BSI Standards Publication

Enterprise-control system integration

Part 2: Objects and attributes for enterprise-control system integration

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National foreword

This British Standard is the UK implementation of EN 62264-2:2013. It is identical to IEC 62264-2:2013. It supersedes BS EN 62264-2:2008 which is withdrawn.

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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EUROPEAN STANDARD

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Enterprise-control system integration - Part 2: Objects and attributes for enterprise-control system integration
(IEC 62264-2:2013)

Intégration des systèmes entreprise-contrôle -
Partie 2: Objets et attributs pour l'intégration des systèmes de commande d'entreprise
(CEI 62264-2:2013)

Integration von Unternehmensführungs- und Leitsystemen -
Teil 2: Objekte und Attribute für die Integration von Unternehmensführungs- und Leitsystemen
(IEC 62264-2:2013)

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 65E/290/FDIS, future edition 2 of IEC 62264-2, prepared by SC 65E "Devices and integration in enterprise systems" of IEC/TC 65 "Industrial-process measurement, control and automation" and by ISO/TC 184/SC5 "Interoperability, integration and architectures for enterprise systems and automation applications" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 62264-2:2013.

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)	2014-05-01
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2016-08-01

This document supersedes EN 62264-2:2008.

EN 62264-2:2013 includes the following significant technical changes with respect to EN 62264-2:2008:

a) update of the first edition;

b) addition of object models for exchange information used in manufacturing operations management activities, instead of just production operations management actives. The added object models were physical asset, operations definition, operations schedule, operations performance, and operations capability;

c) displacement of the production specific object models in Annex A;

d) displacement of the UML object models that were in EN 62264-1:2008 into this standard so that the object models and the associated attribute tables were available in the same document;

e) addition of the Hierarchy scope object definition to replace the Location attribute used in the previous edition;

f) addition of a value type section to define the exchange of non-simple value types;

g) definition of simple value types were defined using the ISO 15000-5.

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

Endorsement notice

The text of the International Standard IEC 62264-2:2013 was approved by CENELEC as a European Standard without any modification.

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

IEC 61512-1	NOTE	Harmonised as EN 61512-1.
ISO 19439	NOTE	Harmonised as EN ISO 19439.
ISO 19440	NOTE	Harmonised as EN ISO 19440.

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   When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 62264-1	-	Enterprise-control system integration - Part 1: Models and terminology	EN 62264-1	-
ISO/IEC 19501	-	Information technology - Open Distributed Processing - Unified Modeling Language (UML)	-	-

CONTENTS

INTRODUCTION

This part of IEC 62264 further defines formal object models for exchange information described in IEC 62264-1 using UML object models, tables of attributes, and examples. The models and terminology defined in this part of IEC 62264:

a) emphasize good integration practices of control systems with enterprise systems during the entire life cycle of the systems;

b) can be used to improve existing integration capability of manufacturing control systems with enterprise systems; and

c) can be applied regardless of the degree of automation.

Specifically, this part of IEC 62264 provides a standard terminology and a consistent set of concepts and models for integrating control systems with enterprise systems that will improve communications between all parties involved. Benefits produced will:

a) reduce the user's time to reach full production levels for new products;

b) enable vendors to supply appropriate tools for implementing integration of control systems to enterprise systems;

c) enable users to better identify their needs;

d) reduce the cost of automating manufacturing processes;

e) optimize supply chains; and

f) reduce life-cycle engineering efforts.

This 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.

It is not the intent of the standards to:

a) suggest that there is only one way of implementing integration of control systems to enterprise systems;

b) force users to abandon their current way of handling integration; or

c) restrict development in the area of integration of control systems to enterprise systems.

ENTERPRISE-CONTROL SYSTEM INTEGRATION –

Part 2: Objects and attributes for enterprise-control system integration

1 Scope

This part of IEC 62264 specifies generic interface content exchanged between manufacturing control functions and other enterprise functions. The interface considered is between Level 3 manufacturing systems and Level 4 business systems in the hierarchical model defined in IEC 62264-1. The goal is to reduce the risk, cost, and errors associated with implementing the interface.

Since this standard covers many domains, and there are many different standards in those domains, the semantics of this standard are described at a level intended to enable the other standards to be mapped to these semantics. To this end this standard defines a set of elements contained in the generic interface, together with a mechanism for extending those elements for implementations.

The scope of IEC 62264-2 is limited to the definition of object models and attributes of the exchanged information defined in IEC 62264-1.

This part of IEC 62264 standard does not define attributes to represent the object relationships.

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

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

3 Terms, definitions and abbreviations

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
equipment class
grouping of role based equipment with similar characteristics

3.1.2
event
representation of a solicited or unsolicited fact indicating a state change in the enterprise

3.1.3
location
scope of exchanged information as identified by an element of the equipment hierarchy

EXAMPLE   There can be an agreement to only supply an "Area" name for exchanged information, because the site and enterprise are implicitly defined through the messaging system

3.1.4
material class
grouping of materials with similar characteristics

3.1.5
material lot
uniquely identifiable amount of a material

Note 1 to entry: It describes the actual or planned total quantity or amount of material available, its current state, and its specific property values.

3.1.6
material definition
definition of the properties for a substance

Note 1 to entry: This includes material that can be identified as raw, intermediate, final material, or consumable.

3.1.7
material sublot
uniquely identifiable subset of a material lot

Note 1 to entry: This can be a single item.

3.1.8
personnel class
grouping of persons with similar characteristics

3.1.9
product
desired output or by-product of the processes of an enterprise

Note 1 to entry: A product can be an intermediate product or end product from a business perspective.

Note 2 to entry: Also defined in ISO 10303-1 as: a substance produced by a natural or artificial process.

3.1.10
property
implementation specific characteristic of an entity

3.2   Abbreviations

For purposes of this standard the following abbreviations apply.

MOM   Manufacturing Operations Management

UML   Unified Modeling Language

4   Production operations models and generic operations models

4.1   Information models

Common objects used in information exchange that relate to personnel, equipment, physical assets, and material are defined in Clause 5.

The information described in IEC 62264-1 for production operations management are represented in the production schedule model, the production performance model, product definition model, and the production capability models, as shown in Figure 1. These objects are defined in Annex A.

Represented in the production schedule model   Represented in the production performance model

| Production schedule | Maintenance schedule | Quality test schedule | Inventory schedule |

| Production performance | Maintenance performance | Quality test performance | Inventory performance |

Manufacturing operations management

Production operations management

Maintenance operations management

Quality operations management

Inventory operations management

| Product definition | Maintenance definition | Quality test definition | Inventory definition |

| Production capability | Maintenance capability | Quality test capability | Inventory capability |

Represented in the production definition model   Represented in the production capability model

Figure 1 – Production operations management information models

A generic operations management information model is used to represent the information from other operations management areas which may be exchanged when more than production information is required. This is illustrated in Figure 2. These objects are defined in Clause 6.

Represented in the operations schedule model

Represented in the operations performance model

Production schedule	Maintenance schedule	Quality test schedule	Inventory schedule

Production performance	Maintenance performance	Quality test performance	Inventory performance

Manufacturing operations management

Production operations management

Maintenance operations management

Quality operations management

Inventory operations management

Product definition	Maintenance definition	Quality test definition	Inventory definition

Production capability	Maintenance capability	Quality test capability	Inventory capability

Represented in the operations definition model

Represented in the operations capability model

Figure 2 – Operations information models for operations management

4.2 General modeling information

This subclause describes the object models and attributes for information exchanged in enterprise-control system integration. The attributes are part of the definition of terms.

In this standard, the word "class" used as part of an object definition name is to be considered as a category, not as a "class" in the UML specification.

EXAMPLE "Personnel class" is to be considered a "personnel category", in the sense of distinguishing between the kinds of personnel in the real world.

A minimum set of industry-independent information has been defined as attributes. 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 presented as property objects. This mechanism is the extension capability referenced in the Scope of this standard. This solution increases the usability through the use of standard attributes, and allows flexibility and extensibility through the use of properties. This was included to make the standard as widely applicable as practical.

4.3 Extensibility of attributes through properties
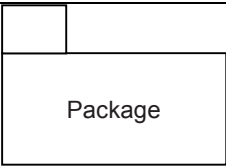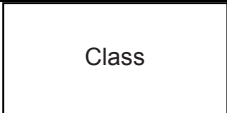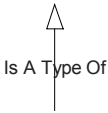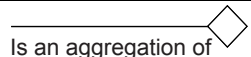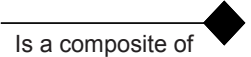
For particular applications the objects defined in the object models will need to be extended through the addition of attributes to object class definitions. Accordingly this standard provides for attributes that are application or industry specific, to be modeled in terms of properties and represented in property classes in the model. For example, the personnel class property would be used to define application or industry specific attributes for personnel classes, and person property would be used to contain instance values for the properties.

4.4   Object model structure

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

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

Table 1 – UML notation used

Symbol	Definition
Package	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.
Class	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.
Role 1..1 0..n Association Name Role	An association between elements of a class and elements of another or the same class. Each association is identified. Can 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 can exist.
Is A Type Of	Generalization (arrow points to the super class) shows that an element of the class is a specialized type of the super class.
depends on	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.
Is an aggregation of	Aggregation (made up of) shows that an element of the class is made up of elements of other classes.
Is a composite of	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.

4.5   Explanation of tables

4.5.1   Tables of attributes

This subclause gives the meaning of the attribute tables. This includes a listing of the object identification, data types, and presentation of the examples in the tables.

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

4.5.2   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 to 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.

4.5.3 Data types

The attributes presented are abstract representations, without any specific data type specified. A specific implementation will show how the information is represented.

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 standard format in one implementation and in Julian calendar format in another. Attributes for date or time can contain values for a date, a date and time or a time value, the standard does not enforce the value semantics. Each implementation will have to negotiate the value semantics.

EXAMPLE 3 An object or attribute relationship can be represented by key fields in data base tables, or by parent/child elements in an XML by nested hierarchy.

4.5.4 Presentation of examples

Examples are included with each attribute given. Examples are presented for each of the main operations categories defined in IEC 62264-1. See Table 2 below for how the example rows and columns are used.

Table 2 – Example table

Attribute name	Description	Production example	Maintenance example	Quality example	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, {}.

The examples are purely fictional. 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.

NOTE 1 Within a table the columns for Production, Maintenance, Quality and Inventory can be examples where the four operations management categories are coordinated or they can be separate examples. For example when one system is coordinating multiple operations management categories the IDs used in each column can be the same. When different systems coordinate multiple operations management categories the IDs can be different. Example attributes are meant to be illustrative, and do not imply requirements.

NOTE 2 Time and date attributes can illustrate a general or specific time horizon. For example a yearly or quarterly plan can use general dates with no specific time, while a detailed schedule can include a specific time stamp down to the minute.

Data resolution for the examples will be fit for purpose, which means that each implementation will negotiate the appropriate resolution required for each attribute.

NOTE 3   When (not applicable) is used as an example this is only illustrative that there is not a value for this attribute in this example. It does not imply there can never be a value. This is also true when all four columns contain (not applicable).

4.5.5   References to resources

The models used to document a reference to a resource, in another package, using the class or instance, with additional optional specification using properties, are not fully illustrated in the object model figures. This relationship is not conformant to the Unified Modeling Language (UML) modeling methodology, but was used to keep the diagrams simpler. Figure 3 below illustrates how it is currently presented, on the left side, and how it could be more accurately modeled in UML on the right side. UML was used in this standard as a visualization method and not meant to describe implementations. The simplified relationship diagram method is used for the following objects and their relationship to another package:

Personnel Capability	*Equipment Capability*
Material Capability	*Personnel Segment Capability*
Equipment Segment Capability	*Material Segment Capability*
Physical Asset Capability	*Physical Asset Segment Capability*
Personnel Segment Specification	*Equipment Segment Specification*
Material Segment Specification	*Physical Asset Segment Specification*
Personnel Specification	*Equipment Specification*
Material Specification	*Physical Asset Specification*
Personnel Requirement	*Equipment Requirement*
Material Requirement	*Physical Asset Requirement*
Personnel Actual	*Equipment Actual*
Material Actual	*Physical Asset Actual*

Simplified relationship model

Detailed relationship model
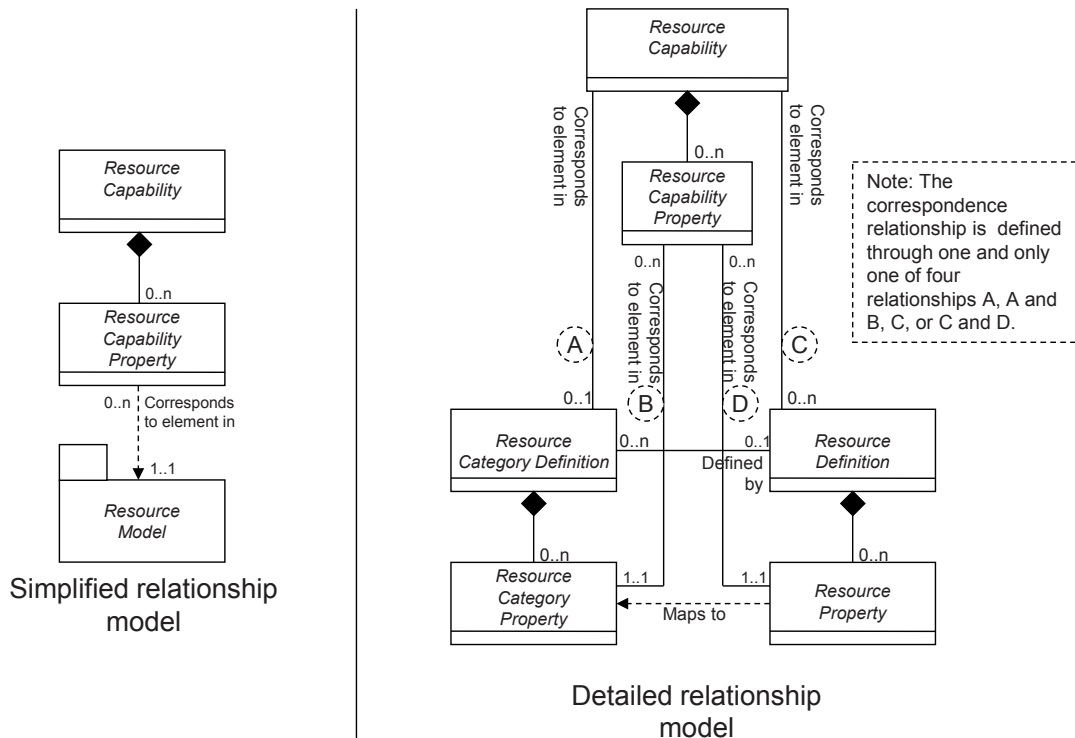
Figure 3 – Detailed resource relationship in models

The correspondence relationship is determined through one and only one of four possible relationships:

1) to the *resource category definition;*
2) to the *resource category definition* and *resource category property;*
3) to the *resource definition;*
4) to the *resource definition* and *resource property.*

In the model above the term *resource category* indicates: *personnel class*, *equipment class*, *physical asset class*, *material class*, and *material definitions*. The term *resource* indicates: *person*, *equipment*, *physical asset*, *material lot*, and *material sublot*. The term *resource capability* indicates the use in the capability models, *process segment capability model, the process segment model, operations definition model, operations schedule model, operations performance model, product definition model, production schedule model,* and *production performance model*.

4.5.6   Object relationships

This part of IEC 62264 does not define attributes to represent the object relationships.

NOTE Different implementations of the object models will have different methods for representing the object relationships. While the relationships can be represented as additional attributes on one implementation, such as a database, they could be represented as containment in another implementation, such as an XML document.

4.6   Relationship of models

The common information object models in Clause 5 describe the different types of resources and their uses in describing a (business) *process segment*. These object models are also used to describe the other (manufacturing) operations management information object models in Clauses 6, 7 and 8.

The operations management information object models described in Clause 6 shall be used for any manufacturing operations category, such as, production, maintenance, quality, inventory, and inventory handling, as defined in IEC 62264-1. Although the generic object model can also be used to describe operations management information models for user-defined operations categories, conformance can be evaluated only if user-specific conformance testing scenarios are available.

Also additional explanations to assist in applying these object definitions to describe the interoperability among the following operations management categories are provided in Annex E:

– production operations;
– maintenance operations;
– quality operations;
– inventory (handling) operations;
– mixed operations;
– user-defined operations.

The production information models described in Annex A reproduce the models in earlier versions of this standard in order to ensure the conformance of existing implementations of the standard.

– An *operations definition* for production operations is the equivalent of a *product definition*.
– An *operations schedule* for production operations is the equivalent of a *production schedule*.

– An *operations performance* for production operations is the equivalent of a *production performance*.

– An *operations capability* for production operations is the equivalent of a *production capability*.

However, for future implementations, it is recommended to use the operation models in Clause 6.

4.7 Hierarchy scope

Hierarchy scope is an attribute used in many other objects. The *hierarchy scope* attribute identifies where the exchanged information fits within the role based equipment hierarchy. It defines the scope of the exchanged information, such as a site or area for which the information is relevant. The *hierarchy scope* identifies the associated instance in the role based equipment hierarchy.

The *hierarchy scope* attribute is optional and is not needed if the context of the exchanged information can be determined based on the exchange mechanism used.

EXAMPLE 1   A *hierarchy scope* can identify a Site, such as WEST-END. A *Production Performance* can have a *Hierarchy Scope* attribute that identifies the WEST-END site.

EXAMPLE 2   A *hierarchy scope* can identify an Area within a Site, such as WEST-END/HOLDING-AREA. A *Production Capability* can have a *Hierarchy Scope* attribute that identifies the area.

EXAMPLE 3   A *hierarchy scope* can identify a WORK CENTER within an Area or Site, such as WEST-END/HOLDING-AREA/CHIPPING-BIN #1.

EXAMPLE 4   A *hierarchy scope* can identify a WORK CENTER without an Area or Site identification because these are already known due to the exchange mechanism, such as CHIPPING-BIN #1.

EXAMPLE 5   A *hierarchy scope* can identify a complete hierarchy of Enterprise, Site, Area, Work Center.

The *hierarchy scope* attribute may be modeled using the model illustrated in Figure 4 with attributes for the *hierarchy scope* object defined in Table 3. Each *hierarchy scope* object defines one element in the equipment hierarchy,
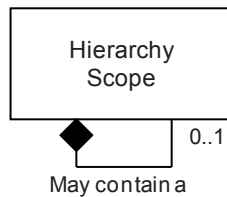
Figure 4 – Hierarchy scope model

Table 3 – Attributes of hierarchy scope

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
Equipment ID	A unique identification of an equipment element	WorkCenter23	West End	Ajax	North Size
Equipment Element Level	Identification of the equipment level if the equipment element is defined	Work Center	Site	Enterprise	Area

4.8 Value types

4.8.1 Value use

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 for *material definitions, material classes, equipment classes, personnel classes, physical asset classes, process segments, operations definitions,* and *product definitions*. Value types thus represent actual single values, actual arrays of values, and ranges of possible values, either as numerical or textual ranges or as sets of values.

4.8.2 Value syntax

The format for values in value attributes is not defined in this part of IEC 62264 and will be defined by implementations of the standard.

EXAMPLE   The following syntax, defined in an EBNF (Extended Backus–Naur Form) notation from ISO 14977, can be used to represent single element values, range specifications, arrays of values, and a set of allowed values as delimited text strings.

<value>	::=	<simpleValue> | <arrayValue> | <rangeValue> | <seriesValue>
<arrayValue>	::=	"[" <arrayElement> *("," <arrayElement>) "]"
<rangeValue>	::=	"{" <rangeElement> *("," <rangeElement> "}"
<seriesValue>	::=	"<" <simpleValue> *("," <simpleValue>) ">"
<arrayElement>	::=	<simpleValue> | <arrayValue>
<rangeElement>	::=	<simpleValue> ".." <simpleValue>
<simpleValue>	::=	string

4.8.3 Simple value types

Simple value types should be derived from core component types that are compatible with the ISO-15000-5 Core Component Technical Specification (CCTS). The CCTS types are a common set of types that define specific terms with semantic meaning (e.g. the meaning of a quantity, currency, amount, and identifier).

Table 4 – Commonly used CCTS types for exchange

AmountType	Used to define a number of monetary units specified in a currency where the unit of currency is explicit or implied.
BinaryObjectType	Used to define a data types representing graphics, pictures, sound, video, or other forms of data that can be represented as a finite length sequence of binary octets.
CodeType	Used to define a character string that is used to represent an entry from a fixed set of enumerations.
DateTimeType	Used to define a particular point in time together with the relevant supplementary information to identify the timezone information. This is a specific instance on time using the ISO 8601 CE (Common Era) calendar extended format and abbreviated versions.
IdentifierType	Used to define a character string to identify and distinguish uniquely, one instance of an object in an identification scheme from all other objects in the same scheme.
IndicatorType	Used to define a list of two mutually exclusive Boolean values that express the only possible states of a Property. For example "True" or "False".
MeasureType	Used to define a numeric value determined by measuring an object along with the specified unit of measure.
NumericType	Numeric information that is assigned or is determined by calculation, counting, or sequencing. It does not require a unit of quantity or unit of measure.
QuantityType	Used to define a counted number of non-monetary units, possibly including fractions.

TextType	Used to define a character string (i.e. a finite set of characters) generally in the form of words of a language.

4.8.4   Unit of measure

This standard defines attributes for value, quantity, and other units of measure. The unit of measure was explicitly specified to ensure that it was not missed in information exchanges. Implementations of this standard may represent the unit of measure in the manner appropriate for the implementation.

4.8.5   Array value types

Arrays of values may be represented following the syntax defined in the EBNF above.

EXAMPLE 1:   A set of values for a single dimension array with 6 values would be represented as:

[1 , 2 , 3 , 4 , 5 , 6]

EXAMPLE 2:   A set of values for a two dimension array of size 2x3 would be represented as:

[[1 , 2] , [3 , 4] , [5 , 6]]

4.8.6   Range value types

Range specifications may be represented following the syntax defined in the EBNF above.

EXAMPLE 1:   A simple range of values can be represented as:

{ 0 .. 100 }

EXAMPLE 2:   A non-continuous range of values can be represented as:

{ a .. z , A .. Z }

{ 0 .. 100 , 200 .. 300 , 500 , 600 .. 650 }

4.8.7   Series value types

A specification defined as a set of allowed values may be represented following the syntax defined in the EBNF above.

EXAMPLE 1:   A series of values that define colors can be represented as:

< Red , Green , Yellow , Blue>

EXAMPLE 2:   A series of values that define equipment hierarchy levels can be represented as:

<Enterprise , Site , Area , WorkCenter , WorkUnit>

4.8.8   Structured value types

Structured data elements may be represented in this standard's property model by representing the atomic elements of the structure in a flattened name space, or by using nested properties to represent the data structure.

NOTE 1   The decision to use a flattened name space, nested properties, or a combination is determined by the specific implementation.

A structure may be modeled by flattening the name space and having a single property for each structure element.

NOTE 2   This standard specifies how to exchange information without regard to the specific exchange element's mapping. With structured elements there is no guarantee that the communicating entities would have the same structure for the data. Therefore flattening the structure to its individual elements provides a transportable format for structured data.

EXAMPLE 1:   A structured element of data would be mapped to a flat name space as follows:

```
Structure Definition                  Flattened Property Name
Struct ABC {
        Integer DEF;                  ABC.DEF
        Float   GHI;                  ABC.GHI
         Array [3] of Integer JKI     ABC.JKI
}
```

A structured data element may be represented by creating a property with no data value or unit of measure and with nested child properties and an identification of the element.

EXAMPLE 2:   A structured data element can be mapped as follows:

```
C# Structure Definition            Equivalent Property

struct Simple    {                 Property [ID="Simple"]
  public int Position;             Property [ID="Simple"] \ Property [ID="Position"]
  public bool Exists;              Property [ID="Simple"] \ Property [ID="Exists"]
  public double LastValue;         Property [ID="Simple"] \ Property [ID="LastValue"]
  };
```

A grouping or collection of related properties may be represented by creating a property with nested child properties.

EXAMPLE 3:   A collection of related nominal properties can be mapped as follows:

```
Collection of Properties           Property Structure
                                   Property [ID="Nominal"]
NominalRate                        Property [ID="Nominal"] \ Property [ID="NominalRate"]
ExpectedRate                       Property [ID="Nominal"] \ Property [ID="ExpectedRate"]
LabelCode                          Property [ID="Nominal"] \ Property [ID="LabelCode"]
```

Nested property objects are only shown in the Personnel, Equipment, Physical Asset, and Material models. All property objects are also nested, as defined in the appropriate section in the text, but are not shown in the model figures in order to reduce the complexity of the figures.

5   Common object models

5.1   Personnel information

5.1.1   Personnel model

The personnel model shown in Figure 5 contains the information about specific personnel, classes of personnel, and qualifications of personnel.
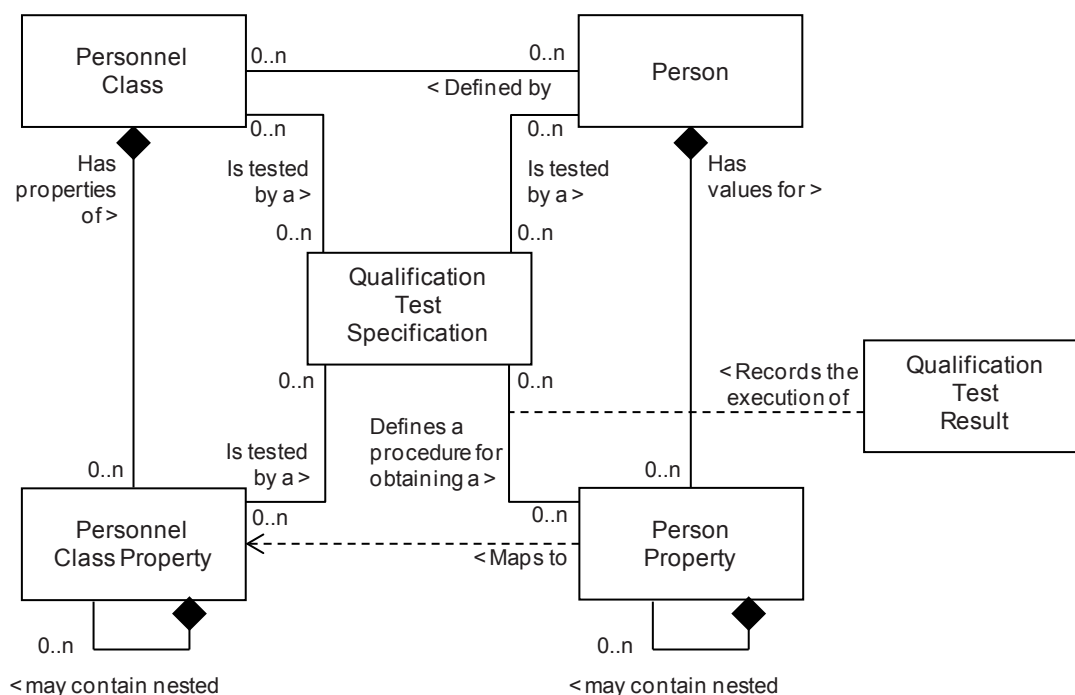
Figure 5 – Personnel model

5.1.2 Personnel class

A representation of a grouping of persons with similar characteristics for a definite purpose such as manufacturing operations definition, scheduling, capability and performance shall be presented as a *personnel class*. Any *person* may be a member of zero or more *personnel classes*. Table 5 lists the attributes of *personnel class*. A *personnel class* may be tested by the execution of a *qualification test specification*.

NOTE   Examples of *personnel classes* are cook machine mechanics, slicing machine operators, cat-cracker operator, and zipper line inspectors.

Table 5 – Attributes of personnel class

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of a specific *personnel class*. These are not necessarily job titles, but identify classes that are referenced in other parts of the model.	Widget assembly operator	Maintenance Technician Grade 1	Senior Lab Assistant	Warehouse Manager
Description	Additional information and description about the *personnel class*.	General information about widget assembly operators.	Highest grade for maintenance technician	Highest level of lab assistants	Person responsible for the warehouse

EXAMPLE   A *personnel class* can be associated to a *qualification test specification* without reference to a property, such as a *qualification test specification* for a fork truck operator, in which the test determined if the person is a member of the class of fork truck operators.

5.1.3 Personnel class property

Properties of a *personnel class* shall be presented as *personnel class properties*. Each *personnel class* shall have zero or more recognized properties. Table 6 lists the attributes of *personnel class property*.

NOTE Examples of *personnel class properties* for the personnel class operators are class 1 certified, class 2 certified, night shift, and exposure hours.

Operations requests may specify required *personnel class property* requirements for an *operations segment*.

A *personnel class property* may be tested by the execution of a *qualification test specification*.

Personnel class properties may contain nested *personnel class properties*.

Table 6 – Attributes of personnel class property

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 *personnel class* object. For example, the property "*Has Class 1 Safety Training*" (with values of *Yes* or *No*) can be defined under several different *personnel class* definitions, such as fork lift operator and pipe fitter classes, but has a different meaning for each class.	Class 1 Certified	Electrician Skills Class	LGC Model 1003 Certified Operator	Lift Truck Driver
Description	Additional information and description about the *personnel class property*.	Indicates the certification level of the operator.	Level of Skill Attained	Indicates if qualified to run equipment	Indicates if allowed to drive lift trucks
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 can be empty if any value is valid.	<True, False>	<Master, Journeyman, Apprentice>	<True, False>	<True, False>
Value Unit of Measure	The unit of measure of the associated property values, if applicable.	Boolean	String	Boolean	Boolean

5.1.4   Person

A representation of a specifically identified individual shall be presented as a *person*. A *person* may be a member of zero or more *personnel classes*.

A *person* may be tested by the execution of a *qualification test specification*.

Person shall include a unique identification of the individual.

Table 7 lists the attributes of *person.*

Table 7 – Attributes of person

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of a specific *person*, within the scope of the information exchanged (*production capability, production schedule, production performance*, …) The ID shall be used in other parts of the model when the *person* needs to be identified, such as the *production capability* for this person, or a *production response* identifying the person.	Employee 23	22828	999-123-4567	007
Description	Additional information about the resource.	Person Information	Maintenance Tech	Lab Tech	Driver
Name	The name of the individual. This is meant as an additional identification of the resource, but only as information and not as a unique value.	Jane	Jim	John	James

5.1.5   Person property

Properties of a *person* shall be presented as *person properties.* Each *person* shall have zero or more person properties. These specify the current property values of the *person* for the associated *personnel class property*.

NOTE   For example, a *person property* can be night shift and its value would be available, and a *person property* can be exposure hours available and its value would be 4.

Person properties may include the current availability of a *person* and other current information, such as location and assigned activity, and the unit of measure of the current information.

A *person property* may be tested by the execution of a *qualification test specification* with test results exchanged in a *qualification test result*.

Person properties may contain nested *person properties*.

Table 8 lists the attributes of *person property.*

Table 8 – Attributes of person property

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of the specific property.	Exposure Hours Available	Union ID	LGC Model 1003 Certified Operator	Lift Truck Driver
Description	Additional information about the *person property*.	Indicates number of exposure hours available this month	Union ID number	Indicates if qualified to run equipment	Indicates if allowed to drive lift trucks
Value	The value, set of values, or range of the property. The value(s) is assumed to be within the range or set of defined values for the related *personnel class property*.	4	CA55363	True	False
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	Hours	String	Boolean	Boolean

5.1.6   Qualification test specification

A representation of a qualification test shall be presented as a *qualification test specification.* A *qualification test specification* may be associated with a *personnel class*, a *personnel class property*, a *person*, or *person property*. This is typically used where a qualification test or properly demonstrated competency is required to ensure that a person has the correct training and/or experience for specific operations.

A *qualification test specification* may test for one or more properties.

A *qualification test specification* shall include:

a)   an identification of the test;

b)   the version of the test;

c)   the description of the test.

Table 9 lists the attributes of *qualification test specification.*

Table 9 – Attributes of qualification test specification

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of a test for certifying one or more values for one or more *person properties*. For example, this can be the name of a document that describes or defines the qualification test.	Class 1 Widget Assembly Certification Test	Union Renewal Test	LGC Model 1003 Certification Test	Fork Truck Driving Test
Description	Additional information and description about the *qualification test specification.*	Identifies the test for Class 1 Widget assembly certification – returns a True or False value for the *Class 1 widget assembly certification* property	Renewal for union membership	Identifies test for correct operation of LGC Model 1003	Identifies test for driving fork truck
Version	An identification of the version of the *qualification test specification*.	V23	01	A	23C

5.1.7   Qualification test result

The results from a qualification test for a specific person shall be presented as a *qualification test result*.

