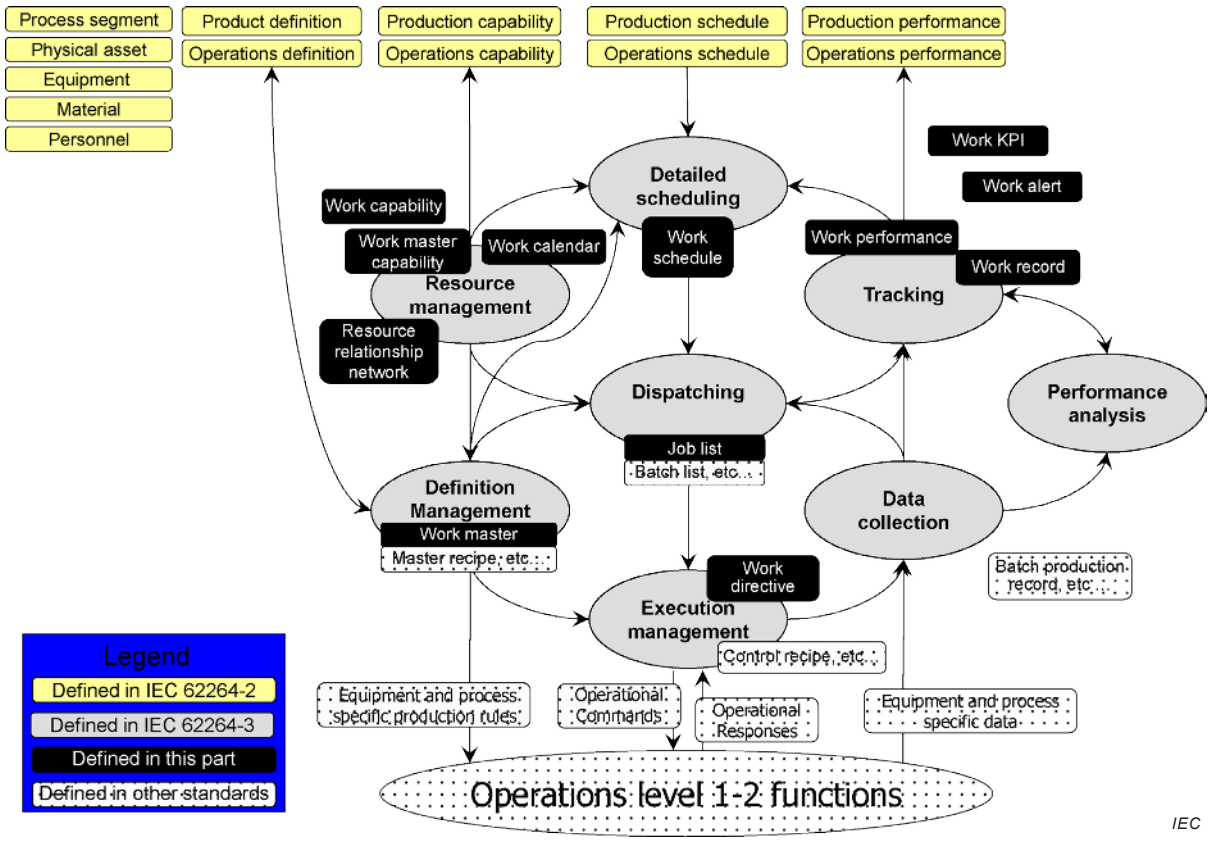


Figure 1 – Information exchange models for manufacturing operations management

NOTE IEC 61512 defines object models that relate to the lower elements of the Level 3 activities and defines the information used to create and manage master recipes, control recipes, batch lists, and batch production records. Equivalent structures, or IEC 61512 structures, could be used for other types of production. This standard does not redefine these objects.

4.2 Information exchange models

4.2.1 Overview

The information exchange models define structures that can be used to define, manage, and execute work within Level 3. The models are similar in structure to those defined in IEC 62264-2 but are defined for information exchange between Level 3 activities.

4.2.2 Process segments and work masters

IEC 62264-2 models define the view of manufacturing as seen by Level 4 business systems and based on a view of the manufacturing processes defined in *process segments*. The models of this part of IEC 62264 define the view of manufacturing as seen by Level 3 operations and are based on a view of the manufacturing processes defined in *work masters*.

Work masters define the resources and steps for *job orders* that are scheduled, displayed, executed, and tracked by Level 3 activities.

NOTE IEC 62264-2 models are used to exchange information from the process segment (business) view for Level 4 planning. Models such as *operations definition* and *operations schedule* support the allocation of resources and scheduling activities to the plant. Models in this part of IEC 62264 are used to exchange information for Level 3 execution. Models such as *work master* reference the operations definition exchanged with Level 4, but they have the details needed for actual execution of Level 3 activities. See Annex B for additional discussion of IEC 62264-2, this part of IEC 62264, and IEC 61512 model relationships.

4.2.3 Common resource definitions

The object models in this part of IEC 62264 use the personnel, equipment, physical asset, and material information defined in IEC 62264-2. When used with Level 3 work objects, the personnel, equipment, physical asset, and material information may include information required for Level 3 activities in addition to the information required to be shared with Level 4 activities.

EXAMPLE 1 The personnel information required for Level 3 activities can include detailed experience and qualification levels that are not shared with a Level 4 personnel or training management system.

EXAMPLE 2 The material information maintained for Level 3 activities can include sublot information which is not shared with Level 4 material management systems.

EXAMPLE 3 Delivery, usage and emission of energy units can be handled as material information.

4.2.4 Work models

The following object models are defined in this part of IEC 62264.

1) Resource relationship network – *Resource relationship networks* are created by tasks in resource management and definition management activities.
2) Work definition
   a) Work master – *Work masters* are created by an engineering activity defined in IEC 62264-1 and to be managed by a task in definition management activities.
   b) Work directive – *Work directives* are created by a task in execution management activities.
3) Work schedule – *Work schedules* are created by a task in detailed scheduling activities.
4) Job list – *Job lists* are created by a task in dispatching activities.

   NOTE 1 In this part of IEC 62264, the term job is sometimes used instead of job order when referring to an entry in a job list.
5) Work performance – *Work performances* are created by a task in tracking activities.
6) Work capability – *Work capabilities* are created by a task in resource management activities.

7) Work master capability – *Work master capabilities* are created by a task in resource management activities.
8) Work KPI – *Work KPIs* may be created by a task in any of the activities.

NOTE 2 See ISO 22400 for a definition of the KPI object model, attributes, and standard KPIs.

9) Work alert – *Work alerts* may be created by any activity in the activity model.
10) Work calendar – *Work calendars* may be created by a task in resource management activities.

NOTE 3 *Work calendars* can also be created by a task in a Level 4 activity.

11) Work record – *Work records* are created by a task in tracking activities.

5 Object model representation

5.1 Minimum attribute sets

Clause 5 describes the methods used to define object models and attributes for information exchanged in between Level 3 activities. The attributes are part of the definition of object models for exchanged information.

A minimum set of industry-independent information are defined as attributes of the object models. However, values for all attributes may not be required depending on the actual usage of the models. If additional information, including industry- and application-specific information, is needed, it shall be represented as property objects. This solution increases the usability through the use of standard attributes, and allows flexibility and extensibility through the use of properties.

NOTE This was written to make the standard as widely applicable as practical.

5.2 Attribute extensibility

For particular applications, the objects defined in the object models will be extended through the addition of attributes to object class definitions. Accordingly this standard provides for attributes that are application or industry specific, to be modeled in terms of properties and represented in property classes in the model.

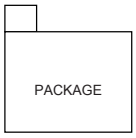
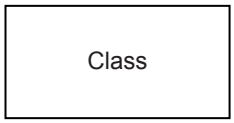
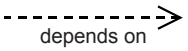
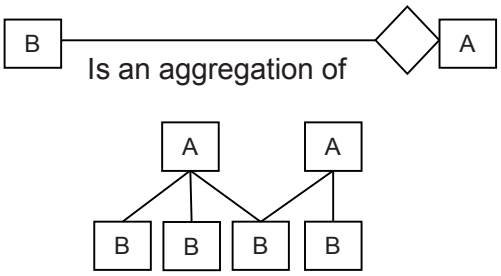
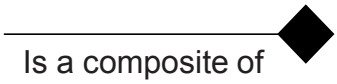
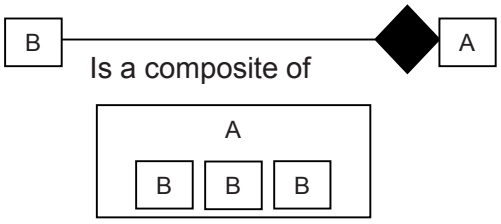
EXAMPLE The personnel class property may define application- or industry-specific attributes for personnel classes, and person property may contain values for the properties.

5.3 Object model structure

The object models are depicted using the Unified Modeling Language (UML) notational methodology, as defined in ISO/IEC 19501, ISO/IEC 19505-1 and ISO/IEC 19505-2.

Table 1 defines the UML notations used in the object diagrams.

Table 1 – UML notation used

Symbol	Definition
	Defines a package, a collection of object models, state models, use cases, and other UML models. Packages are general-purpose grouping mechanisms used to organize semantically related model elements. In this document a package is used to specify an external model, such as a production rule model, or a reference to another part of the model.
	Represents a UML class of objects, each with the same types of attributes. Each object is uniquely identifiable or enumerable. No operations or methods are listed for the classes.
	An association between elements of a class and elements of another or the same class. Each association is identified. May have the expected number or range of members of the subclass, when 'n' indicates an indeterminate number. For example, 0..n means that zero or more members of the subclass may exist.
	Generalization (arrow points to the super class) shows that an element of the class is a specialized type of the super class.
	Dependence is a weak association that shows that a modeling element depends on another modeling element. The item at the tail depends on the item at the head of the relationship.
	Aggregation shows that an element of the class is made up of elements of other classes. EXAMPLE 1 
	Composite shows a strong form of aggregation, which requires that a part instance be included in at most one composite at a time and that the composite object has sole responsibility for disposition of its parts. EXAMPLE 2 

5.4 Conventions used in table of attributes

5.4.1 Attribute table elements

A table is used to describe the attributes of each object in the object model. Each attribute table includes a listing of object attributes, as follows: the object identification, data types, and examples of the attributes and their values.

All attributes in the tables shall be considered optional, except where specified as required in the attribute description.

5.4.2 Object identification

Many objects in the information model require unique identifications (IDs). These IDs shall be unique within the scope of the exchanged information. This may require translations:

– from the internal ID of the source system to the interface content ID

– from the interface content ID to the internal ID of the target system

EXAMPLE A unit can be identified as “X6777” in the interface content, as resource “R100011” in the business system, and as “East Side Reactor” in the control system.

A unique identification set shall be agreed upon in an implementation in order to exchange information.

The object IDs are used only to identify objects within related exchanged information sets. The object ID attributes are not global object IDs or database index attributes.

Generally, objects that are elements of aggregations, and are not referenced elsewhere in the model, do not require unique IDs.

5.4.3 Data types of attributes

The attributes presented are abstract representations, without any specific data type specified.

EXAMPLE 1 An attribute can be represented as a string in one implementation and as a numeric value in another implementation.

EXAMPLE 2 A date/time value can be represented in ISO 8601 standard format in one implementation and in the Julian calendar format in another.

EXAMPLE 3 A relationship can be represented by two fields (type and key) in data base tables or by a specific tag in XML.

5.4.4 Value types

Value attributes are used in properties, parameters, and data to exchange actual values.

Value attributes are also used to exchange the allowed or expected values in properties and parameters. See IEC 62264-2:2013, 4.8, for a complete definition.

5.4.5 Presentation of examples

Example attribute values are included for each attribute. Examples are presented for each of the main operations categories defined in IEC 62264-3. See Table 2 below for how the example rows and columns are used.

Table 2 – Example table

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
Name of first attribute	Description of first attribute	Production example	Maintenance example	Quality example	Inventory example
Name of second attribute	Description of second attribute	Production example	Maintenance example	Quality example	Inventory example
Name of third attribute	Description of third attribute	Production example	Maintenance example	Quality example	Inventory example

When an example value is a set of values, or a member of a set of values, the set of values is given within a set of braces, {}.

NOTE The examples are purely made up. They are provided to further describe attributes in the model. No attempt was made to make the examples complete or representative of any manufacturing enterprise.

5.4.6 References to resources

The models used to document a reference to a resource, in another package with additional optional specification using properties, are not fully illustrated in IEC 62264-2 object model figures. See IEC 62264-2:2013, 4.5.5, for a complete description of data relationships.

6 Resource relationship network model

6.1 Resource relationship network

Resource relationship networks shall be used to describe relationships between two or more resources in order to represent information that may be required for detailed scheduling activities, dispatching activities, execution activities, or other Level 3 activities.

Each *resource relationship network* is a collection of *resource network connections*, as shown in Figure 2.

Each *resource relationship connection* shall be represented as a directed connection between a *to resource reference* and a *from resource reference*.

NOTE 1 Relationships are represented as directed multi-graphs in graph theory. Each relationship represents an “edge” with the resource references represented as vertices.

NOTE 2 The properties of the resource relationship elements are used to represent constraints in the network, such as constraints in flow, direction, set or ordering.

EXAMPLE 1 A “route” *resource network connection* between equipment can include properties that include the material transport time between the equipment and the material transfer rate between the equipment.

EXAMPLE 2 An “approved for use” *resource network connection* between equipment and material definitions can define which specific equipment has been approved for use with specific materials. A property of the *resource network connection* can be the date at which the approval for use is expired or revoked.

EXAMPLE 3 A “material substitution” *resource network connection* can define a primary material and the list of possible alternate materials.

Each *resource network connection* is defined by a *resource network connection type*. The *resource network connection type* may include *resource network connection type properties*, which define the allowable *resource network connection properties*.

NOTE 3 The *resource relationship network* model is conceptually similar to the MIMOSA CCOM network model. See Bibliography.

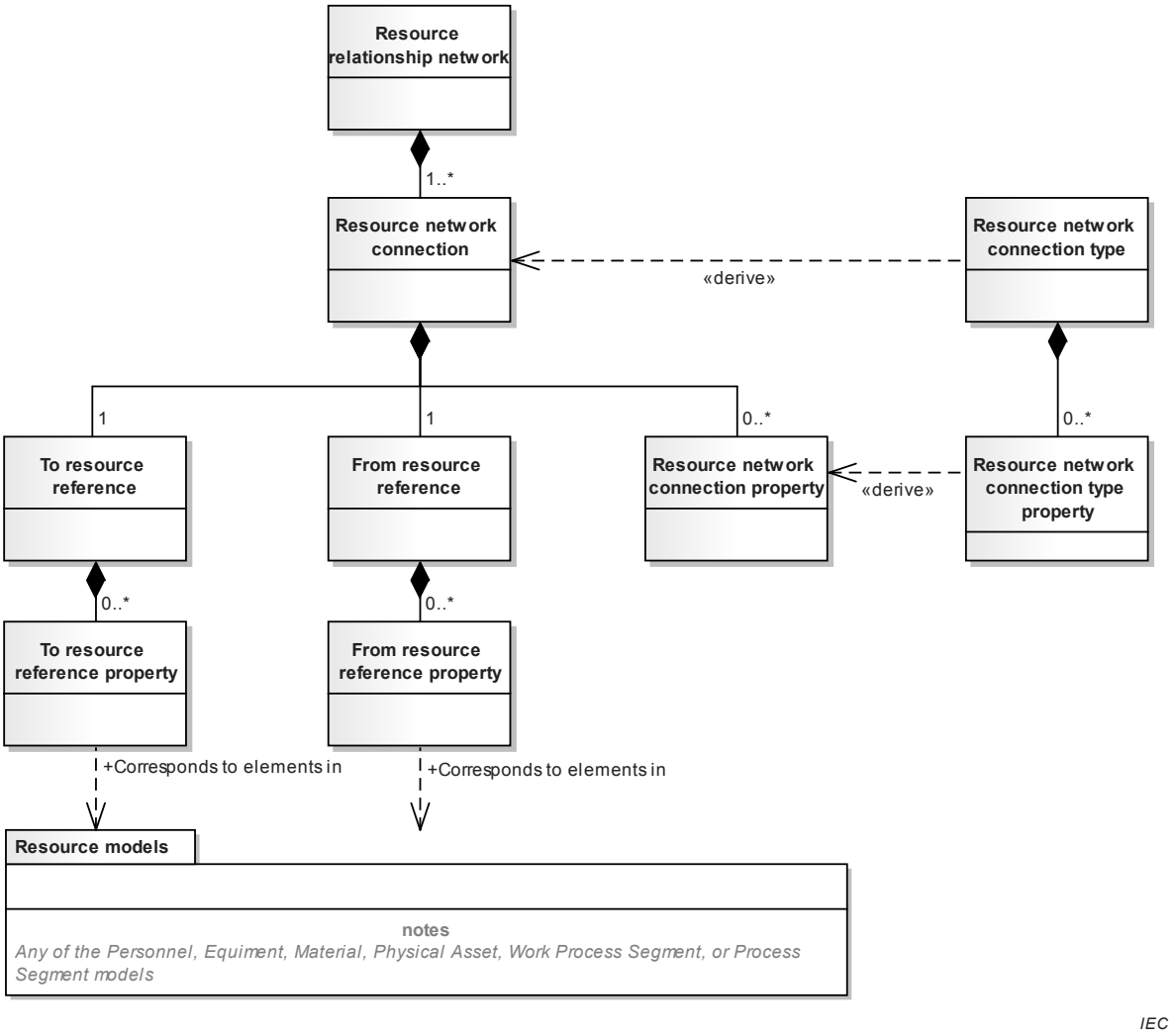


Figure 2 – Resource relationship network model

6.2 Resource relationship network attributes

A *resource relationship network* shall be a composition of one or more *resource network connections*.

Table 3 defines the attributes for *resource relationship network* objects.

Table 3 – Resource relationship network attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of a *resource relationship network*.	BN5FP	B5EN	B5RS	BFFTR
Description	A description of the *resource relationship network*.	Building 5 flow path	Building 5 electrical network	Building 5 receive signoff	Building 5 fork truck route
Relationship type	Optional: Defines the type of the relationship. The defined types are: Physical – The elements of the relationship are physically connected or in the same area. Logical – The elements of the relationship are not necessarily physically connected or in the same area.	Physical	Physical	Logical	Logical
Relationship form	Optional: Defines the form of the relationships. The defined types are: Permanent – The relationship is not intended to be split or changed during operations processes. Transient – The relationship may be spilt or changed during operations processes.	Permanent	Permanent	Permanent	Transient

6.3 Resource network connection

The directed relationship between two resources in a resource relationship network shall be defined as a *resource network connection*.

A *resource network connection* shall be composed of the following:

- a *from resource reference* relationship defining one *resource reference* (as the starting point of a directed connection or the tail of an arrow that graphically represents the relationship);
- a *to resource reference* relationship defining one *resource reference* (as the ending point of a directed connection or the head of an arrow that graphically represents the relationship);
- zero or more *resource network connection properties*;
- an associated *resource network connection type*.

Table 4 defines the attributes for *resource network connection* objects

Table 4 – Resource network connection attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of a *resource network connection*.	7685	6383290	Hyuwq9	TT28623
Description	A description of a *resource network connection*.	Piping	Wiring	Next signer	Next stop

6.4 Resource network connection property

A property of a *resource network connection* shall be defined as a *resource network connection property*.

Resource network connection properties are used to contain property values that are associated with the specific connection.

Table 5 defines the attributes of *resource network connection property* objects.

Table 5 – Resource network connection property attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of a *resource network connection property*.	Pipe type	Gauge	N/A	Inside
Description	Additional information about the *resource network connection property*.	Type of piping	Wire type	N/A	Location
Value	The value, set of values, or range of the property.	53	20	N/A	TRUE
Value unit of measure	The unit of measure of the associated property value, if applicable.	Steel grade	AWG	N/A	Boolean

6.5 From resource reference

A “from” reference to a resource shall be defined as a *from resource reference*.

A *from resource reference* may be composed of zero or more *from resource reference properties*.

Table 6 defines the attributes for *from resource reference* objects.

Table 6 – From resource reference attributes

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	A unique identification of a *from resource reference*.	12345	12346	A123	S7728
Resource ID	The ID of a resource.	B5Tank08	B5V480Box	Supervisor	Line3EndOfLine
Resource type	The type of the resource. The defined types are: Personnel class Person Equipment class Equipment Physical asset class Physical asset Material class Material definition Material lot Material sublot Work master Process segment Operation definition Operations segment	Equipment	Physical asset	Personnel class	Equipment

6.6 From resource reference property

A property of a *from resource reference* shall be defined as a *from resource reference property*.