A *qualification test result* shall include:

a) the date of the test;

b) the result of the test (for example, passed or failed);

c) the expiration date of the qualification.

Table 10 lists the attributes of *qualification test result.*

Table 10 – Attributes of qualification test result

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique instance identification that records the results from the execution of a test identified in a *qualification test specification* for a specific *person*. (For example, this can just be a number assigned by the testing authority.)	T5568700827	UR20070809	LGC553	77276
Description	Additional information and description about the *qualification test results*.	Results from Joe's widget assembly qualification test for October 1999.	Renewal	Particle Analyzer SOP Test	Fork lift driver safety SOP test
Date	The date and time of the qualification test.	1999-10-25 13:30	2007-08-09	2006-10-31 08:40	2002-01-30
Result	The result of the qualification test. For example: Pass, Fail	Pass	Pass	Fail	Fail
Result Unit of Measure	The unit of measure of the associated test result, if applicable.	<Pass, Fail>	<Pass, Fail>	<Pass, Fail>	<Pass, Fail>
Expiration	The date of the expiration of the qualification.	2000-10-25 13:30	2008-08-09	2008-10-31	(not applicable)

5.2 Role based equipment information

5.2.1 Role based equipment model

The *role based equipment model* shown in Figure 6 contains the information about specific equipment, the classes of equipment, and equipment capability tests.

The formal UML role based equipment model object is used to define the role based equipment hierarchy information that is defined in IEC 62264-1. The model contains the information that may be used to construct the hierarchical models used in manufacturing scenarios. For purposes of corresponding to the IEC 62264-1 models, the defined equipment levels, specified in the Equipment Level attributes, for role based equipment are: Enterprise, Site, Area, Work Center, Work Unit, Process Cell, Unit, Production Line, Production Unit, Work Cell, Storage Zone, and Storage Unit.

NOTE The types of work centers can be extended as needed for application specific role based equipment hierarchies where the defined types do not apply. When a new type is added it usually maintains the same relationship within the hierarchy as the defined work center types (within an area and contains work units).

EXAMPLE 1   A laboratory can be an extended equipment level that defines a Work Center that includes all equipment in a test lab.

EXAMPLE 2   A maintenance storage center can be an extended equipment level that defines a Work Center that includes all equipment used by maintenance activities.

EXAMPLE 3   A Mobile Equipment Center can be a work center that includes all mobile equipment which can be used at different work centers or areas at different points in time.
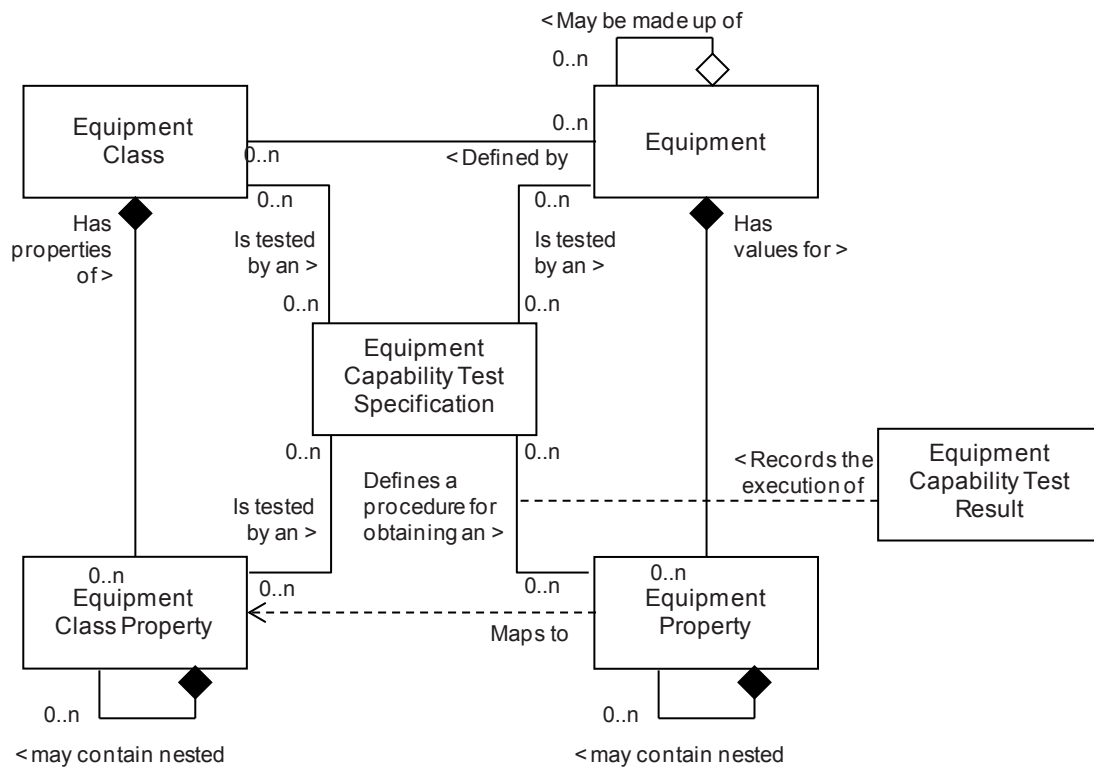
Figure 6 – Role based equipment model

5.2.2   Equipment class

A representation of a grouping of equipment with similar characteristics for a definite purpose such as manufacturing operations definition, scheduling, capability and performance shall be presented as an *equipment class*. Any piece of equipment may be a member of zero or more equipment classes.

An equipment class may be tested by the execution of an *equipment capability test specification*.

NOTE   Examples of *equipment classes* are reactor unit, bottling line, and horizontal drill press.

Table 11 lists the attributes of *equipment class*.

Table 11 – Attributes of equipment class

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of a specific *equipment class*, within the scope of the information exchanged (*production capability*, *production schedule*, *production performance*, …) The ID shall be used in other parts of the model when the *equipment class* needs to be identified, such as the *production capability* for this equipment class, or a *production response* identifying the equipment class used.	WJ6672892	Welder	5662AT	DR-FLT
Description	Additional information about the *equipment class*.	Jigs used to assemble widgets.	Welder to be signed out	Auto Titration Tester	Deep Reach Fork Truck
Equipment Level	An identification of the level in the role based equipment hierarchy.	Production Line	Work Center	Site	Area

5.2.3   Equipment class property

Properties of an equipment class shall be presented as *equipment class properties.* Each may have zero or more recognized properties.

An *equipment class property* may be tested by the execution of an *equipment capability test specification*.

Equipment class properties may contain nested *equipment class properties*.

NOTE   Examples of *equipment class properties* for the *equipment class* reactor unit can be lining material, BTU extraction rate, and volume.

Table 12 lists the attributes of *equipment class property.*

Table 12 – Attributes of equipment class property

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of the specific property.	Template Size	Capacity	Resolution	Max Weight
Description	Additional information about the *equipment class property*.	Range of template sizes for widget machines.	Capacity of the welder	Minimum peak resolution	Maximum carrying weight for the truck
Value	The value, set of values, or range of the property.	{10,20,30,40, 100,200,300}	{10..400}	{1 ..10}	{2 000 .. 36 000}
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	cm	Amperes	ppm	Kg

5.2.4 Equipment

A representation of the elements of the equipment hierarchy model shown in IEC 62264-1 shall be presented as *equipment*. *Equipment* may be a listing of Sites, Areas, Production Units, Production Lines, Work Cells, Process Cells, Units, Storage Zones or Storage Units.

Equipment may be tested by the execution of an *equipment capability test specification*.

Equipment may be made up of other *equipment*, as presented in the equipment hierarchy model.

EXAMPLE 1   A production line can be made up of work cells.

EXAMPLE 2   A reactor can be made up of sensors, valves, an agitator, and level switches.

Table 13 lists the attributes of *equipment.*

Table 13 – Attributes of equipment

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of a specific piece of equipment, within the scope of the information exchanged (manufacturing operations definition, scheduling, capability and performance) The equipment ID shall be used in other parts of the model when the equipment needs to be identified, such as the *production capability* for a piece of equipment, or a *production response* identifying the equipment used.	Jig 347	Wldr445	SN3883AT	VIN28203
Description	Additional information about the equipment.	This is the east side, north building, widget jig.	Welder for north building	Floor 2 lab auto titrator	Shipping dock lift truck
Equipment Level	An identification of the level in the role based equipment hierarchy.	Production Line	Work Center	Site	Area

5.2.5 Equipment property

Properties of *equipment* shall be presented as *equipment properties.* An *equipment* shall have zero or more *equipment properties*. These specify the current property values of the equipment for the associated equipment class property.

Equipment properties may include a unit of measure.

An *equipment property* may be tested by the execution of an *equipment capability test specification* with results exchanged in an *equipment capability test result*.

Equipment properties may contain nested *equipment properties*.

NOTE   An *equipment property* can exist without an associated *equipment class property*, however all parties in an exchange will have to have a common understanding of the *equipment property*.

EXAMPLE 1   An *equipment class property* can be volume with a value of {10 000 – 50 000} with a unit of measure of liters, an *equipment property* can be volume with a value of 30 000 and a unit of measure of liters.

EXAMPLE 2   Examples of equipment properties are

- other current information, such as when calibration is needed;
- maintenance status;
- the current state of the equipment;
- performance values.

Table 14 lists the attributes of *equipment property*.

Table 14 – Attributes of equipment property

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of the specific property.	Run Rate	Capacity	Resolution	Max Weight
Description	Additional information about the *equipment property*.	Widget making average run rate	Capacity of the welder	Minimum peak resolution	Maximum carrying weight for the truck
Value	The value, set of values, or range of the property. The value(s) is assumed to be within the range or set of defined values for the related *equipment property*.	59	{10-200}	0,05	1
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	Widgets/Hour	Amperes	%	Tons

5.2.6   Equipment capability test specification

A representation of a capability test shall be presented as an *equipment capability test specification.* An *equipment capability test specification* may be associated with an *equipment class, equipment class property, equipment* or *equipment property*. This is typically used where a test is required to ensure that the equipment has the necessary capability and capacity.

An *equipment capability test specification* may test for one or more *equipment properties*.

An *equipment capability test specification* shall include:

a) an identification of the test;

b) a version of the test;

c) a description of the test.

Table 15 lists the attributes of *equipment capability test specification.*

Table 15 – Attributes of equipment capability test specification

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of a test for certifying one or more values for one or more *equipment properties*. For example, this can be the name of a document that describes or defines the capability test.	WAJTT-101	Wldr_check	Att-Calibrate	Flt_Safety
Description	Additional information about the *equipment capability test specification*.	Widget assembly jig throughput test – returns the run rate for a specific machine	Welder Safety Check	Auto Titration tester Calibration	Lift truck safety truck
Version	An identification of the version of the capability test specification.	1,0	2,3	1,1	1,1

5.2.7 Equipment capability test result

The results from an equipment capability test for a specific piece of equipment shall be presented as an *equipment capability test result*.

An *equipment capability test* result shall include:

a) the date of the test;

b) the result of the test (passed-failed or quantitative result);

c) the expiration date of the test.

Table 16 lists the attributes of *equipment capability test result.*

Table 16 – Attributes of equipment capability test result

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique instance identification that records the results from the execution of a test identified in a *capability test specification* for a specific piece of *equipment*. (For example, this can just be a number assigned by the testing authority.)	FQ101/01-10-2000	WC888	AT98765	FS7602
Description	Additional information about the *equipment capability test result*.	Results from run rate test for JIG 237 for October 1999.	Results from safety check	Results from calibrate	Results from safety check
Date	The date and time of the capability test.	1999-10-25 13:30	1999-10-25 13:30	1999-10-25 13:30	1999-10-25 13:30
Result	The result of the capability test.	48	Fail	Pass	Pass
Result Unit of Measure	The unit of measure of the associated test result, if applicable.	Widgets/Hour	<Pass, Fail>	<Pass, Fail>	<Pass, Fail>
Expiration	The date of the expiration of the capability.	2000-10-25 13:30	2000-10-25 13:30	2000-10-25 13:30	2000-10-25 13:30

5.3 Physical asset information

5.3.1 Physical asset model

The physical asset model contains information about the physical piece of equipment, usually managed as a physical asset within the enterprise often utilizing a specific serial number. An object in the equipment model defines a role for the equipment, and object in the asset model defines the physical ID and properties of a piece of equipment.

EXAMPLE   Equipment IDs can be represented as TAGs, which define a role such as TC184 for a temperature controller, while the temperature controller is an asset and has a serial number (TC_WED_9982002922).

NOTE   The physical asset can be replaced (e.g. because it is broken) and in that case the TAG will not change, but a new physical asset with a unique serial number will take the place of the old physical asset. Therefore two separate ID's would be used one for the role (equipment ID) and one for the physical asset (physical asset ID).

While assets have Level 4 significance, usually because they have an economic value, this part of IEC 62264 of the standard focuses on the Level 3 significance of the asset. The asset model defines a physical asset as a representation of a physical piece of equipment.

Hierarchy levels in the physical asset hierarchy are not defined in this part of IEC 62264, however the role-based equipment hierarchy names should be used if they are equivalent.

A representation of physical asset equipment is illustrated in Figure 7.
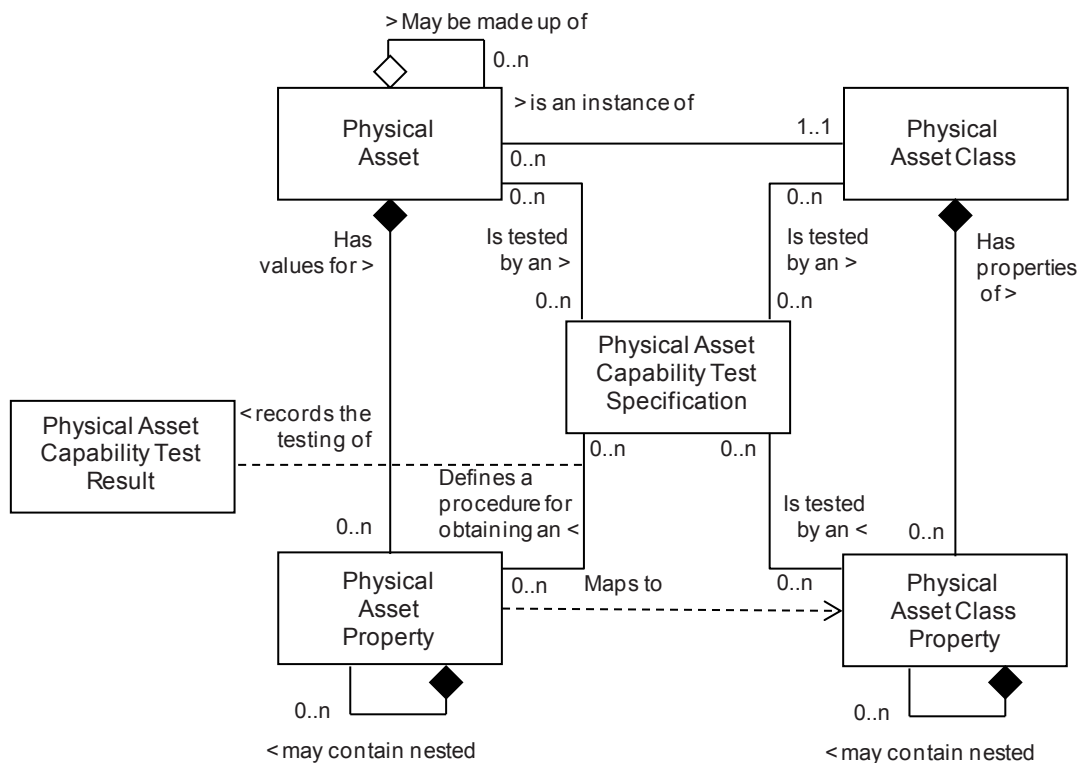
Figure 7 – Physical asset model

The relationship between the *physical asset* information and the *equipment* information is shown in Figure 8. There is a temporal relationship between the role of the *equipment* and the *physical asset*. The *physical asset* performing the role may change over time and the e*quipment asset mapping* maintains the association.
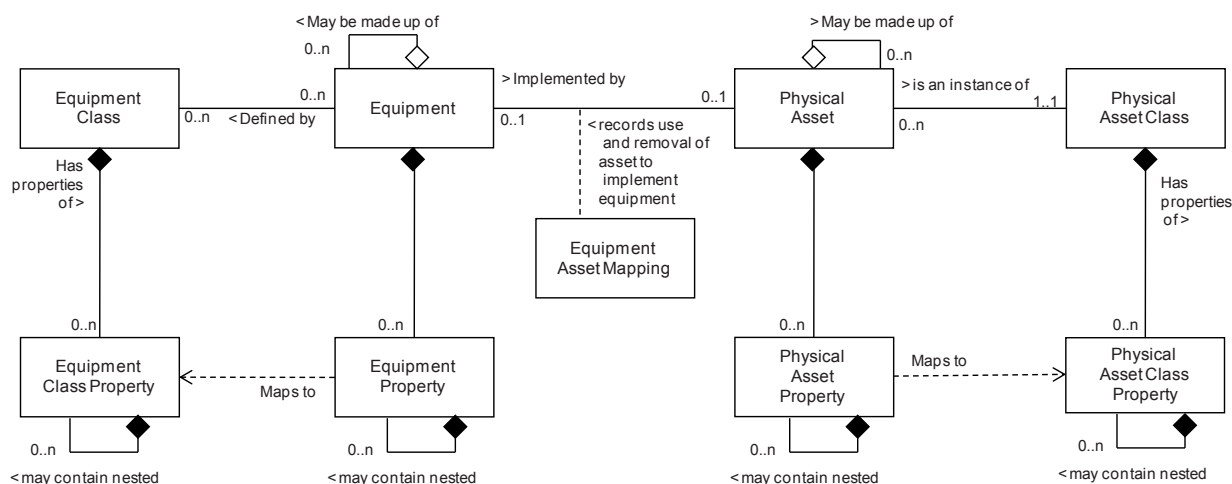
NOTE This model shown in Figure 8 is consistent with the MIMOSA data models, but with various name differences due to their development history.

1. A MIMOSA Asset element maps to a Physical Asset object.

2. A MIMOSA Asset Utilization History element maps to an *equipment asset mapping* object.

3. A MIMOSA Segment element maps to an Equipment object.

4. A MIMOSA Model element maps to a Physical Asset Class object.

A MIMOSA Agent element would map to an attribute or property, where needed.

Figure 8 – Physical asset and equipment relationship

5.3.2   Physical asset

A physical piece of equipment shall be presented as a *physical asset*.

A *physical asset* may be tested by the execution of a *physical asset capability test specification*.

Physical assets may be made up of other *physical assets*. For example, a packaging line may be made up of conveyor sections, motors, and sensors.

Table 17 lists the attributes of a *physical asset*.

Table 17 – Attributes of physical asset

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	Defines a unique identification of a *physical asset*.	SN5246$9	SN68928#1	SN5247$3	VIN 55262528
Description	Contains additional information and descriptions of the *physical asset*.	2 HP Pump	High Performance Welder	Auto titration tester	Fork truck
Physical Location	Actual physical location of the physical asset	Area 54, Unit 3A	Storage Bay 9982	Floor 2 Lab	Docking Bay 3
Fixed Asset ID	Contains a unique identification for financial tracking as required by laws or regulations	2000291	2000292	2000293	2000294
Vendor ID	Contains a vendor's serial number	AT55628	667y62	W78GJ77	H2228

EXAMPLE   Implementations could consider the following rules concerning the use of IDs:

1. The *physical asset* ID could be an enterprise wide identification.

2. If an information exchange is needed to handle assets across enterprises, then the ID could be a GUID (Globally Unique ID).

3. Common local practices may need to have other identifications of physical assets and additional correlated identifications represented as properties.

NOTE   Materials used in maintenance operations can be represented in either the physical asset model, in the material model, or in both. When represented in both models the IDs used to identify the material in both models (Material Lot and Physical Asset ID) would normally be the same.

5.3.3   Physical asset property

Properties of *physical assets* shall be presented as *physical asset properties.* A *physical asset* shall have zero or more *physical asset properties*. These specify the current property values of the *physical asset* for the associated *physical asset class property*. *Physical asset properties* may include a unit of measure.

A *physical asset property* may be tested by the execution of a *physical asset capability test specification* with results exchanged using a *physical asset capability test result*.

Physical asset properties may contain nested *physical asset properties*.

Table 18 lists the attributes of a *physical asset property*.

Table 18 – Attributes of physical asset property

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of the specific property.	Date of Manufacture	Assembly Drawing	Tracked Physical Asset	Tracked Physical Asset
Description	Additional information about the *asset property*.	Name plate date of production	Vendor assembly drawing ID	Indicates that the physical asset shall be signed out and tracked	Indicates the state of the physical asset
Value	The value, set of values, or range of the property. The value(s) is assumed to be within the range or set of defined values for the related *asset property*.	2008 10	ACC08-55642	<Tracked, Not Tracked,>	<Assigned, Issued, Available>
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	Date	String	Boolean	Boolean

5.3.4   Physical asset class

A representation of a grouping of physical assets with similar characteristics for purposes of repair and replacement shall be presented as a *physical asset class*. Any *physical asset* shall be a member of one *physical asset class*.

A *physical asset class* may be tested by the execution of a *physical asset capability test specification*.

Table 19 lists the attributes of a *physical asset class*.

Table 19 – Attributes of physical asset class

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
Manufacturer	An identification of the manufacturer.	Smith Pumps.	Jones Welders	Franz Testers	Chrysler Fleet Car
ID	The manufacture's identification of the specific *physical asset class*. For example: the model number	2HPWP	HPWLDR 103	ATT 99	Series K
Description	Additional information about the *physical asset class*.	Intrinsically Safe	(not applicable)	(not applicable)	(not applicable)

5.3.5 Physical asset class property

Properties of a *physical asset class* shall be presented as *physical asset class properties.* Each may have zero or more recognized properties.

A *physical asset class property* may be tested by the execution of a *physical asset capability test specification*.

Physical asset class properties may contain nested *physical asset class properties*.

Table 20 lists the attributes of a *physical asset class property*.

Table 20 – Attributes of physical asset class property

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of the specific property.	Throughput	Weld Rate	Test Speed	Charge Time
Description	Additional information about the *property*.	Pump throughput	Maximum speed of welder	Average test rate	Hours to recharge truck
Value	The value, set of values, or range of the property. The value(s) is assumed to be within the range or set of defined values for the related *asset property*.	400	5	1 315	5
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	L / min	cm/s	Samples / Hour	Hours

5.3.6 Physical asset capability test specification

A representation of a capability test for a *physical asset* shall be presented as a *physical asset capability test specification*. A *physical asset capability test specification* may be associated with a *physical asset property*. This is typically used where a test is required to ensure that the *physical asset* has the rated capability and capacity.

A *physical asset capability test specification* may test for one or more *physical asset properties*.

A *physical asset capability test specification* shall include:

a) the identification of the test;

b) the version of the test;

c) the description of the test.

Table 21 lists the attributes of a *physical asset capability test specification*.

Table 21 – Attributes of physical asset capability test specification

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of the specific physical asset capability test specification.	WPTT82	WR9	ATT00029	CTIME 99
Description	Additional information about the *test specification*.	Test of Pump Throughput	Test of Maximum speed of welder	Test of Average test rate	Test of Hours to recharge truck
Version	An identification of the version of the capability test specification.	00	1	2	3

5.3.7   Physical asset capability test result

The results from a qualification test for a specific *physical asset* shall be presented as a *physical capability test result*.

A *physical asset capability test result* shall include:

a) the date of the test;

b) the result of the test (passed-failed or quantitative result);

c) the expiration date of the test.

Table 22 lists the attributes of a *physical asset capability test result*.

Table 22 – Attributes of physical asset capability test result

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of the specific physical asset capability test result.	CPT-999	MT- 998	HD-878	IN-BX-7778
Description	Additional information about the *test result*.	the number of chrome plated widgets produced per hour	pH meter calibration result test	Hardness test of unit 878	Cold box storage temp. delta
Date	The date and time of the capability test.	1999-10-25 13:30	1999-10-25 13:30	1999-10-25 13:30	1999-10-25 13:30
Result	The result of the capability test.	48	7,000 1	<Pass, Fail>	1,2
Result Unit of Measure	The unit of measure of the associated test result, if applicable.	Widgets/Hour	pH	Boolean	^{o}C
Expiration	The date of the expiration of the capability.	2000-10-25 13:30	2000-10-25 13:30	2000-10-25 13:30	2000-10-25 13:30

5.3.8 Equipment asset mapping

The relationship between a *physical asset* and an *equipment* shall be presented as an *equipment asset mapping*.

The *equipment asset mapping* records the time period when one *equipment* object and one *physical asset* object were associated.

Table 23 lists the attributes of an *equipment asset mapping*.

Table 23 – Attributes of equipment asset mapping

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of the specific equipment asset mapping.	111	112	113	114
Description	Additional information about the *mapping* element.	(not applicable)	Installed under work order 48423. Removed under work order 93823	(not applicable)	(not applicable)
Start Time	The starting time of the association.	1997-02-10	1997-02-10	2004-04-23	2005-04-30
End Time	The ending time of the association.	2004-12-10	2004-12-10	(not applicable)	(not applicable)

5.4 Material information

5.4.1 Material model

The material model shown in Figure 9 defines the actual materials, material definitions, and information about classes of material definitions. Material information includes the inventory of

raw, finished, intermediate materials, and consumables. The information about planned or actual material is contained in the material lot and material sublot information. Material classes are defined to organize materials.
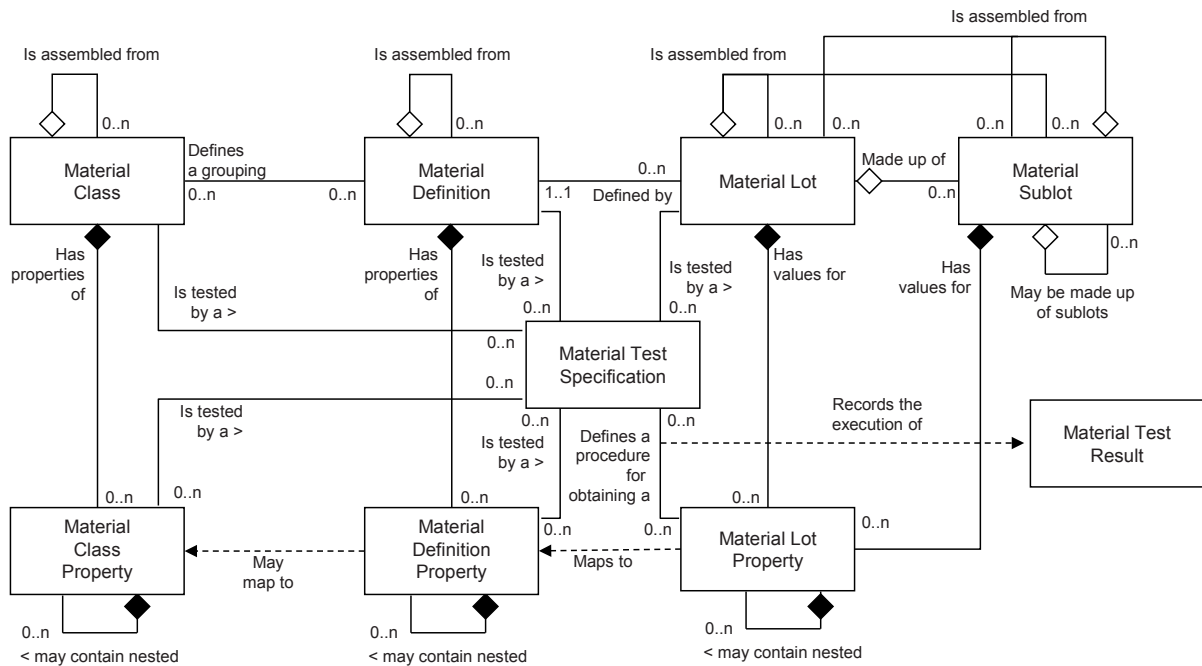
Figure 9 – Material model

5.4.2 Material class

A representation of groupings of *material definitions* for a definite purpose such as manufacturing operations definition, scheduling, capability and performance shall be presented as a *material class*.

A *material class* may be tested by the execution of a *material test specification*.

NOTE   An example of a *material class* can be sweetener, with members of fructose, corn syrup, and sugar cane syrup. Another example of a *material class* can be water, with members of city water, recycled water, and spring water.

A *material definition* shall belong to zero or more *material classes*.

Table 24 lists the attributes of *material class*.

Table 24 – Attributes of material class

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of a specific *material class*, within the scope of the information exchanged (*production capability*, *production schedule*, *production performance*, …) The ID shall be used in other parts of the model when the *material class* needs to be identified, such as the *production capability* for this *material class*, or a *production response* identifying the *material class* used.	Polymer sheet stock 1001A	200 cP Oil (SAE 90)	RH5510	20 mil Wrap
Description	Additional information about the *material class*.	Solid polymer resin	Very High Viscosity Lubricating Oil	Oxidizing Agent	Wrap used to wrap pallets
Assembly Type	Optional: Defines the type of the assembly. The defined types are: Physical – The components of the assembly are physically connected or in the same area. Logical – The components of the assembly are not necessarily physically connected or in the same area.	Physical	Physical	Logical	Physical
Assembly Relationship	Optional: Defines the type of the relationships. The defined types are: Permanent – An assembly that is not intended to be split during the production process. Transient – A temporary assembly using during production, such as a pallet of different materials or a batch kit.	Permanent	Transient	Permanent	Transient

A *material class* may be defined as containing an assembly of *material classes* and as part of an assembly of *material classes*:

    1) A *material class* may define an assembly of zero or more *material classes*.

    2) A *material class* may be an assembly element of zero or more *material classes*.

    3) An assembly may be defined as a permanent or transient assembly of *material classes*.

    4) An assembly may be defined as physical or a logical assembly of *material classes*.

5.4.3   Material class property

Properties of a material class shall be presented as *material class properties.* A *material class* may define zero or more *material class properties*.

A *material class property* may be tested by the execution of a *material test specification*.

Material class properties may contain nested *material class properties*.

NOTE   Examples of *material class properties* include density, pH factor, and material strength.

The *material class properties* often list the nominal, or standard, values for the material. A *material property* does not have to match a *material class property*.

Table 25 lists the attributes of *material class property*.

Table 25 – Attributes of material class property

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of a specific *material class property*.	Polyethylene sheet thickness	Oil Viscosity	pH	Weight
Description	Additional information about the *material class property*.	Sheet Thickness	Coefficient of viscosity	Acidity	Weight to be added to shipping label
Value	The value, set of values, or range of the property.	{5, 10, 25}	(not applicable)	{0..7}	(not applicable)
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	mm	Pa-s	pH	g / m^2

5.4.4   Material definition

A representation of goods with similar name characteristics for the purpose of manufacturing operations definition, scheduling, capability and performance shall be presented as a *material definition*.

A *material definition* may be tested by the execution of a *material test specification*.

NOTE   Examples of *material definitions* are city water, hydrochloric acid from Vendor A, and grade B aluminum.

Any *material lot* shall be associated with one *material definition*.

Table 26 lists the attributes of *material definition.*

Table 26 – Attributes of material definition

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of a specific *material definition*, within the scope of the information exchanged (*operations capability*, *operations schedule*, *operations performance*, …) The ID shall be used in other parts of the model when the *material definition* needs to be identified, such as the *operations capability* for this *material definition*, or a *production response* identifying the *material definition* used.	Sheet stock 1443a	DO200cpO	OA9929	PW882929
Description	Additional information about the *material definition*.	General purpose sheet stock	200 cP Oil from Dino Oil	Oxidizing Agent from RustItAll	General purpose 20 mil wrap
Assembly Type	Optional: Defines the type of the assembly. The defined types are: Physical – The components of the assembly are physically connected or in the same area. Logical – The components of the assembly are not necessarily physically connected or in the same area.	Physical	Physical	Logical	Physical
Assembly Relationship	Optional: Defines the type of the relationships. The defined types are: Permanent – An assembly that is not intended to be split during the production process. Transient – A temporary assembly using during production, such as a pallet of different materials or a batch kit.	Permanent	Transient	Permanent	Transient

A *material definition* may be defined as containing an assembly of *material definitions* and as part of an assembly of *material definitions:*

a) A *material definition* may define an assembly of zero or more *material definitions*.

b) A *material definition* may be an assembly element of zero or more *material definitions*.

c) An assembly may be defined as a permanent or transient assembly of *material definitions*.

d) An assembly may be defined as physical or a logical assembly of *material definitions*.

5.4.5 Material definition property

Properties of a *material definition* shall be presented as *material definition properties*. A *material definition* may define zero or more *material definition properties*.

A *material definition property* may be tested by the execution of a *material test specification*.

Material definition properties may contain nested *material definition properties*.

NOTE   Examples of *material definition property* include density, pH factor, or material strength.

Properties may present the nominal or standard values for the material.

Table 27 lists the attributes of *material definition property.*

Table 27 – Attributes of material definition property

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of the specific material definition property.	1443a5mm	Oil viscosity	pH	Weight
Description	Additional information about the *material definition property.*	5 mm sheet	Coefficient of viscosity	Acidity	Weight to be added to shipping label
Value	The value, set of values, or range of the property.	{4,85 .. 5,15}	{250 × 10^{-3} .. 255 × 10^{-3}}	{3.99 .. 4.01}	20 .. 21
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	mm	Pa-s	pH	g / m^2

5.4.6 Material lot

A uniquely identified specific amount of material, either countable or weighable shall be presented as a *material lot*. A *material lot* describes the planned or actual total quantity or amount of material available, its current state, and its specific property values.

A *material lot* may be tested by the execution of a *material test specification*.

A *material lot* shall include:

a) the unique identification of the lot;

b) the amount of material (count, volume, weight);

c) the unit of measure of the material (for example, parts, liters, kg);

d) the storage location for the material;

e) any status of the lot.

A *material lot* may be made up of *material sublots*. *Material lots* and *material sublots* may be used for traceability when they contain unique identifications.

Table 28 lists the attributes of *material lot.*

Table 28 – Attributes of material lot

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of a specific *material lot*, within the scope of the information exchanged (*operations capability*, *operations schedule*, *operations performance*, …) The ID shall be used in other parts of the model when the *material lot* needs to be identified, such as the *operations capability* for this *material lot*, or an *operations response* identifying the *material lot* used.	L66738-99	L8828-81	L53920-02	L8626-33
Description	Additional information about the material lot.	PlastiFab 10/31 shipment	Oil	Reagent	Wrapping material
Assembly Type	Optional: Defines the type of the assembly. The defined types are: Physical – The components of the assembly are physically connected or in the same area. Logical – The components of the assembly are not necessarily physically connected or in the same area.	Physical	Physical	Logical	Physical
Assembly Relationship	Optional: Defines the type of the relationships. The defined types are: Permanent – An assembly that is not intended to be split during the production process. Transient – A temporary assembly using during production, such as a pallet of different materials or a batch kit. NOTE If material lots (or sublots) are merged or absorbed (e.g. blended), then this is a new material lot.	Permanent	Transient	Permanent	Transient
Status	Status of the *material lot*. For example, released, approved, blocked, in process, in quality check.	In process	approved	blocked	approved
Storage Location	An identification of the storage location or a physical location of the *material lot*.	Work Center 1	Maintenance Shed 4S	Work Bench 10, Top Shelf	Warehouse 1
Quantity	The quantity of the *material lot.*	1 200	20	1	41
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	sheets	Cans	Liter	Rolls

NOTE 1   Representation of non-lot controlled items (for example consumable materials or bulk materials), can be represented in the *material lot* model through the use of a unique IDs for each different *material definition*. For example this could be the *material definition* ID or a system assigned ID,

NOTE 2   If non-lot controlled items are maintained in multiple locations then the information can be represented in the *material sublot* model through the use of unique sublot IDs for each different location and *material definition*.

A *material lot* or a *material sublot* may be defined as containing an assembly of *material lots* or *material sublots* and as part of an assembly of *material lots* or *material sublots*:

1. A *material lot* or a *material sublot* may define an assembly of zero or more *material lots* or *material sublots*.

2. A *material lot* or a *material sublot* may be an assembly element of zero or more *material lots* or a *material sublots*.

3. An assembly may be defined as a permanent or transient assembly of *material lots* or *material sublots*.

    EXAMPLE 1   A transient assembly could be a temporary collection of material maintained as a batch kit on a pallet, the batch kit is identified with a unique identification and can contain specific properties, such as a pallet identification, location, and related batch ID.

    EXAMPLE 2   A permanent assembly of material can be an automobile. The automobile has a unique vehicle identification number (VIN) and other properties. The automobile can contain an assembly of an engine, transmission, chassis, and wheels, each with their own unique identification and properties.

4. An assembly may be defined as physical or a logical assembly of *material lots* or *material sublots*. Assemblies of materials do not imply a manufacturing status.

    EXAMPLE 3   A finished tractor is a physical assembly of materials.

    EXAMPLE 4   An unassembled collection of tractor components that are separately shipped is a logical assembly of materials.

5.4.7   Material lot property

Properties of a *material lot* shall be presented as *material lot properties*. Each material can have unique values for zero or more *material lot properties*, such as a specific pH value for the specific *material lot*, or a specific density for the *material lot*.

A *material lot property* may be tested by the execution of a *material test specification* with results exchanged in a m*aterial test specification result*.

Material lot properties may contain nested *material lot properties*.

A *material lot property* is associated with either a *material lot* or a *material sublot*. When associated with a *material lot* it specifies a property value for all *material sublots*, when associated with a *material sublot* it specifies a property value for a single sublot.

Table 29 lists the attributes of *material lot property.*

Table 29 – Attributes of material lot property

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of the specific *material lot property*.	Average sheet thickness	Oil Viscosity	pH	Weight
Description	Additional information about the *material lot property*.	Measured thickness	Coefficient of viscosity	Acidity	Weight to be added to shipping label
Value	The value, set of values, or range of the property.	5,002	250×10^{-3}	4,01	20,3
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	mm	Pa-s	pH	g / m^2

5.4.8   Material sublot

Each separately identifiable quantity of the same *material lot* shall be presented as a *material sublot*. A *material lot* may be stored in separately identifiable quantities. All *material*

sublots are part of the same *material lot*, so they have the *material lot's* property values. A *material sublot* may be just a single item.

Material sublots may have sublot specific properties.

Material sublot properties may contain nested *material sublot properties*.

EXAMPLE   *Material sublot properties* can be RFID tag IDs or other identification properties, such that each *material sublot* has a different property value.

Each *material sublot* shall contain the location of the *material sublot* and the quantity or amount of material available in the *material sublot*.

Material sublots may contain other *material sublots*.

NOTE   For example, a *material sublot* can be a pallet, each box on the pallet can also be a sublot, and each material blister pack in the box can also be a sublot.

A *material sublot* shall include:

a) a unique identification of the sublot;

b) the storage location of the sublot;

c) the unit of measure of the material (for example, parts, kg, tons);

d) any status of the sublot.

Table 30 lists the attributes of *material sublot*.

Table 30 – Attributes of material sublot

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of a specific *material sublot,* within the scope of the information exchanged (*production capability*, *production schedule*, *production performance* …) The ID shall be used in other parts of the model when the *material sublot* needs to be identified, such as the *production capability* for this *material sublot*, or a *production response* identifying the *material sublot* used.	1999-10-27-a67-B6653	L8828-81-S1	L53920-02-A554	L8626-33-2
Description	Additional information about the *material sublot*.	Pallet 2 of 6	Oil	Reagent	Wrapping material
Assembly Type	Optional Defines the type of the assembly. The defined types are: Physical – The components of the assembly are physically connected or in the same area. Logical – The components of the assembly are not necessarily physically connected or in the same area.	Physical	Physical	Logical	Physical
Assembly Relationship	Optional: Defines the type of the relationships. The defined types are: Permanent – An assembly that is not intended to be split during the production process. Transient – A temporary assembly using during production, such as a pallet of different materials or a batch kit. NOTE If material lots (or sublots) are merged or absorbed (e.g. blended), then this is a new material lot.	Permanent	Transient	Permanent	Transient
Status	Status of the current *material sublot*. For example, released, approved, blocked, in process, in quality check.	Released	approved	blocked	approved
Storage Location	An identification of the storage location or a physical location of the *material sublot*.	Stainless Steel Tote #57	Maintenance Shed 4S, Top Shelf	Work Bench 10, Top Shelf	Warehouse 1
Quantity	The quantity of the *material sublot*.	40	10	1	41
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	sheets	Cans	Liter	Rolls

5.4.9 Material test specification

A representation of a material test shall be presented as a *material test specification.* A *material test specification* shall be associated with one or more *material definition properties*. This is typically used where a test is required to ensure that the material has the required property value. A *material test specification* may identify a test for one or more *material definition properties*. Not all properties need to have a defined *material test specification*.

Material test specifications may also be related to an operations request. The same material may have different specifications for different requests, depending on specific customer requirements.

A *material test specification* shall include

a) an identification of the test;

b) a version of the test;

c) a description of the test.

Table 31 lists the attributes of *material test specification.*

Table 31 – Attributes of material test specification

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of a test for certifying one or more values for one or more *equipment properties*. For example, this can be the name of a document that describes or lists the capability test.	STMT-101	MI330	QA8899	67
Description	Additional information about the *Material Test Specification*.	Sheet thickness measurement test – returns the average sheet thickness based on a sample plan and technique for a specific lot	Test of water content in an oil	Check of vendor's COA on pH.	Check of vendor's COA for weight or wrapping material
Version	An identification of the version of the *Material Test Specification*.	1,0	1,0	2,1	A.1

5.4.10 Material test result

A representation of the results from the execution of a quality assurance test shall be presented as a *material test result*. A *material test result* records the results from a material test for a specific *material lot* or *material sublot.*

The following are some characteristics of *material test results*.

a) They shall be related to a *material lot* or *material sublot.*

b) They may be related to an *operations request.*

c) They may be associated with a specific *operations response.*

d) They may be related to a specific *process segment.*

e) They may include a pass/fail status of the test.

f) They may include quantitative information of the tests.

g) They may include the granting or refusing of an in-process or finished goods waiver request.

h) They may be related to a product characteristic.

Material test results may be associated with a specific *operations response.*

Table 32 lists the attributes of *material test result.*

Table 32 – Attributes of material test result

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique instance identification that records the results from the execution of a test identified in a *material test specification* for a lot or sublot. (For example, this can just be a number assigned by the testing authority.)	THK101/01-10-2000	MO998	7763	u7373
Description	Additional information about the *Material Test Result*.	Results from thickness test for PlastiFab lot on 1999-10-25	Test of metal content in oil	Test of water pH	Check of expiration date
Date	The date of the material test.	1999-10-25 11:30	2008-01-23	2008-01-20	2008-01-23
Result	The value or list of values returned from the performance of the material test. For example: Pass, Fail, 95, Red, Green.	Pass	20	6,9	Pass
Result Unit of Measure	The unit of measure of the associated test result, if applicable.	<Pass, Fail>	ppm	pH	<Pass, Fail>
Expiration	The date of the expiration of the test results.	2000-10-25 13:30	2008-02-23	(not applicable)	(not applicable)

5.4.11 Assemblies

Assemblies are collections or sets of related elements. Assemblies are represented as relationships between elements and attributes of the elements. Each assembly element has its own identity and properties, such as a *material lot* which has its own identity and properties. An object with an assembly (*material lot, material sublot*, *material class*, and *material definition*) shall contain the list of other elements that make up the assembly.

NOTE 1 Many assembly type industries, such as automobile manufacturing, airplane assembly, and furniture manufacturing use the concept of assemblies. A produced material, with a unique identification and properties, is made up of other materials with their own unique identification and properties.

EXAMPLE 1   An "automobile" is a material lot, with specific properties (color, VIN #, make, model, …) while it also contains other chassis parts (engine, transmission, axles …) that also have their own unique identification and properties.

EXAMPLE 2   A transaxle in an automobile has its own identification and also is an assembly of subcomponents, as shown in Figure X, including seals, bearing, axle shaft, etc, as shown in Figure 10. There can be an assembly which defines a specific model of transmission described in a *Material Definition Assembly*, and there can be an assembly that defines a specific transmission described in a *Material Assembly*.

EXAMPLE 3   A "batch kit" is an assembly that contains a collection of different materials that would be used in the production of a batch, for example a batch kit for a soup can contain the seasonings that are used in production of a single batch. There can be an assembly which defines the class of materials used in a batch kit described in a *Material Class Assembly*, and there can be a batch specific assembly which defines specific material lots or sublots described in a *Material Assembly*.
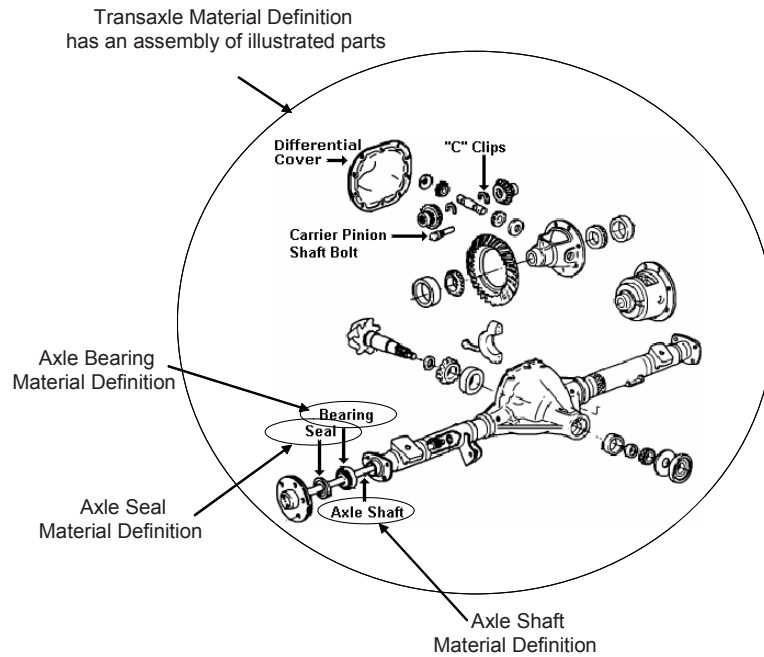
Figure 10 – Example of a material with an assembly

5.5 Process segment information

5.5.1 Process segment model

Process segments are the smallest elements of manufacturing activities that are visible to business processes. The process segment model is a hierarchical model, in which multiple levels of abstraction of manufacturing processes may be defined because there can be multiple business processes requiring visibility to manufacturing activities.

NOTE   The term *business process segment* is a synonym for *process segment* and is used to reflect the business process aspect of the process segment.

Process segments are also logical grouping of personnel resources, equipment resources, physical asset resource and material required to perform a manufacturing operations step. A *process segment* defines the needed classes of personnel, equipment, physical assets, and material, and/or it may define specific resources, such as specific equipment needed. A process segment may define the quantity of the resource needed.

The manufacturing operations step may be a production operations step, inventory operations step, maintenance operations step, and quality operations step.

Figure 11 is the process segment model.
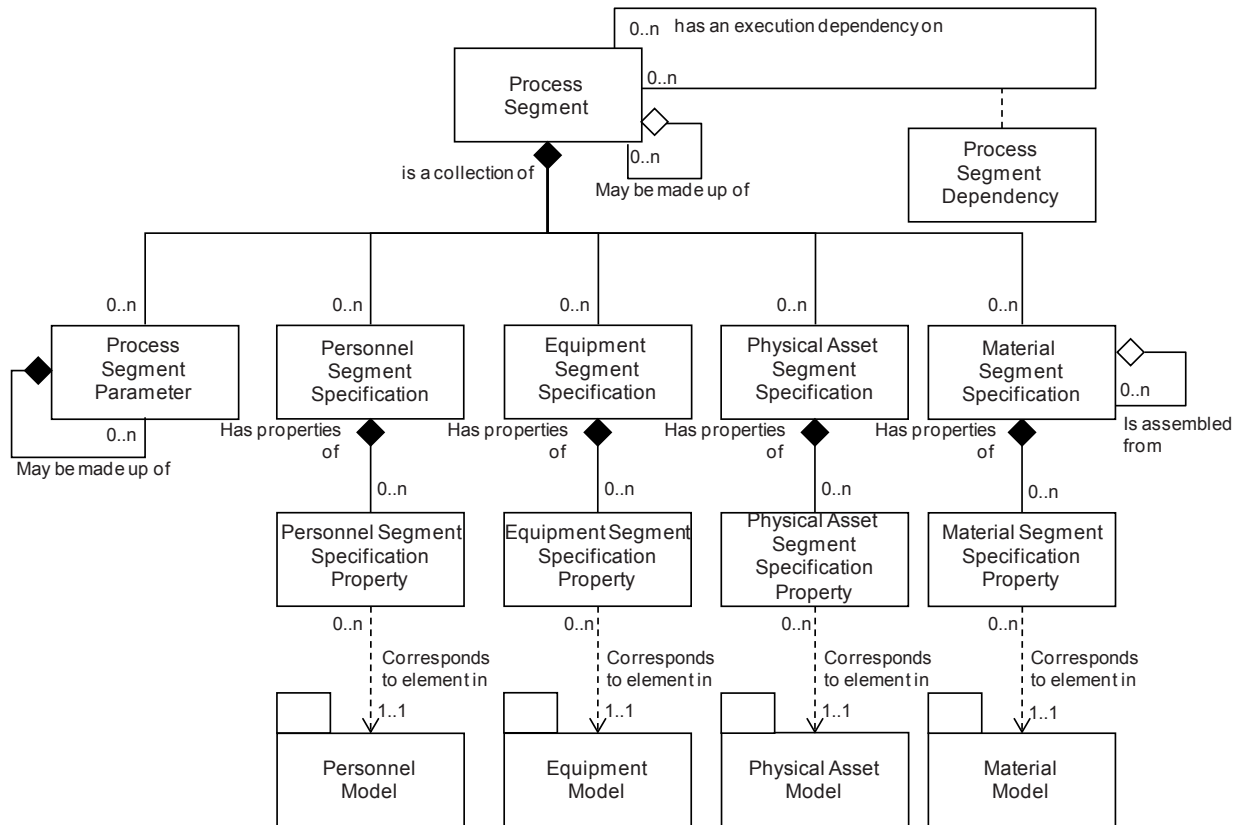
Figure 11 – Process segment model

5.5.2 Process segment

A *process segment* lists the classes of personnel, equipment, physical assets, and material needed, and/or it may present specific resources, such as specific equipment needed for the process segment. A *process segment* may list the quantity of the resource needed.

A *process segment* is something that occurs or can occur during manufacturing operations.

Process segment may identify

a) the time duration associated with the resource;

   NOTE   Five hours or 5 h/100 kg.

b) constraint rules associated with ordering or sequencing of segments.

A process segment may be made up of other process segments, in a hierarchy of definitions.

Process segments may contain specifications of specific resources required by the *process segment*. *Process segments* may contain parameters that can be listed in specific *operations requests*.

Table 33 defines the attributes for *process segment* objects.

Table 33 – Attributes of process segment

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of a *process segment*, within the scope of the information exchanged (*operations capability*, *operations schedule*, *operations performance* …) The ID shall be used in other parts of the model when the *process segment* needs to be identified, such as the *operations capability* for this segment, or an operations *response* identifying the segment.	Widget Frame Milling	Replace Motor	Pull Sample and Run Test	Transfer
Description	Additional information about the *process segment*.	Frame milling operation, separately costed operation	Large size motor replacement	Check purity and concentration	Move pallet from truck to conveyor system
Operations type	Describes the category of the activity Required attribute. Defined values are: Production, Maintenance, Quality, Inventory, or Mixed. "Mixed" shall be used when the activity contains several categories of process segments.	Production	Maintenance	Quality	Inventory
Hierarchy Scope	Identifies where the exchanged information fits within the role based equipment hierarchy. Optionally defines the scope of the process segment definition, such as the site or area it is defined for.	South Shore (Site) / Work Line (Area)	South Shore (SITE) / Packaging (Area)	Mixer Sample Port (Work Unit)	Receiving dock (Work Center)
Duration	Duration of process segment, if known.	25	(not applicable)	20	5
Duration Unit of Measure	The units of measure of the duration, if defined.	Minutes	(not applicable)	minutes	minutes

5.5.3   Personnel segment specification

Personnel resources that are required for a *process segment* shall be presented as *personnel segment specifications*.

Table 34 defines the attributes for *personnel segment specification* objects.

Table 34 – Attributes of personnel segment specification

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
Personnel Class	Identifies the associated *personnel class* or set of *personnel classes* specified	Milling Machine Operator	Type 2 Mechanic	Lab Tech A	Lift truck operator
Person *	Identifies the associated *person* or set of *persons* specified	<n/a>	<n/a>	<n/a>	<n/a>
Description	Contains additional information and descriptions of the *personnel segment specification* definition.	Defines the time for journeyman milling machine operators for each widget frame milling process segment.	Qualified to replace motor type NEMA 4.	Qualified to operation of reflectome-ter	Certified lift truck operator
Personnel Use	Defines the expected use of the personnel class or person.	Allocated	Certified	Certified	Allocated
Quantity	Specifies the personnel resource required for the parent *process segment*, if applicable.	1,3	2	0,5	5
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Hours / piece	Hours / motor	Hours / sample	minutes / transfer
* Typically only *personnel class* is defined.					

5.5.4 Personnel segment specification property

Specific properties that are required for *personnel segment specifications* shall be presented as *personnel segment specification properties*.

Personnel segment specification properties may contain nested *personnel segment specification properties*.

Table 35 defines the attributes for *personnel segment specification property* objects.

Table 35 – Attributes of personnel segment specification property

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of a property of the associated *person property* or *personnel class property*.	Height	Scuba Trained	Color Vision	2nd Shift
Description	Contains additional information and descriptions of the property.	Defines the required minimum height of a milling machine operator.	Class 4 work requires use of scuba underwater	Be able to distinguish red and green	Be able to be able to operate 2nd shift
Value	The value, set of values, or range of the property.	150	TRUE	TRUE	TRUE
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	cm	<True, False>	<True, False>	<True, False>
Quantity	Specifies the personnel resource required, if applicable.	1,3	(not applicable)	(not applicable)	(not applicable)
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Hours / piece	(not applicable)	(not applicable)	(not applicable)

5.5.5 Equipment segment specification

Equipment resources that are required for a *process segment* shall be presented as *equipment segment specifications*.

Table 36 defines the attributes for *equipment segment specification* objects.

Table 36 – Attributes of equipment segment specification

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
Equipment Class	Identifies the associated *equipment class* or set of *equipment classes* of the capability.	(not applicable)	10 Ton Crane	Reflecto-meter	800 kg Fork Truck
Equipment*	Identifies the associated *equipment* or set of *equipment* of the capability.	Milling Machine 001	(not applicable)	(not applicable)	(not applicable)
Description	Contains additional information and descriptions.	Equipment needed for widget milling process segment	Crane required to remove motor	Measures substrate thickness of wafer	Able to lift two standard pallets
Equipment Use	Defines the expected use of the equipment class or equipment in the context of the process segment.	Part Milling	Remove and Replace Motor	Run Test	Material Movement
Quantity	Specifies the amount of resources required, if applicable.	1,3	1	1	1
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Machine Hours / piece	Day	Test	Move
* Typically either *equipment class* or *equipment* is defined.					

5.5.6 Equipment segment specification property

Specific properties that are required for *equipment segment specifications* shall be presented as *equipment segment specification properties*.

Equipment segment specification properties may contain nested *equipment segment specification properties*.

Table 37 defines the attributes for *equipment segment specification property* objects.

Table 37 – Attributes of equipment segment specification property

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of a property of the associated *equipment property* or *equipment class property*.	Milling Direction	Mobile	Calibrated	Power
Description	Contains additional information and descriptions.	Only vertical milling machines are suitable for widget milling.	Mobile crane	Within calibrated date	Type of power
Value	The value, set of values, or range of the property. For example: Vertical, Horizontal	Vertical	TRUE	TRUE	Electric
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	(not applicable)	<True, False>	<True, False>	{Electric, Gas, LP}
Quantity	Specifies the amount of resources required.	1,0	(not applicable)	(not applicable)	(not applicable)
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Machine Hours / piece	(not applicable)	(not applicable)	(not applicable)

5.5.7 Material segment specification

Material resources that are required for a *process segment* shall be presented as *material segment specifications*.

Table 38 defines the attributes for *material segment specification* objects.

Table 38 – Attributes of material segment specification

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
Material Class	Identifies the associated *material class* or set of *material classes* of the capability.*	Polymer sheet stock 1001A	Motor Brushes	Sample Holder	Pallet
Material Definition	Identifies the associated material definition or set of *material definitions* of the capability. *	Sheet stock 1443a	#9949	Polyuretha ne sample holder	Plastic Pallet
Description	Contains additional information and descriptions.	Defines the polymer required for a widget milling process segment.	Brushes required during motor maintenance	Disposabl e sample holder	Pallet used for storage
Assembly Type	Optional: Defines the type of the assembly. The defined types are: Physical – The components of the assembly are physically connected or in the same area. Logical – The components of the assembly are not necessarily physically connected or in the same area.	Physical	Physical	Logical	Physical
Assembly Relationship	Optional: Defines the type of the relationships. The defined types are: Permanent – An assembly that is not intended to be split during the production process. Transient – A temporary assembly using during production, such as a pallet of different materials or a batch kit.	Permanent	Transient	Permanent	Transient
Material Use	Defines the material use. For production defined values are: Consumable, Material Consumed, and Material Produced	Material Consumed	Material Consumed	Material Consumed	Material Consumed
Quantity	Specifies the amount of resources required.	0,35	6	1	(not applicable)
Quantity Unit of Measure	The unit of measure of the associated property value, if applicable.	Sheets / piece	Units	Units	(not applicable)
* Typically either a *material class* or *material definition* is specified.					

A *material segment specification* may be defined as containing an assembly of *material segment specifications* and as part of an assembly of *material segment specifications*:

a) A *material segment specification* may define an assembly of zero or more *material segment specifications*.

b) A *material segment specification* may be an assembly element of zero or more *material segment specifications*.

c) An assembly may be defined as a permanent or transient assembly of *material segment specifications*.

d) An assembly may be defined as physical or a logical assembly of *material segment specifications*.

5.5.8   Material segment specification property

Specific properties that are required for *material segment specifications* shall be presented as *material segment specification properties*.

Material segment specification properties may contain nested *material segment specification properties*.

Table 39 defines the attributes for *material segment specification property* objects.

Table 39 – Attributes of material segment specification property

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of a property of the associated *material property* or *equipment class property*.	Average Surface Roughness	314 Stainless Steel	Sterilized	RFID
Description	Contains additional information and descriptions.	Defines the minimum polyethylene roughness quality.	Required alloy	Sterilized sample holder	Pallet contains an active RFID
Value	The value, set of values, or range of the property.	66,748	TRUE	TRUE	Active
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	Angstroms	<True, False>	<True, False>	<Active, Passive, None>
Quantity	Specifies the amount of resources required, if applicable.	0,10	(not applicable)	(not applicable)	(not applicable)
Quantity Unit of Measure	The unit of measure of the associated property value, if applicable.	Sheets / piece	(not applicable)	(not applicable)	(not applicable)

5.5.9   Physical asset segment specification

Physical asset resources that are required for a *process segment* shall be presented as *physical asset segment specifications*.

Table 40 defines the attributes for *physical asset segment specification* objects.

Table 40 – Attributes of physical asset segment specification

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
Physical Asset Class	Identifies the associated *physical asset class* or set of *physical asset classes* of the capability.	Acme Super TT10	Easy bake 1969	Wafers R Us RF 100	SuperTote 2000
Physical Asset	Identifies the associated *physical asset* or set of *physical assets* of the capability.	TI-101	OV-1200	RF-140	Tote 12A
Description	Contains additional information and descriptions.	Transmitter with most recent calibration date	Oven with minimum 2000 hours on run clock	Measures substrate thickness of wafer	Able to store 200 vials in 40 x 5 matrix
Physical Asset Use	Defines the expected use of the physical asset class or physical asset in the context of the process segment.	Temperature of granulation process	Preventive maintenance	Thickness measure-ment	Storage
Quantity	Specifies the amount of resources required, if applicable.	1	1	1	1
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	°K	hours	micron	Cubic feet

5.5.10 Physical asset segment specification property

Specific properties that are required for *physical asset segment specifications* shall be presented as *physical asset segment specification properties*.

Physical asset segment specification properties may contain nested *physical asset segment specification properties*.

Table 41 defines the attributes for *physical asset segment specification property* objects.

Table 41 – Attributes of physical asset segment specification property

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of a property of the associated *physical asset property* or *physical asset class property*.	Temperature calibration date	Run clock	Calibrated	Tote Type
Description	Contains additional information and descriptions.	Calibration date no later than 6 months from use	Running time hours from last preventive maintenance	Within calibrated date	Only plastic totes
Value	The value, set of values, or range of the property. For example: Vertical, Horizontal	1999-12-31	1200	True	Plastic
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	Date	Hours	<True, False>	String
Quantity	Specifies the amount of resources required.	(not applicable)	(not applicable)	(not applicable)	3
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	(not applicable)	(not applicable)	(not applicable)	Count

5.5.11 Process segment parameter

Specific parameters required for a *process segment* shall be presented as *process segment parameters*.

Process segment parameters may contain nested *process segment parameters*.

Table 42 defines the attributes for *process segment parameter* objects.

Table 42 – Attributes of process segment parameter

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	Identification of the *process segment parameter*.	Milling Time	Crane Lead Time	Sample Size	Number of Pallets
Description	Contains additional information.	Range of acceptable milling times.	Known lead time to get crane available	Size of sample to be pulled	Number of pallets needed for move
Value	The value, set of values, or range of acceptable values	{5..10}	{1..20}	{5-20}	(not applicable)
Unit of Measure	Unit of measure of the values, if applicable.	Minutes	Days	mg	(not applicable)

5.5.12 Process segment dependency

Process dependencies that are independent of any particular product or operations task shall be presented as *process segment dependencies*.

NOTE 1   For example, a *process segment dependency* can define that a testing segment is required to follow an assembly segment.

Table 43 defines the attributes for *process segment dependency* objects.

Table 43 – Attributes of process segment dependency

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	The identification of the unique instance of the *process segment dependency*.	PSD001	34	A35	PSA-I-5563
Description	Contains additional information and descriptions of the *process segment dependency* definition.	Defines the ordering of assembly processes the Widget Assembly process segment	Do not start until production is complete	Can pull samples anytime during production	Do not move to storage until released by quality
Dependency Type	Defines the execution dependency constraints of one segment by another segment	Start *Cleanout* no earlier than T (*Timing Factor*) after *Work* end	Start *Motor Replacement* after *Cleanout* end	*Pull Sample* can run in parallel with *MIX*	*Move Inventory* after *Quality Release*
Dependency Factor	Factor used by dependency	25	(not applicable)	(not applicable)	(not applicable)
Unit of Measure	The units of measure of the dependency factor, if defined.	Minutes	(not applicable)	(not applicable)	(not applicable)

EXAMPLE   Using 'A' and 'B' to identify the process segments, or specific resources within the segments, and T to identify the timing factor, as shown in Figure 12, the dependencies include:

– B cannot follow A

– B can run in parallel to A

– B cannot run in parallel to A

– Start B at A start

– Start B after A start

– Start B after A end

– Start B no later than T (Dependency Factor with time T) after A start

– Start B no earlier than T (Dependency Factor with time T) after A start

– Start B no later than T (Dependency Factor with time T) after A end

– Start B no earlier than T (Dependency Factor with time T) after A end

B may run in parallel to A
Start B at A start
Start B after A start
Start B no later than T time after A start
Start B no earlier than T time after A start
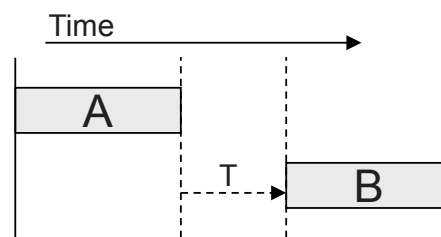
B may not run in parallel to A
Start B at A end
Start B after A end
Start B no later than T time after A end
Start B no earlier than T time after A end

Figure 12 – Segment dependency examples

NOTE 2   The associations to the A and B segments are not represented as attributes, as per 4.5.6.