NOTE A *from resource reference* with one or more *from resource reference properties* defines the subset of the *resource* that has the defined *resource property* values.

Table 7 defines the attributes for *from resource reference property* objects.

Table 7 – From resource reference property attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of a *from resource reference property*.	A7872	CB101	Hhjw78	Tye8
Property ID	The ID of a resource property.	Outlet flow rate	Circuit breaker	Shift	Storage Bay
Value	A value of a property that is used to identify the subset of the resources that are referenced.	200	40	First	42
Value unit of measure	The unit of measure of the associated property value, if applicable.	L/min	A	N/A	N/A

6.7 To resource reference

A “to” reference to a resource shall be defined as a *to resource reference*.

A *to resource reference* may be composed of zero or more *to resource reference properties*.

Table 8 defines the attributes for *to resource reference* objects.

Table 8 – To resource reference attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of a *to resource reference.*	12345	12346	A123	S7728
Resource ID	The ID of a resource.	B5Tank08	B5V480Box	Supervisor	Line3EndOfLine
Resource type	The type of the resource. The defined types are: Personnel class Person Equipment class Equipment Physical asset class Physical asset Material class Material definition Material lot Material sublot Work master Process segment Operation definition Operations segment	Equipment	Physical asset	Personnel class	Equipment

6.8 To resource reference property

A property of a *to resource reference* shall be defined as a *to resource reference property*.

NOTE A *to resource reference* with one or more *to resource reference properties* defines the subset of the *resource* that has the defined *resource property* values.

Table 9 defines the attributes for *to resource reference property* objects.

Table 9 – To resource reference property attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of a *to resource reference property*.	A7872	CB101	Hhjw78	N/A
Property ID	The ID of a resource property.	Outlet flow rate	Circuit breaker	Shift	N/A
Value	A value of a property that is used to identify the subset of the resources that are referenced.	200	40	First	N/A
Value unit of measure	The unit of measure of the associated property value, if applicable.	L/min	A	N/A	Boolean

6.9 Resource network connection type

A definition of a type of a *resource network connection* shall be defined as a *resource network connection type*.

A *resource network connection type* may be composed of zero or more *resource network connection type properties*.

Table 10 defines the attributes of *resource network connection type* objects.

Table 10 – Resource network connection type attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of a *resource network connection type*.	PC01	ME1	QE1	IE1
Description	A description of a *resource network connection type*.	Distribution piping	40 A breakers	N/A	WIP replenish-ment stops
Type	The connection type.	Piping connection	Electrical connection	N/A	WIP-STOPS

6.10 Resource network connection type property

A property of a *resource network connection type* shall be defined as a *resource network connection type property*.

Resource network connection type properties may be used to specify the defined properties that can be associated with the specific *resource network connection type*.

Table 11 defines the attributes of *resource network connection type property* objects.

Table 11 – Resource network connection type property attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of a *resource network connection type property*.	Pipe type	LowArc	N/A	Inside
Description	Additional information about the *resource network connection type property*.	Type of piping	Breaker low arc	N/A	Location
Value	The default value, set of values, or range of the property.	53	1	N/A	TRUE
Value unit of measure	The unit of measure of the associated property value, if applicable.	Steel grade	Type	N/A	Boolean

7 Work definition model

7.1 Work definition

An identification of the resources and workflow required to perform a specified unit of work shall be defined as a *work definition*. The *work definition* may apply to production, maintenance, quality test, and inventory activities. Figure 3 below is the common *work definition* model; objects shown as gray boxes are defined in IEC 62264-2.

Work definitions are modeled as an abstract class. There are two types of *work definitions* that are modeled as non-abstract classes: *work master* and *work directives*.

Work masters are template information not associated with any specific *job order*. *Work directives* start as copies of *work masters* and are augmented with information for a specific *job order*.

A *work definition* may have a reference to an *operations definition*. In this situation the *work definition* defines the detailed steps needed to accomplish all or part of the operation.

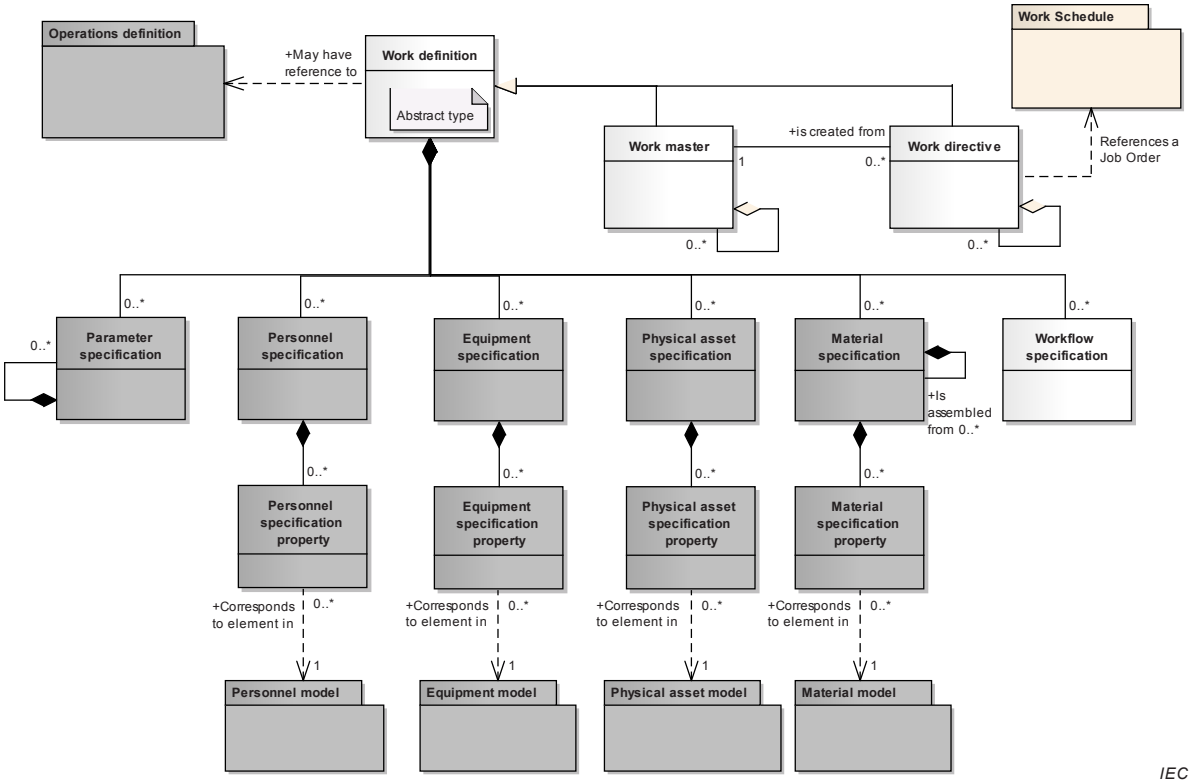


Figure 3 – Work definition model

7.2 Work master

The resources and instructions required to perform a unit of work without reference to a specific *job order* shall be defined as a *work master*. A *work master*:

- identifies material classes or material definitions;
- identifies nominal production run sizes (standard job order size);
- identifies equipment classes for work centers and work units;
- may identify other information required to execute the *work definition* for a *job order*.

EXAMPLE Instructions, automation procedures, SOPs, recipes, drawings, CNC programs, packaging specifications, label specifications, transition specification.

A *work master* may contain zero or more *work masters*, defining a hierarchy of *work masters* with the hierarchy defined through *workflow specification nodes* in the *workflow specification*.

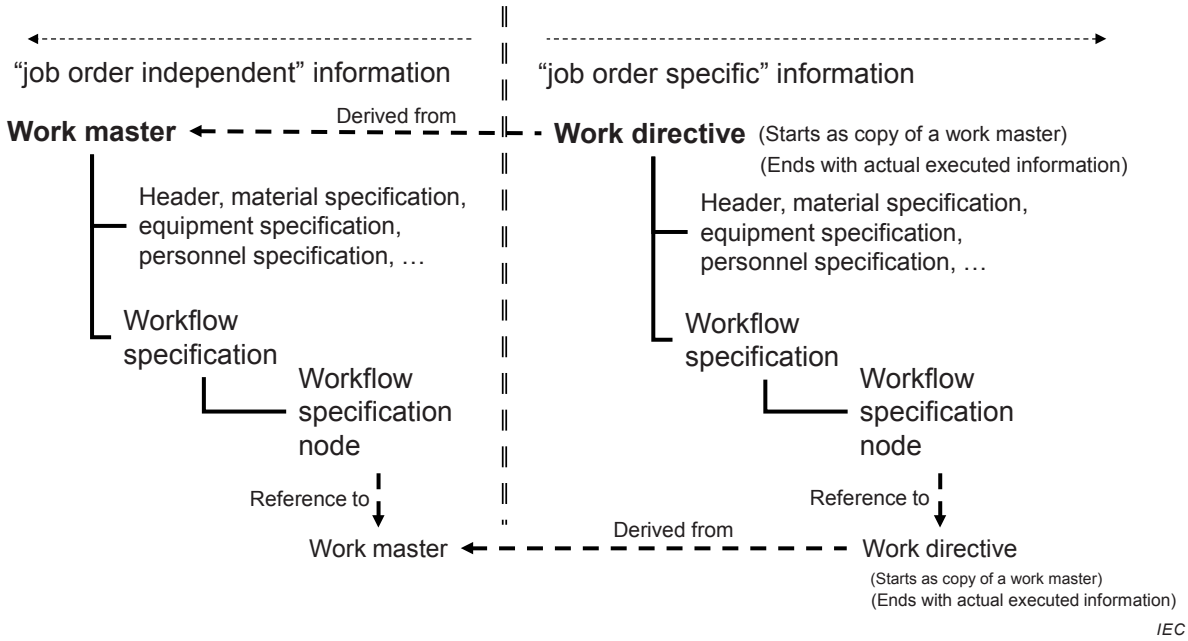
7.3 Work directive

The resources and instructions required to perform a unit of work for a specific *job order* shall be defined as a *work directive*. A *work directive*:

- is created as a copy of a *work master*;
- is used to control one *job order* or part of a *job order*;
- defines exact batch sizes or production run sizes;
- may identify *material lots* or *material sublots* for the *job order*;
- may identify specific work centers and/or work units for the *job order*;
- may identify specific personnel for the *job order*;
- Contains the actual executed information after execution of the *job order*.

A *work directive* may contain zero or more *work directives*, defining a hierarchy of *work directives* with the hierarchy defined through *workflow specification nodes* in the *workflow specification*.

There is one *work directive* for each *job order*. It contains the specific information required to perform the *job order* and the *workflow specification* associated with the *job order*. Figure 4 illustrates the recursive nature of *work masters* and *work directives*.



NOTE The dashed vertical line in Figure 4 represents the tasks in o*perations execution management* that create a *work directive* from a *work master* based on the requirements of the job list.

Figure 4 – Relationship of work master to work directive

Table 12 defines two addition attributes for *material specification* objects to support the *material lot* and *material sublot* information used in *work directives*.

Table 12 – Additional attributes of material specification

Attribute name	Description
Material lot	Identifies the associated *material lot* or set of *material lots* of the specification for a work directive.
Material sublot	Identifies the associated *material sublot* or set of *material sublots* of the specification for a work directive.

7.4 Work definition attributes

Table 13 defines the attributes for *work definition* objects.

Table 13 – Work definition attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of the *work definition*.	Export quality widget	Medium size AC motor overhaul	Potency test procedure	Tank transfer procedure
Version	An identification of the version of the *work definition*. In cases where there are multiple versions of a *work definition*, then the version attribute shall contain the additional identification information to differentiate each version.	1.0	1.4	1.1	1.1
Description	Contains additional information and descriptions of the *work definition.*	"Information defining resources required for work of a single 'export quality widget'"	For overhauls of motors less than 200 HP.	Test for potency of product	Movement of material from one tank to another
Work type	Describes the category of work. Required attribute. Defined values are: production, maintenance, quality, inventory, or mixed. "Mixed" shall be used when the work definition contains resources and routing information required to perform several types of work.	Production	Maintenance	Quality	Inventory
Work definition type	Describes the type of the workflow. It can be used to identify if the work definition is a high level definition used in scheduling/reporting or a low level step. There are no standard work definition types defined.	High level	Low level	Step	Top
Duration	Duration, if known.	25	4	1	40
Duration unit of measure	The units of measure of the duration, if defined.	Minutes	Hours	Day	Minutes

NOTE A MIMOSA *solution package* is the equivalent of a work definition for maintenance.

7.5 Parameter specification

The definition of this object and the attributes for this object are defined in IEC 62264-2.

A *parameter specification* may be made up of zero or more nested *parameter specifications*.

7.6 Personnel specification

The definition of this object and the attributes for this object are defined in IEC 62264-2.

7.7 Personnel specification property

The definition of this object and the attributes for this object are defined in IEC 62264-2.

7.8 Equipment specification

The definition of this object and the attributes for this object are defined in IEC 62264-2.

7.9 Equipment specification property

The definition of this object and the attributes for this object are defined in IEC 62264-2.

7.10 Physical asset specification

The definition of this object and the attributes for this object are defined in IEC 62264-2.

7.11 Physical asset specification property

The definition of this object and the attributes for this object are defined in IEC 62264-2.

7.12 Material specification

The definition of this object and the attributes for this object are defined in IEC 62264-2.

A *material specification* may be an assembly of zero or more nested *material specifications*.

7.13 Material specification property

The definition of this object and the attributes for this object are defined in IEC 62264-2.

7.14 Workflow specification

7.14.1 Workflow specification model

A *workflow specification* is represented as a collection of nodes and connections. Each node is defined by a type definition, and each connection is defined by a type definition. A node may contain a reference to a *work definition*.

Different workflow representations are described as collections of node types and connection types. See Annex C and Annex D for examples of workflow specifications for different formats.

NOTE 1 Workflows are not unique to the manufacturing operations management domain. See the Business Process Model and Notation (BPMN[1]) at http://www.omg.org/spec/BPMN/ as a possible structure for a workflow format.

NOTE 2 The IEC 61512-1 recipe definitions are a workflow format. See the IEC 61512-2 definition for the recipe structure.

NOTE 3 Flowcharts are a workflow format.

NOTE 4 An IDEF (Integrated DEFinition) diagram is a workflow format.

The *workflow specification* model is shown in Figure 5. The model is a general model for exchanging workflows and is not unique to any specific workflow format. It represents the workflow as a collection of nodes and connections. The meaning of the nodes and connections is determined by the workflow format.

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[1] BPMN is an example of a suitable specification available commercially. This information is given for the convenience of users of this standard and does not constitute an endorsement by IEC of BPMN products.

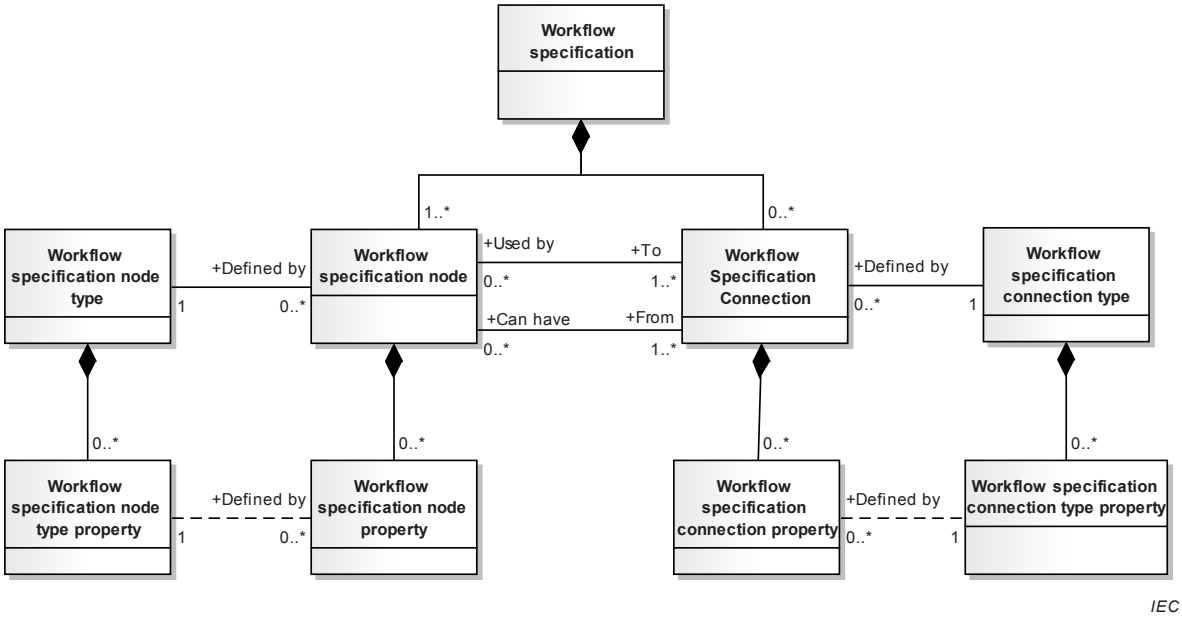


Figure 5 – Workflow specification model

EXAMPLE 1 Figure 6 is a workflow specification described in a BPMN format.

EXAMPLE 2 Examples of representation in a workflow specification include:

1) A *workflow specification* containing two *workflow specification nodes*, one for the MES (manufacturing execution system) and one for the ERP (enterprise resource planning). The MES and ERP nodes are of *workflow specification node type* = POOL.
2) The MES node contains a *workflow specification* (identified here as MES_01).
3) MES_01 contains 6 *workflow specification nodes* and 6 *workflow specification connections*.
4) The Scan Material *workflow specification node* is of *workflow specification node type* = TASK.
5) The connection between Scan Material and Planned contains a FROM link to Scan Material and a TO link to Planned. The connection is of type SEQUENCE FLOW.
6) The ERP node contains a *workflow specification* (identified here as ERP_01).
7) ERP_01 contains 1 *workflow specification node* and 1 *workflow specification connection*.
8) The connection between Get ERP Lot ID and Store Material contains a FROM link to Get ERP Lot ID and a TO link to Store Material. The connection is of type SEQUENCE FLOW.

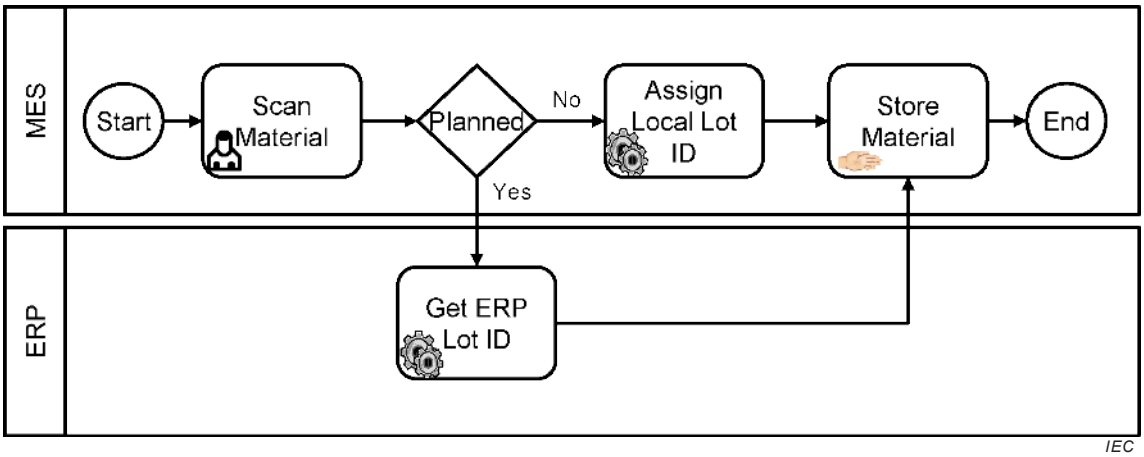


Figure 6 – Example of a workflow specification in BPMN format

EXAMPLE 3 Figure 7 is a workflow described in a flowchart notation.

EXAMPLE 4 Examples of representation in flowchart notation of a workflow specification include:

1) A workflow specification contains 7 workflow specification nodes and 7 workflow specification connections.
2) The Scan Material workflow specification node is of workflow specification node type = ACTIVITY.
3) The connection between Scan Material node and Planned node contains a FROM link to Scan Material and a TO link to Planned. The connection is of type SEQUENCE.
4) The connection between Get ERP Lot ID and Store Material contains a FROM link to Get ERP Lot ID and a TO link to Store Material. The connection is of type SEQUENCE.

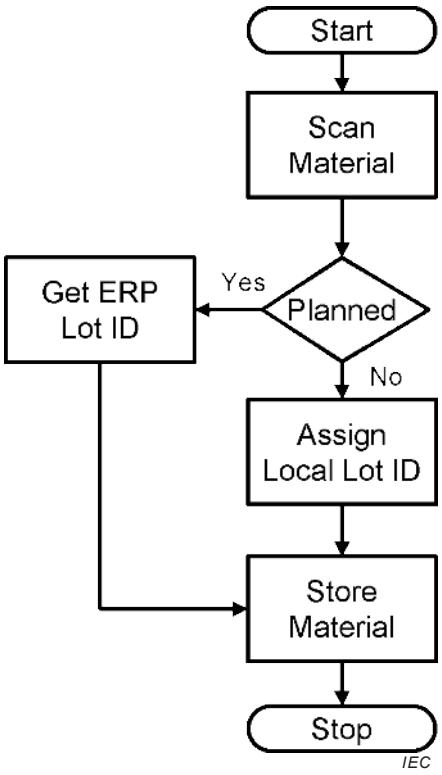


Figure 7 – Example of a workflow specification in flowchart format

7.14.2 Workflow specification attributes

A *workflow specification* shall be defined as a collection of *workflow specification nodes* and *workflow specification connections*.

A *workflow specification* shall contain at least one *workflow specification node*.

Table 14 defines the attributes for *workflow specification* objects.

Table 14 – Workflow specification attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	Uniquely identifies the *workflow specification*.	Make commercial grade widgets	Repair 20 HP water pump	Test receiving material	Receiving materials
Description	Contains additional information and descriptions of the *workflow specification.*	Instructions for making commercial grade widgets	Instructions for rebuild of 20 HP water pump	Instructions for SOP33456	Hazardous materials receiving SOP

7.14.3 Workflow specification node

A *workflow specification node* is a step in a workflow. It may have a reference to an activity executed in Level 2, a reference to a *work definition*, a nested *workflow specification*, or an entity used in the represented format (such as a decision element, transition condition, or starting point).

NOTE Nested workflow specifications, such as the IEC 61512 recipe hierarchy, are represented *through workflow specification nodes* that contain other *workflow specifications* (a unit procedure contains the operation definition).

Table 15 defines the attributes for *workflow specification node* objects.

See Annex C and Annex D for examples.

Table 15 – Workflow specification node attributes

Attribute name	Description
ID	Uniquely identifies the *workflow specification node*.
Description	Contains additional information and descriptions of the *workflow specification node.*
Work definition ID	Contains an identification of either a work master or a work directive

If the *workflow specification* is part of a *work master*, then the work definition ID shall reference a *work master*, else if the *workflow specification* is part of a *work directive*, then the work definition ID shall reference a *work directive*, otherwise if the *workflow specification* is directly exchanged then the work definition ID shall reference a *work master*.

7.14.4 Workflow specification node property

A property of a *workflow specification node* shall be defined as a *workflow specification node property*.

Workflow specification node properties may be used to specify the defined properties that can be associated with the specific node type.

Table 16 defines the attributes for *workflow specification node property* objects.

See Annex C and Annex D for examples.

Table 16 – Workflow specification node property attributes

Attribute name	Description
ID	A unique identification of the property.
Description	Additional information about the property.
Value	The default value, set of values, or range of the property.
Value unit of measure	The unit of measure of the associated property value, if applicable.

7.14.5 Workflow specification connection

A *workflow specification connection* represents a many-to-many link between *workflow specification nodes*.

NOTE The workflow specification connection type defines the allowed multiplicity of FROM and TO links.

Table 17 defines the attributes for *workflow specification connection* objects.

See Annex C and Annex D for examples.

Table 17 – Workflow specification connection attributes

Attribute name	Description
ID	Uniquely identifies the *workflow specification connection*.
Description	Contains additional information and descriptions of the *workflow specification connection.*

EXAMPLE In a BPMN workflow structure, some of the following structuring elements would be represented as workflow specification connections; Sequence Flow, Default Flow, Conditional Flow.

7.14.6 Workflow specification connection property

A property of a *workflow specification connection* shall be defined as a *workflow specification connection property*.

Workflow specification connection properties may be used to specify the defined properties that can be associated with the specific connection.

Table 18 defines the attributes for *workflow specification connection property* objects.

See Annex C and Annex D for examples.

Table 18 – Workflow specification connection property attributes

Attribute name	Description
ID	A unique identification of the property.
Description	Additional information about the property.
Value	The default value, set of values, or range of the property.
Value unit of measure	The unit of measure of the associated property value, if applicable.

7.14.7 Workflow specification node type

A *workflow specification node type* defines the properties that can be associated with a specific *workflow specification node*.

Table 19 defines the attributes for *workflow specification node type* objects.

See Annex C and Annex D for examples.

Table 19 – Workflow specification node type attributes

Attribute name	Description
ID	Uniquely identifies the *workflow specification node type*.
Description	Contains additional information and descriptions of the *workflow specification node*.

7.14.8 Workflow specification node type property

A property of a *workflow specification node type* shall be defined as a *workflow specification node type property*.

Workflow specification node properties types specify the allowed properties that can be associated with a specific *workflow specification node*.

Table 20 defines the attributes for *workflow specification node type property* objects.

See Annex C and Annex D for examples.

Table 20 – Workflow specification node type property attributes

Attribute name	Description
ID	A unique identification of the property.
Description	Additional information about the property.
Value	The default value, set of values, or range of the property.
Value unit of measure	The unit of measure of the associated property value, if applicable.

7.14.9 Workflow specification connection type

A *workflow specification connection type* specifies the permissible information on a connection.

Table 21 defines the attributes for *workflow specification connection* objects.

See Annex C and Annex D for examples.

Table 21 – Workflow specification connection type attributes

Attribute name	Description
ID	Uniquely identifies the *workflow specification connection type*.
Description	Contains additional information and descriptions of the *workflow specification connection*.
From multiplicity	Defines the multiplicity of the from connection: one, one or more, zero or more, or an allowed range.
To multiplicity	Defines the multiplicity of the “to” connection: one, one or more, zero or more, or an allowed range.

7.14.10 Workflow specification connection type property

A property of a *workflow specification connection type* shall be defined as a *workflow specification connection type property*.

Workflow specification connection properties types specify the allowed properties that can be associated with specific *workflow specification connections*.

Table 22 defines the attributes for *workflow specification connection property* objects.

See Annex C and Annex D for examples.

Table 22 – Workflow specification connection property attributes

Attribute name	Description
ID	A unique identification of the property.
Description	Additional information about the property.
Value	The default value, set of values, or range of the property.
Value unit of measure	The unit of measure of the associated property value, if applicable.

8 Work schedule and job list models

8.1 Work schedule

A request for work shall be listed as a *work schedule*. A *work schedule* shall be made up of one or more *work requests*.

The *work schedule* may apply to scheduling of production, maintenance, quality test and inventory, or to other extended categories of activities.

A *work schedule* may be defined for any specific category of work: production, maintenance, quality, or inventory, or it may be defined for a combination of categories. When a combination is selected, then the *work requests* or *segment requirement* specifies the category of the work.

Figure 8 is the *work schedule* and *job list* model; objects shown as gray boxes are defined in IEC 62264-2.

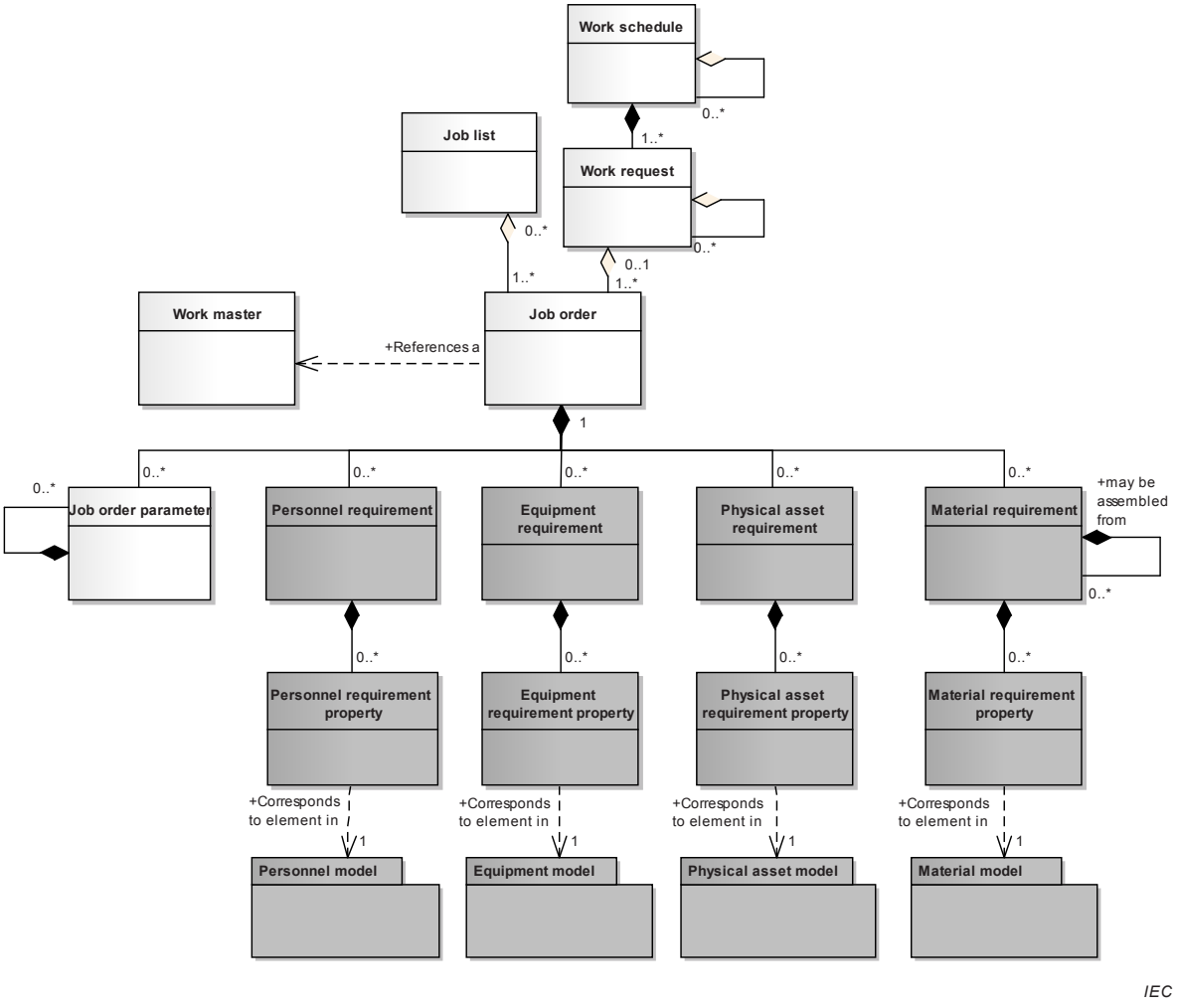


Figure 8 – Work schedule model

EXAMPLE 1 Figure 9 is an example of an *operations schedule* for a site.

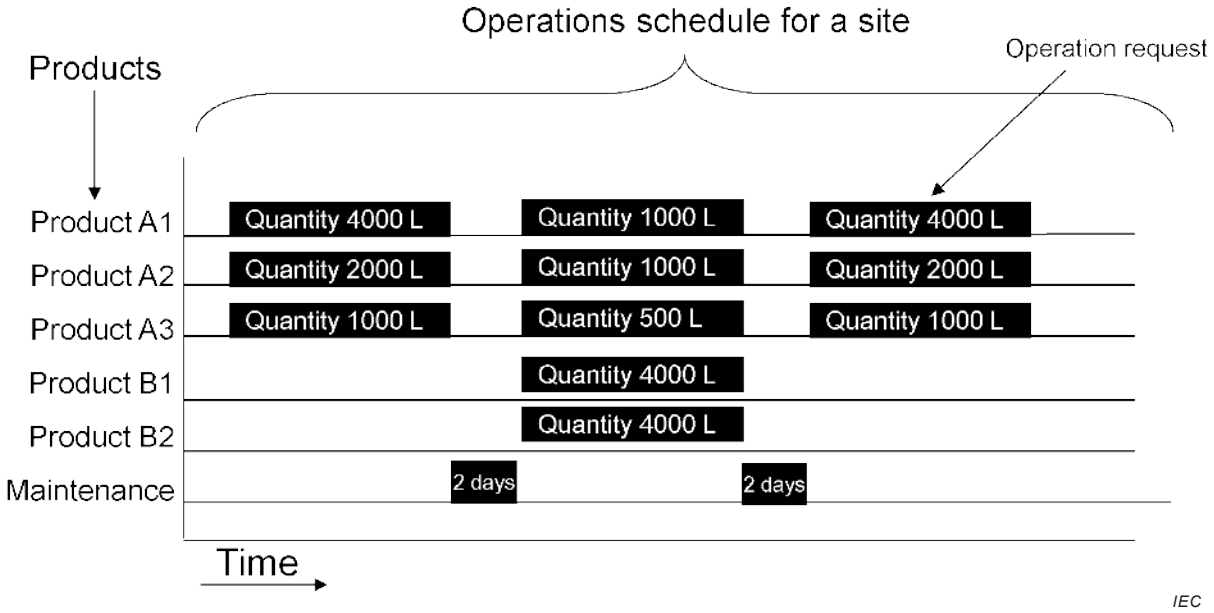


Figure 9 – Operations schedule for a site

EXAMPLE 2 Figure 10 is an example of a *work schedule* for an area in which one *operation request* is implemented in multiple *work requests*. In this example each *work request* is made up of multiple *job orders*.

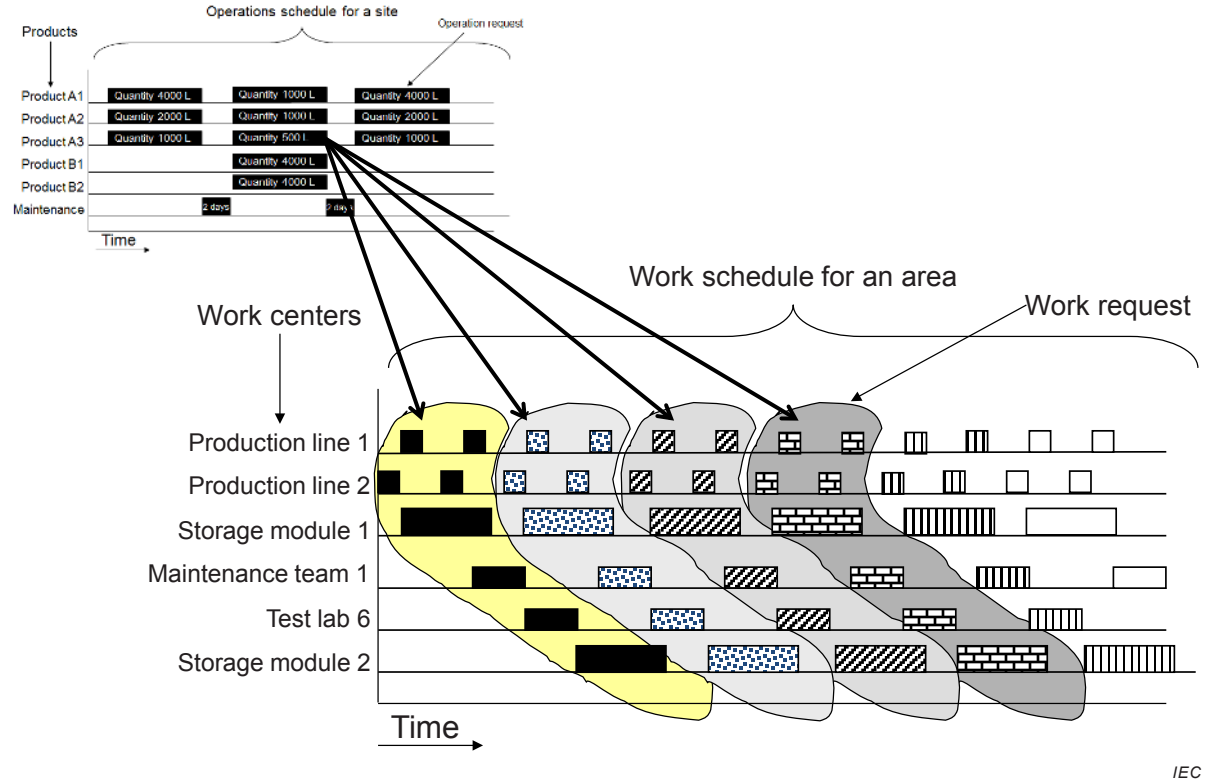


Figure 10 – Work schedule for an area

EXAMPLE 3 Figure 11 is an example of a *work request* with nested *job orders* and the associated *work master* for a *job order*. Each *job order* is associated with a *work master*.

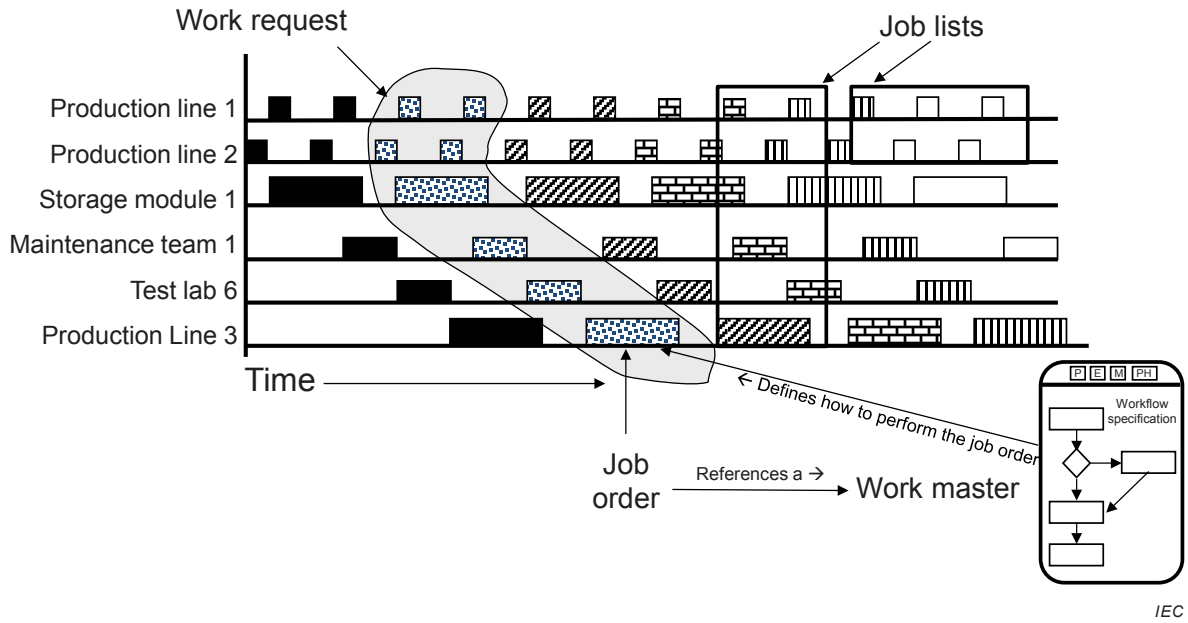


Figure 11 – Work request, job order, job list

Example 4 Figure 12 illustrates the use of a *work request* in a continuous process, where there can be no unused time between activities and where the *job list* can be the *job orders* required to perform a product slate switchover.

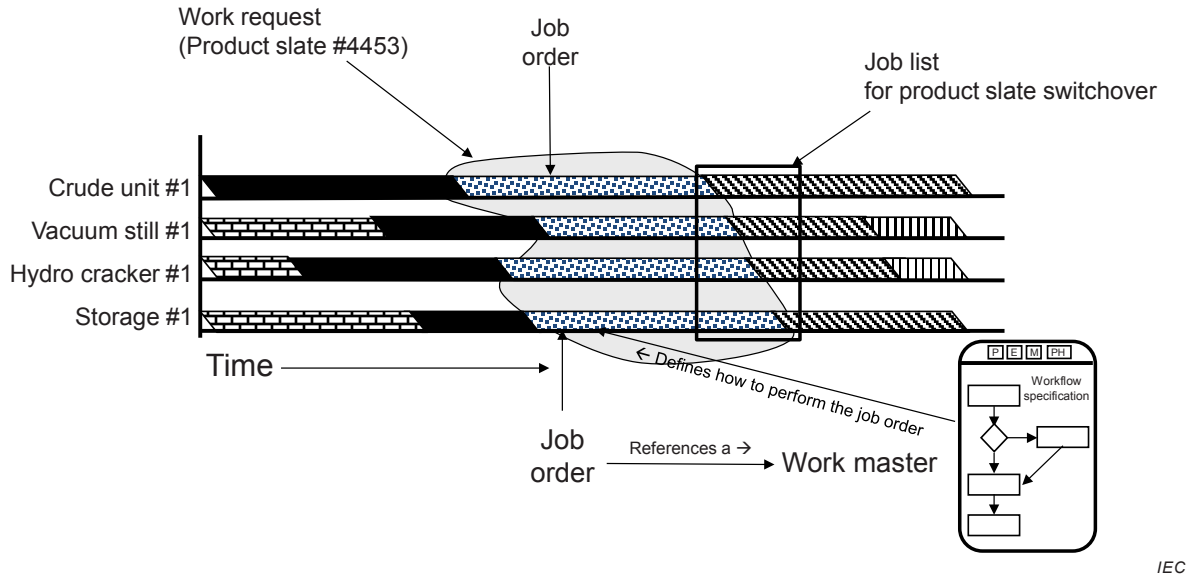


Figure 12 – Work request example for continuous processing

8.2 Work schedule attributes

Table 23 defines the attributes for *work schedule* object.