5.6 Containers, tools and software

5.6.1 Containers

A container for material shall be presented as role based equipment, physical asset, or both of type storage zone or storage unit.

EXAMPLE 1   In a refinery; bulk storage tanks would be represented as Storage Units and as containers for specific materials.

EXAMPLE 2   In an automotive plant; assembly parts bins would be represented as Storage Units and as containers for an assembly of parts.

EXAMPLE 3   In a pharmaceutical plant; portable tote bins or pallets that hold tablets would be represented as Storage Units for a specific material lot or sublot.

EXAMPLE 4   Properties of containers would be represented as Equipment Class, Equipment, Physical Asset Class, or Physical Asset properties, such as: Readiness, Transportability, Disposable, and Cleanness.

The association of *material lots* and *material sublots* to containers shall be presented as properties of the *material lot* or *material sublot*.

The association of containers to *material lots* and *material sublots* shall be presented as properties of the container.

5.6.2 Tools

A tool shall be presented as role based equipment, physical asset, or both.

EXAMPLE 1   In a pharmaceutical plant; a tablet die used to compress and shape tablets would be represented as a Work Unit. The tablet die work unit can have properties that identified the expected use time and the actual use time.

EXAMPLE 2   In plastics parts manufacturing; an extruder die would be represented as a Work Unit. The extruder machine could be represented as a Work Cell.

EXAMPLE 3   In semiconductor manufacturing; a multi-platen multi-wafer CMP (Chemical Mechanical Polishing) tool would be represented as a Work Cell.

EXAMPLE 4   A micrometer used for measuring sheet metal thickness in a general purpose machine shop can be recorded as equipment but not tracked as a physical asset.

5.6.3 Software

Software shall be presented as role based equipment, physical asset, or both.

NOTE   Level 3 applications can have responsibility for keeping the actual software up to date. In the context of this standard, information about the software can need to be specified, reported or synchronized with Level 4 systems.

EXAMPLE 1   When a patch is applied to software the change may need to be known by Level 3 systems to allow additional testing and Level 4 systems to update security settings.

EXAMPLE 2   When a physical asset is decommissioned and it contains licensed software, then a Level 4 system can need the information to order software uninstalls, to order asset memory clearing or to know to cancel the maintenance license fee.

6   Operations management information

6.1   Operations definition information

6.1.1   Operations definition model

An *operations definition* defines the resources required to perform a specified operation. The operations definition may apply to defining production, maintenance, quality test and inventory

operations. The actual definition of how to perform the operation is not included in the object model and are defines in a work definition.

Work definitions are defined as the information used to instruct a manufacturing operation how to perform the operation. Production operations specific operations instructions may be called a general, site or master recipe (IEC 61512 series), standard operating procedure (SOP), standard operating conditions (SOC), master or product routing, or assembly steps based on the production strategy used.

Figure 13 below is the *operations definition* model.
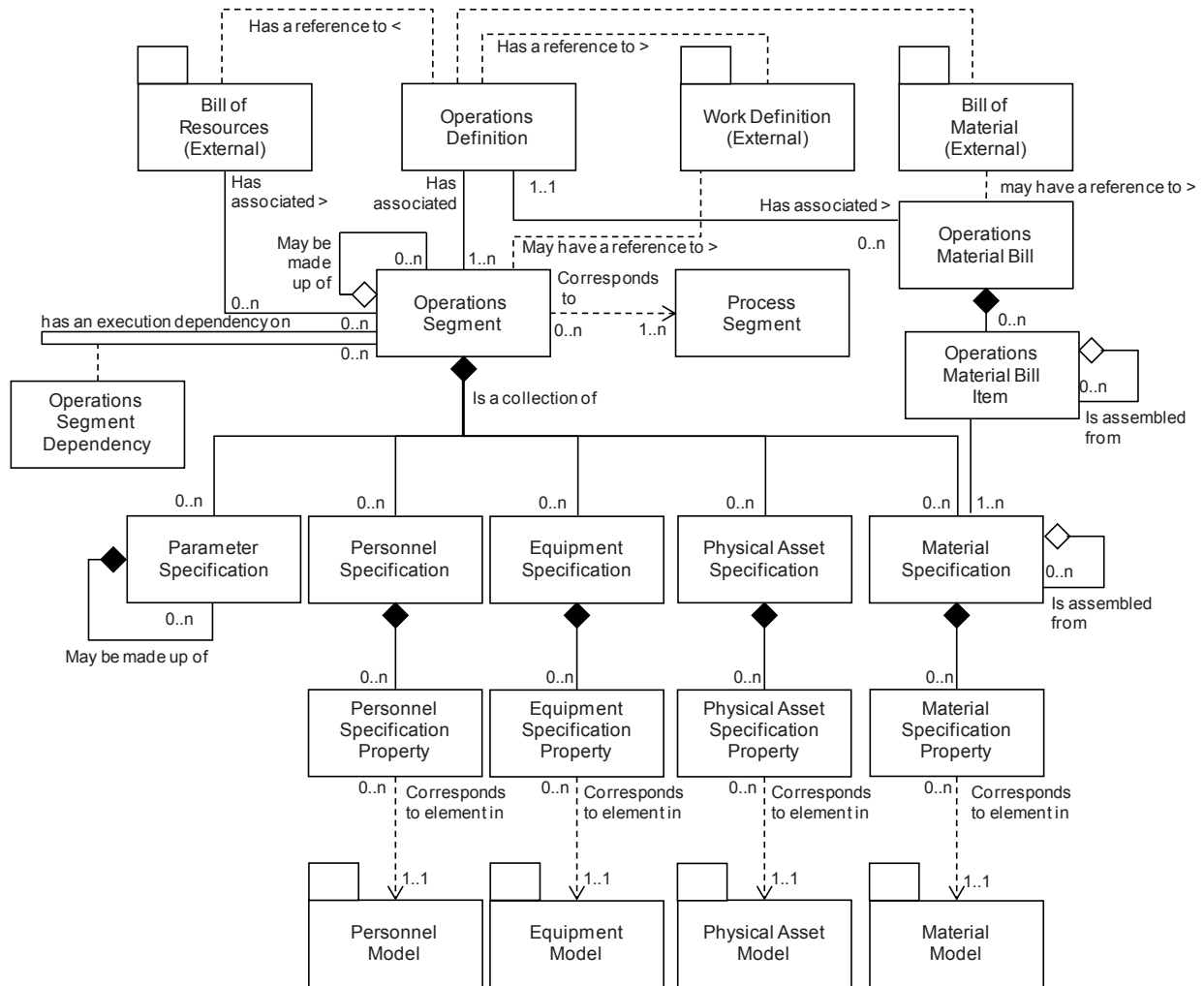
Figure 13 – Operations definition model

6.1.2 Operations definition

The resources required to perform a specified operation shall be presented as an *operations definition*.

Table 44 defines the attributes for *operations definition* objects.

Table 44 – Attributes of operations definition

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	Uniquely identifies the operations definition. The ID shall be used in other parts of the model when the *operations definition* needs to be identified	Export Quality Widget	Medium Size AC Motor Overhaul	Potency Test Procedure	Tank Transfer Procedure
Version	An identification of the version of the *Operations definition*. In cases where there are multiple versions of an *Operations 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 *Operations definition*	Information defining resources required for production 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
Operations type	Describes the category of operation Required attribute Defined values are: Production, Maintenance, Quality, Inventory, or Mixed. "Mixed" shall be used when the operations definition contains several types of operations requests and/or segment requirements	Production	Maintenance	Quality	Inventory
Hierarchy Scope	Identifies where the exchanged information fits within the role based equipment hierarchy.	East Wing(AREA)/ Manufacturing Line #2(WORK CENTER)	CNC Machine Asset ID 13465	Test Cell 4 Receiving	Ware-house B
Bill of Material ID	Identification of the external Bill Of Material associated with this Operation Definition	BOM9929	BOM9928	BOM9927	BOM9926
Work Definition ID	Identification of the external Work Definition associated with this Operations Definition	WD009 V0.23	WD008 V03	WD007 V1.3	WD006
Bill of Resource ID	Identification of the external Bill Of Resource associated with this Operation Definition	BOR77782 V01	BOR77783	BOR77784 V11	BOR77785 V3.45
NOTE 1 In the case of production, an Operations Definition ID can be the same ID as a Material Definition.					
NOTE 2 A product definition, as defined in IEC 62264-1, is the equivalent of an Operations Definition for production.					
NOTE 3 A MIMOSA *Solution Package* is the equivalent of an Operations Definition for maintenance.					

6.1.3   Operations material bill

The collection of all material used in the operation, independent of the *process segment* the material is used in, shall be presented as *operations material bills*.

There may be multiple *operations material bills*, with different uses.

EXAMPLE   There can be one *operations material bill* for consumed materials and a second *operations material bill* for produced materials.

Table 45 defines the attributes for *operations material bill* objects.

Table 45 – Attributes of operations material bill

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of a *manufacturing bill*.	10000	552619	Q123AC3	755433
Description	Contains additional information of the *manufacturing bill*.	All materials required in the manufacturing process for a single widget.	Silicon Base Bearing Grease	Chart Paper	Pallet

6.1.4   Operations material bill item

The items that make up the complete operations material bill shall be presented as *operations material bill items*.

An *operations material bill item* may be defined as containing an assembly of *operations material bill items* and as part of an assembly of *operations material bill items*.

a) An operations material bill item may define an assembly of zero or more operations material bill items.

b) An operations material bill item may be an assembly element of zero or more operations material bill items.

c) An assembly may be defined as a permanent or transient assembly of operations material bill items.

d) An assembly may be defined as physical or a logical assembly of operations material bill items.

Table 46 defines the attributes for *operations material bill item* objects.

Table 46 – Attributes of operations material bill item

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of a *bill* item.	10000827	552619	Q123AC3	755433
Description	Contains additional information of the *bill* item.	All materials required in the manufacturing process for a single widget.	Silicon Base Bearing Grease	Chart Paper	Pallet
Material Class	Identifies the associated *material class* or set of *material classes* required.	{Polymer sheet stock 1001A, Rivets}	Fred's Bearing, Grease	Circular Chart Paper	4x4 pallet
Material Definition	Identifies the associated *material definition* or set of *material definitions* required.	{Sheet stock 1443a , Rivet-10002}	{20 mm Bearing, NLGI Grade 2 Grease}	10" diameter circular chart paper	1 000 lb Weight load 4x4 pallet
Use type	Defines the use of the material. Example 1: Consumed – indicates that bill items are all consumed material. Example 2: Produced – indicates that bill items are all produced materials.	Consumed	Consumed	Consumed	Consumed
Assembly Type	Optional: Defines the type of the assembly. The defined types are: Physical – The components of the assembly are physically connected or in the same area. Logical – The components of the assembly are not necessarily physically connected or in the same area.	Physical	Physical	Logical	Physical
Assembly Relationship	Optional: Defines the type of the relationships. The defined types are: Permanent – An assembly that is not intended to be split during the production process. Transient – A temporary assembly using during production, such as a pallet of different materials or a batch kit.	Permanent	Transient	Permanent	Transient
Quantity	Specifies the amount of resources required.	{1,0, 26}	{2, 30}	5	100
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	{Sheets / piece, Number / piece}	{piece, ml}	Each	Each

6.1.5 Operations segment

The information needed to quantify a segment for a specific operation shall be presented as an *operations segment*. An *operations segment* identifies, references, or corresponds to a *process segment*.

Table 47 defines the attributes for *operations segment* objects.

Table 47 – Attributes of operations segment

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of a specific segment within the scope of the information exchanged. The ID shall be used in other parts of the model when the segment needs to be identified.	Final Polished Widget	200 HP AC Motor Disassemble	120VAC Meter Test 001	Line 1 Raw Material Stage
Description	Contains additional information of the segment	A brightly polished widget.	Disassembly of motor prior to rebuild	Test range of volt meter	Material staging for shift
Hierarchy Scope	Identifies where the exchanged information fits within the role based equipment hierarchy.	East Wing(AREA)	Asset ID 13465	Test Cell 4	Ware-house B
Duration	Duration of segment, if known.	25 min	4	15	30
Duration Unit of Measure	The units of measure of the duration, if defined.	Minutes	Hours	Seconds	Minutes
Process segment	Identifies the associated Process segments. There can be multiple alternate process segments that could be used for the operations segment.	Widget Polishing	AC Motor Disassemble	Volt Meter Test	Raw Material Stage
Operations type	Describes the category of operation. Required attribute. Defined values are: Production, Maintenance, Quality, Inventory, or Mixed. "Mixed" shall be used when the operations segment contains several types of operations requests and/or segment requirements.	Production	Maintenance	Quality	Inventory
Work Definition ID	Identification of the external Work Definition associated with this Operations Segment	WD009 V0.23	WD008 V03	WD007 V1.3	WD006

NOTE 1   A MIMOSA *Ordered List* is the equivalent of an *operations segment* for maintenance operations.

NOTE 2   A MIMOSA *Ordered List Resource Item* is the equivalent of a single item *personnel specification, equipment specification, physical asset specification* or *material specification* for a maintenance operations segment.

NOTE 3   A *product segment* is the equivalent of an *operations segment* for production operations. See Annex A.

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6.1.6   Parameter specification

Specific parameters required for an *operations segment* shall be presented as *parameter specifications.* An *operations segment* may have an associated set of zero or more *parameter specifications*. The *parameter specification* contains the names and types of the values that may be sent to the Level 3 systems to parameterize the operation.

Parameter specifications may contain nested *parameter specifications*.

NOTE   Examples of *parameter specifications* are pH of 3,5, pressure limit of 35 psi, and flange color = orange.

Parameter specifications shall include:

   a) an identification of the parameter;

   b) the units of measure of the parameter value.

Parameter specifications should include

   1) a default value for the parameter or;

   2) possible ranges of the parameter value.

EXAMPLE Ranges can be alarm or quality ranges; tolerances for acceptable parameter values.

Table 48 defines the attributes for *parameter specification* objects.

Table 48 – Attributes of parameter specification

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	Identification of the *parameter* for a specific segment.	Widget roughness	Torque Value	Visco-meter spindle size	Cases per pallet
Description	Contains additional information of the *parameter*.	Range of acceptable surface roughness to be manufactured.	Maximum torque value for fly wheel assembly	Spindle size for correct viscosity range	Number of cases per pallet
Value	The value, set of values, or range of acceptable values	{80..2 500}	35	2	124
Value Unit of Measure	Unit of measure of the values, if applicable.	Angstroms	Nm	cP	Each

6.1.7   Personnel specification

An identification, reference, or correspondence to a personnel capability shall be presented as a *personnel specification*. A *personnel specification* usually specifies a *personnel class* but may specify a *person*. A *personnel specification* identifies the specific personnel capability that is associated with the identified *operations segment* or *product segment*.

A *personnel specification* shall include:

a) an identification of the personnel capability needed;

b) the quantity of the personnel capability needed;

c) the unit of measure of the quantity.

Specific elements associated with a *personnel specification* may be included in one or more *personnel specification properties*.

Table 49 defines the attributes for *personnel specification* objects.

Table 49 – Attributes of personnel specification

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
Personnel Class	Identifies the associated *personnel class* or set of *personnel classes* of the specification for a specific segment.	Widget Polisher	Diesel mechanic grade 2	Lab Tech II	warehouse manager
Person	Identifies the associated *person* or set of *persons* of the specification for a specific segment.	999-12-3456	DMG2 422	LT-101	999-99-9999
Description	Contains additional information of the *personnel specification*.	Polisher skill required for export quality polished widget	Certified Diesel mechanic for heavy equipment	Level 2 certified quality technician	Schedules line side inventory deliveries in terms of this segment
Personnel Use	Defines the expected use of the personnel class or person.	Allocated	Allocated	Allocated	Allocated
Quantity	Specifies the amount of personnel resources required for the parent segment, if applicable.	0,25	2	1	0,000 1
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	person hours	People	Tech	Man years

6.1.8 Personnel specification property

Specific properties that are required for *personnel specifications* shall be presented as *personnel specification properties*.

NOTE   Examples of *personnel specification properties* are training level required, specific skill required, and exposure availability.

Personnel specification properties may contain nested *personnel specification properties*.

Table 50 defines the attributes for *personnel specification property* objects.

Table 50 – Attributes of personnel specification property

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of a property of the associated *person property* or *personnel class property* for a specific segment.	Polishing Certification Level	Grade 2 Diesel mechanic	Lab Tech II	warehouse manager
Description	Contains additional information and descriptions of the *personnel specification property* definition.	Level of polishing skill certification required for the widget polisher	Level of skill required to work on diesel engine	Level of skill required to operate lab instrument	Level of skill required to manage warehouse scheduling
Value	The value, set of values, or range of the property. For example: Apprentice, Journeyman, Master	Master	Level 2	Level 2 certified quality technician	MBA
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	{Apprentice, Journeyman, Master}	Skill Level	Skill Level	Degree
Quantity	Specifies the amount of personnel resources required for the parent segment, if applicable.	0,10	2	1	1
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Hours / piece	People	Tech	Manager

6.1.9 Equipment specification

An identification, reference, or correspondence to an equipment capability shall be presented as an *equipment specification*. An *equipment specification* may specify either an *equipment class* or a piece of *equipment*. An *equipment specification* identifies the specific equipment capability that is associated with the segment.

An *equipment specification* shall include:

a) an identification of the equipment capability needed either as the equipment class needed or specific equipment;

b) the quantity of the equipment capability needed;

c) the unit of measure of the quantity.

Specific elements associated with an *equipment specification* may be included in one or more *equipment specification properties*.

Table 51 defines *equipment specification* object.

Table 51 – Attributes of equipment specification

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
Equipment Class	Identifies the associated *equipment class* or set of *equipment classes* of the specification for a specific segment.	Widget Polishing Machine	Drill	GCMS	5000 LB CAP SS containment vessel
Equipment	Identifies the associated *equipment* or set of *equipment* of the specification for a specific segment.	WPM-10	18 VDC Hand Drill #5	GCMS-#1001	VC#5
Description	Contains additional information and descriptions of the *equipment specification*	Equipment required to polish Export Quality Widgets.	Battery operated drill required for remote, manual task	Gas chroma-tograph for analyzing volatiles	Interme-diate bulk container
Equipment Use	Defines the expected use of the equipment class or equipment.	Part finishing	Assembly setup	%VOC Test result	Raw material staging
Quantity	Specifies the amount of equipment resources required for the parent segment, if applicable.	0,5 {shared between two segments}	1	1	1
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Each	Each	Each	Each

6.1.10 Equipment specification property

Specific properties that are required for *equipment specifications* shall be presented as *equipment specification properties*.

NOTE   Examples of *equipment specification properties* are material of construction, maximum material capacity, and minimum heat extraction amount.

Equipment specification properties may contain nested *equipment specification properties*.

Table 52 defines the attributes for *equipment specification property* object.

Table 52 – Attributes of equipment specification property

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of the associated *equipment property* or *equipment class property* for a specific segment.	Voltage Rating	Chuck Size	Carrier Gas	Stainless Steel Type
Description	Contains additional information and descriptions of the *equipment specification property* definition.	The voltage rating required for operation	The range of the chuck	The carrier gas used to carry the sample	The type of SS
Value	The value, set of values, or range of the property. For example: Wet, Dry	190 ~ 240	20 to 40	He	316
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	Volts	mm	<n/a>	Composi-tion
Quantity	Specifies the amount of equipment resources required for the parent segment, if applicable.	n/a	2	0,5	n/a
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	n/a	Each	L	n/a

6.1.11 Physical asset specification

An identification, reference, or correspondence to a physical asset capability shall be presented as a *physical asset specification*. A *physical asset specification* may specify either a *physical asset* or a *physical asset class*. A *physical asset specification* identifies the specific physical asset capability that is associated with the segment.

A *physical asset specification* shall include:

a) an identification of the physical asset capability needed either as the *physical asset class* or *physical asset*;

b) the quantity of the physical asset capability needed;

c) the unit of measure of the quantity.

Specific elements associated with a *physical asset specification* may be included in one or more *physical asset specification properties*.

Table 53 defines *physical asset specification* object.

Table 53 – Attributes of physical asset specification

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
Physical asset class	Identifies the associated *Physical Asset Class* or set of *Physical Asset Classes* of the specification for a specific segment.	Polishing Machine	Torque Wrench	GCMS	IBC
Physical Asset	Identifies the associated *physical asset* or set of *physical assets* of the specification for a specific segment.	20090121	100 N-m Torque Wrench	Model GCMS100	Model IBC-SS-5K
Description	Contains additional information and descriptions of the *physical asset specification*	Polisher	Wrench used for specific torque rating	Used to measure VOC conc.	Stainless Steel 5000 lb capacity
Physical Asset Use	Defines the expected use of the physical asset class or physical asset.	Polish	Wrench required for proper tightening of motor head	Gas Chromatography test	Raw material staging
Quantity	Specifies the amount of physical asset resources required for the parent segment, if applicable.	1,25	2	1	5 000
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Minutes / piece	Each	Each	Each

6.1.12 Physical asset specification property

Specific properties that are required for *physical asset specifications* shall be presented as *physical asset specification properties*.

Physical asset specification properties may contain nested ph*ysical asset specification properties*.

Table 54 defines the attributes for *physical asset specification property* object.

Table 54 – Attributes of physical asset specification property

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of the associated *physical asset property* or *physical asset class property* for a specific segment.	Polisher Type	Torque range	Min. detectable concentration	Opening type
Description	Contains additional information and descriptions of the *physical asset specification property* definition.	Wet polisher required for fine polishing.	Min-Max torque ratings	Sensitivity of the detector	top bung opening
Value	The value, set of values, or range of the property. For example: Wet, Dry	Wet	10-80	< 1	Top bung
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	(not applicable)	ft. lbs.	ppm	(not applicable)
Quantity	Specifies the amount of physical asset resources required for the parent segment, if applicable.	0,10	1	1	(not applicable)
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Minutes / piece	each	(not applicable)	(not applicable)

6.1.13 Material specification

An identification or correspondence to a material capability shall be presented as a *material specification*. A *material specification* specifies a *material, material definition* or *material class*. A *material specification* identifies the specific material specification that is associated with the identified *operations segment*.

A *material specification* shall include:

a) an identification of the material needed;

b) the quantity of the material needed;

c) the unit of measure of the quantity.

Specific elements associated with a *material specification* may be included in one or more *material specification properties*.

Table 55 defines *material specification* objects.

Table 55 – Attributes of material specification

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
Material Class	Identifies the associated *material class* or set of *material classes* of the specification for a specific segment.*	Abrasives	Impeller	Reference gas	Bung
Material Definition	Identifies the associated *material definition* or set of *material definition* of the specification for a specific segment.*	Rouge	Motor-Impeller Subassembly	Nitrous Oxide 10 ppm	2" bung
Description	Contains additional information and descriptions of the *material specification*.	Polishing material for Export Quality Widget polishing.	Replacement impeller	Calibration gas	4x2 304 Stainless Steel bung
Material Use	Defines the material use: Material Consumed, Material Produced, or Consumable	Consumable	Consumable	Consumable	Consumable
Quantity	Specifies the amount of material resources required for the parent segment, if applicable.	10	1	1,5	1
Quantity Unit of Measure	The unit of measure of the associated property value, if applicable.	gm / piece	each	Liter	Each
Assembly Type	Optional: Defines the type of the assembly. The defined types are: Physical – The components of the assembly are physically connected or in the same area. Logical – The components of the assembly are not necessarily physically connected or in the same area.	Physical	Physical	Logical	Physical

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
Assembly Relationship	Optional: Defines the type of the relationships. The defined types are: Permanent – An assembly that is not intended to be split during the production process. Transient – A temporary assembly using during production, such as a pallet of different materials or a batch kit.	Permanent	Transient	Permanent	Transient
* Typically either a *material class* or *material definition* is specified.					

A *material specification* may be defined as containing an assembly of *material specifications* and as part of an assembly of *material specifications*:

a) a material specification may define an assembly of zero or more material specifications;

b) a material specification may be an assembly element of zero or more material specifications;

c) an assembly may be defined as a permanent or transient assembly of material specifications;

d) an assembly may be defined as physical or a logical assembly of material specifications.

6.1.14 Material specification property

Specific properties that are required for *material specifications* shall be presented as *material specification properties*.

NOTE   Examples of *material specification properties* are color range, density tolerance, and maximum scrap content.

Material specification properties may contain nested *material specification properties*.

Table 56 defines the attributes for *material specification property* object.

Table 56 – Attributes of material specification property

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of the associated *material property* for a specific segment.	Grit Size	Pitch	Purity	Material of Constru-ction
Description	Contains additional information and descriptions of the *material specification property*.	Measure of required grit size for Export Quality Widget polishing.	Percentage of blade length per angle of progression	Reference gas concentra-tion	MOC
Value	The value, set of values, or range for the associated property.	{1 300..1 500}	16-21	± 500	304 Stainless Steel
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	Grit Number	Pitch	ppb	Grade
Quantity	Specifies the amount of material resources required for the parent segment, if applicable.	5	(not applicable)	(not applicable)	(not applicable)
Quantity Unit of Measure	The unit of measure of the associated property value, if applicable.	gm / piece	(not applicable)	(not applicable)	(not applicable)

6.1.15 Operations segment dependency

Operations dependencies that are operation or product specific shall be presented as *operations segment dependencies*.

EXAMPLE 1   A wheel assembly operation and a frame assembly operation can run in parallel.

Table 57 lists the attributes of an *operations segment dependency*.

Table 57 – Attributes of operations segment dependency

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	The identification of the unique instance of the *operations segment dependency*.	PSD001	34	A35	PSA-I-5563
Description	Contains additional information and descriptions of the *operations segment dependency* definition for a specific segment.	Defines the sequencing of widget washing during the Widget Assembly product segment	Defines the sequence for replacing an impeller	Defines sampling sequence	Defines IBC sealing
Dependency Type	Defines the execution dependency constraints of one segment by another segment.	Start *Acid Addition* no later than *T* (*Timing Factor*) after *Reaction Complete* end	Start disassembly after lock-out and tag-out segments are complete	Start calibration gas X minutes after purge gas ends	Insert and secure bung after IBC filling complete
Dependency Factor	Factor used by dependency	25	<True, False>	50	<True, False>
Unit of Measure	The units of measure of the dependency factor, if defined.	Minutes	Boolean	Minutes	Boolean

EXAMPLE 2   Dependency type using A and B to identify the segments, or specific resources within the segments, and T to identify the timing factor, as shown in Figure 12, include the following:

– B cannot follow A
– B can run in parallel to A
– B cannot run in parallel to A
– start B at A start
– Start B after A start
– Start B after A end
– Start B no later than T (Dependency Factor with time T) after A start
– Start B no earlier than T (Dependency Factor with time T) after A start
– Start B no later than T (Dependency Factor with time T) after A end
– Start B no earlier than T (Dependency Factor with time T) after A end

NOTE   The associations to the A and B segments are not represented as attributes, as per 4.5.6.

6.2 Operations schedule information

6.2.1 Operations schedule model

A request for operations to be performed is an operations schedule. The schedule may apply to scheduling of production, maintenance, quality test, and inventory operations.

Figure 14 is the *operations schedule* model.
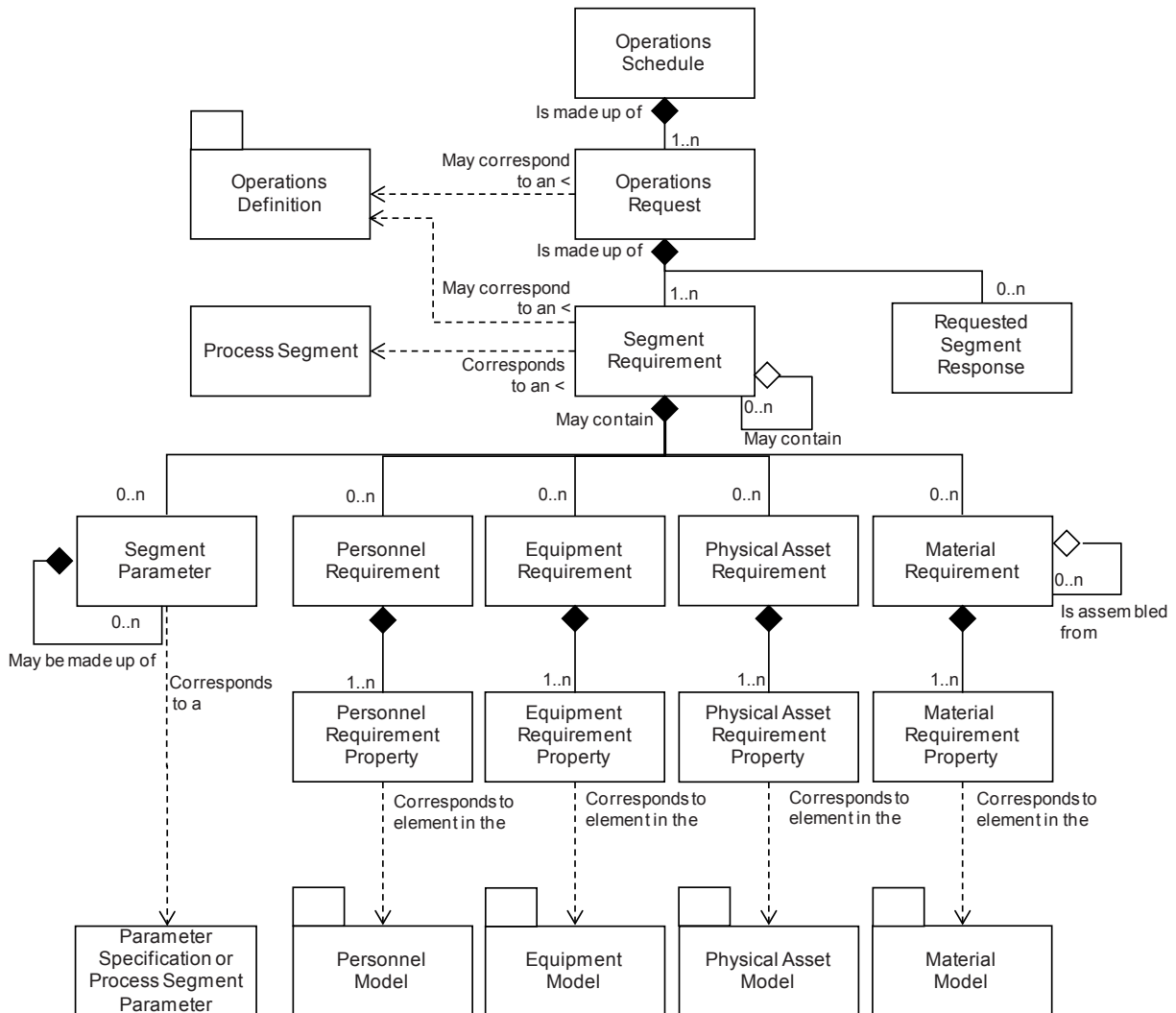
Figure 14 – Operations schedule model

6.2.2 Operations schedule

A request for operations to be performed shall be presented as an *operations schedule*. An *operations schedule* shall be made up of one or more *operations requests*.

An *operations schedule* may be defined for any specific category of operations; production, maintenance, quality, or inventory, or it may be defined for a combination of categories. When a combination is selected, then the *operations requests* or *segment requirements* specify the category of the operation.

Table 58 defines the attributes for *operations schedule* object.

Table 58 – Attributes of operations schedule

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of the *operations schedule* and could include version and revision identification. The ID shall be used in other parts of the model when the *operations schedule* needs to be identified.	PMMFUF	MWOIDND	QNFKVUV	IECBDU
Description	Contains additional information and descriptions of the *operations schedule.*	Widget manufacturing schedule	Daily Planned Maintenance	Widget raw material testing schedule	Widget raw material staging schedule
Operations type	Describes the category of operation. Required attribute Defined values are: Production, Maintenance, Quality, Inventory, and Mixed. "Mixed" shall be used when the operations schedule contains several types of operations requests and/or segment requirements.	Production	Maintenance	Quality	Inventory
Start Time	The starting time for the associated *operations schedule*, if applicable.	10-28-2006	10-27-2006	10-28-2006	10-28-2006
End Time	The ending time for the associated *operations schedule*, if applicable.	10-30-2006	10-31-2006	10-30-2006	10-30-2006
Published Date	The date and time on which the *operations schedule* was published or generated.	10-17-2006 18:30 UTC	10-17-2006 18:30 UTC	10-17 2006 18:30 UTC	10-17-2006 18:30 UTC
Hierarchy Scope	Identifies where the exchanged information fits within the role based equipment hierarchy.	East Wing(AREA)/ Manufacturing Line #2(WORK CENTER)	CNC Machine Asset ID 13465	Test Cell 4 Receiving	Warehouse B
Scheduled State	Indicates the state of the operations schedule. Defined values are: Forecast and Released. Forecast - The requirements have not been released for use. Example: This can be a schedule which is an estimate of a future schedule to allow long-term planning by the receiver, with a later "Released" schedule when the schedule has been approved and released to production. Released - The requirements have been released for use.	Released	Forecast	Released	Released
NOTE A MIMOSA *Segment Request for Work* and an *Asset Request for Work* are the equivalent of an operations request for either equipment or for a physical asset. The table of *Request for Work* is the equivalent of the Operations schedule.					