A *work schedule* may be made up of zero or more nested *work schedules*.

Table 23 – Work schedule attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of the *work schedule* and could include version and revision identification. The ID shall be used in other parts of the model when the *work schedule* needs to be identified.	PMMFUF	MWOIDND	QNFKVUV	IECBDU
Work type	Describes the category of work. Required attribute. Defined values are: production, maintenance, quality, inventory, and mixed. "Mixed" shall be used when the work schedule contains several types of work requests and/or segment requirements.	Production	Maintenance	Quality	Inventory
Description	Contains additional information and descriptions of the *work schedule*.	"Widget manufacturing schedule"	"Daily planned maintenance"	"Widget raw material testing schedule"	"Widget raw material staging schedule"
Start time	The starting time for the associated *work schedule*, if applicable.	10-28-2006	10-28-2006	10-28-2006	10-28-2006
End time	The ending time for the associated *work schedule*, if applicable.	10-30-2006	10-30-2006	10-30-2006	10-30-2006
Published date	The date and time on which the *work schedule* was published or generated.	12-30-1951 18:30 UTC	10-17-2005 18:30 UTC	10-17-2005 18:30 UTC	10-17-2005 18:30 UTC
Hierarchy scope	Identifies where the exchanged information fits within the role based equipment hierarchy.	East Wing manufacturing line #2	CNC Machine Asset ID 13465	Test cell 4 Receiving	Warehouse B

NOTE A MIMOSA *segment request for work* and an *asset request for work* are the equivalent of a work request for either equipment or for a physical asset. The table of *request for work* is the equivalent of the work schedule.

8.3 Work request attributes

A request for work defined by a set of *job orders* shall be defined as a *work request*. A *work request* contains the information required by manufacturing to fulfill scheduled work. This may be a subset of the business information, or it may contain additional information not normally used by the business system.

A *work request* shall contain at least one *job order*.

A *work request* may include

a) when to start work, typically used if a scheduling system controls the schedule;

b) when the work is to be finished, typically used if the manufacturing operations system controls its internal schedule to meet deadlines;

c) the priority of the request, typically used if exact ordering of production is not externally scheduled.

Additional information may be described in the associated *job order's* parameters, personnel requirements, equipment requirements, and material requirements.

A *work request* may be made up of zero or more nested *work requests*.

A *work request* may be reported on by one or more *work responses*.

Table 24 defines the attributes for *work request* objects.

Table 24 – Work request attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of the *work request*. The ID shall be used in other parts of the model when the *work request* needs to be identified.	1001091	CNC-PM-F1	SAMP#1A	BLEND KIT 101
Work type	Describes the category of work. Required attribute. Defined values are: production, maintenance, quality, inventory, and mixed. "Mixed" shall be used when the work request contains several types of job orders.	Production	Maintenance	Quality	Inventory
Description	Contains additional information and descriptions of the *work request*.	"Work request for export quality widgets for October 29, 1999"	Preventive maintenance of CNC machine for runtime exceeding 1 500 h	Take batch sample at end of batch	Prepare dispense kit for batch
Start time	When work is to be started, if applicable.	1999-10-27 8:00 UTC	2011-03-07	N/A	8:00 AM
End time	When work is to be completed, if applicable.	1999-10-27 17:00 UTC	2011-03-10	N/A	8:30 AM
Priority	The priority of the request, if applicable.	Highest	Low	High	N/A
Hierarchy scope	Identifies where the exchanged information fits within the role based equipment hierarchy.	East Wing manufacturing line #2	CNC machine Asset ID 13465	Test cell 4 Receiving	Warehouse B

8.4 Job list definition

A *job list* shall be defined as a collection of *job orders* for a specific period of time and selected work centers or other resources. A *job list* may be considered as a slice of *work schedules*.

A *job list* may contain *job orders* from multiple *work requests* and *work schedules*. The model for *job lists* is shown in Figure 8; objects shown as gray boxes are defined in IEC 62264-2.

NOTE 1 The determination of how to specify a slice of work *schedules is* not defined in this standard.

EXAMPLE 1 Slices can be by time, for example, all *job orders* for the first shift for a specific day, or by equipment and time such as all *job orders* for production line 1 for the next week.

EXAMPLE 2 Slices can be by resource, for example all *job orders* for a specific work cell for some period of time.

NOTE 2 The level of granularity of a *job list* is determined by the applications. It can be very granular and refer to level 2 equipment, or it can be less granular and refer to equipment at the planning level.

Job lists may contain a sequence of *job orders*. In this case the order in which *job orders* are sequenced is embedded in the *job list* entry start rules.

8.5 Job list attributes

Table 25 lists the attributes of *job list. Job list* has the same attributes as *work requests*, because it is a slice of a *work schedule*.

Table 25 – Job list attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of the *job list* and could include version and revision identification. The ID shall be used in other parts of the model when the *job list* needs to be identified.	PMMFUF	MWOIDND	QNFKVUV	IECBDU
Work type	Describes the category of work. Required attribute. Defined values are: production, maintenance, quality, inventory, and mixed. “Mixed” shall be used when the work schedule contains several types of job orders.	Production	Maintenance	Quality	Inventory
Description	Contains additional information and descriptions of the *job list*.	“Widget manufacturing schedule”	“Daily planned maintenance”	“Widget raw material testing schedule”	“Widget raw material staging schedule”
Start time	The starting time for the associated *job list*, if applicable.	10-28-2006	10-28-2006	10-28-2006	10-28-2006
End time	The ending time for the associated *job list*, if applicable.	10-30-2006	10-30-2006	10-30-2006	10-30-2006
Published date	The date and time on which the *job list* was published or generated.	12-30-1951 18:30 UTC	10-17-2005 18:30 UTC	10-17-2005 18:30 UTC	10-17-2005 18:30 UTC
Hierarchy scope	Identifies where the exchanged information fits within the role based equipment hierarchy.	East Wing manufacturing line #2	CNC machine Asset ID 13465	Test cell 4 Receiving	Warehouse B

8.6 Job order attributes

The unit of work requested for execution in a *job list* and a *work request* shall be defined as a *job order*. A *job order* references an associated *work master*.

A *job order* may be reported by one or more *job responses*.

Table 26 lists the attributes of *job order.* It has attributes to contain information added by the dispatching activities.

Table 26 – Job order attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of the *job order*. The ID shall be used in other parts of the model when the *job order* needs to be identified.	1001091	DO4833-A	EE9O989	38483ED
Work type	Describes the category of work. Required attribute. Defined values are: production, maintenance, quality, inventory, and mixed. "Mixed" shall be used when the work request contains several types of segment requirements.	Production	Maintenance	Quality	Inventory
Description	Contains additional information and descriptions of the *job order.*	"Work request for export quality widgets for October 29, 1999"	"Work order to repair shear"	"Ambient temperature sampling procedure"	"Stage material for production"
Work master ID	Identifies the associated *work master* to be used, if applicable.	Export quality widget	Repair shear	Raw material sampling procedure	Kit assembly
Work master version	Identifies the version of the associated *work master* to be used, if applicable.	V010		943	A84
Start time	When work is to be started, if applicable.	1999-10-27 8:00 UTC	2014-03-07 10:00 UTC	2010-04-27 20:30	2011-01-20 14:45 UTC-10:00
End time	When work is to be completed, if applicable.	1999-10-27 17:00 UTC	2014-03-08 08:00 UTC	2010-06-27 17:00	2011-01-27 09:30 UTC-10:00
Priority	The priority of the request, if applicable.	Highest	3	A	Medium
Hierarchy scope	Identifies where the exchanged information fits within the role based equipment hierarchy.	East Wing manufac-turing line #2	Lid press Asset ID 13465	Test cell 4 Receiving	Warehouse B
Command	Identifies the action the execution management activity is to perform on the job order.	Start Hold Cancel Abort Stop	Start Hold Cancel Abort Stop	Start Hold Cancel Abort Stop	Start Hold Cancel Abort Stop
Dispatch status	Identifies the status of the entry from the perspective of the dispatch activity. NOTE This status is similar to what planners would write on their whiteboard to track a job order.	Dispatched Pending Held Cancelled Delayed Completed	Dispatched Acknowledged In process Waiting for part	Dispatched Sampling Lab test in progress	Dispatched In transit In receipt Staged
Command rule	Instruction to execution management activities specifying conditions to execute the command.	Equipment is clean After *job order* WED89 is complete	Parts available and equipment not in production	Request from production Request from receiving	Stock out condition

8.7 Job order parameter

Information to be exchanged which cannot be mapped as personnel, equipment, physical asset or material properties shall be defined as *job order parameters*.

The attributes for a *job order parameter* are the same as those for a *segment parameter* defined in IEC 62264-2.

A *job order parameter* may be made up of zero or more nested *job order parameters*.

A *job order parameter* should include a set of limits that apply to any change to the value, such as quality limits and safety limits.

8.8 Personnel requirement

The definition of this object and the attributes for this object are defined in IEC 62264-2.

8.9 Personnel requirement property

The definition of this object and the attributes for this object are defined in IEC 62264-2.

8.10 Equipment requirement

The definition of this object and the attributes for this object are defined in IEC 62264-2.

8.11 Equipment requirement property

The attributes for equipment requirement property are defined in IEC 62264-2.

8.12 Physical asset requirement

The definition of this object and the attributes for this object are defined in IEC 62264-2.

8.13 Physical asset requirement property

The attributes for physical asset requirement property are defined in IEC 62264-2.

8.14 Material requirement

The definition of this object and the attributes for this object are defined in IEC 62264-2.

A *material requirement* may be an assembly of zero or more nested *material requirements*.

8.15 Material requirement property

The definition of this object and the attributes for this object are defined in IEC 62264-2.

8.16 Job order to work master relationship

Figure 13 illustrates an example of how a *job order* references a *work master*, and how steps in the *work master's workflow specification* may request additional *job orders* that have their own references to other *work masters*.

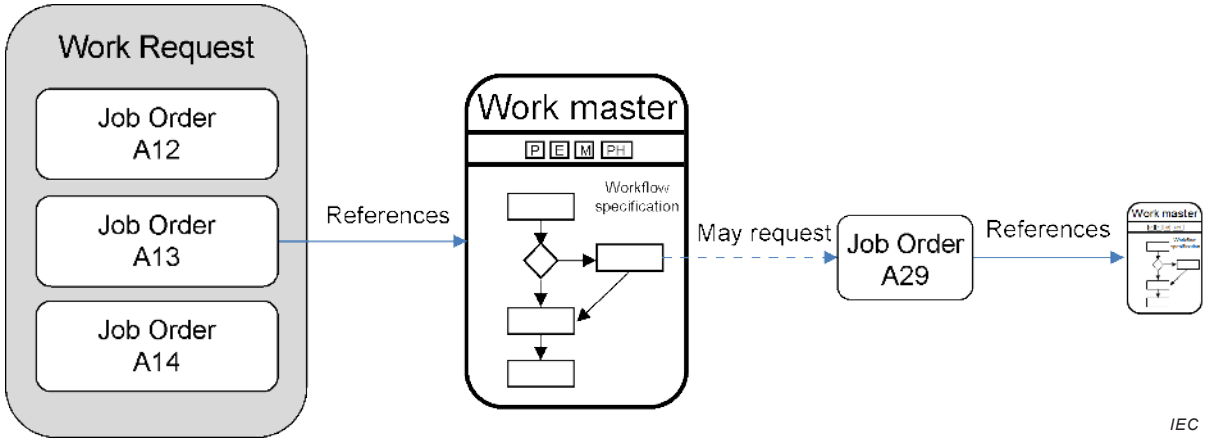


Figure 13 – Example of job orders and work master relationships

9 Work performance model

9.1 Work performance

Work performance shall be defined as a collection of *work responses* that is a report on requested manufacturing information. *Work responses* are responses from manufacturing that are associated with a *work request*. There may be one or more work responses for a single *work request* if the manufacturing facility needs to split the *work request* into smaller elements.

Figure 14 is the *work performance* model; objects shown as gray boxes are defined in IEC 62264-2.

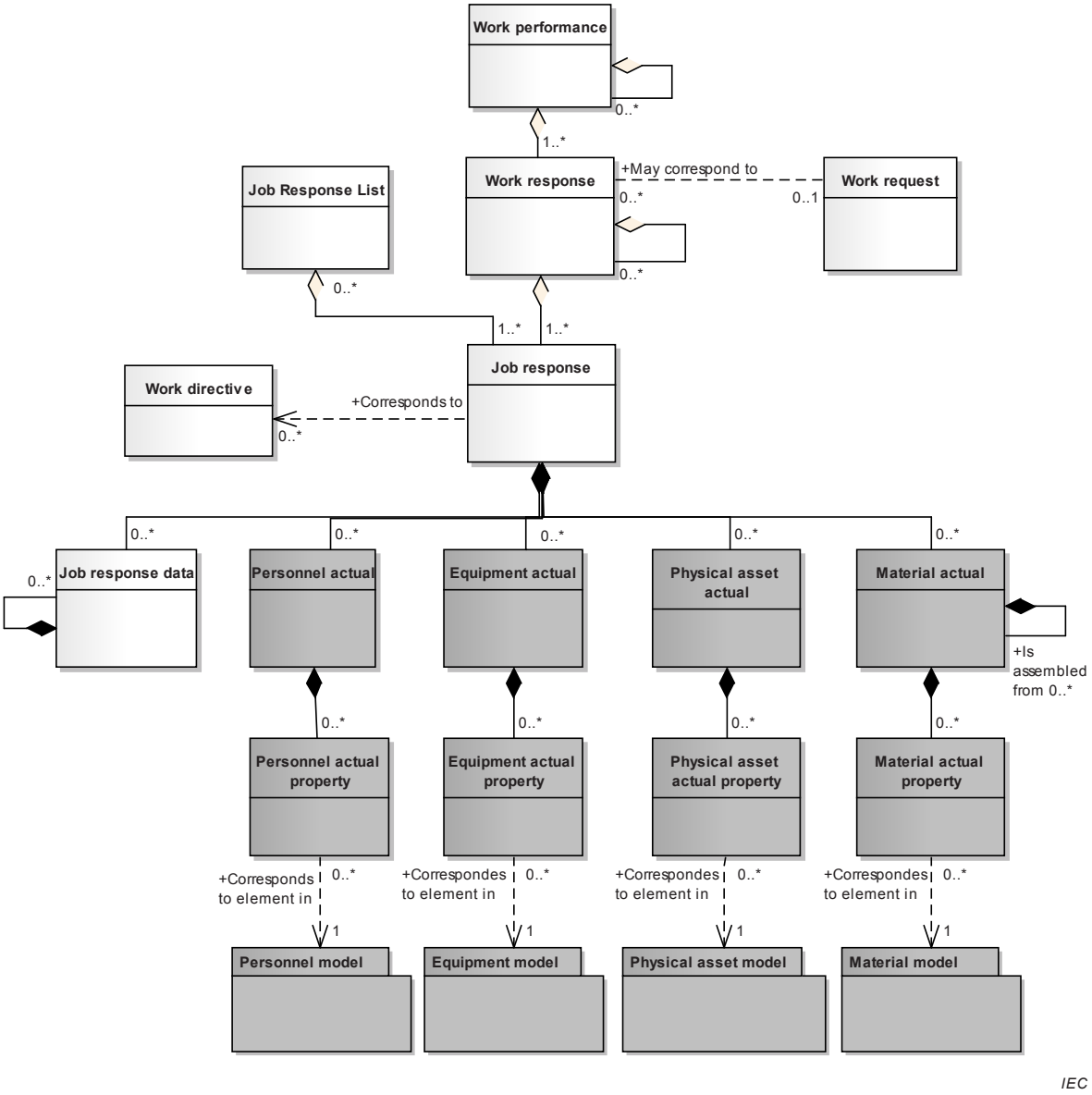


Figure 14 – Work performance model

9.2 Work performance attributes

Table 27 defines the attributes for *work performance* objects.

A *work performance* may be made up of zero or more nested *work performances*.

Table 27 – Work performance attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of the *work performance* and could include version and revision identification. The ID shall be used in other parts of the model when the *work performance* needs to be identified.	1999-10-27-A15	CNC-PM-20110307-13465	B12345-S01	B12345-KIT101-A
Work type	Describes the category of work.	Production	Maintenance	Quality	Inventory
Description	Contains additional information and descriptions of the *work performance*.	"Work performance report on October 27, 1999 work schedule."	Preventive maintenance performed on CNC machine	Production sample for batch 12345	Dispense kit for batch 12345
Work schedule	An identification of the associated *work schedule*, if applicable. *Work performance* may not relate to a *work schedule*, it may be a report on all work for a specific time, or reported on by plant floor events.	1999-10-27-A15	07MAR2011-CNC-13465	BATCH 12345 SAMPLE #1	BATCH 12345 KIT #1
Start time	The starting time of the associated *work performance*, if applicable.	10-28-1999	2011-03-07 09:31	N/A	2011-03-07 08:01
End time	The ending time of the associated *work performance*, if applicable.	10-30-1999	2011-03-10 11:15	N/A	2011-03-07 08:31
Published date	The date and time in which the *work performance* was published or generated.	10-27-1999 13:42 EST	2011-03-10 13:21	2009-12-14 13:31 PT	2011-03-07 08:33
Hierarchy scope	Identifies where the exchanged information fits within the role based equipment hierarchy.	East Wing manufacturing line #2	CNC machine Asset ID 13465	Test cell 4 Receiving	Warehouse B

9.3 Work response

The responses from manufacturing that are associated with a *work request* shall be defined as *work responses*. There may be one or more *work responses* for a single *work request* if the manufacturing facility needs to split the *work request* into smaller elements of work.

A *work response* may include the status of the request, such as the percentage complete, a finished status, or an aborted status.

A *work response* may be made up of zero or more nested *work responses*.

Table 28 defines the attributes for *work response* objects.

Table 28 – Work response attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification within the associated *work performance*. The ID shall be used in other parts of the model when the *work response* needs to be identified.	1001091	R-CNC-PM-20110307-13465	B12345-S01-RESP	B12345-KIT101-R
Work type	Describes the category of work.	Production	Maintenance	Quality	Inventory
Work request	An identification of the associated *work request*, if applicable. *Work response* may not relate to a *work request*, it may be a report on all work for a specific time, or reported on by plant floor events.	1001091	CNC-PM-20110307-13465	B12345-S01	B12345-KIT101-A
Start time	The starting time of this *work response*.	1999-10-27 8:33 UTC	2011-03-07 09:31	2011-03-10 15:12	2011-03-07 08:01
End time	The ending time of this *work response*.	1999-10-27 16:55 UTC	2011-03-10 11:15	2011-03-10 18:00	2011-03-07 08:31
Hierarchy scope	Identifies where the exchanged information fits within the role based equipment hierarchy.	East Wing manufacturing line #2	CNC machine Asset ID 13465	Test cell 4 Receiving	Zone B

9.4 Job response list

A *job response* list shall be defined as a collection of *job responses* for a specific period of time and selected work centers or other resources. A *job response list* may be considered as a slice of *work performances*.

A *job response list* may contain *job responses* from multiple *work responses* and *work performances*.

Table 29 defines the attributes for *job response list* objects.

Table 29 – Job response list attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification within the associated *job response list*.	Area51/Line 2	R-CNC-PM-20110307-13465	B12345-S01-RESP	B12345-KIT101-R
Work type	Describes the category of work.	Production	Maintenance	Quality	Inventory
Start time	The starting time of this *job response list*.	1999-10-27 8:33 UTC	2011-03-07 09:31	2011-03-10 15:12	2011-03-07 08:01
End time	The ending time of this *job response list*.	1999-10-27 16:55 UTC	2011-03-10 11:15	2011-03-10 18:00	2011-03-07 08:31
Hierarchy scope	Identifies where the exchanged information fits within the role based equipment hierarchy.	East Wing manufacturing line #2	CNC machine Asset ID 13465	Test cell 4 Receiving	Zone B

9.5 Job response

The responses from manufacturing that are associated with a *job order* shall be defined as a *job response*. There may be one or more *job responses* for a single *job order* if the manufacturing facility needs to split the *job order* into smaller elements of work.

A *job order* may include the status of the request, such as the percentage complete, a finished status, or an aborted status.

Table 30 defines the attributes for *job response* objects.

Table 30 – Job response attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification within the associated *work response*. The ID shall be used in other parts of the model when the *work response* needs to be identified.	1001091	R-CNC-PM-20110307-13465	B12345-S01-RESP	B12345-KIT101-R
Work type	Describes the category of work.	Production	Maintenance	Quality	Inventory
Job order	An identification of the associated *job order*, if applicable. *Job responses* may not relate to a *job order*, it may be a report on all work for a specific time, or reported on by plant floor events.	1001091	CNC-PM-20110307-13465	B12345-S01	B12345-KIT101-A
Work directive	Identifies the associated *work directive* that was used, if applicable. This may not match the request, if alternate specifications are allowed.	Export quality widget	Preventive maintenance of CNC machine	Take batch sample	Prepare kit
Work directive version	Identifies the version of the associated *work directive* that was used, if applicable.	1.0	V1.0	V2.0	VER A
Start time	The actual starting time of information in the *job response*.	1999-10-27 8:33 UTC	2011-03-07 09:31	2011-03-10 15:12	2011-03-07 08:01
End time	The actual ending time of information in the *job response*.	1999-10-27 16:55 UTC	2011-03-10 11:15	2011-03-10 18:00	2011-03-07 08:31
Hierarchy scope	Identifies where the exchanged information fits within the role based equipment hierarchy.	East Wing manufacturing line #2	CNC machine Asset ID 13465	Test cell 4 Receiving	Zone B

9.6 Job response data

Other information related to the actual work made shall be presented as *job response data*.

The attributes for *job response* data are defined in IEC 62264-2 as *segment data*.

A *job response data* object may be made up of zero or more nested *job response data* objects.

9.7 Personnel actual

The definition of this object and the attributes for this object are defined in IEC 62264-2.

9.8 Personnel actual property

The definition of this object and the attributes for this object are defined in IEC 62264-2.

9.9 Equipment actual

The definition of this object and the attributes for this object are defined in IEC 62264-2.

9.10 Equipment actual property

The definition of this object and the attributes for this object are defined in IEC 62264-2.

9.11 Physical asset actual

The definition of this object and the attributes for this object are defined in IEC 62264-2.

9.12 Physical asset actual property

The definition of this object and the attributes for this object are defined in IEC 62264-2.

9.13 Material actual

The definition of this object and the attributes for this object are defined in IEC 62264-2.

A *material actual* may be an assembly of zero or more nested *material actuals*.

9.14 Material actual property

The definition of this object and the attributes for this object are defined in IEC 62264-2.

10 Work capability model

10.1 Work capability

The collection of information about the resources for work for selected future and past times shall be defined as *work capability*. This is made up of information about committed, available, and unattainable equipment, material, personnel, physical assets, and work master capabilities. *Work capability* describes the names, terms, statuses, and quantities of which the manufacturing control system has knowledge.

NOTE *Work capability* is used when the capability and capacity do not vary based on the product being produced or any specific *work master* used.

Figure 15 is the *work capability* model that applies to the production, maintenance, quality test and inventory; objects shown as gray boxes are defined in IEC 62264-2.

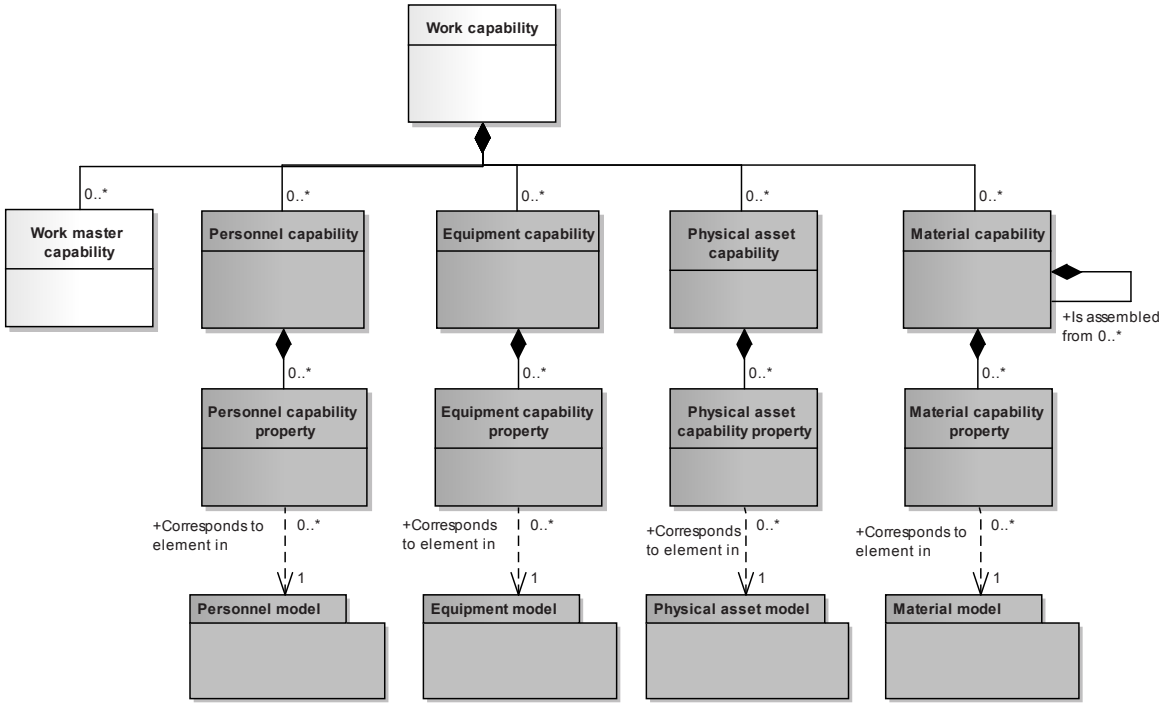


Figure 15 – Work capability model

10.2 Work capability attributes

Table 31 defines the attributes for *work capability* objects.

Table 31 – Work capability attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	Defines a unique instance of a *work capability* for a specified element of the equipment hierarchy model [IEC 62264-1:2013, 5.2] (*enterprise, site, area, work center, or work unit*).	1999/12/30-HPC52	HHG6778	LAB6678	AGV556
Description	Contains additional information and descriptions of the *work capability*.	"One day's work capacity for the Boston Widget Company."	Motor shop capacity, week 15	Lab centrifuge capacity	Pallet movement capacity
Capacity type	The capacity type: used, unused, total, available, unattainable, or committed.	Available	Total	Committed	Available
Reason	Defines the reason for the capability type. Example 1: If committed, then committed for work or for maintenance, or if unattainable, then the reason for the unavailability. Example 2: If unused capacity, then the reason the capacity was unused, such as a specific equipment failure or unacceptable product quality.	Available for work	Total hours of motor maintenance	Stability tests	Uncom-mitted AGVs
Confidence factor	A measure of the confidence of the capacity value. Example 3: A percentage value representing the confidence of the capacity.	90 %	100 %	100 %	75 %
Hierarchy scope	Identifies where the exchanged information fits within the role based equipment hierarchy. Zero or more as required to identify the specific scope of the work capability definition.	Boston Widget Company	Boston Widget Company	Boston Widget Company	Boston Widget Company
Start time	The starting date and time of the work capability.	2015-12-29 11:59	2011-04-03 12:00	2011-04-03 12:00	2011-04-03 12:00
End time	The ending date and time of the work capability.	2015-12-30 12:00	2011-04-09 11:59	2011-04-09 11:59	2011-04-09 11:59
Published date	The date and time on which the *work capability* was published or generated.	2015-11-03 13:55	2011-04-01 8:00	2011-04-01 8:00	2011-04-01 8:00

10.3 Personnel capability

The definition of this object and the attributes for this object are defined in IEC 62264-2.

10.4 Personnel capability property

The definition of this object and the attributes for this object are defined in IEC 62264-2.

10.5 Equipment capability

The definition of this object and the attributes for this object are defined in IEC 62264-2.

10.6 Equipment capability property

The definition of this object and the attributes for this object are defined in IEC 62264-2.

10.7 Physical asset capability

The definition of this object and the attributes for this object are defined in IEC 62264-2.

10.8 Physical asset capability property

The definition of this object and the attributes for this object are defined in IEC 62264-2.

10.9 Material capability

The definition of this object and the attributes for this object are defined in IEC 62264-2.

A *material capability* may be an assembly of zero or more nested *material capabilities*.

10.10 Material capability property

The definition of this object and the attributes for this object are defined in IEC 62264-2.

11 Work master capability model

11.1 Work master capability

A representation of a logical grouping of personnel resources, equipment resources, physical asset resources, and material that is committed, available, or unavailable for a given *work master* for a specific time shall be defined as a *work master capability*, as shown in Figure 16; objects shown as gray boxes are defined in IEC 62264-2.

NOTE *Work master capability* is used when the capability and capacity vary based on the product being produced or the specific *work master* used.

The *work master capability* shall identify:

a) the capability type (available, unattainable, committed, used, unused, total);

b) the time associated with the capability (for example, third shift on a specific date).

The *work master capabilities* shall be made up of:

c) personnel segment capabilities, which list specific properties required in personnel segment capability properties;

d) equipment segment capabilities, which list specific properties required in equipment capability properties;

e) physical asset segment capabilities, which list specific properties required in physical asset capability properties;

f) material segment capabilities, which list specific properties required in material segment capability properties.

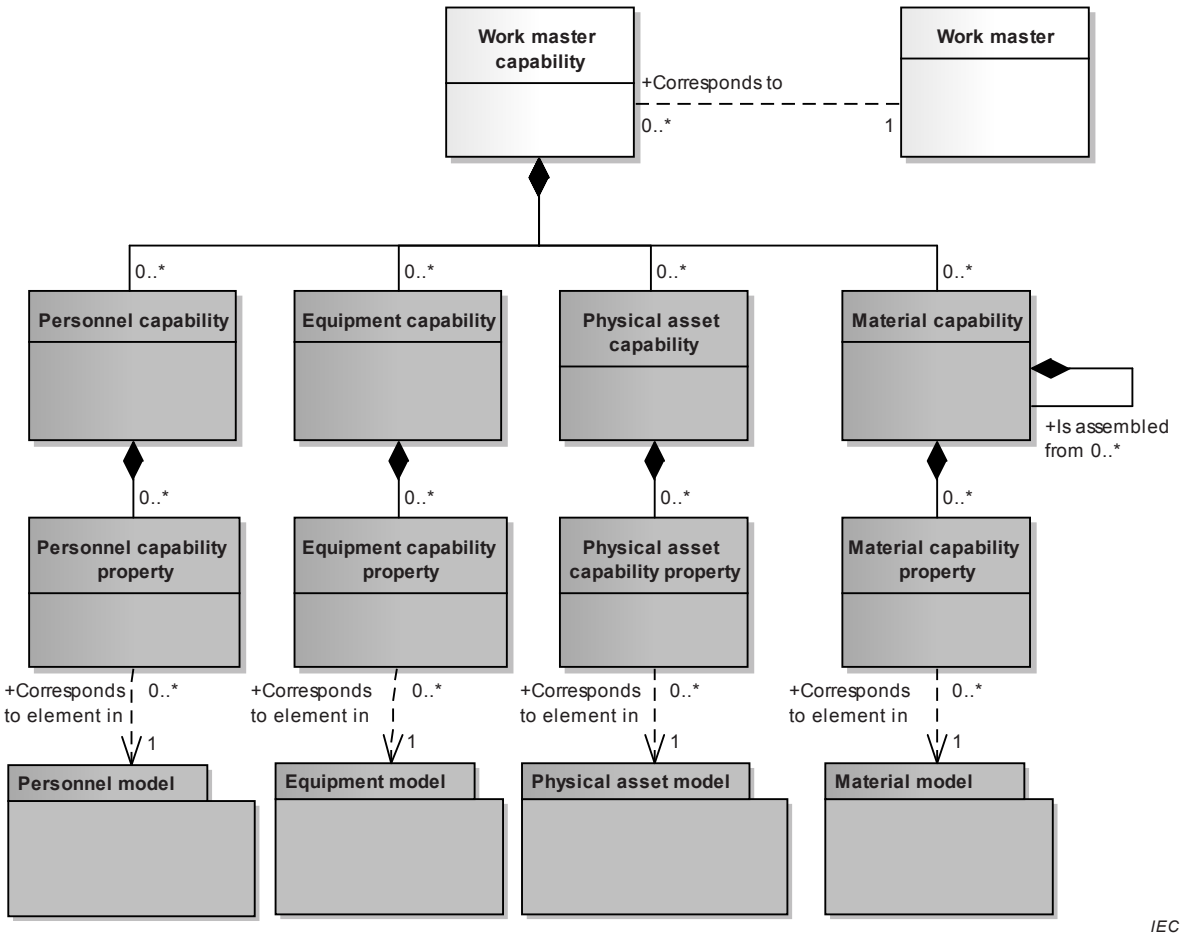


Figure 16 – Work master capability object model

11.2 Work master capability attributes

Table 32 lists the attributes of *work master capability. Work master capability* has an equivalent structure to the personnel, equipment and material structure of *work capability*, except the *work master capability* is defined for a specific *work master*.

Table 32 – Work master capability attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of the *work master capability*.	A7756	20121111	20121111Q	
Description	Contains additional information and descriptions of the *work master capability*.	"Defines the available capability for the widget assembly process segment"	Calibration of custody transfer gas flow meters	Hazardous material incoming inspection	Movement of hazardous material to warehouse
Work master	Identifies the *work master*.	Widget assembly	CTCF calibration	HMII	Fork truck movement
Capacity type	The capacity type: available, unattainable, or committed.	Available	Committed	Available	Available
Reason	Gives the reason for the capacity type.	Available for production	Required by regulation	Available from scheduling	Available for scheduling
Confidence Factor	A measure of the confidence of the capacity value. Example 3: A percentage value representing the confidence of the capacity	90%	100%	Medium	2
Hierarchy scope	Identifies where the exchanged information fits within the role based equipment hierarchy. If omitted, then the capability is associated to the parent *work master capability* hierarchy scope. Zero or more as required to identify the specific scope of the production capability definition.	Production Line #15	West production site	Receiving warehouse 13	Receiving warehouse 13
Start time	The starting time of the time span defining the capacity type. If omitted, then the capability is associated to the parent *work master capability* start time.	2013-12-30 11:59	2012-11-11 11:59	2012-11-11 11:59	2012-11-11 11:59
End time	The ending time of the time span defining the capacity type. If omitted, then the capability is associated to the parent *work master capability* end time.	2014-01-01 12:00	2012-11-12 11:59	2012-11-12 11:59	2012-11-12 11:59
Published Date	The date and time on which the *work master capability* was published or generated.	1999-11-03 13:55	10-25-2006 00:00 UTC	10-25-2006 00:00 UTC	10-25-2006 00:00 UTC

11.3 Personnel capability

The definition of this object and the attributes for this object are defined in IEC 62264-2.

11.4 Personnel capability property

The definition of this object and the attributes for this object are defined in IEC 62264-2.

11.5 Equipment capability

The definition of this object and the attributes for this object are defined in IEC 62264-2.

11.6 Equipment capability property

The definition of this object and the attributes for this object are defined in IEC 62264-2.

11.7 Physical asset capability

The definition of this object and the attributes for this object are defined in IEC 62264-2.

11.8 Physical asset capability property

The definition of this object and the attributes for this object are defined in IEC 62264-2.

11.9 Material capability

The definition of this object and the attributes for this object are defined in IEC 62264-2.

11.10 Material capability property

The definition of this object and the attributes for this object are defined in IEC 62264-2.

12 Work KPI model

Values that have a business or operational value related to a measure of performance shall be defined as *Work KPIs* (key performance indicators). KPIs are registered and defined. Registered KPI values are exchanged on a regular or event basis. See ISO 22400 for a definition of the KPI object model, attributes, and standard KPIs.

13 Work alert model

13.1 Work alert

A notification of a Level 3 event shall be defined as a *work alert*. Not all events warrant creating a *work alert*. A *work alert* does not require acknowledgement. If acknowledgement is needed, then an alarm model may be used (see IEC 62682 for information on alarms). *Work alerts* may be generated by any Level 3 activity.

Work alert definitions are descriptions of the available types of *work alerts*.

NOTE 1 The detailed configuration data for *work alerts*, such as trigger conditions, registration of recipients and actions to be taken upon receipt are out of the scope of this part of IEC 62264.

NOTE 2 *Work alerts* differ from *work KPIs* in that the primary content of a *work alert* is the contextual information required to convey that an event has occurred.

EXAMPLE 1 This is similar to a “gate change alert” emailed to a traveler if an airplane gate change occurs. It indicates a potentially significant event but does not require any response or action.

EXAMPLE 2 A calculation or checking of a *work KPI* may trigger a *work alert*, but other events may also trigger a work alert.

EXAMPLE 3 A *work alert* that indicates the completion of a production run may be a trigger to start the execution of a workflow.

EXAMPLE 4 A workflow event, such as the expiration of a deadline timer, may trigger a *work alert*.

Figure 17 is the *work alert* model.

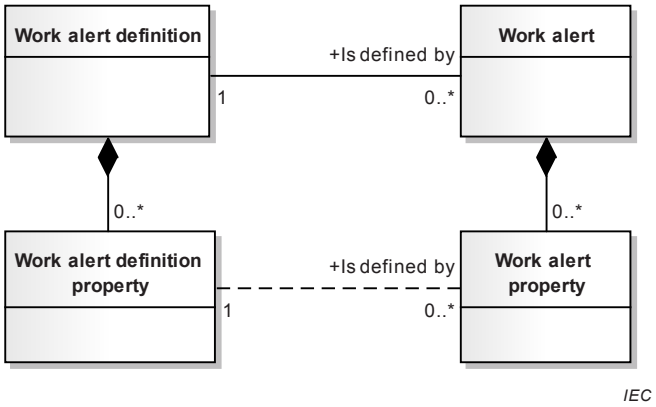


Figure 17 – Work alert model

13.2 Work alert definition

Table 33 lists the attributes of the *work alert definition.*

Table 33 – Work alert definition attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	Unique identification of the *work alert definition*.	P_0004293	M32D	834	Inven88
Description	Contains additional information and descriptions of the *work alert definition*.	Notification of job order started	Reminder that PM is overdue	Test setup complete	Shipment arrived
Priority	List of the priorities that act as a guide to the relative level of importance of a *work alert.*	{1,2,3}	{Low, Medium, High}	{Information, Error}	{1..10}
Category	General grouping associated with a *work alert definition*.	Scheduling	PM	Lab	Receiving

13.3 Work alert definition property

Table 34 lists the attributes of a *work alert definition property.*

Table 34 – Work alert definition property attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of the specific property, unique under the scope of the parent *work alert definition* object.	Job order ID	Physical asset ID	Test ID	Quantity
Description	Additional information and description about the *work alert definition property*.	Identification of the associated job order	Identification of the equip-ment to be maintained	Identifica-tion of the test type	Quantity of material received
Value	The value, set of values, or range of the property. This presents a range of possible numeric values, a list of possible values, or it may be empty if any value is valid.	Not applicable	Not applicable	0..99999	0..20000
Value unit of measure	The unit of measure of the associated property values, if applicable.	Not applicable	Not applicable	Not applicable	Kg

EXAMPLE Possible properties for *work alerts* are shown in Table 35:

Table 35 – Examples of work alert properties

Property	Description
Asset key	A unique data source identifier of the asset associated with the alert
Help	Text to provide additional information about the alert and may include information about the cause of the problem and suggestions on how to fix the problem

13.4 Work alert attributes

Table 36 lists the attributes of *work alerts*.

Table 36 – Work alert attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	Unique identification of the *work alert*.	4929384752 3	M-53A	ER4232	INV-FG
Message text	Textual content of the *work alert*.	Vacuum gas unit switched to feedstock ABC	Overdue PM on compressor 105, WO # 2843	Test #88765 ready	Material arrived
Timestamp	Timestamp the work alert was generated.	Mon August 16 at 01:36 PM	2014-03-07 10:00 UTC	2010-04-27 10:30	2011-01-20 14:45 UTC-10:00
Priority	Guide to the relative level of importance of the value for the *work alert*. NOTE 1 No standard priority types are defined in this standard.	1	Medium	Informa-tional	8
Category	General grouping associated with a *work alert*. NOTE 2 No standard categories are defined in this standard.	Scheduling	PM	Lab	Receiving

13.5 Work alert property

Table 37 lists the attributes of *work alert properties.*

Table 37 – Work alert property attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of the specific *work alert property*.	Job order ID	Physical asset ID	Test ID	Quantity of material received
Description	Additional information about the *work alert property*.	On time switch over	Scheduled maintenance	Test ready	Not applicable
Value	The value, set of values, or range of the property.	99387A	105	88765	1856
Value unit of measure	The unit of measure of the associated property value, if applicable.	Not applicable	Not applicable	Not applicable	Kg

14 Work calendar model

14.1 Work calendar definition and work calendar

Work calendar definitions define a set of rules that specify specific calendar entries, along with repeat rules, duration, starting and ending dates and times for the entries. The entries can be used to generate a *work calendar*, which is a calendar of specific entries for specific dates (and times).