6.2.3 Operations request

A request for an element of an *operation schedule* shall be presented as an *operations request*. An *operations request* contains the information required by manufacturing to fulfill the scheduled operation. An *operations request* may be a subset of the business information, or it may contain additional information not normally used by the business system.

An *operations request* may identify or reference the associated operations instructions. An *operations request* shall contain at least one *segment requirement*, even if the *segment requirement* spans all of the operation.

An *operations request* may include:

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

b) when the operation 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.

An *operations request* may be reported on by one or more *operations responses*. Additional information may be described in the *production parameters, personnel requirements, equipment requirements, physical asset requirements* and *material requirements*.

Table 59 defines the attributes for *operations request* objects.

Table 59 – Attributes of operations request

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of the *operations request*. The ID shall be used in other parts of the model when the *operations request* needs to be identified.	1001091	59328AC8	E938723	KIT493
Description	Contains additional information and descriptions of the *operations request*.	Operations request for export quality widgets for October 29, 1999.	Daily maintenance request	Test incoming materials	Prepare kit for production run
Operations type	Describes the category of operations. Required attribute Defined values are: Production, Maintenance, Quality, Inventory, and Mixed. "Mixed" shall be used when the operations request contains several types of operations requests.	Production	Maintenance	Quality	Inventory
Start Time	When operation is to be started, if applicable.	1999-10-27 8:00 UTC	10-28-2006 2:00 UTC	10-28-2006 4:00 UTC	10-28-2006 2:00 UTC
End Time	When operation is to be completed, if applicable.	1999-10-27 17:00 UTC	10-28-2006 2:30 UTC	10-28-2006 4:30 UTC	10-28-2006 4:00 UTC
Priority	The priority of the request, if applicable.	Highest	1	B	High

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
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	Ware-house B
Operations Definition ID	Identifies the associated *Operations definition* to be used, if applicable.	Export Quality Widget	CNC Daily Maintenance Procedure	T48323	BOM for Export Quality Widget
Request State	Indicates the state of the operations request. Defined values are: Forecast and Released. Forecast - The requirements have not been released for use. Released - The requirements have been released for use.	Released	Forecast	Released	Released

6.2.4   Segment requirement

An *operations request* shall be made up of one or more *segment requirements*. Each *segment requirement* shall correspond to, or reference, an identified *operations segment* or *process segment*. The *segment requirement* identifies or references the segment capability to which the associated personnel, equipment, physical assets, materials, and segment parameters correspond.

The *segment requirement properties* and *segment parameters* shall align with the parameters sent as part of a production request.

EXAMPLE There can are multiple *segment requirements* defined. There is one master *segment requirement* that applies to the entire *operations request*. The master *segment requirement* can be made up of multiple nested *segment requirements* for individually specified and reported segments.

NOTE   Information that applies across all segments of the *operations request*, such as a customer name, can be represented as a *segment parameter* in the master segment requirement. Information that applies to specific *segment requirements* can be specified as part of the *segment requirement*.

Table 60 defines the attributes for *segment requirement* object.

Table 60 – Attributes of segment requirement

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of the *segment requirement* within the scope of an operation*s request*.	A6646	KU492	48283	4883DV
Description	Contains additional information and descriptions of the *segment requirement.*	Polishing segment, containing specifications for personnel, materials and equipment.	Test program to verify X-Y coordinates within calibration	Verify stock dimen-sions	Pull part from ware-house, tag, and forward stage
Operations type	Describes the category of operation. Required attribute. Defined values are: Production, Maintenance, Quality, Inventory, and Mixed.	Production	Maintenance	Quality	Inventory
Segment	An identification of the segment associated with the *segment requirement*, if applicable.	Polishing Segment	Run X-Y test	RMT38283	Kiting segment
Earliest Start Time	The expected earliest start time of this *segment requirement*, if applicable.	10-28-2006 4:00 UTC	10-28-2006 2:00 UTC	10-28-2006 4:00 UTC	10-28-2006 4:00 UTC
Latest End Time	The expected latest ending time of this *segment requirement*, if applicable.	10-28-2006 10:00 UTC	10-28-2006 2:15 UTC	10-28-2006 4:30 UTC	10-28-2006 6:30 UTC
Duration	The expected duration of this segment requirement, if applicable. Note, this should match the associated segment duration.	15	4	0,5	2,5
Duration Unit of Measure	The unit of measure of the duration, if applicable.	Minutes	Minutes	Hours	Hours
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	Ware-house B
Operations Definition ID	Identifies the associated *Operations definition* to be used, if applicable.	Export Quality Widget	CNC Daily Maintenance Procedure	T48323	BOM for Export Quality Widget
Segment State	Indicates the state of the segment request. Defined values are: Forecast and Released. Forecast - The requirements have not been released for use. Released - The requirements have been released for use.	Released	Forecast	Released	Released

6.2.5   Segment parameter

Specific parameters required for a *segment requirement* shall be presented as *segment parameters*.

A *segment parameter* shall include:

a) an identification of the parameter that matches parameter specification of the operations definition, such as target acidity;

b) a value for the parameter, such as 3,4;

c) the unit of measure of the parameter, such as pH.

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

Segment parameters may contain nested *segment parameters*.

Table 61 defines the attributes for *segment parameter* objects.

Table 61 – Attributes of segment parameter

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	The identification of the *segment parameter*.	Widget roughness	Test hole location tolerance	Thickness	Staging location
Description	Contains additional information and descriptions of the *segment parameter*	Range of acceptable surface roughness to be manufactured.	Range of acceptable hole locations	Thickness of stock sheets	Forward staging location for production use
Value	The value, set of values, or range of the value to be used for this parameter.	{80..2 500}	± 0,01	5	East Wing Manufacturing Line #2
Value Unit of Measure	The engineering units in which the value is defined, if applicable.	Angstroms	cm	mm	(not applicable)

6.2.6   Personnel requirement

The identification of the number, type, duration, and scheduling of specific certifications and job classifications needed to support the current operations request shall be presented as *personnel requirements*.

NOTE 1   Examples of job classification types include mechanics, operators, health and protection, and inspectors.

NOTE 2   For example, there can be a requirement for one operator with a specified level of certification available 2 h after production starts. There would be one personnel requirement for the requirement for the operator and two personnel requirement properties, one for the certification level and one for the time requirement.

A *personnel requirement* shall include

a) the identification of the personnel needed, such as milling machine operator;

b) the quantity of personnel needed.

Specific elements associated with each *personnel requirement* may be included in one or more *personnel requirement properties*.

Table 62 defines the attributes for *personnel requirement* objects.

Table 62 – Attributes of personnel requirement

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
Personnel Class	Identifies the associated *personnel class* or set of *personnel classes* of the requirement for a specific *segment requirement*.	Widget Polisher	CNC operator	Quality Assurance Tech	Ware-house worker
Person	Identifies the associated *person* or set of *persons* of the requirement for a specific *segment requirement*. Typically either *personnel class* or *person* is specified, but not both.	Gidget	Charlie Goode	(not applicable)	Joe Wurzel-bacher
Description	Contains additional information and descriptions of the *personnel requirement.*	Defines the specific polishing operator assigned to this operations request.	Trained CNC operator	Quality personnel trained in stock inspe-ctions	Person to assemble the kit
Personnel Use	Defines the expected use of the personnel class or person.	Allocated	Certified	Certified	Uncertified
Quantity	Specifies the amount of personnel resources required for the parent segment, if applicable. Applies to each member of the *person* and *personnel class* sets.	1	1	1	1
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	Full Time Equivalents	Full Time Equivalents	Full Time Equiva-lents	Full Time Equiva-lents

6.2.7 Personnel requirement property

Specific properties that are required for *personnel requirements* shall be presented as *personnel requirement properties*.

EXAMPLE   Examples of *personnel requirement properties* are training and certification, specific skill, physical location, seniority level, exposure level, training certification, security level, experience level, physical requirements, and overtime limitations and restrictions.

Personnel requirement properties may contain nested *personnel requirement properties*.

Table 63 defines the attributes for *personnel requirement property* objects.

Table 63 – Attributes of personnel requirement property

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of the associated *person property* or *personnel class property* for a specific *segment requirement*.	Polishing Certification Level	CNC daily maintenance certification	Stock receiving inspection certifica-tion	Steel toed shoes
Description	Contains additional information and descriptions of the *personnel requirement property* definition.	Level of polishing skill certification required for the widget polisher	Training level required	current certifica-tion	PPE required
Value	The value, set of values, or range of the property. For example: Apprentice, Journeyman, Master	Journeyman	<True, False>	<True, False>	<True, False>
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	(not applicable)	Boolean	Boolean	Boolean
Quantity	Specifies the amount of the property required for the parent personnel requirement, if applicable.	(not applicable)	(not applicable)	(not applicable)	(not applicable)
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	(not applicable)	(not applicable)	(not applicable)	(not applicable)

6.2.8   Equipment requirement

The identification of the number, type, duration, and scheduling of specific equipment and equipment classifications or equipment constraints needed to support the current operations request shall be presented as an *equipment requirement*. The operations request may include one or more equipment requirements. Requirements can be as generic as materials of construction, or as specific as a particular piece of equipment. Each of these requirements shall be an instance of an *equipment requirement*.

Properties of the *equipment requirement* shall be presented as *equipment requirement properties*.

Each *equipment requirement* identifies a general class of equipment (such as reactor vessels), a specific class of equipment (such as isothermal reactors), or a specific piece or set of equipment (such as isothermal reactor #7). The specific requirements on the equipment, or equipment class are listed as equipment requirement property objects.

An *equipment requirement* shall include

a) the identification of the equipment needed, such as milling machine;

b) the quantity of equipment needed.

Specific elements associated with each *equipment requirement* may be included in one or more *equipment requirement properties*.

Table 64 defines the attributes for *equipment requirement* objects.

Table 64 – Attributes of equipment requirement

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
Equipment Class	Identifies the associated *equipment class* or set of *equipment classes* of the requirement for a specific *segment requirement*.	Widget Polishing Machine	CNC Drill Press	Micrometer	Bar code scanner
Equipment	Identifies the associated *equipment* set of *equipment* of the requirement for a specific *segment requirement*. Typically either *equipment class* or *equipment* is specified, but not both.	WPM-19	DP-1	(not applicable)	(not applicable)
Description	Contains additional information and descriptions of the *equipment requirement*	Specifics the expected machine to be used for this operations request.	Automated drill press	Measurement tool	Warehouse bar code scanner
Equipment Use	Defines the expected use of the equipment class or equipment.	Production	Repair	Testing	Transport
Quantity	Specifies the amount of equipment resources required for the parent segment, if applicable. Applies to each member of the *equipment* and *equipment class* sets.	1	1	1	1
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Units	Machine	Tool	Tool
Equipment Level	A definition of the level of the associated element of the equipment model. For example: Enterprise, Site, Area, Unit, Equipment module, Control Module	Production Line	Work Center	(not applicable)	(not applicable)

6.2.9   Equipment requirement property

Specific properties that are required for *equipment requirements* shall be presented as *equipment requirement properties*.

EXAMPLE   Examples of *equipment requirement properties* are material of construction and minimum equipment capacity.

Equipment requirement properties may contain nested *equipment requirement properties*.

Table 65 defines the attributes for *equipment requirement property* objects.

Table 65 – Attributes of equipment requirement property

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of the associated *equipment property* or *equipment class property* for a specific *segment requirement*.	Polisher Type	Spindle run-out	Scale definition	Portable with LED
Description	Contains additional information and descriptions of the *equipment requirement property* definition.	Polisher required for this operations request.	Max allowed spindle run-out	Units of measure	Type description
Value	The value, set of values, or range of the associated property. For example: Wet, Dry	Dry	less than 0,000 08	Metric	<True, False>
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	(not applicable)	Inches	(not applicable)	Boolean
Quantity	Specifies the amount of equipment property required for the parent equipment requirement, if applicable.	1	(not applicable)	1	1
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Units	(not applicable)	Each	Each

6.2.10 Physical asset requirement

The identification of the number, type, duration, and scheduling of specific physical assets and physical asset class constraints needed to support the current operations request shall be presented as a *physical asset requirement*. The operations request may include one or more physical asset requirements. Requirements can be as generic as materials of construction, or as specific as a particular piece of physical asset. Each of these requirements shall be an instance of a *physical asset requirement*.

Properties of the *physical asset requirement* shall be presented as *physical asset requirement properties*.

A *physical asset requirement* shall include

a) the identification of the physical asset needed, such as milling machine serial number #345334;

b) the quantity of physical asset needed.

Specific elements associated with each physical asset requirement may be included in one or more physical asset requirement properties.

Table 66 defines the attributes for *physical asset requirement* objects.

Table 66 – Attributes of physical asset requirement

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
Physical Asset Class	Identifies the associated *physical asset model* or set of *physical asset models* of the requirement for a specific *segment requirement*.	(not applicable)	Model 105, XYZ Corp, CNC Drill Press	(not applicable)	(not applicable)
Physical Asset	Identifies the associated *physical asset* or set of *physical assets* of the requirement for a specific *segment requirement*. Typically either *physical asset* or *physical asset class* is specified, but not both.	(not applicable)	Serial #: 5563442 Asset ID: 44Q56W	(not applicable)	(not applicable)
Description	Contains additional information and descriptions of the *physical asset requirement.*	(not applicable)	Cameroon Drill Press	(not applicable)	(not applicable)
Physical Asset Use	Defines the expected use of the physical asset class or physical asset.	(not applicable)	Calibrate	(not applicable)	(not applicable)
Quantity	Specifies the amount of equipment resources required for the parent segment, if applicable. Applies to each member of the *physical asset* and *physical asset class* sets.	(not applicable)	1	(not applicable)	(not applicable)
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	(not applicable)	Machine	(not applicable)	(not applicable)
Equipment Level	A level definition for the associated element in the hierarchy of the physical asset model	(not applicable)	Work Center	(not applicable)	(not applicable)

EXAMPLE   The following list contains maintenance examples for *physical asset* use:

a) Repair - Very frequent action. Take action to return asset to its condition prior to the event that prompted the request. Does not necessarily return to original design specs, but the condition immediately prior to which it was withdrawn from service. Generally performed in place. Action does not alter the value of the asset or its depreciation. Example: Pulley belt has broken on an induced draft fan, and the belt needs to be replaced.

b) Remove - Infrequent action. Remove of obsolete asset. Does not involve repair, does not involve replacement. It is removed from active service, and salvaged/scrapped/removed from an asset accounting perspective. Example: A truck off-loading transfer pump – used by a former trucking contractor – now no longer needed as trucks are all pump-equipped to do their own transfer.

c) Replacement - Frequent action, where the entire asset is removed and replaced with an equal or like asset in terms of asset performance. Conditions are brought up to original performance of the asset. Action does not alter the value of the asset or its depreciation. Example: Remove and replace a 25 HP centrifugal transfer pump.

d) Calibrate - Moderate frequency, but skilled action. The asset is calibrated and often verified (tested/certified) for accuracy and precision. Often associated with field instrumentation (sensors and valves). A related action is re-calibration or re-ranging to a differing process range. Action does not alter the value of the asset or its depreciation. Example: the RTD on tank 225 was re-ranged and calibrated to 0 – 200 °F.

e) Modify/Improve - Relatively frequent. Often involving some elements of design, this involves altering the original asset design to improve its usability and performance in operations. This alters its design to make it perform better. Because of this, its asset value has increased by the amount of capital invested to make this improvement. Example: A rigid shaft coupling on a 50 hp centrifugal pump is replaced with a flexible coupler to reduce the frequent bearing and/or seal failures in the original design. A second (simple) example is to replace a failed 20 hp centrifugal pump with a 30 hp centrifugal pump: rather than replace like for like, it us up-graded to higher horsepower. Again, its asset value has increased by the amount of additional capital invested to make this improvement (30 hp vs. 20 hp pump).

6.2.11 Physical asset requirement property

Specific properties that are required for *physical asset requirements* shall be presented as *physical asset requirement properties*.

EXAMPLE Examples of *physical asset requirement properties* are material of construction and minimum physical asset capacity.

Physical asset requirement properties may contain nested *physical asset requirement properties*.

Table 67 defines the attributes for *physical asset requirement property* objects.

Table 67 – Attributes of physical asset requirement property

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of the associated *equipment property* or *equipment class property* for a specific *segment requirement*.	(not applicable)	Repeatability	(not applicable)	(not applicable)
Description	Contains additional information and descriptions of the *equipment requirement property* definition.	(not applicable)	Drilling consistency	(not applicable)	(not applicable)
Value	The value, set of values, or range of the associated property. For example: Wet, Dry	(not applicable)	0,000 2	(not applicable)	(not applicable)
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	(not applicable)	Inches	(not applicable)	(not applicable)
Quantity	Specifies the amount of physical asset property required for the parent physical asset, if applicable.	(not applicable)	(not applicable)	(not applicable)	(not applicable)
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	(not applicable)	(not applicable)	(not applicable)	(not applicable)

6.2.12 Material requirement

An identification of a material that is expected to be used in the operations request shall be presented as a *material requirement*. *Material requirements* contain definitions of materials that may be consumed, produced, replaced, sampled, or otherwise used in manufacturing.

Table 68 defines the attributes for *material requirement* objects.

Table 68 – Attributes of material requirement

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
Material Class	Identifies the associated *material class* or set of *material classes* of the requirement for a specific *segment requirement*.*	Widgets	Aluminum	Widgets	Bolt
Material Definition	Identifies the associated *material definition* or set of *material definitions* of the requirement for a specific *segment requirement*.*	Export Quality Widgets	Aluminum sheet	Export Quality Widgets	10 mm bolt
Material Lot	Identifies the associated material lot, or set of *material lots* of the requirement for a specific *segment requirement*.*	BWLOT-2282	DW94	BWLOT-2282	4823
Material Sublot	Identifies the associated material sublot, or set of *material sublots* of the requirement for a specific *segment requirement*.*	BWLOT-2282-A	(not applicable)	(not applicable)	A
Description	Contains additional information and descriptions of the *material requirement* definition.	Master Segment - Number of Widgets to produce.	Blank sheet to run test on	Material to inspect/ test -- selected randomly from production lot	Export quality bolt
Material Use	Identifies the use of the material.	Consumed	Consumed	Inspection	Consumable
Storage Location	Identifies the proposed location of the material, if applicable.	Finished Goods Inventory	Rack 11	Finished Goods Inventory	Warehouse B, Bin 42
Quantity	Specifies the amount of material to be used, if applicable. Applies to each member of the *material lot*, *materials definition*, or *material class* sets.	1 500	1	1	4
Quantity Unit of Measure	Identifies the unit of measure of the quantity if applicable.	Units	Sheet	Each	Each
Assembly Type	Optional: Defines the type of the assembly. The defined types are: Physical – The components of the assembly are physically connected or in the same area. Logical – The components of the assembly are not necessarily physically connected or in the same area.	Physical	Physical	Logical	Physical
Assembly Relationship	Optional: Defines the type of the relationships. The defined types are: Permanent – An assembly that is not intended to be split during the production process. Transient – A temporary assembly using during production, such as a pallet of different materials or a batch kit. NOTE If material lots (or sublots) are merged or absorbed (e.g. blended), then this is a new material lot.	Permanent	Transient	Permanent	Transient

* Typically either a material class, material definition, material lot, or material sublot is specified.

Defined values for *Material Use* for production operations shall be: Consumable, Consumed, Produced.

Defined values for *Material Use* for maintenance operations shall be: Consumable, Replaced Asset, Replacement Asset

Defined values for quality operations shall be: Consumable, Sample, Returned Sample.

Defined values for *Material Use* for inventory operations shall be: Consumable, Carrier, Returned Carrier.

A *material requirement* may be defined as containing an assembly of *material requirements* and as part of an assembly of *material requirements*:

a) a *material requirement* may define an assembly of zero or more *material requirements*;

b) a *material requirement* may be an assembly element of zero or more *material requirements*;

c) an assembly may be defined as a permanent or transient assembly of *material requirements;*

d) an assembly may be defined as physical or a logical assembly of *material requirements*.

6.2.13   Material requirement property

Properties of a *material requirement* shall be presented as *material requirement properties*. Specific elements associated with each *material requirement* may be included in one or more *material requirement properties*.

Table 69 defines the attributes for *material requirement property* objects.

Material requirement properties may contain nested *material requirement properties*.

Table 69 – Attributes of material requirement property

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of a property of the associated *material property* or *material class property* for a specific *segment requirement*.	Color	Size	OD	MOC
Description	Contains additional information and descriptions of the *material produced requirement property* definition.	Specifies the color for this specific operations request., in the polishing segment	Size required by calibration test	Outside diameter	Material of Constru-ction
Value	The value, set of values, or range of the associated property. For example Red, Orange, Yellow, Green, Blue, Indigo, Violet	Red	3 × 5	3,257	304 Stainless
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	(not applicable)	Feet	cm	(not applicable)
Quantity	Specifies the amount of material to be produced, if applicable.	100	(not applicable)	(not applicable)	(not applicable)
Quantity Unit of Measure	Identifies the unit of measure of the quantity if applicable.	Units	(not applicable)	(not applicable)	(not applicable)

6.2.14 Requested segment response

The identification of the information sent back as a result of the *production request* shall be presented as a *requested segment response*. This information is of the same form as a *segment response*, but without actual values. (see 6.3.4)

A *requested segment response* may include required information, which presents information reported on from production, such as the actual amount of material consumed.

A *requested segment response* may include optional information, which presents information that may be reported on from production, such as operator-entered comments.

6.3 Operations performance information

6.3.1 Operations performance model

Operations performance is a report on requested manufacturing and is a collection of *operations responses. Operations responses* are responses from manufacturing that may be associated with an *operations request*. There may be one or more *operations responses* for a single *operations request* if the manufacturing facility needs to split the *operations request* into smaller elements.

Figure 15 below is the operations performance model.
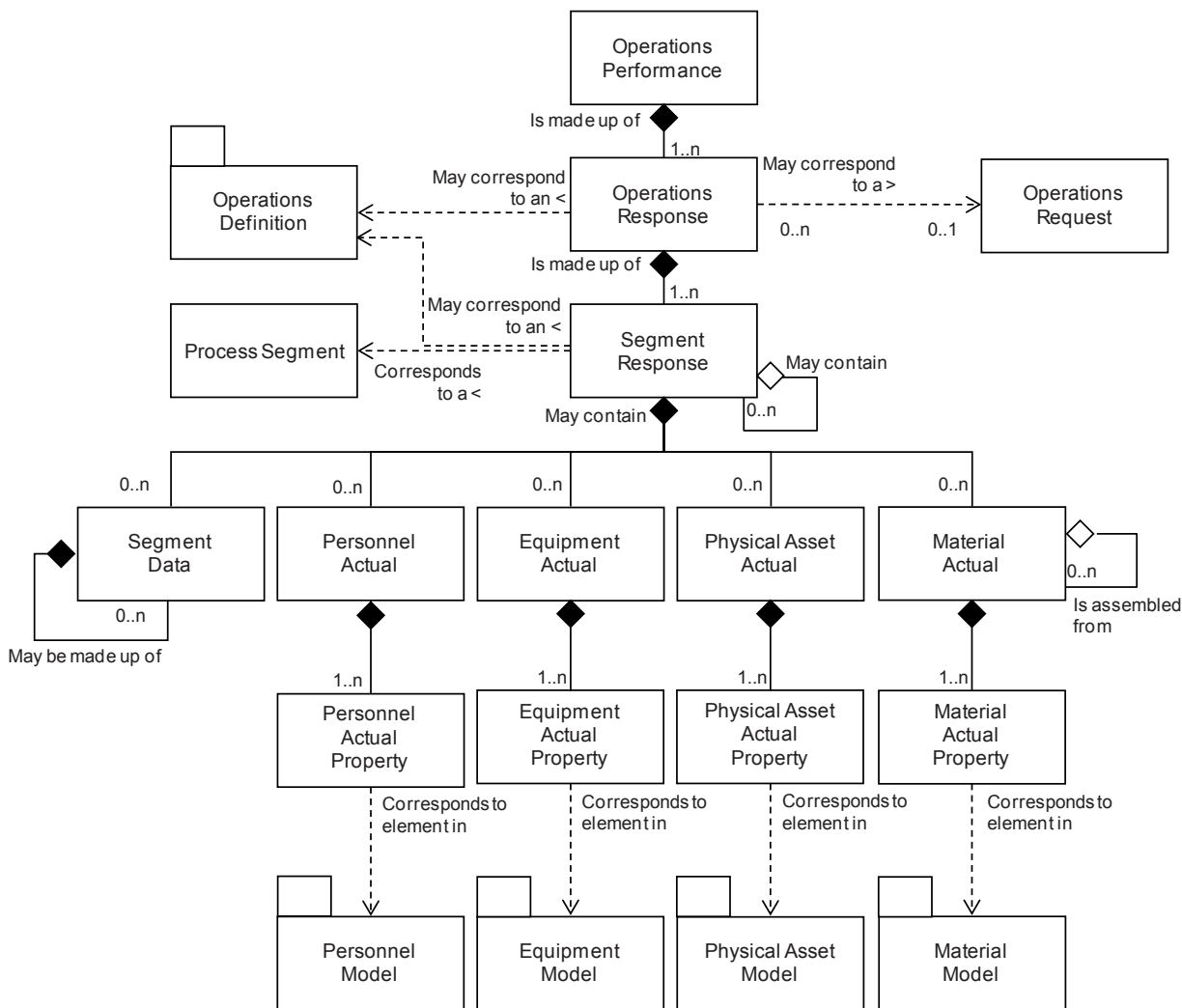
Figure 15 – Operations performance model

6.3.2   Operations performance

The performance of the requested manufacturing requests shall be presented as an *operations performance*. *Operations performance* shall be a collection of *operations responses*.

Table 70 defines the attributes for *operations performance* objects.

Table 70 – Attributes of operations performance

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of the *operations performance* and could include version and revision identification. The ID shall be used in other parts of the model when the *operations performance* needs to be identified.	1999-10-27-A15	20061027M04	20061027M04	20061027M04
Description	Contains additional information and descriptions of the *operations performance*.	Operations performance report on Oct 27, 1999 operations schedule.	Maintenance performance message	(not applicable)	(not applicable)
Operations type	Describes the category of operations. Required attribute Defined values are: Production, Maintenance, Quality, Inventory, or Mixed. "Mixed" shall be used when operations performance contains several categories of operations responses or segment responses.	Production	Maintenance	Quality	Inventory
Operations schedule	An identification of the associated *operations schedule*, if applicable.	1999-10-27-A15	MWOIDND	QTEST55	MOVE99
Start Time	The starting time of the associated *operations performance*, if applicable.	10-28-1999	10-28-2006 2:00 UTC	10-28-2006 2:00 UTC	10-28-2006 2:00 UTC
End Time	The ending time of the associated *operations performance*, if applicable.	10-30-1999	10-28-2006 2:30 UTC	10-28-2006 2:30 UTC	10-28-2006 2:30 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	(not applicable)	(not applicable)
Performance State	Indicates the state of the Operations Performance. Possible values are "Ready", "Completed", "Aborted", and "Holding"	Ready	Completed	Holding	Aborted
Published Date	The date and time on which the *operations performance* was published or generated.	10-27-1999 13:42 EST	10-28-2006 11:00 UTC	10-28-2006 11:00 UTC	10-28-2006 11:00 UTC

6.3.3 Operations response

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

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

Table 71 defines the attributes for *operations response* objects.

Table 71 – Attributes of operations response

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification within the associated *operations response*. The ID shall be used in other parts of the model when the *operations response* needs to be identified.	1001091	8490234	E938723	KPP84022
Description	Contains additional information and descriptions of the *operations response.*	July Actuals	Test program to verify X-Y coordinates within calibration	Verify stock dimen-sions	Pull part from ware-house, tag, and forward stage
Operations type	Describes the category of operations. Required attribute Defined values are: Production, Maintenance, Quality, Inventory, or Mixed. "Mixed" shall be used when operations response contains several categories of segment responses.	Production	Maintenance	Quality	Inventory
Operations request	An identification of the associated *operations request*, if applicable.	1001091	59328AC8	E938723	KIT493
Start Time	The starting time of this *operations response*.	1999-10-27 8:33 UTC	10-28-2006 2:00 UTC	10-28-2006 4:00 UTC	10-28-2006 3:30 UTC
End Time	The ending time of this *operations response*.	1999-10-27 16:55 UTC	10-28-2006 2:30 UTC	10-28-2006 4:45 UTC	10-28-2006 5:00 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	Ware-house B
Operations Definition ID	Identifies the associated *Operations definition* that was used, if applicable.	Export Quality Widget V02	CNC Daily Maintenance Procedure	T48340 v1.2	BOM for Export Quality Widget
Response State	Indicates the state of the Operations Response. Possible values are "Ready", "Completed", "Aborted", and "Holding"	Ready	Completed	Holding	Aborted

6.3.4 Segment response

Information on a segment of an operations response shall be presented as a *segment response*. A *segment response* shall be made up of zero or more sets of information on *segment data, personnel actual, equipment actual,* and *material actual*.

A *segment response* shall include

a) an identification of the associated *operations segment*;

b) the actual starting time;

c) the actual stopping time.

NOTE 1   A response actual can contain information that defines if the response was required or optional when the segment response is used as a requested segment response.

NOTE 2   Information that applies across all segments of the operations response, such as a final material produced, can be represented as a material produced in the master segment.

NOTE 3   Information that applies to specific segments, such as widget polishing equipment actually used can be reported as part of the polishing segment.

EXAMPLE There can be multiple segments defined. There can be one master segment that applies to the entire operations response. The master segment is made up of multiple nested segments for individually reported segments.

Table 72 defines the attributes for *segment response* objects.

Table 72 – Attributes of segment response

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	Uniquely identifies an instance of a *process segment* executed. NOTE The same process segment can be referenced multiple times in a segment response.	A54-1	KU492-SP	48283-SR	44828377 37883829
Description	Contains additional information and descriptions of the *segment response.*	Master segment, containing material produced actuals.	Test program to verify X-Y coordinates within calibration	Verify stock dimen-sions	Pull part from ware-house, tag, and forward stage
Operations type	Describes the category of operations. Required attribute Defined values are: Production, Maintenance, Quality, Inventory, or Mixed.	Production	Maintenance	Quality	Inventory
Process Segment	An identification of the *process segment* associated with the *segment response.*	Master Segment	Run X-Y test	RMT38283	Kiting segment
Actual Start Time	The actual start time of this *segment response.*	1999-10-27 8:33 UTC	10-28-2006 2:00 UTC	10-28-2006 4:00 UTC	10-28-2006 4:00 UTC
Actual End Time	The actual end time of this *segment response.*	1999-10-27 16:55 UTC	10-28-2006 2:30 UTC	10-28-2006 4:30 UTC	10-28-2006 6:30 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	Ware-house B
Operations Definition ID	Identifies the associated *Operations definition* that was used, if applicable.	Export Quality Widget V02	CNC Daily Maintenance Procedure	T48340 v1.2	BOM for Export Quality Widget
Segment State	Indicates the state of the Operations Response. Possible values are "Ready", "Completed", "Aborted", and "Holding"	Ready	Completed	Holding	Aborted

6.3.5   Segment data

Other information related to the actual operations made shall be presented as *segment data.*

Segment data may contain nested *segment data*.

Table 73 defines the attributes for *segment data* objects.

Table 73 – Attributes of segment data

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	The identification of the *segment data*.	Widget Clock Speed	Comment	Thickness	Location
Description	Contains additional information and descriptions of the *segment data*.	Defines the average measured clock speed of the produced widgets.	Comment entered by maintenance	Actual measure-ment	Actual location kit was left in
Value	The value or set of values of the *segment data*.	233	Sheet was nicked in first test. Second sheet was ok.	6	East Wing Manufac-turing Line #2
Value Unit of Measure	The engineering units in which the value is defined, if applicable.	MHz	(not applicable)	mm	(not applicable)

6.3.6   Personnel actual

An identification of a personnel capability used during a specified *segment response* shall be presented as *personnel actual*.

NOTE 1   In operational functions people are often a resource to carry out tasks.

Personnel actuals shall include the identification of each resource used, usually identifying a specific personnel capability or personnel class, such as end-point transmission assembly operators, or personnel IDs such as Jean Smith or SS# 999-123-4567.

Specific information about *personnel actuals* shall be presented in *personnel actual properties*.

NOTE 2   Examples of *personnel actual properties* are:
– the actual duration of use of the personnel during the product segment, such as 2 h; this information is often needed for actual costing analysis;
– actual monitored exposure times by the personnel during the product segment;
– the location of the personnel after use in the product segment, such as area 51; this information is often used for short-term scheduling of personnel resources.

Table 74 defines the attributes for *personnel actual* objects.

Table 74 – Attributes of personnel actual

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
Personnel Class	Identifies the associated *personnel class* or set of *personnel classes* actually used for a specific *segment response*.	Widget Polisher	CNC operator	[not applicable	Warehouse worker
Person	Identifies the associated *person* or set of *persons* actually used for a specific *segment response*. Typically either *personnel class* or *person* is specified, but not both.	Gidget	(not applicable)	261343	Sara Feye
Description	Contains additional information and descriptions of the *personnel actual*	Defines the specific polishing operator used in operations request.	Trained CNC operator	Quality personnel trained in stock inspections	Person to assemble the kit
Personnel Use	Defines the actual use of the personnel class or person.	Allocated	Certified	(not applicable)	(not applicable)
Quantity	Specifies the amount of personnel resources used in the parent segment, if applicable. Applies to each member of the *person* and *personnel class* sets.	1	1	1	1
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	Full Time Equivalents	Full Time Equivalents	Full Time Equivalents	Full Time Equivalents

6.3.7 Personnel actual property

Specific properties that are required for a *personnel actual* shall be presented as *personnel actual properties*.

Table 75 defines the attributes for *personnel actual property* objects.

Personnel actual properties may contain nested *personnel actual properties*.

Table 75 – Attributes of personnel actual property

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of the associated *person property* or *personnel class property* for a specific *segment response*.	Polishing Certification Level	CNC daily maintenance certification	Stock receiving inspection certifica-tion	(not applicable)
Description	Contains additional information and descriptions of the *personnel actual property* definition.	Level of polishing skill certification actually used for the widget polisher	Training level required	current certifica-tion	(not applicable)
Value	The value or set of values for the associated property. For example: Apprentice, Journeyman, Master	Master	True	True	(not applicable)
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	(not applicable)	Boolean	Boolean	(not applicable)
Quantity	Specifies the amount of personnel resources used in the parent segment, if applicable.	0,25	(not applicable)	(not applicable)	(not applicable)
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	Hour	(not applicable)	(not applicable)	(not applicable)

6.3.8 Equipment actual

An identification of an equipment capability used during a specified segment shall be presented as an *equipment actual*.

NOTE 1 In operations functions equipment are often a resource to carry out tasks.

Equipment actual shall include the identification of the equipment used, usually identifying a specific piece of equipment.

Specific information about *equipment actuals* shall be presented in *equipment actual properties*.

NOTE 2 Examples of *equipment actual properties* are

– the actual duration of use of the equipment during the product segment; this information is often needed for actual costing analysis;

– the equipment condition, after use in the product segment, such as a status of available, out-of-service, or cleaning; this information is often used for short-term scheduling of equipment resources;

– the equipment set-up procedures used for the product segment; this information is often needed for actual costing analysis and scheduling feedback;

– other equipment attributes, such as percentage of available capability used.

Table 76 defines the attributes for *equipment actual* objects.

Table 76 – Attributes of equipment actual

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
Equipment Class	Identifies the associated *equipment class* or set of *equipment classes* actually used for a specific *segment response*.	Widget Polishing Machine	CNC Drill Press	(not applicable)	(not applicable)
Equipment	Identifies the associated *equipment* or set of *equipment* actually used for a specific *segment response*. Typically either *equipment class* or *equipment* is specified, but not both.	WPM-20	DP-1	(not applicable)	(not applicable)
Description	Contains additional information and descriptions of the *equipment actual*	Specifics the actual machine used for this operations request.	Automated drill press	(not applicable)	(not applicable)
Equipment Use	Defines the actual use of the equipment class or equipment.	(not applicable)	(not applicable)	(not applicable)	(not applicable)
Quantity	Specifies the amount of equipment resources used in parent segment, if applicable. Applies to each member of the *equipment* and *equipment class* sets.	0,05	1	(not applicable)	(not applicable)
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	Machine Hours	Machine	(not applicable)	(not applicable)

6.3.9 Equipment actual property

Specific properties that are required for an *equipment actual* shall be presented as *equipment actual properties*.

Table 77 defines the attributes for *equipment actual property* objects.

Equipment actual properties may contain nested *equipment actual properties*.

Table 77 – Attributes of equipment actual property

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of the associated *equipment property* or *equipment class property* for a specific *segment response*.	Polisher Type	Holes out of tolerance	(not applicable)	(not applicable)
Description	Contains additional information and descriptions of the *equipment actual property* definition.	Actual polisher used for this process segment.	Number of drilled hole out of x-y tolerance	(not applicable)	(not applicable)
Value	The value or set of values for the associated property. For example: Wet, Dry.	Dry	0	(not applicable)	(not applicable)
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	(not applicable)	Number of Holes	(not applicable)	(not applicable)
Quantity	Specifies the amount of equipment resources used in parent segment, if applicable	0,05	2	(not applicable)	(not applicable)
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	Machine Hours	Tests	(not applicable)	(not applicable)

6.3.10 Physical asset actual

An identification of a physical asset capability used during a specified segment shall be presented as a *physical asset actual*.

NOTE   In operations functions physical asset are often a resource to carry out tasks.

Physical asset actual shall include the identification of the *physical asset* used, usually identifying a specific piece of physical asset.

Specific information about *physical asset* actuals shall be presented in *physical asset actual properties*.

Table 78 defines the attributes for *physical asset actual* objects.

Table 78 – Attributes of physical asset actual

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
Physical Asset Class	Identifies the associated *physical asset class* or set of *physical asset classes* actually used for a specific *segment response*.	(not applicable)	CNC Drill Press	(not applicable)	(not applicable)
Physical Asset	Identifies the associated *physical asset* or set of *physical assets* actually used for a specific *segment response*. Typically either *physical asset class* or *physical asset* is specified, but not both.	(not applicable)	Serial #: 5563442 Asset ID: 44Q56W	(not applicable)	(not applicable)
Description	Contains additional information and descriptions of the *physical asset actual*	(not applicable)	Cameroon Drill Press	(not applicable)	(not applicable)
Physical Asset Use	Defines the actual use of the physical asset class or physical asset. Example for maintenance: Repaired, Removed, Replacement, Calibrated, Modified/Improved	(not applicable)	Calibrated	(not applicable)	(not applicable)
Quantity	Specifies the amount of equipment resources used in parent segment, if applicable. Applies to each member of the *equipment* and *equipment class* sets.	(not applicable)	1	(not applicable)	(not applicable)
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	(not applicable)	Machine	(not applicable)	(not applicable)

6.3.11   Physical asset actual property

Specific properties that are required for a *physical asset actual* shall be presented as *physical asset actual properties*.

Table 79 defines the attributes for *physical asset actual property* objects.

Physical asset actual properties may contain nested *physical asset actual properties*.

Table 79 – Attributes of physical asset actual property

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of the associated *physical asset property* or *physical asset class property* for a specific *segment response*.	Polisher Type	Repeatability	(not applicable)	(not applicable)
Description	Contains additional information and descriptions of the *physical asset actual property* definition.	Actual polisher used for this process segment.	Drilling consistency	(not applicable)	(not applicable)
Value	The value or set of values for the associated property. For example: Wet, Dry.	Dry	0,000 2	(not applicable)	(not applicable)
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	(not applicable)	Inches	(not applicable)	(not applicable)
Quantity	Specifies the amount of physical asset resources used in parent segment, if applicable	0,05	2	(not applicable)	(not applicable)
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	Machine Hours	Tests	(not applicable)	(not applicable)

6.3.12 Material actual

An identification of a material that was used in the operations request shall be presented as a *material actual*. *Material actuals* contain definitions of materials that may have be consumed, produced, replaced, sampled, or otherwise used in manufacturing.

A *material actual* may be defined as containing an assembly of *material actuals* and as part of an assembly of *material actuals*:

a) A *material actual* may define an assembly of zero or more *material actuals*.

b) A *material actual* may be an assembly element of zero or more *material actuals*.

c) An assembly may be defined as a permanent or transient assembly of *material actuals*.

d) An assembly may be defined as physical or a logical assembly of *material actuals*.

Table 80 defines the attributes for *material actual* objects.

Table 80 – Attributes of material actual

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
Material Class	Identifies the associated *material class* or set of *material classes* actually made for a specific *segment response*.*	Widgets	Aluminum	(not applicable)	Bolt
Material Definition	Identifies the associated *material definition* or set of *material definitions* actually made for a specific *segment response*.*	Export Quality Widgets	Aluminum sheet	(not applicable)	10 mm bolt
Material Lot	Identifies the associated *material lot* or set of *material lots* actually made for a specific *segment response*.*	BWLOT-2282	DW94	(not applicable)	4857
Material Sublot	Identifies the associated *material sublot* or set of *material sublots* actually made for a specific *segment response*.*	BWLOT-2282-A	DW94-3	(not applicable)	4857F
Description	Contains additional information and descriptions of the *material produced actual*.	Master Segment - Number of Widgets actually produced.	Blank sheet to run test on	(not applicable)	Export quality bolt
Material Use	Identifies the use of the material. Defined values for production operations are: Consumable, Consumed, Produced. Defined values for maintenance operations are: Consumable, Replaced Asset, Replacement Asset Defined values for quality operations are: Consumable, Sample, Returned Sample Defined values for inventory operations are: Consumable, Carrier, Returned Carrier	Produced	Consumed	(not applicable)	Consumed
Storage Location	Identifies the actual location of the produced material, if applicable.	Finished Goods Inventory	Rack 11	(not applicable)	Ware-house B, Bin 42
Quantity	Specifies the amount of material produced by the parent segment. Applies to each member of the *material lot*, *materials definition*, or *material class* sets.	1 498	2	(not applicable)	4
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	Units	Sheet	(not applicable)	Each
Assembly Type	Optional: Defines the type of the assembly. The defined types are: Physical – The components of the assembly are physically connected or in the same area. Logical – The components of the assembly are not necessarily physically connected or in the same area.	Physical	Physical	Logical	Physical

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
Assembly Relationship	Optional: Defines the type of the relationships. The defined types are: Permanent – An assembly that is not intended to be split during the production process. Transient – A temporary assembly using during production, such as a pallet of different materials or a batch kit.	Permanent	Transient	Permanent	Transient
* Typically either a material class, material definition, material lot, or material sublot is specified.					

6.3.13 Material actual property

Specific properties that are required for a *material actual* shall be presented as *material actual properties*.

Material actual properties may contain nested *material actual properties*.

Table 81 defines the attributes for *material actual property* objects.

Table 81 – Attributes of material actual property

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of the associated *material property* or *material class property* for a specific *segment response*.	Color	Size	(not applicable)	MOC
Description	Contains additional information and descriptions of the *material produced actual property* definition.	Defines the color actually produced, in the polishing segment	Size required by calibration test	(not applicable)	Material of Constru-ction
Value	The value or set of values for the associated property. For example: Red, Orange, Yellow, Green, Blue, Indigo, Violet.	Red	3 x 5	(not applicable)	316 Stainless
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	Color	Feet	(not applicable)	(not applicable)
Quantity	Specifies the amount of material produced by the parent segment. Applies to each member of the *material lot*, *materials definition*, or *material class* sets.	1 002	(not applicable)	(not applicable)	(not applicable)
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	Units	(not applicable)	(not applicable)	(not applicable)

6.4 Operations capability information

6.4.1 Operations capability model

Operations capability information is the collection of information about all resources for operations for selected future and past times. This is made up of information about equipment, physical assets, material, personnel, and process segments. Operations capability describes the names, terms, statuses, and quantities of which the manufacturing control system has knowledge.

Figure 16 is the operations capability model that applies to production, maintenance, quality test and inventory.
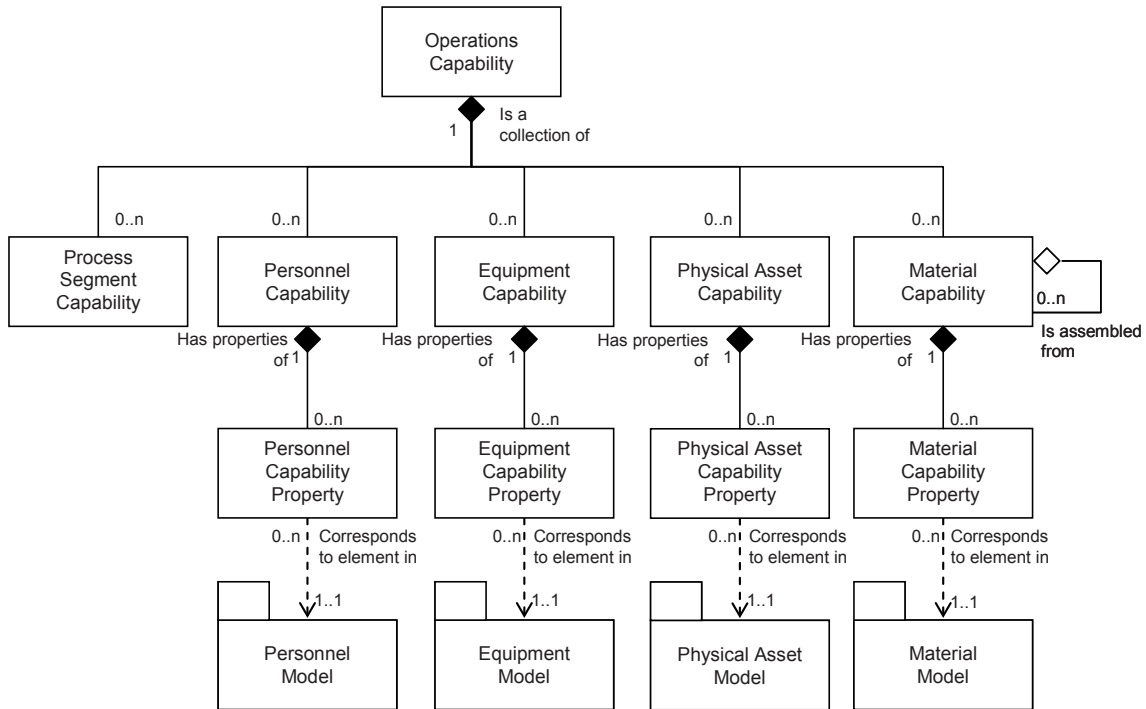
Figure 16 – Operations capability Model

6.4.2 Operations capability

A collection of personnel capabilities, equipment capabilities, physical asset capabilities, material capabilities, and process segment capabilities, for a given slice of time (past, current, or future), and defined as committed, available, and unattainable shall be presented as an *operations capability*.

Table 82 defines the attributes for *operations capability* objects.

Table 82 – Attributes of operations capability

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	Defines a unique instance of an operations capability for a specified element of the equipment hierarchy model (*enterprise, site, area, work center, or work unit*).	1999/12/30-HPC52	84818343DF	4737845	EDIDCUIUE
Description	Contains additional information and descriptions of the *operations capability* definition.	One day's operations capacity for the Boston Widget Company.	Maintenance capability for one week	Test incoming material	Ware-house kit prep
Capacity Type	The capacity type: Used, Unused, Total, Available, Unattainable, or Committed.	Available	Committed	Available	Unattai-nable
Reason	Defines the reason for the capability type. Example 1: If committed, then committed for production or for maintenance, or if unavailable, then the reason for the unavailability. Example 2: If unused capacity, then the reason for the capacity was unused, such as a specific equipment failure or unacceptable product quality	Available for Work	Scheduled calibration	Available for inspe-ctions	Down for inventory cycle count
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
Start Time	The starting date and time of the operations capability.	1999-12-29 11:59	10-28-2006 2:00 UTC	10-28-2006 00:00 UTC	10-28-2006 00:00 UTC
End Time	The ending date and time of the operations capability.	1999-12-30 12:00	10-28-2006 2:15 UTC	10-28-2006 8:00 UTC	10-29-2006 00:00 UTC
Published Date	The date and time on which the *operations 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
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 operations capability definition.	Boston Widget Company	CNC Machine Asset ID 13465	Test Cell 4 Receiving	Warehouse B

6.4.3   Personnel capability

The capability of persons or personnel classes that is committed, available, or unattainable for a defined time shall be presented as a *personnel capability*. *Personnel capability* may contain references to either persons or personnel classes.

Personnel capability shall identify:

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

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

Specific *personnel capabilities* shall be presented in *personnel capability properties*. The *personnel capability property* may include the quantity of the resource referenced.

NOTE   For example, 3 horizontal drill press operators available for the third shift on 2000-02-29.

Table 83 defines the attributes for *personnel capability* objects.

Table 83 – Attributes of personnel capability

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
Personnel Class	Identifies the associated *personnel class* of the capability.	Widget Assembly Machine Operator	CNC operator	Quality Assurance Tech	(not applicable)
Person	Identifies the associated *person* of the capability.	SSN 999-55-1212	Charlie Goode	(not applicable)	(not applicable)
Description	Contains additional information and descriptions of the *personnel capability* definition.	Widget machine operator availability over the 2000 New Year boundary	Trained CNC operator	Quality personnel trained in stock inspections	(not applicable)
Capability Type	The capability type: Used, Unused, Total, Available, Unattainable, or Committed.	Available	Committed	Available	(not applicable)
Reason	Defines the reason for the capability type.	Available for Work	Scheduled calibration	Available for incoming inspections	(not applicable)
Confidence Factor	A measure of the confidence of the capacity value.	90 %	100 %	100 %	(not applicable)
Hierarchy Scope	Identifies where the exchanged information fits within the role based equipment hierarchy. If omitted, then the capability is associated to the parent *operations capability* hierarchy scope. Zero or more as required to identify the specific scope of the operations capability definition.	South Shore Work Plant	CNC Machine Asset ID 13465	Test Cell 4 Receiving	(not applicable)
Personnel Use	Defines the expected capability use of the personnel class or person.	(not applicable)	(not applicable)	(not applicable)	(not applicable)
Start Time	The starting time associated with the *personnel capability*. If omitted, then the capability is associated to the parent *operations capability* start time.	1999-12-30 11:59	10-28-2006 2:00 UTC	10-28-2006 00:00 UTC	(not applicable)
End Time	The ending time associated with the *personnel capability*. If omitted, then the capability is associated to the parent *operations capability* end time.	2000-01-01 12:00	10-28-2006 2:15 UTC	10-28-2006 8:00 UTC	(not applicable)
Quantity	Specifies the quantity of the personnel capability defined, if applicable.	48	1	1	(not applicable)
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Hours	Full Time Equivalent	Full Time Equivalent	(not applicable)

Where *persons* are members of multiple *personnel classes* then the *personnel capability* information defined by *personnel class* should be used carefully because of possible double counts, and personnel resources should be managed at the instance level.

6.4.4 Personnel capability property

Specific properties that are required for *personnel capabilities* shall be presented as *personnel capability properties*.

Personnel capability properties may contain nested *personnel capability properties*.

Table 84 defines the attributes for *personnel capability property* objects.

Table 84 – Attributes of personnel capability property

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of a property of the associated *person property* or *personnel class property*.	Packing Machine Certified	CNC daily maintenance certification	Stock receiving inspection certifica-tion	(not applicable)
Description	Contains additional information and descriptions of the *personnel capability property* definition.	Level of packing machine operator certification	Training level required	current certifica-tion	(not applicable)
Value	The value, set of values, or range of the property.	Journeyman	True	True	(not applicable)
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	(not applicable)	Boolean	Boolean	(not applicable)
Quantity	Specifies the quantity of the personnel capability defined, if applicable.	16	(not applicable)	(not applicable)	(not applicable)
Quantity Unit of Measure	The unit of measure of the associated quantity.	Hours	(not applicable)	(not applicable)	(not applicable)

6.4.5 Equipment capability

A representation of the capability of equipment or equipment classes that is committed, available, or unattainable for a specific time shall be presented as an *equipment capability*. *Equipment capability* may contain references to either equipment or equipment classes.

Equipment capability shall identify

a) the availability (available, unattainable, committed, used, unused, total);
b) the time associated with the availability (for example, third shift on a specific date).

Specific *equipment capabilities* may have *equipment capability properties*. The *equipment capability properties* may include the quantity of the resource referenced.

NOTE For example, 3 horizontal drill presses currently available.

Table 85 defines the attributes for *equipment capability* objects.

Table 85 – Attributes of equipment capability

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
Equipment Class	Identifies the associated *equipment class* of the capability.	Widget Lathe	CNC Drill Press	Micro-meter	(not applicable)
Equipment	Identifies the associated *equipment* of the capability.	Lathe machine 15	DP-1	(not applicable)	(not applicable)
Description	Contains additional information and descriptions of the *equipment capability* definition.	Widget Lathe availability over the 2000 New Year boundary	Automated drill press	Measure-ment tool	(not applicable)
Capability Type	The capability type: Used, Unused, Total, Available, Unattainable, or Committed.	Unattainable	Committed	Available	(not applicable)
Reason	Defines the reason for the capability type.	Due to Y2K Non compliance	Schedule calibration	Available for measurem ent	(not applicable)
Confidence Factor	A measure of the confidence of the capacity value.	90 %	100 %	100 %	(not applicable)
Hierarchy Scope	Identifies where the exchanged information fits within the role based equipment hierarchy. If omitted, then the capability is associated to the parent *operations capability* hierarchy scope. Zero or more as required to identify the specific scope of the operations capability definition.	South Shore Work Plant	CNC Machine Asset ID 13465	Test Cell 4 Receiving	(not applicable)
Equipment Use	Defines the expected capability use of the equipment class or equipment.	(not applicable)	(not applicable)	(not applicable)	(not applicable)
Start Time	The starting time associated with the *equipment capability*. If omitted, then the capability is associated to the parent *operations capability* start time.	1999-12-30 11:59	10-28-2006 2:00 UTC	10-28-2006 00:00 UTC	(not applicable)
End Time	The ending time associated with the *equipment capability*. If omitted, then the capability is associated to the parent *operations capability* end time.	2000-01-01 12:00	10-28-2006 2:15 UTC	10-28-2006 8:00 UTC	(not applicable)
Quantity	Specifies the quantity of the equipment capability defined, if applicable.	48	1	1	(not applicable)
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Hours	Machine	Tool	(not applicable)

Where *equipment* are members of multiple *equipment classes* then the *equipment capability* information defined by *equipment class* should be used carefully because of possible double counts, and equipment resources should be managed at the instance level.

6.4.6 Equipment capability property

Specific properties that are required for *equipment capabilities* shall be presented as *equipment capability properties*.

Table 86 defines the attributes for *equipment capability property* objects.

Equipment capability properties may contain nested *equipment capability properties*.

Table 86 – Attributes of equipment capability property

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of a property of the associated *equipment property* or *equipment class property*.	Volume	Spindle run-out	Scale definition	(not applicable)
Description	Contains additional information and descriptions of the *equipment capability property* definition.	Measure of the equipment volume.	Max allowed spindle run-out	Units of measure	(not applicable)
Value	The value, set of values, or range of the property.	10 000	less than 0,000 08	Metric	(not applicable)
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	Liters	Inches	(not applicable)	(not applicable)
Quantity	Specifies the quantity of the equipment capability defined, if applicable.	12	(not applicable)	1	(not applicable)
Quantity Unit of Measure	The unit of measure of the associated quantity.	Hours	(not applicable)	Each	(not applicable)

6.4.7 Physical asset capability

A representation of the capability of a *physical asset* or *physical asset class* that is committed, available, or unattainable for a specific time shall be presented as a *physical asset capability*. *Physical asset capability* may contain references to either physical asset or physical asset class.

Physical asset capability shall identify

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

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

Specific *physical asset capabilities* may contain *physical asset capability properties*. The *physical asset capability properties* may include the quantity of the resource referenced.

Table 87 defines the attributes for *physical asset capability* objects.

Table 87 – Attributes of physical asset capability

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
Physical Asset Class	Identifies the associated *physical asset class* of the capability.	Jones Model 23 Lathe	Model 105, XYZ Corp, CNC Drill Press	(not applicable)	(not applicable)
Physical Asset	Identifies the associated *physical asset* of the capability.	Machine #99298	Serial #: 5563442 Asset ID: 44Q56W	(not applicable)	(not applicable)
Description	Contains additional information and descriptions of the *physical asset capability* definition.	Widget Lathe availability over the 2000 New Year boundary	Cameroon Drill Press	(not applicable)	(not applicable)
Capability Type	The capability type: Used, Unused, Total, Available, Unattainable, or Committed.	Unattainable	Committed	(not applicable)	(not applicable)
Reason	Defines the reason for the capability type.	Due to Y2K Non compliance	Scheduled calibration	(not applicable)	(not applicable)
Confidence Factor	A measure of the confidence of the capacity value.	90 %	100 %	(not applicable)	(not applicable)
Hierarchy Scope	Identifies where the exchanged information fits within the role based equipment hierarchy. If omitted, then the capability is associated to the parent *operations capability* hierarchy scope. Zero or more as required to identify the specific scope of the operations capability definition.	South Shore Work Plant	CNC Machine Asset ID 13465	(not applicable)	(not applicable)
Physical Asset Use	Defines the expected capability use of the physical asset class or physical asset.	(not applicable)	(not applicable)	(not applicable)	(not applicable)
Start Time	The starting time associated with the *physical asset capability*. If omitted, then the capability is associated to the parent *operations capability* start time.	1999-12-30 11:59	10-28-2006 2:00 UTC	(not applicable)	(not applicable)
End Time	The ending time associated with the *physical asset capability*. If omitted, then the capability is associated to the parent *operations capability* end time.	2000-01-01 12:00	10-28-2006 2:15 UTC	(not applicable)	(not applicable)
Quantity	Specifies the quantity of the physical asset capability defined, if applicable.	48	1	(not applicable)	(not applicable)
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Hours	Machine	(not applicable)	(not applicable)

6.4.8 Physical asset capability property

Specific properties that are required for *physical asset capabilities* shall be presented as *physical asset capability properties*.

Physical asset capability properties may contain nested *physical asset capability properties*.

Table 88 defines the attributes for *physical asset capability property* objects.

Table 88 – Attributes of physical asset capability property

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of a property of the associated *physical asset property* or *physical asset class*.	Volume	Repeatability	(not applicable)	(not applicable)
Description	Contains additional information and descriptions of the *physical asset capability property* definition.	Measure of the equipment volume.	Drilling consistency	(not applicable)	(not applicable)
Value	The value, set of values, or range of the property.	10 000	0,000 2	(not applicable)	(not applicable)
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	Liters	Inches	(not applicable)	(not applicable)
Quantity	Specifies the quantity of the physical asset capability defined, if applicable.	12	(not applicable)	(not applicable)	(not applicable)
Quantity Unit of Measure	The unit of measure of the associated quantity.	Hours	(not applicable)	(not applicable)	(not applicable)

6.4.9   Material capability

A representation of the capability of material that is committed, available, or unattainable for a specific time shall be presented as a *material capability*. *Material capability* is used for *material lots* and *material sublots*. This includes information that is associated with the functions of material and energy control and product inventory control. The currently available and committed material capability is the inventory. WIP (work in progress) is a material capability currently under the control of production.

Material capability shall identify

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

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

Specific *material capabilities* may have *material capability properties*. The *material capability properties* may include the quantity of the material referenced.

NOTE   For example, 3 sublots in building 3 of material starch lot #12345 committed to production for 2000-02-29.

A Material Capability may be defined as containing an assembly of Material Capabilities and as part of an assembly of Material Capabilities:

1. A Material Capability may define an assembly of zero or more Material Capabilities.

2. A Material Capability may be an assembly element of zero or more Material Capabilities.

3. An assembly may be defined as a permanent or transient assembly of Material Capabilities.

4. An assembly may be defined as physical or a logical assembly of Material Capabilities.

Table 89 defines the attributes for *material capability* objects.

Table 89 – Attributes of material capability

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
Material Class	Identifies the associated *material class* of the capability.*	Lubricant Oil	Aluminum	(not applicable)	(not applicable)
Material Definition	Identifies the associated *material definition* of the capability.*	Lube Oil 8999	Aluminum sheet	(not applicable)	(not applicable)
Material Lot	Identifies the associated *material lot* of the capability.*	8999LU-5G	DW94	(not applicable)	(not applicable)
Material Sublot	Identifies the associated *material sublot* of the capability.*	8999LU-5G-SL15	(not applicable)	(not applicable)	(not applicable)
Description	Contains additional information and descriptions of the *material capability* definition.	Lubricant oil commitment over the 2000 New Year boundary	Blank sheet to run test on	(not applicable)	(not applicable)
Capability Type	The capability type: Used, Unused, Total, Available, Unattainable, or Committed.	Committed	Committed	(not applicable)	(not applicable)
Reason	Defines the reason for the capability type.	Available for Work	Scheduled calibration	(not applicable)	(not applicable)
Confidence Factor	A measure of the confidence of the capacity value.	90 %	100 %	(not applicable)	(not applicable)
Hierarchy Scope	Identifies where the exchanged information fits within the role based equipment hierarchy. If omitted, then the capability is associated to the parent *operations capability* hierarchy scope. Zero or more as required to identify the specific scope of the operations capability definition.	Work Line 15	CNC Machine Asset ID 13465	(not applicable)	(not applicable)
Material Use	Defines the expected capability use of the material. For example, Consumed, Produced, or Consumable	Consumed	Committed	(not applicable)	(not applicable)
Start Time	The starting time associated with the *material capability*. If omitted, then the capability is associated to the parent *operations capability* start time.	1999-12-30 11:59	10-28-2006 2:00 UTC	(not applicable)	(not applicable)
End Time	The ending time associated with the *material capability*. If omitted, then the capability is associated to the parent *operations capability* end time.	2000-01-01 12:00	10-28-2006 2:15 UTC	(not applicable)	(not applicable)
Quantity	Specifies the quantity of the material capability defined, if applicable.	155	1	(not applicable)	(not applicable)
Quantity Unit of Measure	The unit of measure of the material quantity, if applicable.	Liters	Sheet	(not applicable)	(not applicable)

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
Assembly Type	Optional: Defines the type of the assembly. The defined types are: Physical – The components of the assembly are physically connected or in the same area. Logical – The components of the assembly are not necessarily physically connected or in the same area.	Physical	Physical	Logical	Physical
Assembly Relationship	Optional: Defines the type of the relationships. The defined types are: Permanent – An assembly that is not intended to be split during the production process. Transient – A temporary assembly using during production, such as a pallet of different materials or a batch kit.	Permanent	Transient	Permanent	Transient
* Typically either a material class, material definition, material lot, or material sublot is specified.					

Where *materials* are members of multiple *material classes* then the *material capability* information defined by *material class* should be used carefully because of possible double counts, and material resources should be managed at the instance level.

6.4.10   Material capability property

Specific properties that are required for *material capabilities* shall be presented as *material capability properties*.

Material capability properties may contain nested *material capability properties*.

Table 90 defines the attributes for *material capability property* objects.

Table 90 – Attributes of material capability property

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of a property of the associated *material property* or *equipment class property*.	pH	Size	(not applicable)	(not applicable)
Description	Contains additional information and descriptions of the *material capability property* definition.	pH of active ingredient	Size required by calibration test	(not applicable)	(not applicable)
Value	The value, set of values, or range of the property.	6,3	3×5	(not applicable)	(not applicable)
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	pH	Feet	(not applicable)	(not applicable)
Quantity	Specifies the quantity of the material capability defined, if applicable.	2 567	(not applicable)	(not applicable)	(not applicable)
Quantity Unit of Measure	The unit of measure of the associated quantity.	KiloLiters	(not applicable)	(not applicable)	(not applicable)

6.5 Process segment capability information

6.5.1 Process segment capability model

A process segment capability is a representation of a logical grouping of personnel resources, equipment resources, physical asset resources, and material that is committed, available, or unavailable for a defined process segment for a specific time.