The model defines an exchange format for exchanging the rules (*work calendar definition*) or a calendar with specific dates (*work calendar*).

EXAMPLE The information of the *work calendar* can be used for different purposes:

- Assigning personnel to different shifts and track their work time compared to the assigned shifts;
- Use calendar information in order to correctly calculate and track operations performance;
- Use calendar information for detailed operations scheduling;
- Determine planned production and non-production times for equipment that is used for production performance calculations;
- Account work hours for personnel;
- Compare actual production time with planned production times.

NOTE *Work calendar definitions* and *work calendars* could represent time periods of different dimensions:

- Work / non-work time definition: hours or minutes;
- Shift definition – day or shifts;
- Work day Definition – days or day;
- Pattern – months or weeks;
- Work shift calendar – years or months.

Figure 18 is the model for *work calendar definitions* and *work calendars*.

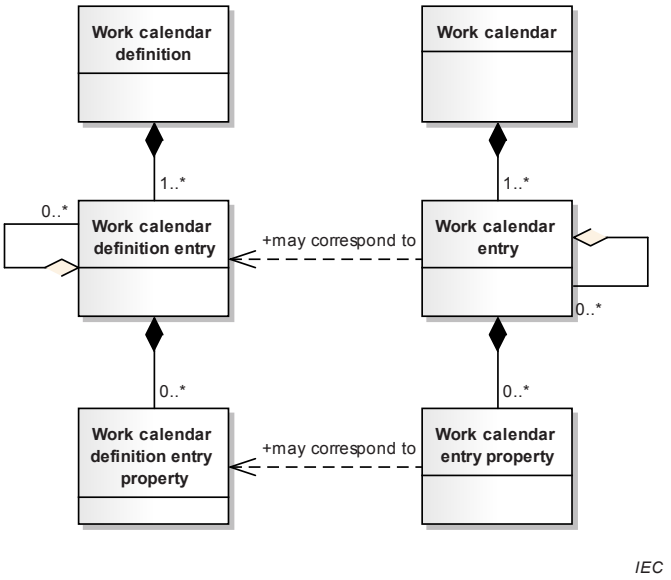


Figure 18 – Work calendar model

14.2 Work calendar definition

The *work calendar definition* shall be defined as a collection of *work calendar definition entries*.

Table 38 lists the attributes of *work calendar definitions.*

Table 38 – Work calendar definition attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of the specific *work calendar definition*.	7 days	Maintenance	Quality env check	3 shifts
Description	Additional information about the *work calendar definition*.	7-day fortnight shift pattern	Weekly maintenance	Periodic environmental quality checks	3-shift pattern

14.3 Work calendar definition entry

The *work calendar* shall be defined as a set of start, duration, and recurrence rules that can be used to create *work calendar entries* of a specific type.

A *work calendar definition entry* may be made up of zero or more nested *work calendar definition entries*.

Table 39 lists the attributes of the *work calendar definition entry.*

Table 39 – Work calendar definition entry attributes

Attribute name	Description	Examples
ID	An identification of the specific *work calendar definition entry*.	123
Description	Additional information about the *work calendar definition entry*.	Drop New Year's ball
Start rule	Defines the starting date and time for the *work calendar definition entry* in ISO 8601 format for a date and time. The Start Rule may include an ending time, following ISO 8601 format for a time interval.	2014-01-01T00:00/2114-12-31T00:00:00
Recurrence time interval rule	Defines the rule for recurrence of the entry in ISO 8601 format for recurrences.	R/P1Y
Duration rule	Defines the duration of the *work calendar definition entry* in ISO 8601 format for durations.	PT24H
Entry type	Defines the type of *work calendar definition entry*. There are no standard entry types defined.	Work shift Bank holiday Plant shutdown

The Start Rule in a *work calendar definition entry* shall be defined in ISO 8601 format for a date and time.

EXAMPLE 1 2014-05-01.

The Start Rule may include an ending time, following ISO 8601 format for a time interval.

EXAMPLE 2 2014-05-01/2015-06-01.

The Recurrence Time Interval Rule in a *work calendar definition entry* shall be defined in ISO 8601 format for recurrences.

EXAMPLE 3 R2M15D – Recurrence every 2 months and 15 days.

The Duration Rule in a *work calendar definition entry* shall be defined in ISO 8601 format for durations.

EXAMPLE 4 PT15H – 15 hours.

14.4 Work calendar definition entry property

The *work calendar definition entry property* shall be defined as property on a *work calendar definition entry*.

Table 40 lists the attributes of the *work calendar definition entry property.*

Table 40 – Work calendar definition entry property attributes

Attribute name	Description
ID	A unique identification of the property.
Description	Additional information about the property.
Value	The default value, set of values, or range of the property.
Value unit of measure	The unit of measure of the associated property value, if applicable.

14.5 Work calendar

The *work calendar* shall be defined as a collection of *work calendar entries*.

Table 41 lists the attributes of the *work calendar.*

Table 41 – Work calendar attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of the specific *work calendar*.	First shift	Planned shutdowns	Reagent order	Tank transfers
Description	Additional information about the *work calendar*.	Definition of the first shift with holidays	Planned shutdowns for next year	Schedule to order reagents	Tank transfer calendar

14.6 Work calendar entry

The *work calendar entry* shall be defined as a calendar entry with a start date and time, a finish date and time, and an entry type.

A *work calendar entry* may be made up of zero or more nested *work calendar entries*.

Table 42 lists the attributes of a *work calendar entry.*

Table 42 – Work calendar entry attributes

Attribute name	Description	Examples
ID	An identification of the specific *calendar entry*.	001
Description	Additional information about the *calendar entry*.	May Day Holiday
Start date time	Defines the starting date and time of the work calendar entry.	2014-05-01T00H00M00S
Finish date time	Defines the ending date and time of the work calendar entry.	2014-05-01T23H59M59S
Entry type	Defines the type of *work calendar entry*. There are no standard entry types defined.	Work shift Bank holiday Plant shutdown

14.7 Work calendar entry property

The *work calendar entry property* shall be defined as a property on a *work calendar entry*.

Table 43 lists the attributes of the *work calendar entry property.*

Table 43 – Work calendar entry property attributes

Attribute name	Description
ID	A unique identification of the property.
Description	Additional information about the property.
Value	The default value, set of values, or range of the property.
Value unit of measure	The unit of measure of the associated property value, if applicable.

15 Work documents

Work documents should be represented as materials, role based equipment, or a physical asset when documents are considered a resource necessary to perform a unit of work.

NOTE 1 Documents are mentioned as a resource in IEC 62264-1:2013, 5.2.4.2:

> "The MOM domain shall include the functionality of managing resources directly associated with control and manufacturing. The resources in the MOM domain include personnel, equipment, and material, as well as other entities, such as documents, that are required for work to start and to be completed. The management of these resources may include local resource reservation to meet production-scheduling objectives."

NOTE 2 Documentation is mentioned as a resource in IEC 62264-3:2007, 7.5:

> "Maintenance resource management shall be defined as the collection of activities that manage the information about the state of the resources and relationships between resources used within the domain of control of maintenance. The managed resources may include maintenance equipment, maintenance tools, personnel (with skill sets), documentation and material and energy used in maintenance."

In manufacturing operations management it is often necessary to manage work documents as resources necessary to perform specific units of work, like other resources already addressed in this standard.

NOTE 3 Work documents can represent any kind of media, e.g., paper, electronic file, etc.

NOTE 4 The work documents discussed here are limited to the documents required for operations.

NOTE 5 Work Masters and Work Performance may contain references to the work documents.

EXAMPLE Work documents that may need to be managed include:

- equipment or system drawings
- SOPs
- engineering documentation
- manuals
- instructions

16 Work record model

16.1 Work record definition

A *work record* shall be defined as a subset of the execution and business information that is retained based upon business requirements identified by a work record specification. A *work record* consists of data about the manufacture of the product plus all supporting data required to meet the business requirements of the record.

NOTE 1 This information could include the workflow execution information, both specific equipment information, operator comments, alarms, elements related to the definition of a job (such as *work masters*, *work directives*, *work schedule* information), and information important to the operation (such as training logs, maintenance records, and environmental conditions).

NOTE 2 *Work performance* contains information to a specific set of job orders. *Work records* can contain information about multiple *job orders* and information not directly related to any specific *job order*. A *work record* can contain a *work performance* (or *work response*). Generally a *work performance* is the response to performing the work specified in a *work schedule*. A *work record* contains additional details of all activities involved in operations

Work records are intended to provide a vendor-neutral representation of information in a form suitable for archiving and storage. Figure 19 illustrates the activities and information associated with creating, maintaining, and using *work records*. Only the i(the white box) is defined in this standard; the activities and other information sets (the gray boxes and activities) are shown to illustrate the environment of *work records*. There is an activity of creating *work records*, which uses operations information, usually from multiple sources and in multiple forms and formats, and which uses a specification of the information to be used to create the *work record*. There is an activity which uses *work records* and work record report specifications to generate work record reports that are suitable for print or display.

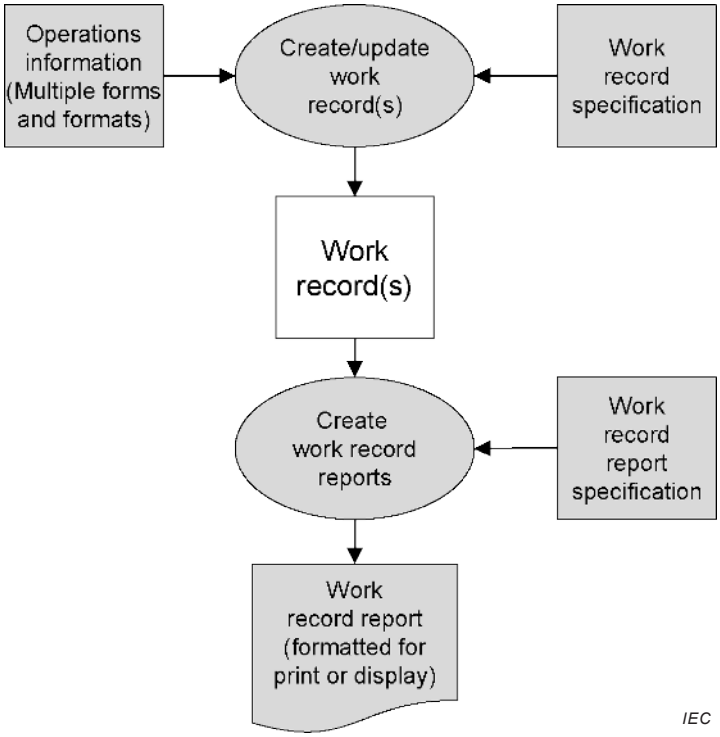


Figure 19 – Work record environment

NOTE 3 A work record specification is the information that is intended to be used to define a work record. The content and format for work record specifications are not defined in this part of IEC 62264.

NOTE 4 A work record report specification is the information that is intended to be used to define a work record report. The content and format for work record report specifications are not defined in this part of IEC 62264.

16.2 Work record

A *work record* shall use IEC 61512-4 batch production record definitions with the following exceptions:

1) The *work record* shall be used in place of *batch production record*;
2) The work record specification shall be used in place of batch production record specification;
3) The *work record entry* shall be used in place of *batch production record entry*;
4) The *work record* specification ID shall be used in place of *batch production record* specification ID. This is a unique identification of a work record specification used to create a *work record*;
5) The *work record data reference* shall be used in place of *BPR* (batch production record) *data reference*;

   NOTE This is a reference to a data element in a *work record*.

6) A *work record* may contain an IEC 61512-4 *batch production record*;
7) Event information associated with a *work alert* may be represented in an alarm event.

16.3 Work record extensions

The *work record* shall be an extension to the definition of IEC 61512-4 *batch production record* with the additional following extensions:

1) *Operations schedules* are included as a collection of *operations schedule* elements (as defined in IEC 62264-2);

2) *Operations definitions* are included as a collection of *operations definition* elements (as defined in IEC 62264-2);
3) *Operations performances* are included as a collection of *operations performance* elements (as defined in IEC 62264-2);
4) *Work masters* are included as a collection of *work master* elements;
5) *Work directives* are included as a collection of *work directive* elements;
6) *Work schedules* are included as a collection of *work schedule* elements;
7) *Work performance* are included as a collection of *work performance* elements;
8) Batch specific elements were removed;
9) *Batch production records* are included as a collection of *batch production record* elements (as defined in IEC 61512-4).

A *work record* is a container for containers and each sub-container has zero or more elements for a specific type of object. Figure 20 illustrates a sample *work record* (the outer white box) that contains one of each type of sub-container (the inner white boxes) and multiple elements within each sub-container (the gray boxes).

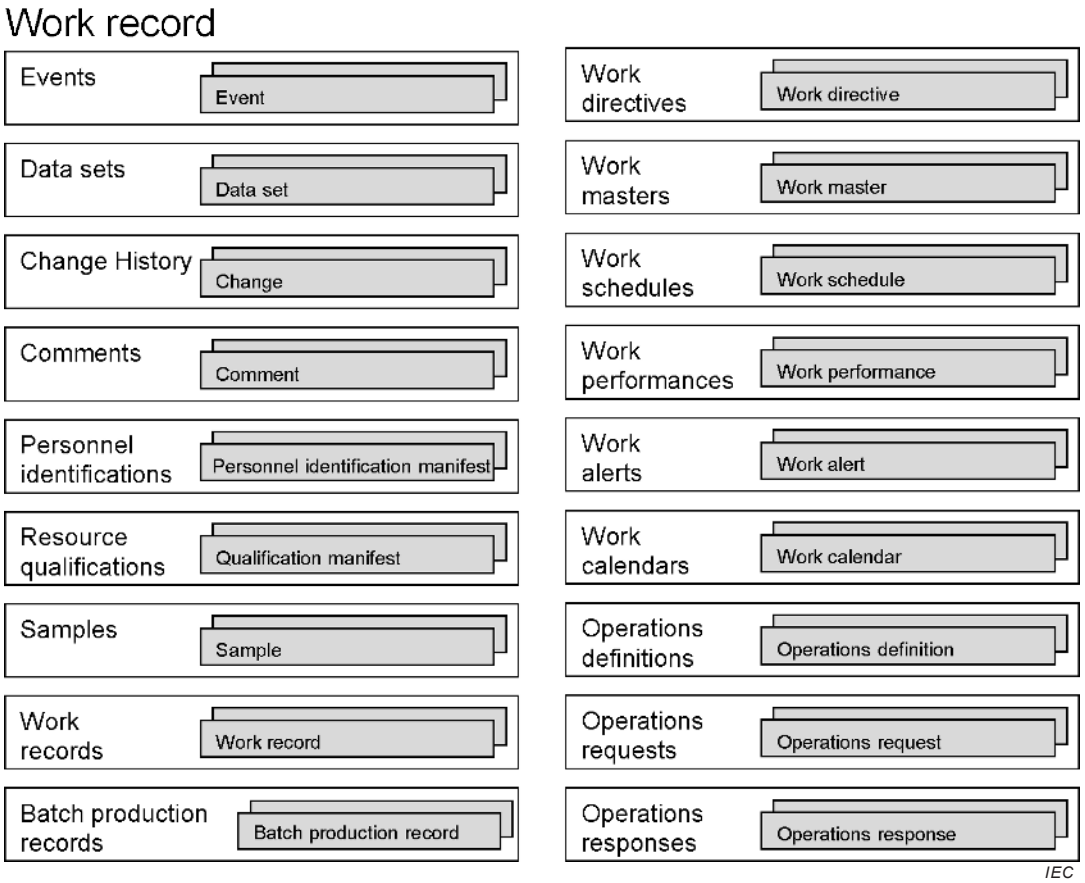


Figure 20 – Work record container example

Elements of a *work record* can reference other elements within the *work record*, as illustrated in Figure 21. It shows an example with one *change history* that references a changed *work directive workflow specification*, two *personnel identification manifests*, and one *comment* that references a *change history element*. One *personnel identification manifest* identifies the person and "Done by" action on the *change history*. The second identifies the person and "Checked by" action on the *change history*. The *comment* contains a comment associated with the change.

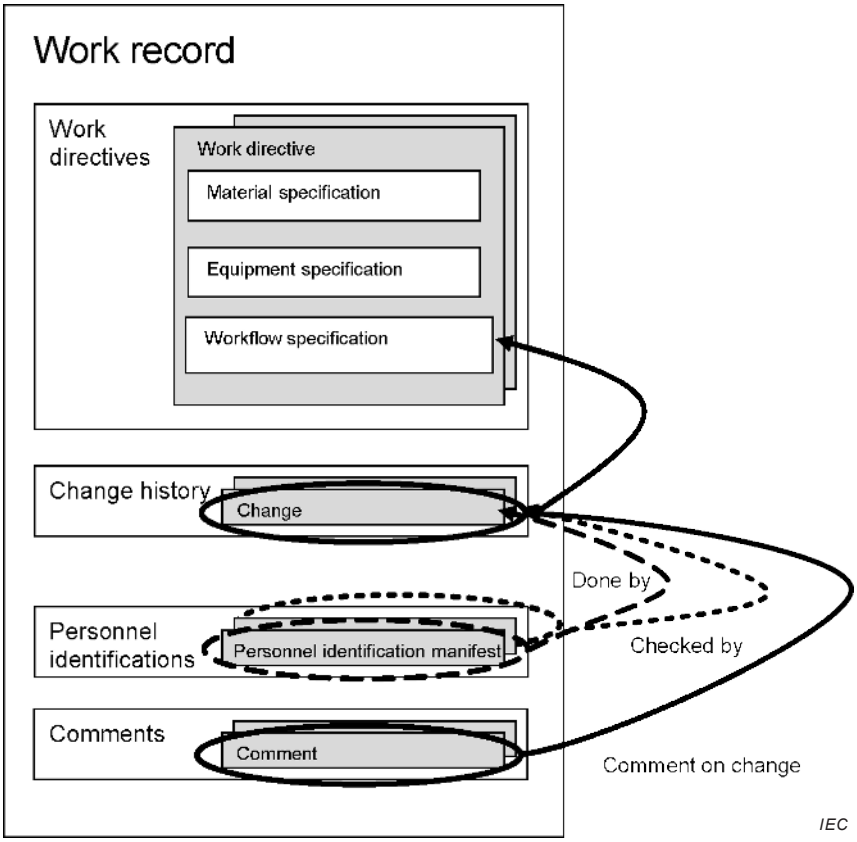


Figure 21 – Work record element reference example

16.4 Work record model

The object model for a *work record* is shown in Figure 22. The objects with gray shading are defined in IEC 61512-4.

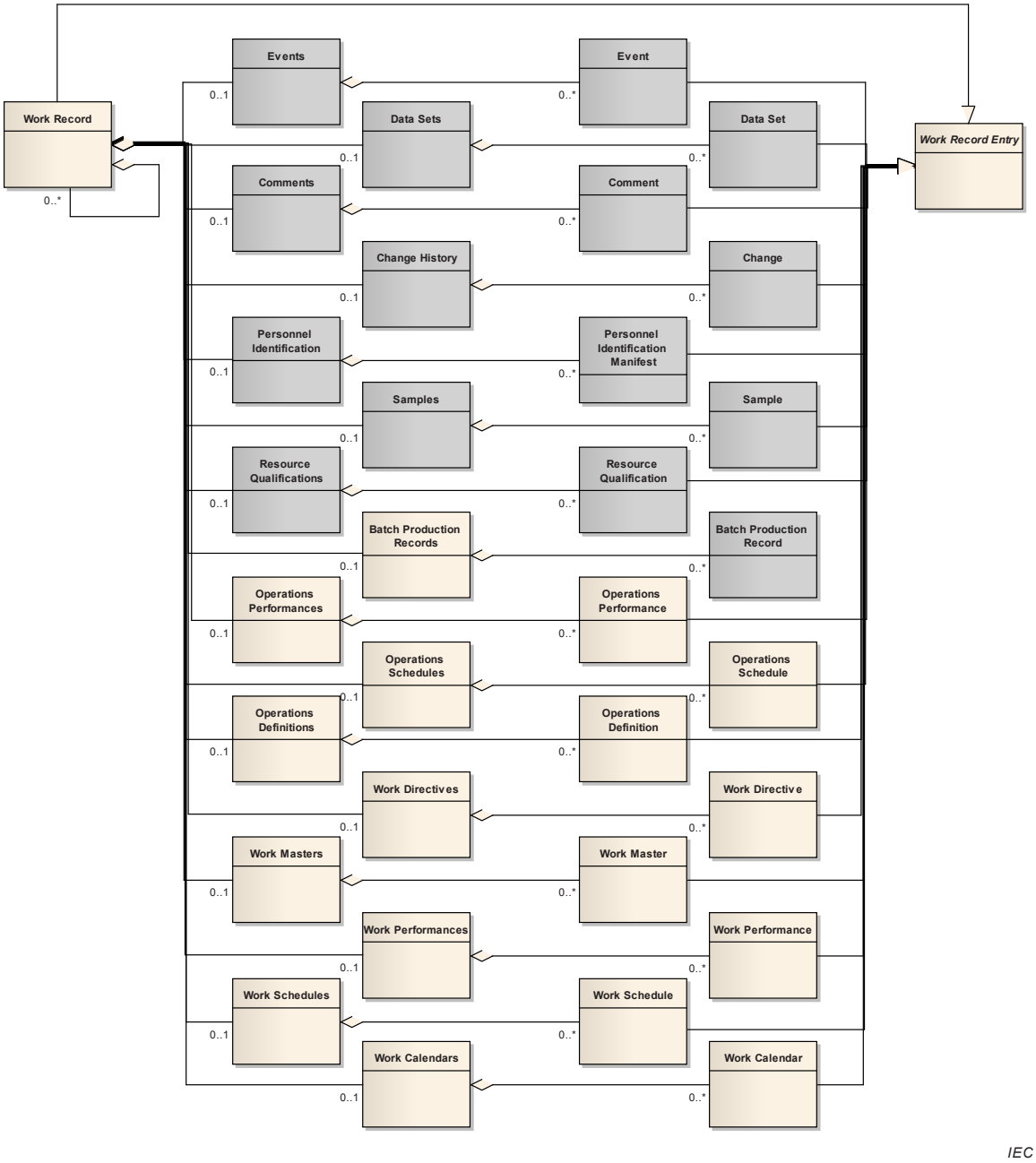


Figure 22 – Work record model

16.5 Work record entry

A *work record entry* is an abstract type used to define common attributes for many of the objects that make up a *work record*. All specialized types of *work record entry* objects (shown in Figure 22) shall have the attributes defined in Table 44.

Table 44 – Work record entry attributes

Attribute name	Description	Examples
Entry ID	ID which is unique within the scope of a *work record*. This attribute is mandatory.	1 239432 4A34B
Description	Additional information about the entry.	The work directive is embedded in this work record. Data set time series data is stored in the historian database.
External reference	Contains a reference to data which is stored externally to the work record. NOTE 1 If data is embedded in the work record this attribute is not used. NOTE 2 The format of the reference is determined by a conforming specification.	Control system for work cell A \\dept_share\archive2004\ product_ABC
Object type	Identifies the type of object an entry is based upon.	Work master Data set Change history
Time stamp	The time stamp associated with the entry.	2013-07-14 1454+0100 01 March 2014 14:25 UTC April 23, 2012 8:30 AM ET

16.6 Work record container objects

The following objects are container objects, which have no defined attributes.

1) *Operations schedules* shall be defined as a container of *operations schedule* elements (as defined in 62264-2).
2) *Operations definitions* shall be defined as a container of *operations definition* elements (as defined in 62264-2).
3) *Operations performances* shall be defined as a container of *operations performance* elements (as defined in 62264-2).
4) *Work masters* shall be defined as a container of *work master* elements.
5) *Work directives* shall be defined as a container of *work directive* elements.
6) *Work schedules* shall be defined as a container of *work schedule* elements.
7) *Work performances* shall be defined as a container of *work performance* elements.
8) *Work calendars* shall be defined as a container of *work calendar* elements.
9) *Batch production records* shall be defined as a container of *batch production record* elements (as defined in IEC 61512-4).

16.7 Event types and subtypes

The procedural execution event (defined in IEC 61512-4) shall be used to refer to events associated with a job order's workflow.

The standard event types and event subtypes defined in Table 45 shall be added to the IEC 61512-4 standard event types:

Table 45 – Additional event types and subtypes

Event type	Event subtype	Description
Work directive	Modification	Change in value for a parameter in a work directive. Value attribute contains the new data value. The previous value contains the old data value. EXAMPLE 1: Temperature set point changed to 500, scaling factor applied to work directive.
Work directive	Equipment	Change in equipment assigned to or bound to a work directive. Value attribute contains the new equipment name. The previous value contains the old data's equipment name. EXAMPLE 2: Packing Line 22 bound to Workflow Step 184.
Equipment	Allocation	Allocation of equipment to a job order. Value attribute contains the equipment ID. EXAMPLE 3: Work unit acquired.
Equipment	Deallocation	Deallocation of equipment from a job order. Value attribute contains the equipment ID. EXAMPLE 4: Work unit released.
Procedural execution	Prompt	A request from a workflow to the operator to provide information for the completion of the workflow logic. Value attribute contains text sent to the operator. EXAMPLE 5: Execute SOP 324, perform line clearance per SOP 394.
Physical asset	Allocation	Allocation of a physical asset to a job order. Value attribute contains the equipment ID. EXAMPLE 6: Work unit acquired.
Physical asset	Deallocation	Deallocation of a physical asset from a job order. Value attribute contains the equipment ID. EXAMPLE 7: Work unit released.
Personnel	Assignment	Assignment of a person to a job order. Value contains the person ID.
Personnel	Unassigned	Removal of an assignment of a person to a job order. Value contains the person ID.
Work alert	Generated	A work alert was generated. Value contains the work alert information. Additional information may be recorded in an Alarm Event object (defined in IEC 61512-4).

17 Object lists and relationships

Figure 23 provides an illustration of how some of the object models inter-relate.

NOTE 1 The *work alert* and *work KPI* models are not directly related to the other models.

NOTE 2 The *resource relationship network* model is not shown because it relates to the resources (defined in IEC 62264-2).

The slanted rectangles in Figure 23 represent any of the resources (personnel, equipment, physical asset, or material) or properties of the resources.

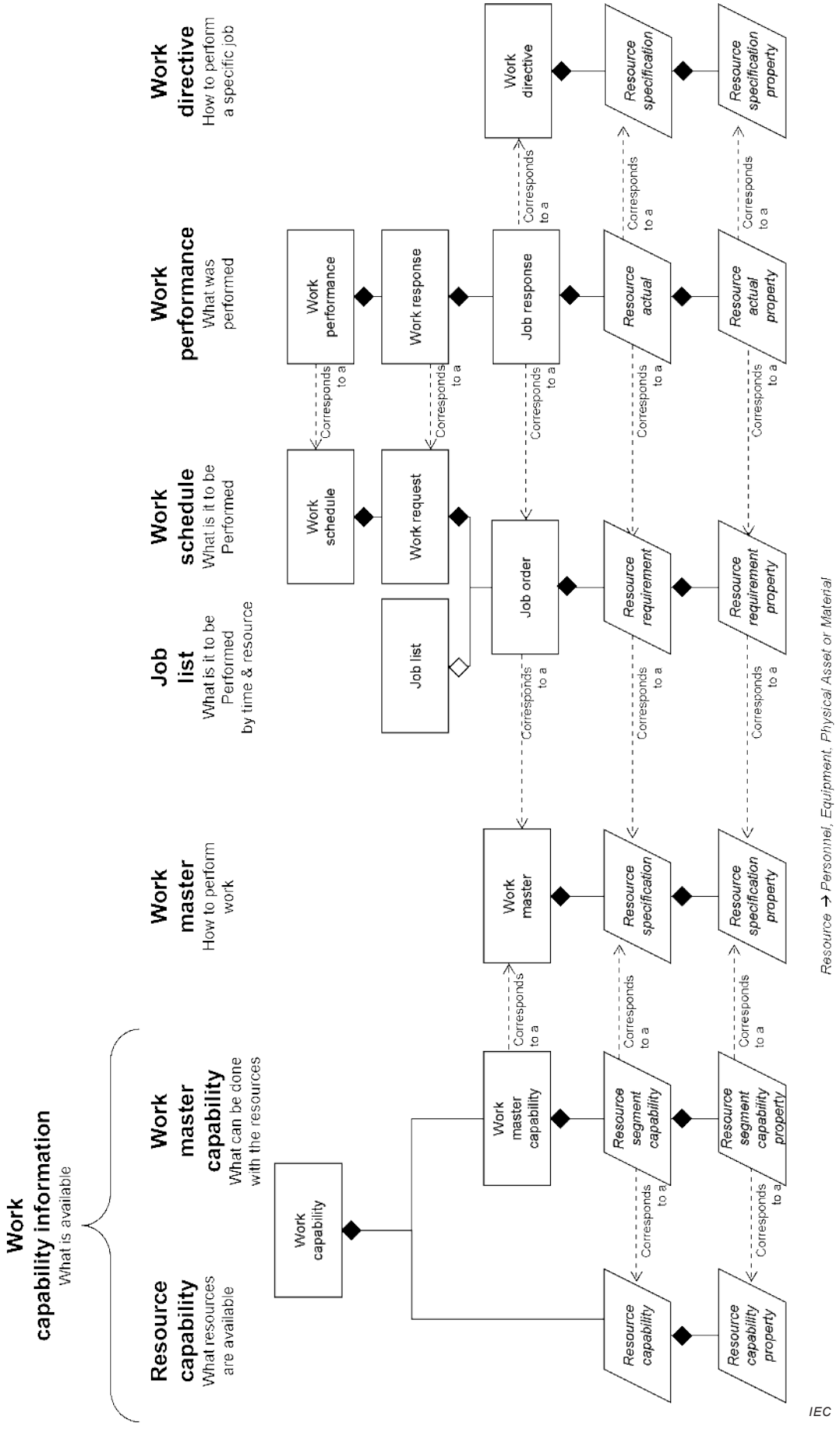


Figure 23 – Relationship between models

Table 46 presents the objects defined in this standard and the associated model.

Table 46 – Objects and models

Object	Model
From resource reference	Resource relationship network model
From resource reference property	Resource relationship network model
Job list	Work schedule model
Job order	Work schedule model
Job order parameter	Work schedule model
Job response	Work performance model
Job response list	Work performance model
Job response data	Work performance model
Resource network connection	Resource relationship network model
Resource network connection property	Resource relationship network model
Resource network connection type	Resource relationship network model
Resource network connection type property	Resource relationship network model
Resource relationship network	Resource relationship network model
To resource reference	Resource relationship network model
To resource reference property	Resource relationship network model
Work alert	Work alert model
Work alert definition	Work alert model
Work alert definition property	Work alert model
Work alert property	Work alert model
Work capability	Work capability model
Work definition	Work definition model
Work directive	Work definition model
Work master	Work definition model
Work master capability	Work master capability model
Work performance	Work performance model
Work request	Work schedule model
Work response	Work performance model
Work schedule	Work schedule model
Work specification	Work definition model
Workflow specification	Workflow specification model
Workflow specification connection	Workflow specification model
Workflow specification connection property	Workflow specification model
Workflow specification connection type	Workflow specification model
Workflow specification connection type property	Workflow specification model
Workflow specification node	Workflow specification model
Workflow specification node property	Workflow specification model
Workflow specification node type	Workflow specification model
Workflow specification node type property	Workflow specification model
Work record	Work record model
Work calendar definition	Work calendar model
Work calendar	Work calendar model

18 Compliance

Any assessment of compliance of a specification shall be qualified by the following:

a) the use of the terminology defined in this standard;

b) the object models supported (resource relationship network, work definition, work schedule, work performance, work capability, job list, and work alert);

c) the use of objects listed in Table 46 that are supported;

d) the use of the attributes for each supported object;

e) the relationships between the supported objects;

f) a statement of the total compliance concerning definitions, objects, attributes, and relationships or, in case of partial compliance, a statement identifying explicitly the areas of noncompliance.

Annex A
(informative)

Questions and answers about object use

A.1 How are dependencies in the work schedule and work response handled?

Question:

How are dependencies in the *work schedule* and *work response* handled?

Answer:

There are different types of dependencies (resource availability, customer priority, process dependency, and other).

Real applications need to model different types of dependencies between *work requests*.

For example, an MRP/ERP at Level 4 can produce separate requests for subassemblies or a single request for the final assembly of a given finished product and for the manufacturing of the intermediate materials that are the subassemblies to be assembled. Of course, there is a work process dependency relationship and final assembly shall start after all subassemblies have been manufactured. This is handled in an implementation where a production or *work request* states the start time and/or end time and then the associated *segment requests* specify the earliest start time, latest end time and duration for each segment. The algorithm for the actual dispatching of work can be done at Level 4 or Level 3, but be represented in the *production schedule* or *work schedule* request.

A.2 What are examples of resource relationships?

Question:

What are some examples of resource relationship networks and how are they important?

Answer:

Resource relationships networks model resources that have some form of dependency among the resources.

In the examples below the *resource relationship network* may be annotated with properties that are relevant to the environment. Properties such as optimum paths, rework paths, and selection criteria for scheduling and planning applications could be included.

The resource relationships may be an input to an application indicating configuration properties of the system or an output representing the result of a calculation such as an optimization process that has generated a resource relationship model to indicate its output.

The following example describes three different *resource relationship networks* using the equipment resources shown in Figure A.1.

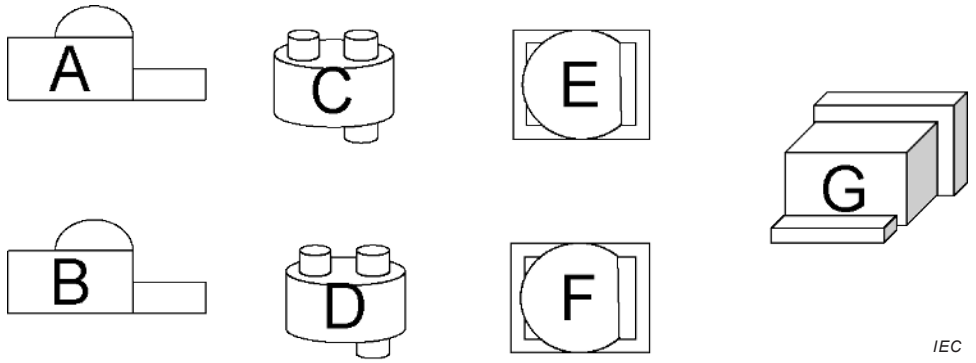


Figure A.1 – Equipment resources

The first relationship is a material flow routing network as shown in Figure A.2.

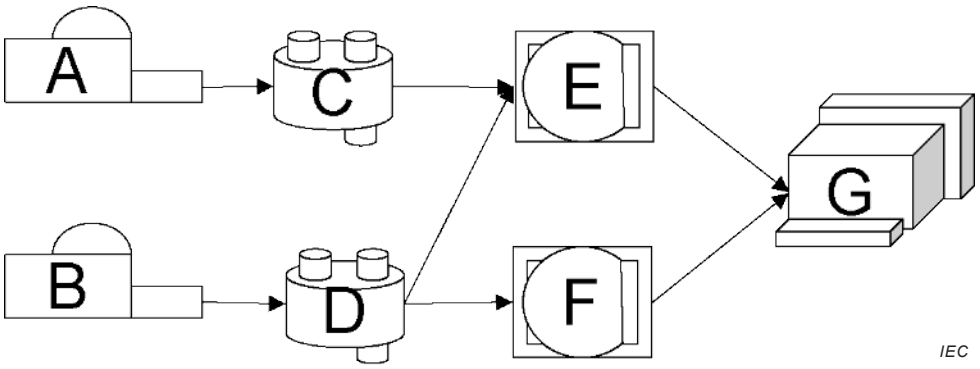


Figure A.2 – Routing relationship network

The routing relationship network would be modelled as a set of *resource network connections*:

<Resource Network Connection AC> <From Resource Reference to A> <To Resource Reference to C>
<Resource Network Connection CE> <From Resource Reference to C> <To Resource Reference to E>
<Resource Network Connection EG> <From Resource Reference to E> <To Resource Reference to G>
<Resource Network Connection BD> <From Resource Reference to B> <To Resource Reference to D>
<Resource Network Connection DE> <From Resource Reference to D> <To Resource Reference to E>
<Resource Network Connection DF> <From Resource Reference to D> <To Resource Reference to F>
<Resource Network Connection FG> <From Resource Reference to F> <To Resource Reference to G>

A detailed scheduling package would use the routing network to determine which paths through the equipment should be used for each production run.

The next relationship, shown in Figure A.3 with the same equipment, illustrates a gas line relationship, showing which equipment is connected to a gas main. This relationship could be used by a maintenance scheduling activity to determine which equipment is to be shut down when maintenance is performed on the gas main network.

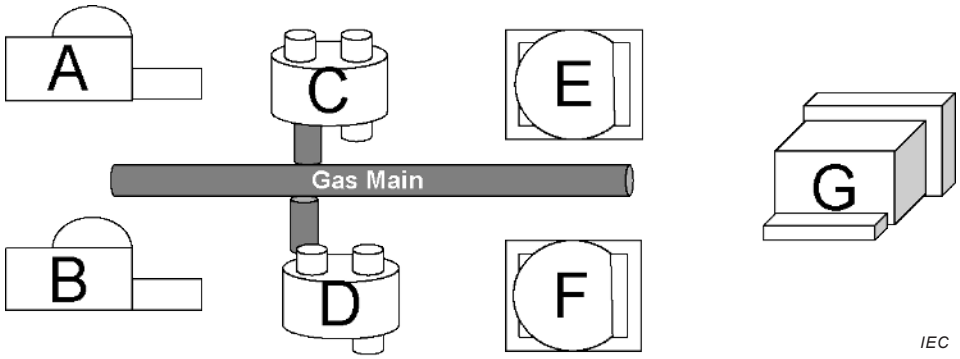


Figure A.3 – Gas main relationship network

The gas main relationship network would be modelled as a set of resource network connections:

<Resource Network Connection GM1> <From Resource Reference to GAS_MAIN> <To Resource Reference to C>
<Resource Network Connection GM2> <From Resource Reference to GAS_MAIN> <To Resource Reference to D>

A resource relationship network across resource types is shown in Figure A.4. This relationship defines which equipment can be used for material definition X.

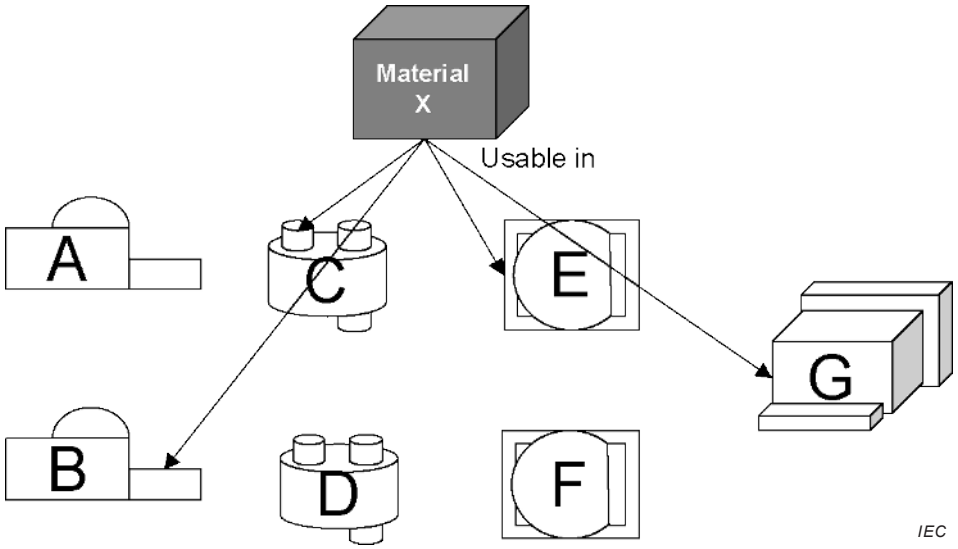


Figure A.4 – "Usable in" relationship network

The "usable in" relationship network would be modelled as a set of *resource network connections*, with each relationship containing selection criteria relevant to the selection algorithm:

<Resource Network Connection X1> <From Resource Reference to Material X> <To Resource Reference to B>
<Resource Network Connection X2> <From Resource Reference to Material X> <To Resource Reference to C>
<Resource Network Connection X3> <From Resource Reference to Material X> <To Resource Reference to E>
<Resource Network Connection X4> <From Resource Reference to Material X> <To Resource Reference to G>

This relationship would be used by a detailed scheduler to determine which resources may be used for production of material X.