A *process segment capability* is related to a *process segment* that can occur during operations.

Process segment 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).

Process segment capabilities shall be made up of

c) *personnel capabilities*, and any specific properties required in *personnel segment capability properties*;

d) *equipment capabilities*, and any specific properties required in *equipment capability properties*;

e) *physical asset capabilities*, and any specific properties required in *physical asset capability properties*;

f) *material capabilities*, and any specific properties required in *material capability properties.*

Figure 17 is the *process segment capability* model.
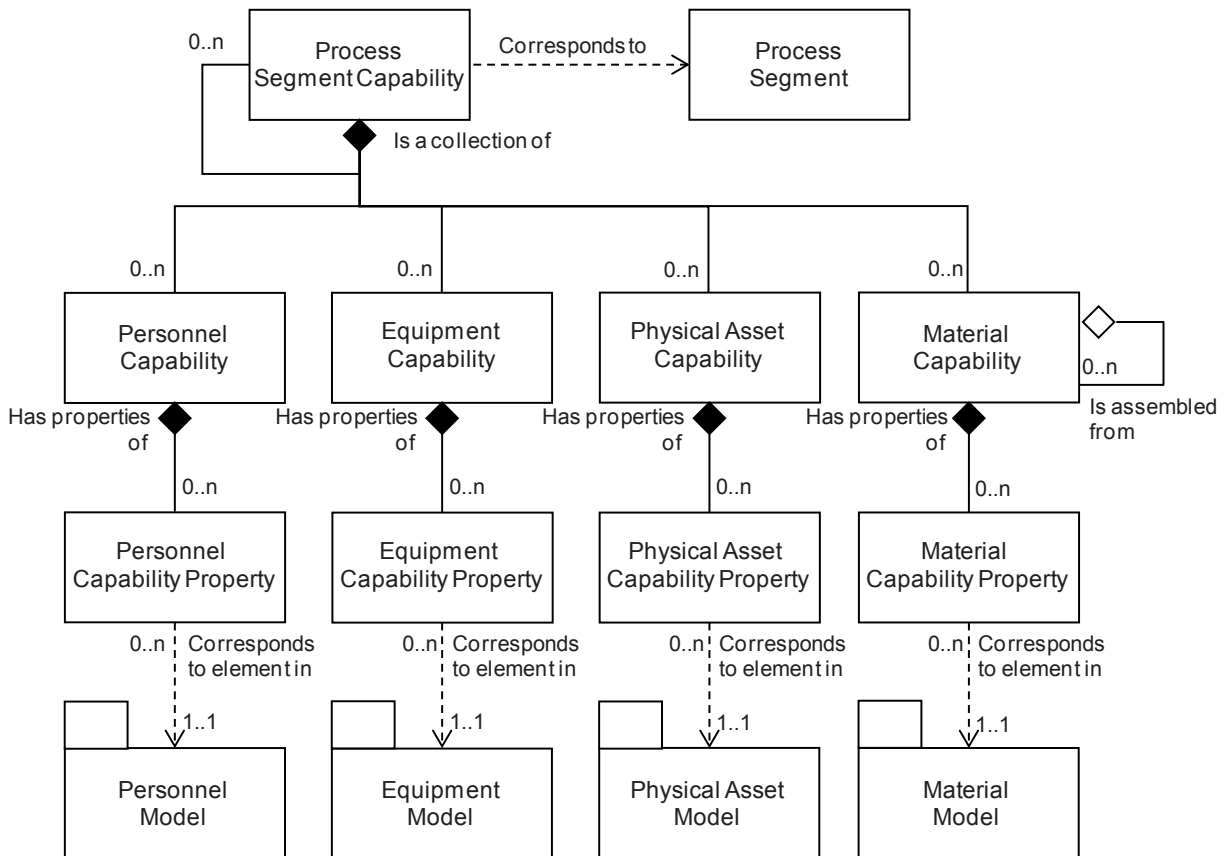
Figure 17 – Process segment capability object model

6.5.2 Process segment 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 process segment for a specific time shall be presented as a *process segment capability*.

Process segment capability has an equivalent structure to the personnel, equipment and material structure of *operations capability*, except the *process segment capability* is defined for a specific *process segment*.

Table 91 lists the attributes of *process segment capability*.

Table 91 – Attributes of process segment capability

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	Defines a unique instance of a process segment capability for a specified element of the equipment hierarchy model (*enterprise, site, area, work center, or work unit*).	1999/12/30-HPC52	84818343DF	4737845	EDIDCUIUE
Description	Contains additional information and descriptions of the *process segment capability* definition.	Defines the available capability for the Widget Assembly process segment	Calibration of CNC Drill Press	Incoming aluminum sheet thickness test	Kiting segment
Process Segment	Identifies the *process segment*.	Widget Assembly	Run X-Y test	RMT38283	Kiting segment
Capacity Type	The capacity type: Available, Unattainable, or Committed.	Available	Committed	Available	Unattainable
Reason	Gives the reason for the capacity type.	Available for Production	Scheduled calibration	Available for incoming inspection	Down for inventory cycle count
Hierarchy Scope	Identifies where the exchanged information fits within the role based equipment hierarchy. If omitted, then the capability is associated to the parent *process segment capability* hierarchy scope. Zero or more as required to identify the specific scope of the production capability definition.	Production Line #15	CNC Machine Asset ID 13465	Test Cell 4 Receiving	Ware-house B
Start Time	The starting time of the time span defining the capacity type. If omitted, then the capability is associated to the parent *process segment capability* start time.	1999-12-30 11:59	10-28-2006 2:00 UTC	10-28-2006 00:00 UTC	10-28-2006 00:00 UTC
End Time	The ending time of the time span defining the capacity type. If omitted, then the capability is associated to the parent *process segment capability* end time.	2000-01-01 12:00	10-28-2006 2:15 UTC	10-28-2006 8:00 UTC	10-29-2006 00:00 UTC

Process segment capabilities should be used carefully because of possible double counts of resources.

EXAMPLE   A resource can be shown as available in multiple *process segments*, but in actual fact can be available for use in only a single *process segment*.

7   Object model inter-relationships

Figure 18 provides an informative illustration of how the object models inter-relate. The operations information presents what was made and what was used. Its elements correspond to information in operations scheduling that listed what to make and what to use. The operations scheduling elements correspond to information in the operations definition. The operations definition elements correspond to information in the process segment descriptions that present what can be performed with the resources. The operations capability contains what capacities exist for specified resources and for specific process segments for specific periods of time.

The slanted rectangles in Figure 18 represent any of the resources (personnel, equipment, physical assets, or material) and properties of the resources.

Resource → Personnel, Equipment, Physical Asset, or Material
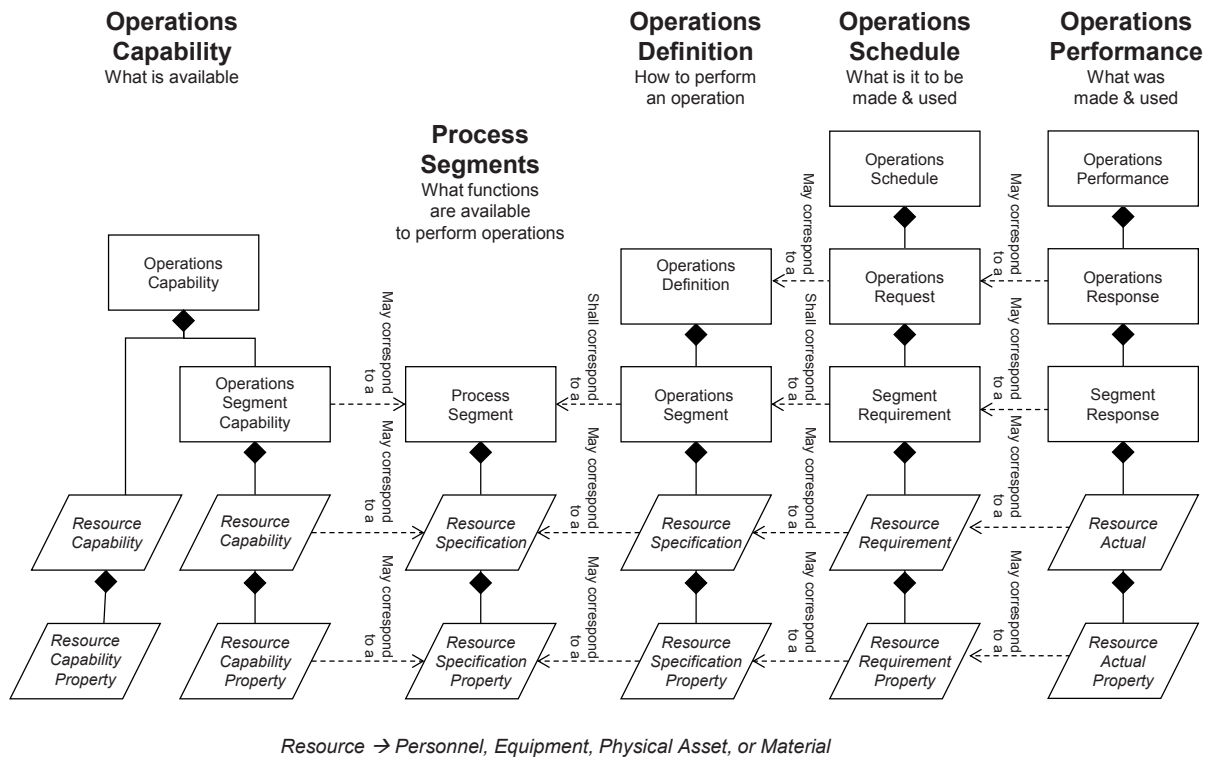
Figure 18 – Object model inter-relationships

NOTE   Both resource capability properties and operation segment's operations specifications/properties map their properties to the process segment's resource specification/ properties. They can be subsets of the process segment's resource specification /properties where capability properties are used to evaluate availability and product segment properties can be used to determine requirement specifics for scheduling.

Table 92 provides a cross-reference between the elements of the information flows in the data flow model and the corresponding clause describing the object model.

Table 92 – Model cross-reference *(1 of 2)*

IEC 62264-1 Data flow model information	IEC 62264-1 - From function	IEC 62264-1 - To function	Part 2 - Object model clause
6.5.2 Schedule	Production scheduling	Production control	6.2 and A.2
6.5.3 Production from plan	Production control	Production scheduling	6.3 and A.3
6.5.4 Production capability	Production control	Production scheduling	6.4 and A.4
6.5.5 Material and energy order requirements	Material and energy control	Procurement	Described in terms of the material model, 5.4.
6.5.6 Incoming order confirmation	Material and energy control	Procurement	Described in terms of the material model, 5.4.
6.5.7 Long-term material and energy requirements	Production scheduling	Material and energy control	Described in terms of the material model, 5.4.
6.5.8 Short-term material and energy requirements	Production control	Material and energy control	Described in terms of the material model, 5.4.
6.5.9 Material and energy inventory	Material and energy control	Production control	Described in terms of the material model, 5.4.
6.5.10 Production cost objectives	Product cost accounting	Production control	6.2 and A.2
6.5.11 Production performance and costs	Production control	Product cost accounting	6.3 and A.3
6.5.12 Incoming material and energy receipt	Material and energy control	Product cost accounting	<Not detailed in object model>
6.5.13 Quality assurance results	Quality assurance	Production control	5.4 and 6.3
6.5.14 Standards and customer requirements	Marketing and sales	Quality assurance	6.1 and A.1
	Quality assurance	Production control	
6.5.15 Product and process requirements	Research, development, and engineering	Quality assurance	6.1 and A.1
6.5.16 Finished goods waiver	Order processing	Quality assurance	<Not detailed in object model> Typically unstructured information handled on an *ad hoc* basis
6.5.17 In-process waiver request	Production control	Quality assurance	Described in terms of the material model, 5.4.
6.5.18 Finished goods inventory	Product inventory control	Production scheduling	Described in terms of the material model, 5.4.
6.5.19 Process data	Production control	Quality assurance	6.3 and A.3
6.5.20 Pack-out schedule	Production scheduling	Product inventory control	6.2 and A.2

Table 92 *(2 of 2)*

Data flow model information	From function	To function	Object model clause
6.5.21 Product and process information request	Production control	Research, development, and engineering	<Not detailed in object model>
6.5.22 Maintenance requests	Production control	Maintenance management	6.2
6.5.23 Maintenance responses	Maintenance management	Production control	6.3
6.5.24 Maintenance standards and methods	Production control	Maintenance management	<Not detailed in object model>
6.5.25 Maintenance technical feedback	Maintenance management	Production control	<Not detailed in object model>
6.5.26 Product and process technical feedback	Production control	Research, development, and engineering	<Not detailed in object model>
6.5.27 Maintenance purchase order requirements	Maintenance management	Procurement	<Not detailed in object model>
6.5.28 Production order	Order processing	Production scheduling	<Not detailed in object model>
6.5.29 Availability	Production scheduling	Order processing	<Not detailed in object model>
6.5.30 Release to ship	Product shipping administration	Product inventory control	<Not detailed in object model>
6.5.31 Confirm to ship	Product inventory control	Product shipping administration	<Not detailed in object model>

8   List of objects

The following tables present a complete list of the objects discussed in this standard.

Table 93 – Common resource objects *(1 of 4)*

Object	Model
personnel class	Personnel Model
personnel class property	Personnel Model
person	Personnel Model
person property	Personnel Model
qualification test specification	Personnel Model
qualification test result	Personnel Model
equipment class	Equipment Model
equipment class property	Equipment Model
equipment	Equipment Model
equipment property	Equipment Model
equipment capability test specification	Equipment Model
equipment capability test result	Equipment Model
physical asset	Physical Asset Model

Table 93 *(2 of 4)*

Object	Model
physical asset property	Physical Asset Model
physical asset class	Physical Asset Model
physical asset class property	Physical Asset Model
physical asset capability test specification	Physical Asset Model
physical asset capability test result	Physical Asset Model
equipment asset mapping	Physical Asset Model
material class	Material Model
material class property	Material Model
material definition	Material Model
material definition property	Material Model
material lot	Material Model
material lot property	Material Model
material sublot	Material Model
material test specification	Material Model
material test result	Material Model
material assembly	Material Model
material definition assembly	Material Model
material class assembly	Material Model
process segment	Process Segment Model
process segment parameter	Process Segment Model
personnel segment specification	Process Segment Model
personnel segment specification property	Process Segment Model
equipment segment specification	Process Segment Model
equipment segment specification property	Process Segment Model
physical asset segment specification	Process Segment Model
physical asset segment specification property	Process Segment Model
material segment specification	Process Segment Model
material segment specification property	Process Segment Model
material segment specification assembly	Process Segment Model
process segment dependency	Process Segment Model
operations definition	Operations Definition Model
operations material bill	Operations Definition Model
operations material bill item	Operations Definition Model
operations segment	Operations Definition Model
parameter specification	Operations Definition Model
personnel specification	Operations Definition Model
personnel specification property	Operations Definition Model
equipment specification	Operations Definition Model
equipment specification property	Operations Definition Model
physical asset specification	Operations Definition Model
physical asset specification property	Operations Definition Model
material specification	Operations Definition Model

Table 93 *(3 of 4)*

Object	Model
material specification property	Operations Definition Model
material specification assembly	Operations Definition Model
operations segment dependency	Operations Definition Model
operations schedule	Operations Schedule Model
operations request	Operations Schedule Model
requested segment response	Operations Schedule Model
segment requirement	Operations Schedule Model
segment parameter	Operations Schedule Model
personnel requirement	Operations Schedule Model
personnel requirement property	Operations Schedule Model
equipment requirement	Operations Schedule Model
equipment requirement property	Operations Schedule Model
physical asset requirement	Operations Schedule Model
physical asset requirement property	Operations Schedule Model
material requirement	Operations Schedule Model
material requirement property	Operations Schedule Model
material requirement assembly	Operations Schedule Model
operations performance	Operations Performance Model
operations response	Operations Performance Model
segment response	Operations Performance Model
segment data	Operations Performance Model
personnel actual	Operations Performance Model
personnel actual property	Operations Performance Model
equipment actual	Operations Performance Model
equipment actual property	Operations Performance Model
physical asset actual	Operations Performance Model
physical asset actual property	Operations Performance Model
material actual	Operations Performance Model
material actual property	Operations Performance Model
material actual assembly	Operations Performance Model
operations capability	Operations Capability Model
personnel capability	Operations Capability Model
personnel capability property	Operations Capability Model
equipment capability	Operations Capability Model
equipment capability property	Operations Capability Model
physical asset capability	Operations Capability Model
physical asset capability property	Operations Capability Model
material capability	Operations Capability Model
material capability property	Operations Capability Model
material capability assembly	Operations Capability Model
process segment capability	Process Segment Capability Model

Table 93 *(4 of 4)*

Object	Model
product definition	Product Definition Model
product segment	Product Definition Model
manufacturing bill	Product Definition Model
manufacturing bill assembly	Product Definition Model
production schedule	Production Schedule Model
production request	Production Schedule Model
production parameter	Production Schedule Model
production performance	Production Performance Model
production response	Production Performance Model
production data	Production Performance Model
production capability	Production Capability Model

9 Compliance

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

a) the use of the terminology defined in this part of IEC 62264,

b) the object models supported (*personnel, material, equipment, physical asset, process segment, operations capability, operations definition, operations schedule, operations performance, production capability, process segment capability, product definition, production schedule,* and *production performance*)

c) the use of objects listed in Clause 8 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
(normative)

Production specific information

A.1 Product definition information

A.1.1 Product definition model

The production information models are a specialized subset of the operations model with alternative object names for purposes of backward compatibility. New implementations should use the operations models.

The product definition model is shown in Figure A.1. It defines the shared information between product production rule, bill of material, and bill of resources. These three external models are represented by packages in Figure A.1; their definitions are outside the scope of this standard.
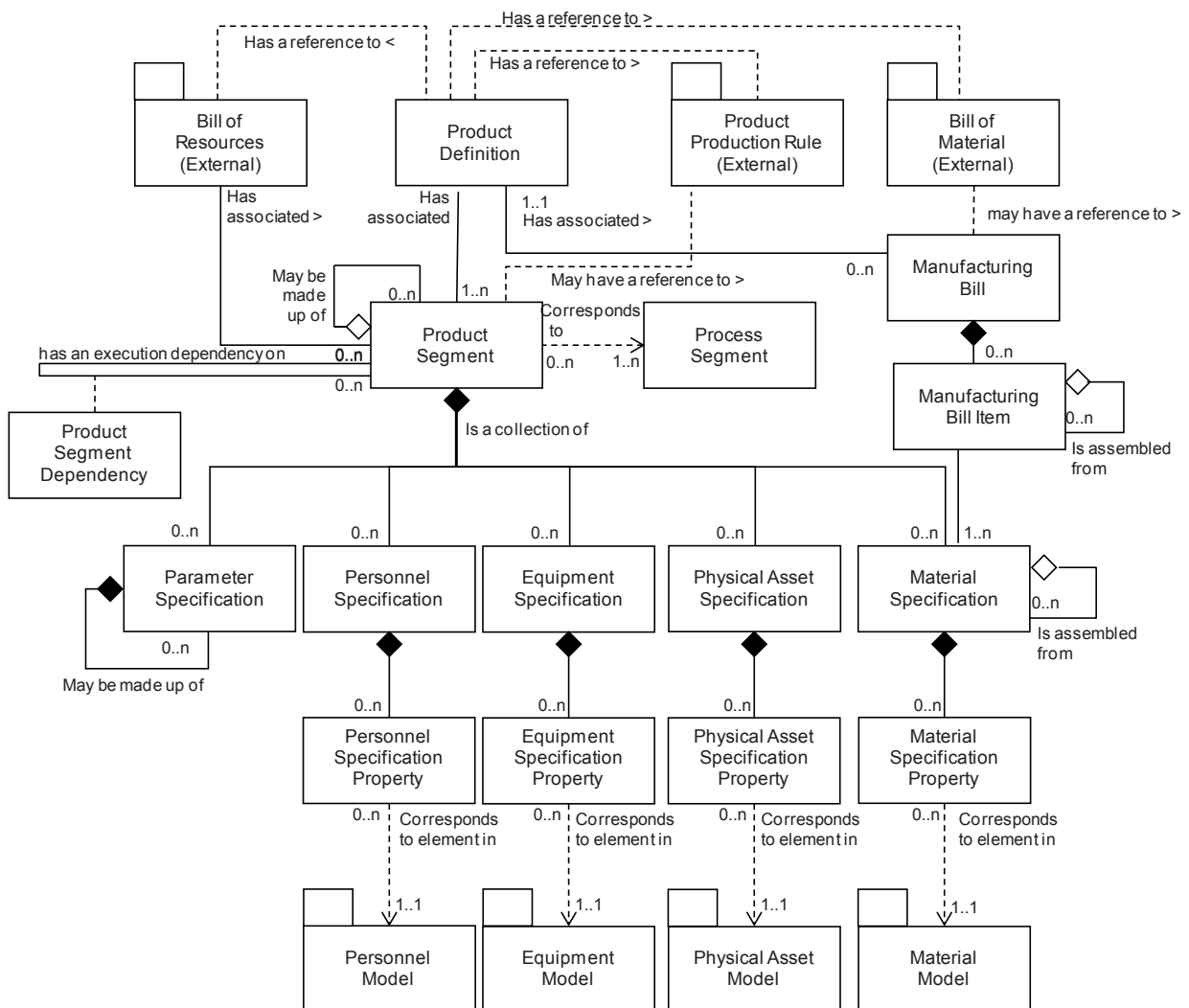
Figure A.1 – Product definition model

Product production rules are defined as the information used to instruct a production operation how to perform the operation. Product production rules are production specific

operations instructions. These may be called a general, site or master recipe (IEC 61512), standard operating procedure (SOP), standard operating conditions (SOC), routing, or assembly steps based on the production strategy used.

A.1.2 Product definition

The resources required to produce a specific product may be presented as a *product definition*. A *product definition* contains a listing of the exchanged information about a product. The information is used in a set of product segments. A *product definition* has a reference to a bill of materials, a product production rule, and a bill of resources.

The attributes of a *product definition* are the same as an *operations definition*, as defined in 6.1, except that *operations type* is optional and if defined shall have the value "Production".

NOTE   A Product Definition ID can be the same ID as a Material Definition.

A.1.3 Manufacturing bill

The identification of the material or material classes that are needed for production of the product shall be presented as a *manufacturing bill*. *Manufacturing bills* contain an identification of materials that make up the items of a complete manufacturing bill.

The *manufacturing bill* includes all uses of the material in production of the product, while the *material specification* gives just the amount used in a *product segment*.

NOTE   For example, a *manufacturing bill* can identify 55 Type C left-threaded screws, where 20 are used in one *product segment*, 20 in another *product segment*, and 15 in a third *product segment*.

The attributes of *manufacturing bill* are the same as the attributes for an *operations material bill* defined in Table 45.

A.1.4 Manufacturing bill item

Each material in a *manufacturing bill* shall be presented as a *manufacturing bill item*.

The attributes of a *manufacturing bill item* are the same as the attributes for an *operations material bill item* defined in Table 46.

A.1.5 Product segment

The values needed to quantify a segment for a specific product shall be presented as a *product segment*. A *product segment* identifies, references, or corresponds to a *process segment*. A *product segment* is related to a specific product, while a *process segment* is product independent.

NOTE   Examples include the requirement of a specific number of operators with specific qualifications.

The collection of *product segments* for a product gives the sequence and ordering of segments required to manufacture a product in sufficient detail for production planning and scheduling. The corresponding product production rule presents the additional detail required for actual production.

A *product segment* may define zero or more resources, which correspond to an *equipment specification,* a *physical asset specification,* a *personnel specification* or a *material specification*. A *product segment* may have parameter values for parameters specified in the corresponding *process segment*.

A *product segment* may have a reference to a product production rule that corresponds to the rules required to implement the specific product segment when more granularity is needed than one product production rule for the product definition.

EXAMPLE   There can be a master recipe (IEC 61512) for each product segment.

The attributes of a *product segment* are the same as an *operations segment*, as defined in 6.1, except that operations type is optional and if defined shall have the value "Production".

A.1.6   Product parameter

Specific parameters required for a *product segment* shall be presented as *product parameters.* The attributes for a *product parameter* are the same as the attributes for a *parameter specification*, as defined in 6.1.6.

A.1.7   Product segment dependency

Production dependencies that are product specific shall be presented as *product segment dependencies*. The attributes for a *product segment dependency* are the same as the attributes for an *operations segment dependency*, as defined in 6.1.15.

A.2   Production schedules

A.2.1   Production schedule model

A *production schedule* is a request for production. A *production schedule* is made up of one or more *production requests*. A *production request* is a request for production of a product identified by a product production rule. A *production request* contains the information required by manufacturing to fulfill scheduled production. A *production request* contains at least one *segment requirement*, even if the *segment requirement* spans all production of the product.

Figure A.2 is the *production schedule* model.
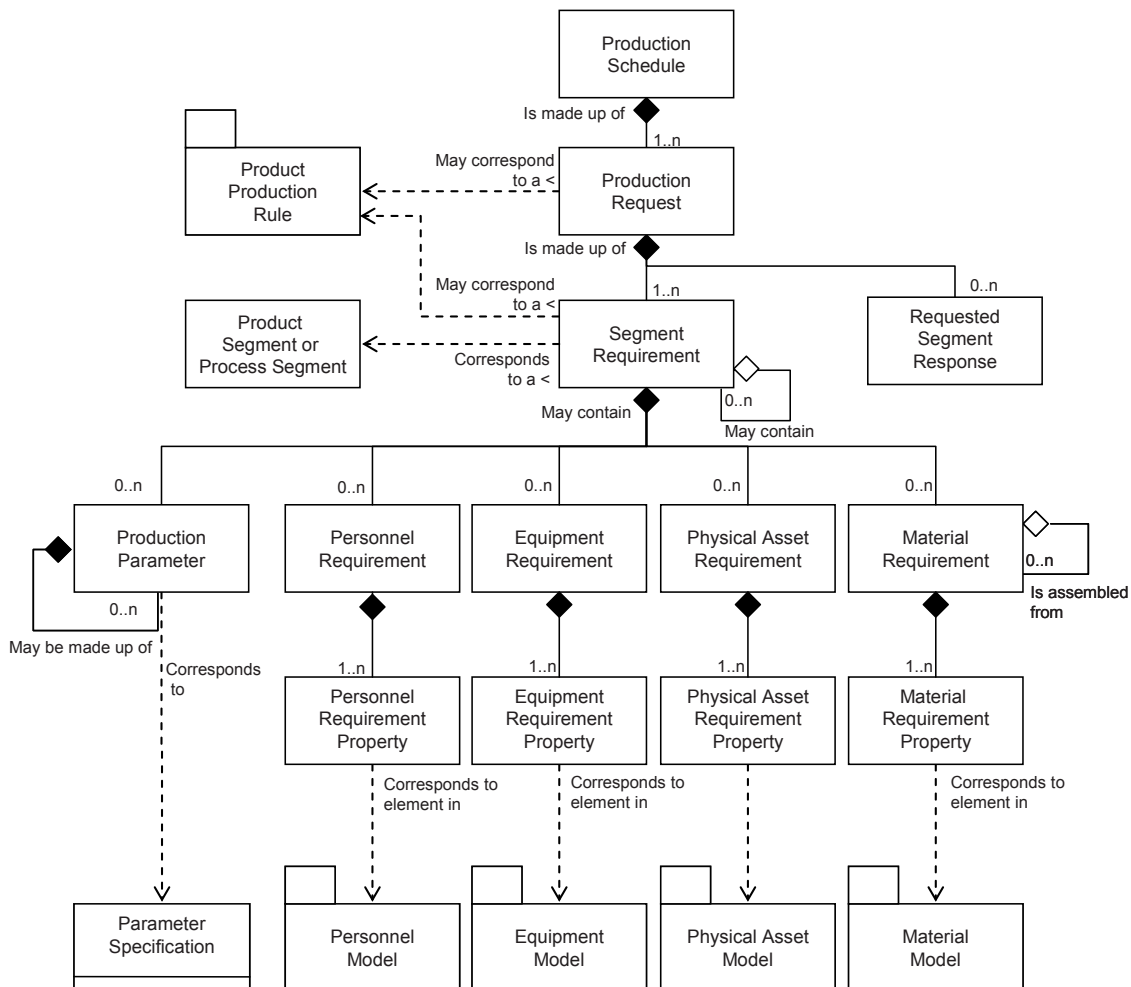
Figure A.2 – Production schedule model

NOTE The previous version of this standard contained specific objects for each use type of materials. These objects were removed from this version. The removed objects are: Material Produced Requirement, Material Consumed Requirement, and Consumable Expected. An attribute of the Material Requirement Property is to be used to determine the use of the material.

A.2.2   Production schedule

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

The attributes for *production schedule* are the same as *operations schedule* defined in Table 58, except that the *operations type* attribute is optional, and if specified shall be "Production".

A.2.3   Production request

A request for production for a single product identified by a product production rule shall be presented as a *production request*. A *production request* contains the information required by manufacturing to fulfill scheduled production. This may be a subset of the business production order information, or it may contain additional information not normally used by the business system.

A *production request* may identify or reference the associated product production rule. A *production request* shall contain at least one *segment requirement*, even if the *segment requirement* spans all production of the product. If not uniquely given by the product production rule, then a *segment requirement* shall contain at least one *material produced*

requirement with the identification, quantity, and units of measure of the material to be produced.

A *production request* may be reported on by one or more *production responses*. In some situations, the material identification, product production rule identification, and material quantity may be all that is needed for manufacturing. Other situations may require additional information. The additional information may be described in the production parameters, personnel requirements, equipment requirements, physical asset requirements, and material requirements.

The attributes of a *production request* are the same as an *operations request* and are defined in Table 59.

A.2.4   Production parameter

Specific parameters required for a *production request* shall be presented as *production parameters*.

Production parameters may be either product parameters that show some characteristics of the product (such as paint color), or process parameters that present some characteristics of the production process (such as bake time).

NOTE   Examples of *production parameters* are:

–   quality limits;

–   set points;

–   targets;

–   specific customer requirements (such as purity = 99,95 %);

–   final disposition of the produced product;

–   transportation information;

–   other information not directly related to control (such as a customer order number required for labeling or language for labels).

The attributes for a *production parameter* are the same as for a *segment parameter* and are listed in Table 61.

A.3   Production performance

A.3.1   Production performance model

Production performance is a report on requested manufacturing and is a collection of production responses. Production responses are responses from manufacturing that are associated with a production request. There may be one or more production responses for a single production request if the production facility needs to split the production request into smaller elements of production.