Annex B
(informative)

Related standards

Level 3 to Level 2 interfaces are defined in IEC 62541.

Standards for recipes are defined in IEC 61512.

As shown in Figure B.1, there is a relationship between the information models in IEC 62264-2, the models in this part of IEC 62264, and the models in IEC 61512. IEC 62264-2 models are used to exchange information based on the Level 4 business view of operations, using *process segments* as the method to define segments of operation as viewed by the business processes. Models such as *operations definition* and *operations schedule* support the business view by defining the allocation of resources and scheduling activities to the site.

Models in this part of IEC 62264 are used to exchange information for Level 3 execution. Models such as *work definition* may reference the *operations definition* exchanged with Level 4, but they contain the details needed for actual execution of Level 3 activities. Additionally, *work master* and *work directive* are types of work definitions that provide the details needed for work execution.

A single *operations definition* may relate to one or more *work masters*. The *work masters* describe how to perform the work, using the resources identified in the *operations definition*. A *work directive* is created from a *work master* for a specific *job order*. If the step in a *work directive* defines a batch process (or work accomplished through a recipe), then the step in a *work master* may reference a *master recipe* (IEC 61512-1) and a step in the *work directive* may reference a *control recipe* (IEC 61512-1).

An *operations schedule* (IEC 62264-2) (defining the resource allocation) is used to create a *work schedule* (defining the physical routing and sequencing) in a detailed production scheduling activity (IEC 62264-3). An operations dispatching activity (IEC 62264-3) uses the *job list* view of the *work schedule*. If there are batch processes in the *job list*, then the created batches are maintained in a *batch list* (IEV 61512-1).

Information on the execution of a batch can be maintained in a *batch production record*. This information could then be combined with other information in a *work production record*. This information can then be used to create *work performance* information (defining the resource usage for the physical routing), which in turn can be used to create *production performance* information (IEC 62264-2) (defining the resource usage as viewed by business activities).

IEC 61512-3 defines an object model for general and site recipes, which define a research and development view of a product, independent of any specific equipment. There is no direct equivalent for these in the IEC 62264 models. However the IEC 61512 models may be used to help define Level 4 operations definitions and/or Level 3 work masters by relating process stages (IEC 61512) and process operations (IEC 61512) to process segments and to the routing defined in operations definitions and work masters.

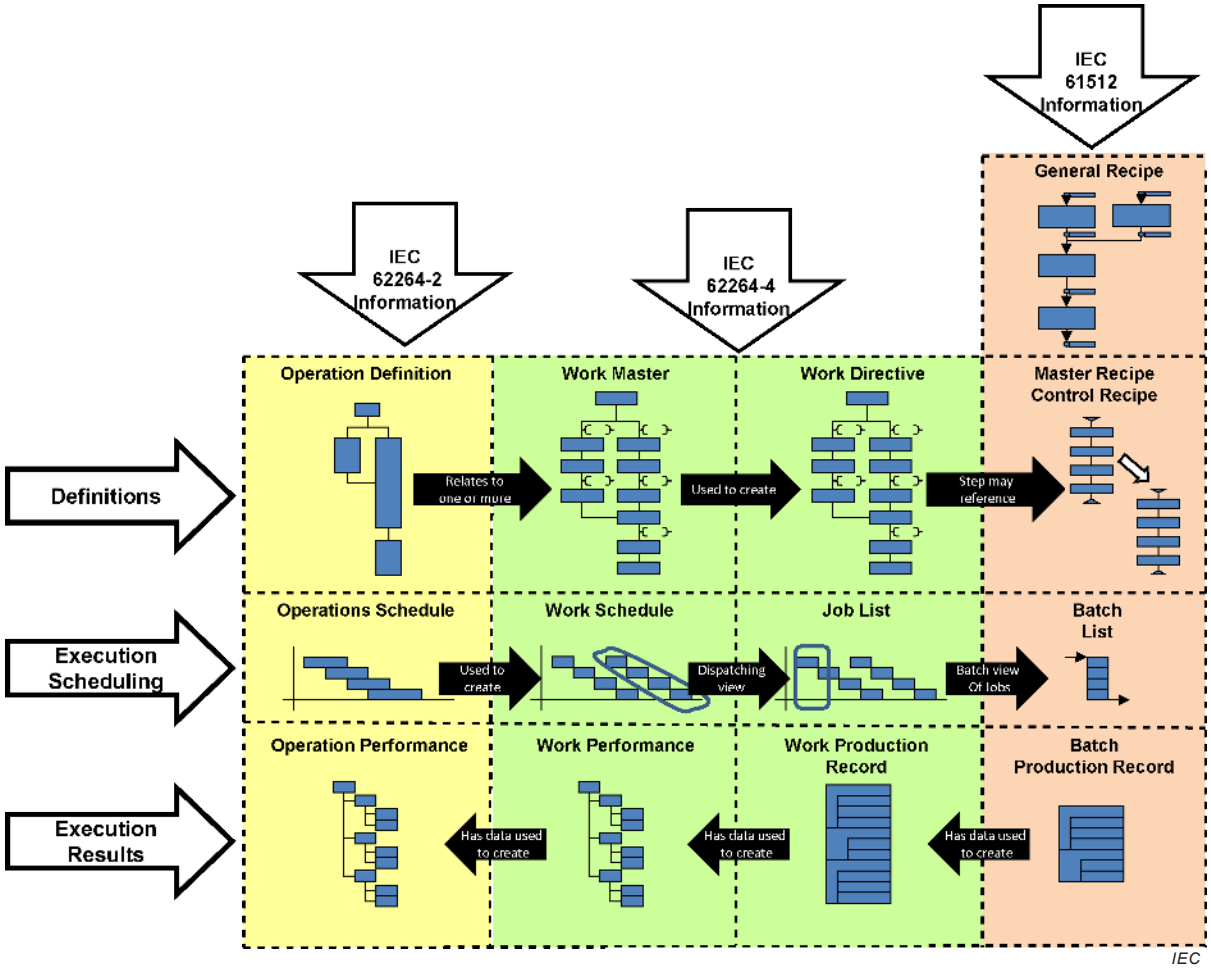


Figure B.1 – Relationship to IEC 62264-2 and IEC 61512 standards

Annex C
(informative)

Representing a workflow specification in BPMN

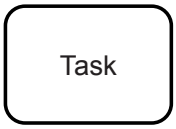
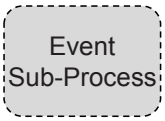
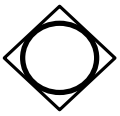
Annex C defines a possible mapping of BPMN 2.0 – Business Process Model and Notation to a *workflow specification*.

BPMN defines multiple different elements in a collaboration diagram; these include activities, gateways, events, data, choreographies, and conversations.

In general the following elements would be represented as *workflow specification connection types*:

Name	Symbol	Description
Sequence flow		Defines the execution order of activities
Default flow		Defines the default branch chosen if all other conditions evaluate to false.
Conditional flow		Defines a branch with a condition assigned that defines whether or not the flow is used.
Message flow		Symbolizes information flow across organizational boundaries.
Conversation link		Connects communications and participants.
Forked conversation link		Connects communications and multiple participants.

The following *workflow specification node types* could be defined to match elements in BPMN. The following is a partial list of all activities, gateways, events, data, choreographies, and conversations types.

Name	Symbol	Description
Task		Represents a unit of work, the job to be performed. May be annotated with different: – activity markers: sub-process marker, loop marker, parallel MI marker, sequential MI marker, ad hoc marker, compensation marker; – task types: send task, receive task, user task, manual task, business rule task, service task, script task.
Transaction		A set of activities that logically belong together.
Event sub-process		A task that is activated when the start event is triggered.
Call activity		A wrapper for a globally defined sub-process or task,
Exclusive gateway		When splitting, it routes the sequence flow to exactly one of the outgoing branches. When merging, it waits for one incoming branch to complete before triggering the outgoing flow.
Event-based gateway		Is always followed by catching events or receive tasks.
Parallel gateway		When used to split the sequence flow, all outgoing branches are activated simultaneously. When merging parallel branches it waits for all incoming branches to complete.
Inclusive gateway		When splitting one or more branches are activated,
Complex gateway		Complex merging and branching behavior that is not captured in other gateways.

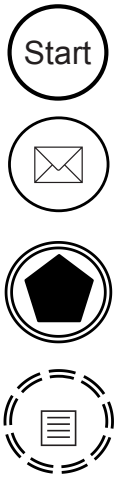
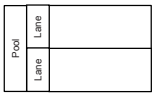
Name	Symbol	Description
Event		There are multiple types of events and each event may be defined for a different position in the execution sequence. Special indications: – message, timer, escalation, conditional, link, error, cancel, compensation, signal, multiple, parallel multiple, terminate. Sequence indications: – top-level, start – event sub-process interrupting, start – event sub-process non-interrupting, intermediate catching, intermediate boundary interrupting, intermediate boundary non-interrupting, intermediate throwing, end. Each event subtype would be represented as a different symbol on a BPMN diagram, as shown with figures to the left.
Input		An external input for the entire process.
Output		A variable available as the result of the entire process.
Data store		A place where the process can read and/or write data.
Pool (swimlane)		Represents responsibilities for activities in a process.
Lane (swimlane)		Represents responsibilities for activities in a process.

Figure C.1 is used to illustrate a BPMN process which is mapped to a *workflow specification* as illustrated in Figure C.2. The following abbreviations are used: *workflow specification* (WFS), *workflow specification node* (WSN), *workflow specification node property* (WSNP), *workflow specification connection* (WSC), and *workflow specification connection property* (WSCP).

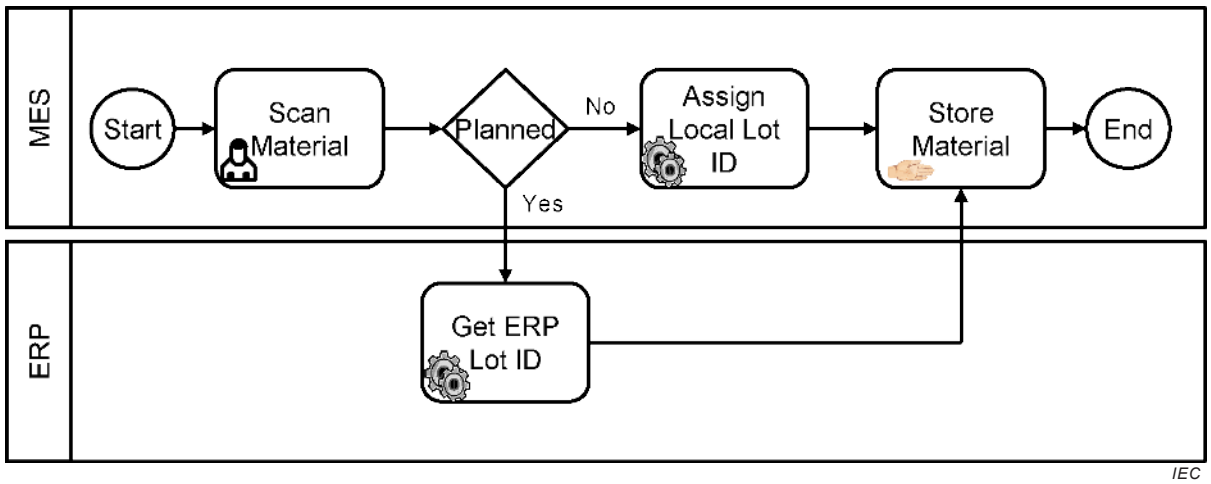


Figure C.1 – Example of a workflow specification in BPMN notation

Figure C.2 illustrates the aggregation hierarchy of the *workflow specification model*.

```
WS: ID=EXAMPLE

   +--- WSN: ID=MES, Type=LANE

        +---- WSN: ID=Start, Type=EVENT START

        +---- WSN: ID=Scan Material, Type=TASK

              +---- WSNP: Task Type=MANUAL

        +---- WSN: ID=Planned, Type=EXCLUSIVE GATEWAY

        +---- WSN: ID= Assign Local Lot ID, Type=TASK

              +---- WSNP: Task Type=SERVICE

        +---- WSN: ID= Store Material, Type=TASK

              +---- WSNP: Task Type=USER TASK

        +---- WSN: ID= End, Type=EVENT END

        +---- WSC: From=Start, To=Scan Material

        +---- WSC: From= Scan Material, To=Planned

        +---- WSC: From=Planned, To=Get ERP Lot ID

              +---- WSCP: Condition=YES

        +---- WSC: From=Planned, To=Assign Local Lot ID

              +---- WSCP: Condition=NO

        +---- WSC: From= Assign Local Lot ID, To=End

   +--- WSN: ID=ERP, Type=LANE

        +---- WSN ID=Get ERP Lot ID, Type=TASK

              +---- WSNP: Task Type=SERVICE

        +---- WSC: From= Get ERP Lot ID, To=Assign Local Lot ID
```

Figure C.2 – Example workflow process in the workflow specification model

Annex D
(informative)

Representing a workflow specification in flowchart notation

Annex D defines a possible mapping of flowcharts to a *workflow specification*.

The following *workflow specification node types* could be defined to match elements in a flow chart:

process, decision, data, document, predefined process, stored data, internal storage, sequential data, direct data, manual input, card, paper tape, display, manual operation, preparation, parallel mode, loop limit, terminator

The following *workflow specification connection type* could be defined to match the links between flowchart elements:

control transfer

Figure D.1 is used to illustrate a flowchar which is is mapped to a *workflow specification* as illustrated in Figure D.2. The following abbreviations are used: *workflow specification* (WPN), *workflow specification node* (WSN), *workflow specification node property* (WSNP), *workflow specification connection* (WSC), and *workflow specification connection property* (WSCP).

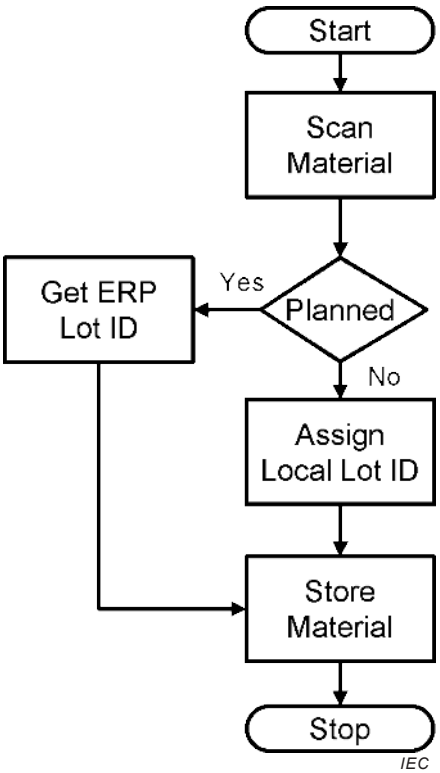


Figure D.1 – Example of a workflow specification in flowchart notation

Figure D.2 illustrates the aggregation hierarchy of the *workflow specification model*.

```
WPN: ID=EXAMPLE

   +--- WSN: ID=MES, Type=LANE

        +---- WSN: ID=Start, Type=START

        +---- WSN: ID=Scan Material, Type=PROCESS

        +---- WSN: ID=Planned, Type=DECISION

        +---- WSN: ID= Assign Local Lot ID, Type= PROCESS

        +---- WSN: ID= Store Material, Type= PROCESS

        +---- WSN: ID= Stop, Type=TERMINATOR

        +---- WSC: From=Start, To=Scan Material

        +---- WSC: From= Scan Material, To=Planned

        +---- WSC: From=Planned, To=Get ERP Lot ID

              +---- WSCP: Condition=YES

        +---- WSC: From=Planned, To=Assign Local Lot ID

              +---- WSCP: Condition=NO

        +---- WSC: From= Assign Local Lot ID, To=End

   +--- WSN: ID=ERP, Type=LANE

        +---- WSN ID=Get ERP Lot ID, Type= PROCESS

        +---- WSC: From= Get ERP Lot ID, To=Assign Local Lot ID
```

Figure D.2 – Example workflow process in the workflow specification model

Annex E
(informative)

Example of work calendars

E.1 Four-day 24-hour shift pattern

Table E.1 illustrates a *work calendar* that defines a 4-day, 24-hour work shift pattern, with 24 hours on shift and 48 hours off shift. A is the first shift team, B is the second shift team, C is the third shift team, and D is the fourth shift team. The *work calendar* defines the times that each shift team is working.

Table E.1 – Four-day 24-hour shift pattern example

12/24/12/48 shift example																														
Time		**Week 1**							**Week 2**							**Week 3**							**Week 4**						
		Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Daily	06:00–18:00	A	C	D	B	A	C	D	B	A	C	D	B	A	C	D	B	A	C	D	B	A	C	D	B	A	C	D	B
Nightly	18:00–06:00	B	A	C	D	B	A	C	D	B	A	C	D	B	A	C	D	B	A	C	D	B	A	C	D	B	A	C	D
Pattern		Run 1				Run 2			Run 3				Run 4			Run 5							Run 6			Run 7			

The *work calendar definition* used to define the shift pattern is illustrated in Table E.2.

Table E.2 – Work calendar definition for 4-day 24–hour shift entry examples

Attribute	Value
ID	001
Description	Four-day 24-hour shift pattern

The *work calendar definition entries* used to define the shift pattern are illustrated in Table E.3.

Table E.3 – Work calendar definition entry for 4-day 24–hour shift example

First entry	
Attribute	Value
ID	Shift team A
Description	24 hours on, 48 hours off shift pattern team A
Start rule	0001-01-01T00:00:00
Recurrence time interval rule	R/P4D
Duration rule	PT12H
Entry type	Work shift
Second entry	
Attribute	Value
ID	Shift team B
Description	24 hours on, 48 hours off shift pattern team B
Start rule	0001-01-01T00:00:00
Recurrence time interval rule	R/P4D
Duration rule	PT24H
Entry type	Work shift
Third entry	
Attribute	Value
ID	Shift team C
Description	24 hours on, 48 hours off shift pattern team C
Start rule	0001-01-01T00:00:00
Recurrence time interval rule	R/P4D
Duration rule	PT24H
Entry type	Work shift
Fourth entry	
Attribute	Value
ID	Shift team D
Description	24 hours on, 48 hours off shift pattern team D
Start rule	0001-01-01T00:00:00
Recurrence time interval rule	R/P4D
Duration rule	P242H
Entry type	Work shift

Some of the *work calendar entries* that define the 2014 shift pattern for the 24 hours on and 48 hours off shift pattern are illustrated in Table E.4.

Table E.4 – Work calendar entries for 2014 shift calendar

ID	Description	Start date time	Finish date time	Entry type
1	Team A	2014-01-01T00:00:00	2014-01-01T23:59:59	Work shift
2	Team B	2014-01-02T00:00:00	2014-01-02T23:59:59	Work shift
3	Team C	2014-01-03T00:00:00	2014-01-03T23:59:59	Work shift
4	Team D	2014-01-04T00:00:00	2014-01-04T23:59:59	Work shift
5	Team A	2014-01-05T00:00:00	2014-01-05T23:59:59	Work shift
6	Team B	2014-01-06T00:00:00	2014-01-06T23:59:59	Work shift

E.2 Example of ISO 8601 format strings

ISO 8601 format is used to define the start rule, the recurrence time interval rule, and the duration rule. In ISO 8601 format some of these could be represented as a single string. In order to provide the necessary flexibility these are represented as separate ISO 8601 strings in this standard.

An ISO 8601 format string that represents a rule that defines the 15th of every month would be represented as: “R/2000-01-15/P1M”.

This is represented as two separate ISO 8601 strings. The start rule is “2000-01-15”and the recurrence time interval rule is “R/P1M”.

E.3 Bank holiday work calendar

Table E.5 defines a work calendar definition for 2014 England bank holidays. This work calendar definition could be combined with other work calendar definitions, such as company holidays and plant shutdown calendars, to determine working days during the year.

Table E.5 – Work calendar definition for 2014 England bank holidays

Attribute	Value
ID	001
Description	2014 England bank holidays

Table E.6 defines the work calendar definition entries for 2014 England bank holidays.

Table E.6 – Work calendar definition entries for 2014 England bank holidays

ID	Description	Start rule	Recurrence time interval rule	Duration rule	Entry type
001	New year's day	2014-01-01T00:00	<na>	P1D	Bank holiday
002	Good Friday	2014-18-04T00:00	<na>	P1D	Bank holiday
003	Easter Monday	2014-21-04T00:00	<na>	P1D	Bank holiday
004	May Day	2014-05-05T00:00	<na>	P1D	Bank holiday
005	Spring bank holiday	2014-05-26T00:00	<na>	P1D	Bank holiday
006	Summer bank holiday	2014-08-25T00:00	<na>	P1D	Bank holiday
007	Christmas and Boxing day	2014-12-25T00:00	<na>	P1D	Bank holiday

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