Figure A.3 is the production performance object model.
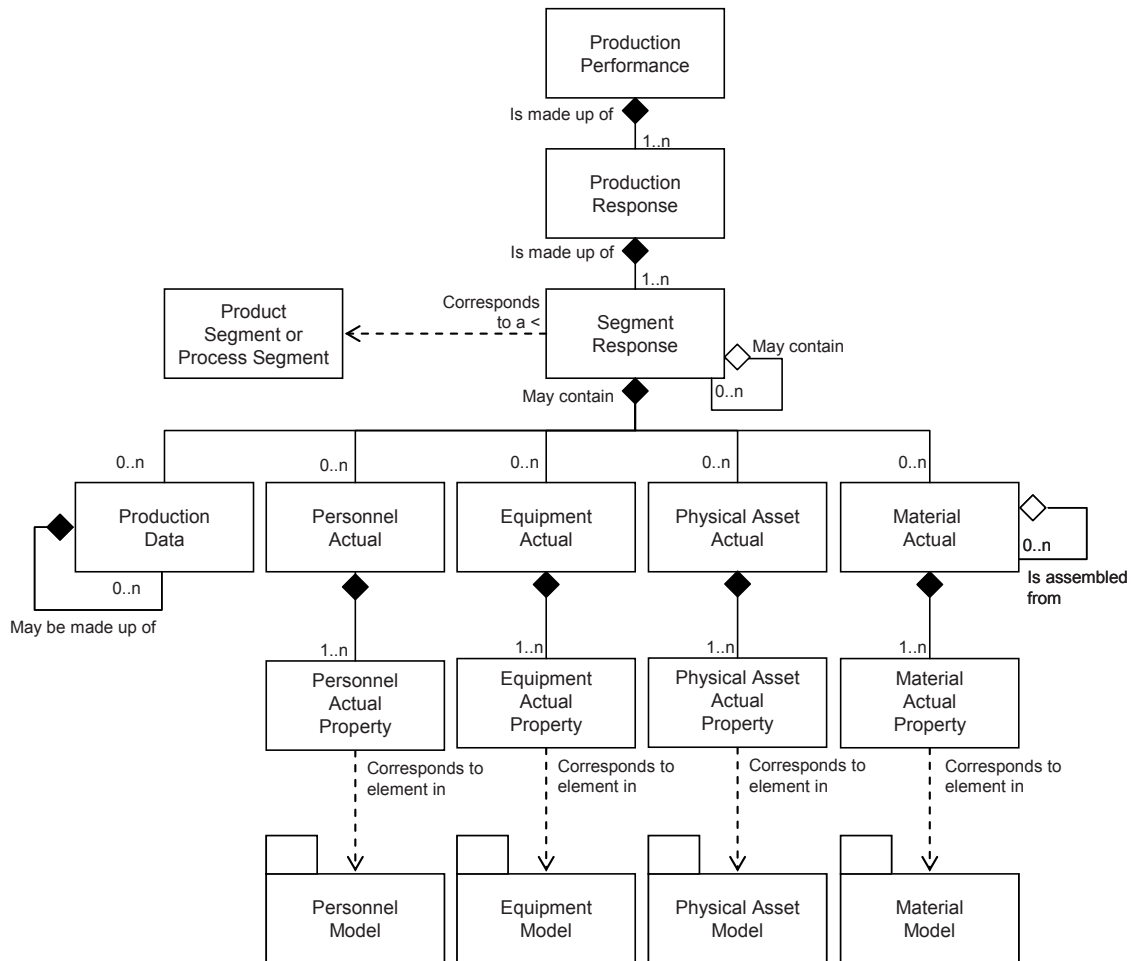
Figure A.3 – Production performance model

NOTE The previous version of this standard contained specific objects for each use type of materials. These objects were removed from this version. The removed objects are: Material Produced Actual, Material Consumed Actual, and Consumable Actual. An attribute of the Material Requirement Property can be used to determine the use of the material.

A.3.2　Production performance

The performance of the requested production requests shall be presented as *production performance*. *Production performance* shall be a collection of *production responses*.

The attributes for *production performance* shall be the same as the attributes for *operations performance* as defined in Table 70, except that the operations type attribute is optional and if specified shall be "Production".

A.3.3　Production response

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

NOTE For example, a single *production request* for the production of 200 gears can be reported on by 10 production response objects of 20 gears each because of manufacturing restrictions.

Production responses contain the items reported back to the business system, at the end of production or during production. The business system may need to know intermediate

production response statuses, rather than waiting for the final production response status, because of cost accounting of material produced or intermediate materials.

The attributes for *production response* shall be the same as the attributes for *operations response* as defined in Table 71, except that the *operations type* attribute is optional and if specified shall be "Production".

A.3.4   Production data

Other information related to the actual production made shall be presented as *production data*.

NOTE   Examples of *production data* are

– a customer order number associated with the production request;

– specific commercial notes from operations related to the customer order, such as order complete, order incomplete, or an anticipated completion date and time;

– quality information;

– certification of analysis;

– procedural deviations, such as an identification of an event used in another system and alarm information;

– process behaviour, such as temperature profiles;

– operator behaviour, such as interventions, actions, and comments.

The attributes for *production data* shall be the same as the attributes of *segment data*, as defined in Table 73.

A.4   Production capability

A.4.1   Production capability model

Production capability information is the collection of information about all resources for production for selected times. This is made up of information about equipment, material, personnel, physical assets, and process segments. Production capability describes the names, terms, statuses, and quantities of which the manufacturing control system has knowledge.

Production capability is defined as a collection of personnel capabilities, equipment capabilities, physical asset capabilities, material capabilities, and process segment capabilities, for a given segment of time (current or future), and defined as committed, available, and unattainable.

The production capability model is shown in Figure A.4.
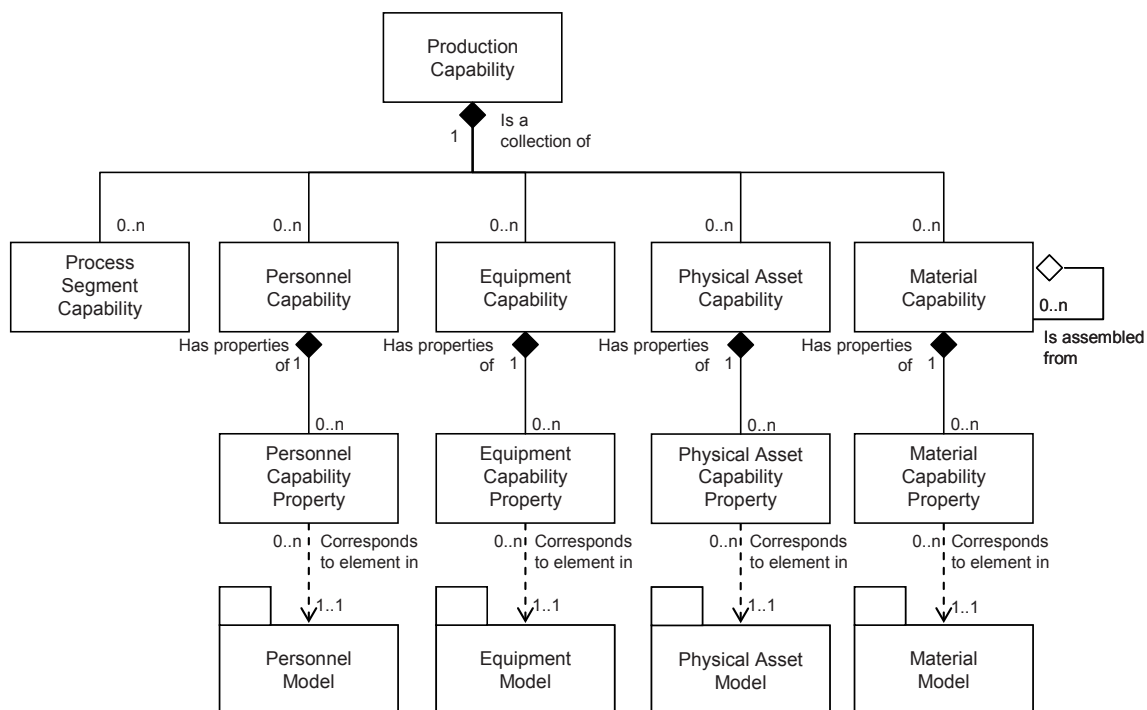
Figure A.4 – Production capability model

A.4.2   Production capability

A collection of personnel capabilities, equipment capabilities, physical asset capabilities, material capabilities, and process segment capabilities, for a given slice of time (past, current, or future), and defined as committed, available, and unattainable for production operations shall be presented as a *production capability*. The attributes of *production capability* are the same as *operations capability* as defined in Table 82.

Annex B
(informative)

Use and examples

B.1   Use and examples

This standard is expected to be used in the specification of interfaces (at Level 3 and Level 4) between new applications, between legacy applications, or between new applications and legacy applications. That can facilitate the usage of packaged software in a legacy application context, which can be the most powerful initial use of the standard.

Through the use of this standard the definition of the interface content can be provided faster and more accurately. In addition the specification of interface content can be easily reused. This will be facilitated by the correct use of compliance assessments that identify which object models are supported by the interface content specification.

IEC 62264-1 defines the categories of information that should be exchanged between Business Systems and Manufacturing Operations and Control Systems. Four (4) categories are defined:

- *operations definition*

- *operations capability*

- *operations schedule*

- *operations performance*   operations Information

Each of these four (4) categories relies on the five (5) resources also defined in IEC 62264-1.

- *personnel*

- *equipment*

- *physical asset*

- *material*

- *process segment*

Part 2 presents the corresponding UML models and attributes for the objects contained in the UML models. The UML models are software independent descriptions of the data exchange between Business Systems and the Manufacturing Operations and Control Systems.

UML relies on object-oriented methodology. Very briefly, this means that there are classes, subclasses and instances (objects). A class can for example be Car, and the instances can be "Mrs Mine's car" or "My car". A class has attributes, and the instances have values on the attributes, e.g., the class Car has an attribute "License plate" whereas the Instance "Mrs. Mine's car" has the attribute "license plate= ABC 123".

EXAMPLE Figure B.1 shows the UML model for Personnel.
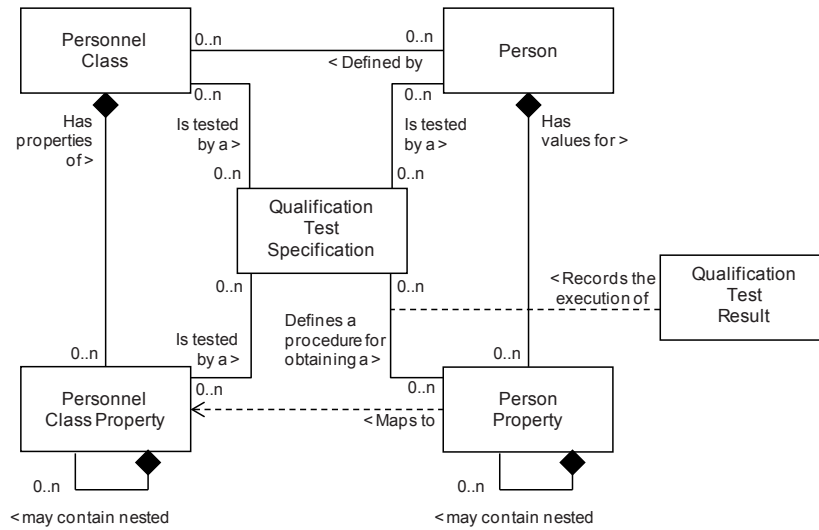
Figure B.1 – Personnel model

The model shown in Figure B.1, a copy of Figure 5, defines six (6) classes: *person, personnel class, person property, personnel class property, qualification test specification* and *qualification test results*.

Table B.1 shows the attributes for Person (a copy of Table 5).

Table B.1 – Attributes of person

Attribute Name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of a specific person, within the scope of the information exchanged (*production capability, production schedule, production performance*, …) The ID shall be used in other parts of the model when the *person* needs to be identified, such as the *production capability* for this person, or a *production response* identifying the person.	Employee 23	22828	999-123-4567	007
Description	Additional information about the resource.	Person Information	Maintenance Tech	Lab Tech	Driver
Name	The name of the individual. This is meant as an additional identification of the resource, but only as information and not as a unique value.	Jane	Jim	John	James

This means that the class *person* should have ID, Description and Name as attributes.

Figure B.2 shows the class *person* with the attributes, and two instances e.g. John Smith and Lou Brown.
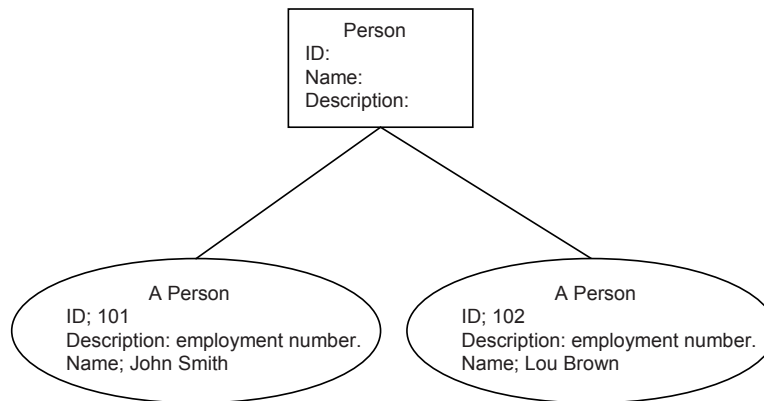
Figure B.2 – Instances of a person class

In the same manner there is a class for *personnel class* (*personnel class* should be thought of as personnel group/category), the instances used depends on the application but could be e.g., engineers, night-shift workers, drilling-machine-operators etc.

Of course certain attributes for classes will depend on the application. To support application specific attributes the "property" should be used. The instances of the properties will define the attributes for the corresponding class. The UML model says that there can be none, one or many properties linked to the corresponding class as shown in Figure B.3.
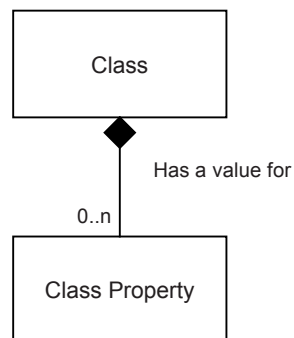
Figure B.3 – UML model for class and class properties

This means that all the instances of property will effectively describe attributes to the class. Each instance of the class will contain values for the attributes.

Certain attributes for *person* as well as for *personnel class* depend on the application, e.g., it might be useful to exchange info about a person's date-of-birth in one application but not in another. To support application specific attributes the *person property* or *personnel class property* should be used. The instances of the properties will define the attributes for the person/personnel class. The UML model says that there can be none, one or many properties linked to *person/personnel class*.

There is a class called *person property*. Each property is uniquely defined by its ID, Description, Value and Value Unit of Measure, as shown in Figure B.4.
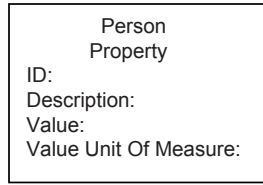
Figure B.4 – Class property

The class can have four instances, two for the date of birth, one for John and one for Lou, and two for shoe sizes, one for John and one for Lou, as shown in Figure B.5.
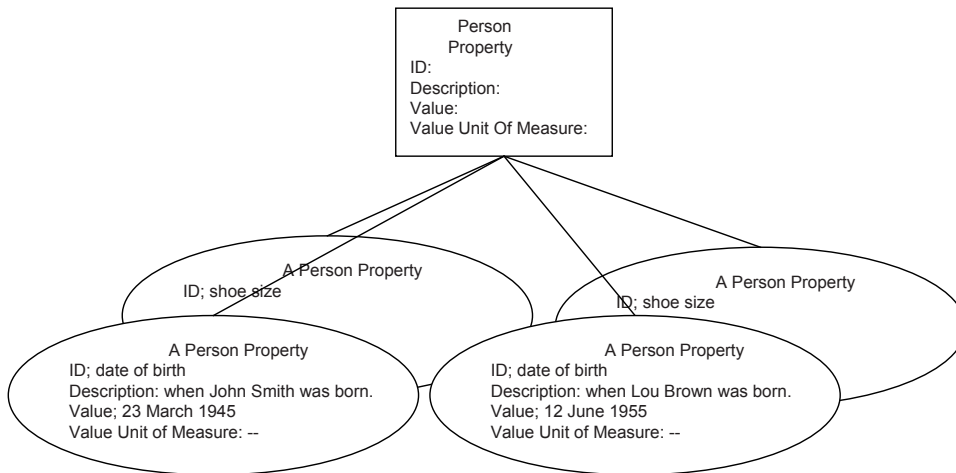
Figure B.5 – Instances of a person properties

This means that each *person* (instance) will have info about its properties, as shown in Figure B.6.
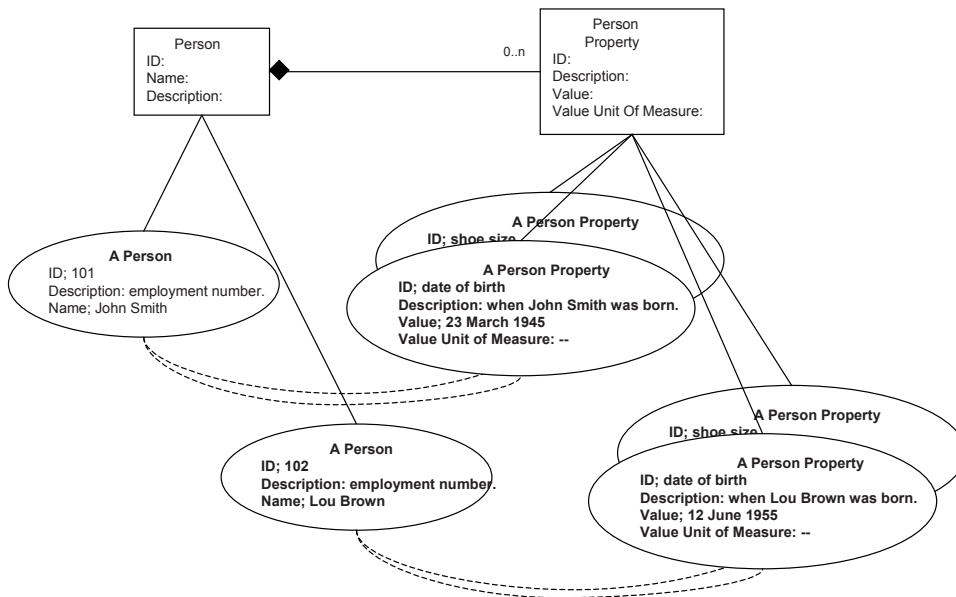
Figure B.6 – Instances of person and person properties

It is important to note that the classes will have to be defined within a product as well as support within a product to create and manipulate instances. However, the specific instances created will depend on the application.

B.2 Application of the standard

When designing or creating a system that implements the standard, one will need to make sure that the system supports the classes needed (e.g. *person, personnel class, person property, personnel class property* etc). To completely comply with the standard all classes defined in the standard should be supported in the system.

Before the systems are put in execution mode it has to be decided what properties the classes should have (i.e., what instances the property class should have). Of course, only the properties that need to be exchanged between the systems have to be decided. The reasons this has to be decided include.

- Due to the internal structure of databases, some databases cannot be enlarged during execution mode, and therefore it needs to know in advance what properties should be supported.

- Different systems might have different constraints on the naming of the properties e.g., a maximum length of property-name, the usage of upper and lower case letters.

- Different systems might be developed in different languages, e.g., in one system all properties are presented in French, whereas in another one, the properties are presented in English.

During execution, data regarding the instances can be exchanged. The data exchanged can be implemented in many different forms. One possibility is through databases, another possibility is through XML and XML schemas that have been developed in accordance with the models of this standard.

B.3 Database mapping of the models

If a database is used for data exchange, then there are many different ways of structuring the database. Tables B.2 and B.3 are included as examples of a data base structure that can be used to contain the data. The attribute "Key" indicates a unique value that can be required for relational integrity.

Table B.2 – Database structure for person

TABLE: Person		
ID	Description	Name

Table B.3 – Database structure for person property

TABLE: Person Property				
ID	Description	Value	Value Unit Of Measure	Key

When the system is in execution the database could contain the information shown in Table B.4 and Table B.5.

Table B.4 – Database for person with data

TABLE: Person		
ID	Description	Name
101	The employment number	John Smith
102	The employment number	Lou Brown
103	The employment number	Jane Mine

Table B.5 – Database for person property with data

TABLE: Person Property				
ID	Description	Value	Value Unit Of Measure	Key
Date of Birth	Indicates when a person is born	1945-03-23	YYYY-MM-DD	101
Shoe size	Indicates the shoe size of a person	43		101
Date of Birth	Indicates when a person was born	1955-06-12	YYYY-MM-DD	102
Shoe size	Indicates the shoe size of a person	45		102
Date of Birth	Indicates when a person is born	1969-12-24	YYYY-MM-DD	103
Shoe size	Indicates the shoe size of a person	38		103

B.4 XML usage

If XML documents are used for data exchange, then there are many different ways of structuring the documents. The structure for an XML document is defined in a "schema". A schema is the equivalent of a data base table definition.

Figure B.7 illustrates a possible XML schema for "Person". The schema defines a place for ID, Description, Name, the person properties, and a place to contain the list of Personnel Classes the person belongs to. A Person (instance) is defined by its ID, Description, Name, PersonProperty, and PersonnelClassID. The ID, Description and Name, correspond to the attributes ID, Description and Name defined in this part of IEC 62264.

PersonnelClassID is defined as the ID of a personnel class. PersonnelClassID (there can be many) contains a link to instances of PersonnelClass.

PersonProperty is defined as a complex type that contains the property ID, description, and value.

```
<xsd:complexType name = "PersonType">
    <xsd:sequence>
            <xsd:element name = "ID"             type = "xsd:string"/>
            <xsd:element name = "Description"    type = "xsd:string"
                                                 minOccurs = "0"
                                                 maxOccurs = "unbounded"/>
            <xsd:element name = "Name"           type = "xsd:string"/>
            <xsd:element name = "PersonProperty"
                                                 type = "PersonPropertyType"
                                                 minOccurs = "0"
                                                 maxOccurs = "unbounded"/>
            <xsd:element name = "PersonnelClassID"
                                                 type = "PersonnelClassIDType"
                                                 minOccurs = "0"
                                                 maxOccurs = "unbounded"/>
    </xsd:sequence>
</xsd:complexType>

<xsd:simpleType name="PersonnelClassIDType">
    <xsd:restriction base="xsd:string">
    </xsd:restriction>
</xsd:simpleType>
```

Figure B.7 – XML schema for a person object

PersonProperty contains the instances of PersonProperty (there can be many). A PersonProperty (instance) is defined by its ID, Description, Value, and Value Unit of Measure. The ID, Description and Value and Value Unit of Measure, correspond to the attributes ID, Description and Name defined in this part of IEC 62264.

A PersonProperty (instance) could be defined in the schema shown in Figure B.8

```
<xsd:complexType name = "PersonPropertyType">
    <xsd:sequence>
            <xsd:element name = "ID"                  type = "IDType"/>
            <xsd:element name = "Description"    type = "DescriptionType"
                          minOccurs = "0" maxOccurs = "unbounded"/>
            <xsd:element name = "Value"          type = "ValueType"
                          minOccurs = "0" maxOccurs = "unbounded"/>
            <xsd:element name = "ValueUnitOfMeasure" type = "ValueUOMType"
                          minOccurs = "0" maxOccurs = "unbounded"/>
            <xsd:element name = "QualificationTestSpecificationID"
                          type = "QualificationTestSpecificationIDType"
                          minOccurs = "0" maxOccurs = "unbounded"/>
            <xsd:element name = "TestResult"     type = "TestResultType"
                          minOccurs = "0" maxOccurs = " unbounded"/>
    </xsd:sequence>
</xsd:complexType>
```

Figure B.8 – XML schema for person properties

During execution an XML document is created and the values of the attributes are filled in and exchanged between the systems. Figure B.9 illustrates a sample XML document, matching the schema above, that contains person and person property information.

```
        <PersonType>
            <ID> 101</ID>
            <Description>Employment Number</Description>
            <Name>John Smith</Name >
            <PersonProperty>
                <ID>date-of-birth</ID>
                <Description>indicates when a person is born
                </Description>
                <Value>1945-03-23</Value>
                <Value Unit of Measure> YYYY-MM-DD
            </Value Unit of Measure>
                <ID>Shoe size</ID>
                <Description>indicates the shoe size </Description>
                <Value>43</Value>
            </ PersonProperty >
            <PersonnelClassID>{night-shift-operator, engineer}
            </PersonnelClassID>
        </PersonType>
```

Figure B.9 – Example of person and person property

The information about an instance (e.g., Product manager or Engineer) of PersonnelClass could be exchanged in a separate XML schema, as shown in Figure B.10.

```
<PersonClassType>
    <ID>Engineer</ID>
    <Description> a registered professional engineer</Description>
    <PersonnelClassPropertyType>
        <ID>Engineer's License Number</ID>
        <Description>"The official engineer's license number"
        </Description>
    </PersonnelClassPropertyType>
</PersonClassType>
```

Figure B.10 – Example of person class information

Since the XML schemas or the objects and their attributes might not be implemented or called the same thing inside different systems, it might be required to have an "adapter/translator" inside the systems. This "adapter/translator" translates from the IEC 62264-1 terminology to the terminology used within the different systems. Figure B.11 illustrates an adaptor that maps property IDs and property types (date formats).
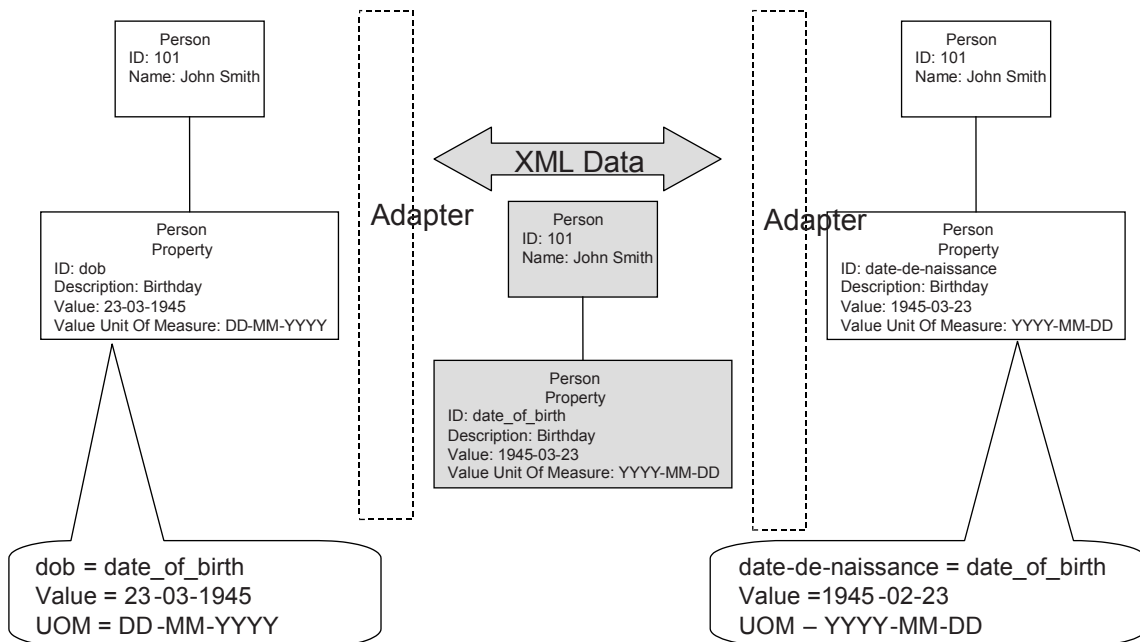
Figure B.11 – Adaptor to map different property IDs and values

Annex C
(informative)

Example data sets

C.1   General

The following clauses contain example data sets, based on the Part 2 models and attributes.

C.2   Material model example

This is a simplified example of material information that can be used in the food processing industry. The example presents shared information about a material class (Pork), a material definition (Pork 80 % Lean), a material lot, and a material sublot. In a full example there can be multiple material classes and material description information sets that are shared, with lot and sublot dynamically shared. Indentation of objects is used to illustrate the relationship between the objects.

Material Class

    ID - Pork
    Description -
    Properties

        ID - Lethal Heat
        Description - Temperature to kill bacteria
        Value - 160
        Units of Measure - Degrees F

        ID - Receiving Temperature Target
        Description -
        Value - 32
        Units of Measure - Degrees F

        ID - Receiving Temperature Max
        Description -
        Value - 36
        Units of Measure - Degrees F

        ID - Receiving Temperature Min
        Description -
        Value - 28
        Units of Measure - Degrees F

        ID - Maximum Allowable Cut Time
        Description - Time since cut
        Value - 3
        Units of Measure - Days

Material Definition

    ID - Pork 80
    Description - Boneless pork cut up with a target lean percentage of 80
    Value -
    Unit of Measure -
    Properties

        ID - Percentage Lean
        Description -
        Value - 80
        Units of Measure – Percentage

            Material Test Specification
                ID - JackSpratTest1
                Description - Test to determine percent of fat.
                Version - 1997-04-02

ID - Percentage Fat
Description -
Value - 20
Units of Measure - Percentage

Material Lot

ID - 20000115091345
Description -
Status   approved
Properties

ID - Delivery Temperature
Description - Temperature at delivery
Value - 37.5
Units of Measure - Degrees F

Material Test Result

ID - 2000-01-16-4930-TEMP
Description - Internal temperature of pork
Date - 2000-01-16
Result - Failed
Expiration - None

ID - Cut
Description - Cut Date
Value - 2000-01-14
Units of Measure -

ID - Expiration
Description - Expiration Date
Value - 2000-01-17
Units of Measure -

ID - Fat
Description - Actual Percent Fat
Value - 20
Units of Measure – Percent

Material Test Result

ID - 2000-01-16-4930-SPRAT
Description -
Date - 2000-01-16
Result - Pass
Expiration – None

ID - Lean
Description - Actual Percent Lean
Value - 80
Units of Measure – Percent

Material Test Result

ID - 2000-01-16-4930-SPRAT
Description -
Date - 2000-01-16
Result - Pass
Expiration - None

Material SubLot

ID - 20000115091345-1
Description -
Storage Location - Tote 392, Level 3, Rack 49
Value - 200
Unit of Measure - Pounds

ID - 20000115091345-2
Description -
Storage Location - Tote 852, Level 3, Rack 50
Value - 300
Unit of Measure – Pounds

C.3 Equipment Model Examples

Pulp and paper example

Enterprise	Site	Area	Work Center	Work Unit	Equipment	Notes
paper producer						
	deep woods river site					integrated paper mill complex
		wood preparation plant				
			rail yard			storage
			saw mill			continuous
				slasher deck		
				splitting		
				conveyor		
			wood room			
				debarking		
				chippers		
				screend		
				chip conveyors		
				chip bins/silos		storage
				grinders		
			wood yard			storage
				pile a		
				pile b		
				pile c		
		steam plant				
			boiler room			
				furnace #1		
					stack	
					esp	environmental controls - electrostatic precipitator
				boiler #1		
					gauges & instruments	
		pulp mill -- chemical pulp -- kraft process				batch (product) / continuous (machine operation)
			cooking & washing -- wood chips			
				chip storage		storage
				white liquor storage		storage
				digester		
				blow tank		
				washers		
			acid plant			chemical recovery system
				black liquor storage		storage
				evaporators		
				recovery furnace		
				dissolving tank		
				green liquor storage		storage

Enterprise	Site	Area	Work Center	Work Unit	Equipment	Notes
paper producer						
				slaker		
				clarifier		
				lime mud washer		
				white liquor storage		storage
				lime kiln		
			steam plant			
				refuse boilers		
			by-products			storage
			pulp processing			
				bleaching		
				washer vacuum		
				centrifugal screening		
				pressure screening		
				pulp press		
		paper mill				batch (product) / continuous (machine operation)
			beater room			
				beating engine #1		
			machine room			
				paper machine #2		west end
					screens	
					head box	
					wire pit	
					press	
			wet end			
				paper machine #2		dry end
					drying section	
					calendar stack #1	
					calendar stack #2	
					reeler	
					winder	
				machine drive		
				roll handler/conveyor		
				roll storage		storage
		finishing				discrete
			coating			
				coater # 1		
					coater mix	
					coater	
					dryer	
				supercalendar # 1		
				coater # 2		
				supercalendar # 2		
			slitting -- reels			
				slitter # 1		
					knife set	
					kickup	
				conveyor		

Enterprise	Site	Area	Work Center	Work Unit	Equipment	Notes
paper producer						
			sheeting			
				sheeter		
				stacker		
				bundler		
		shipping warehouse				storage
		lumber mill				lumber / board

Semiconductor Manufacturing

Site	Area	Work Center/ Work Cell	Work Unit	Equipment	Notes
					Assumption process starts with SOI wafers (Silicone on Insulation) that were purchased.
FAB 1					
	front end				
		deposition			
			CVD	deposition tools	CVD Chemical Vapor Deposition
				thickness tool	
			PVD		PVD (Physical Vapor Deposition)
		metrology		thickness tool	thickness defect
				defect tool	
				characteristics	
		polishing	CMP		CMP Chemical Mechanical Polishing (Wafer is ready for the next step.)
		lithography		tools	electrical circuit mask
		etch		tools	
		furnace		tools	
					Repeat the above steps over and over until the wafer of devices is built.
	back end				
		passivation			Preparation for pad bonding.
		bonding			
		dicing			
		packaging			
		test			

C.4   Personnel model example

This is a simplified example of personnel information that might be used in the petrochemical processing industry. The example lists shared information about personnel classes and persons, including qualification test information.

Personnel Class

>   ID - Operator Level A
>   Description - Top level operator certification for petrochemical plant
>
>   ID - Operator Level B
>   Description - Basic level operator certification for petrochemical plant
>
>   ID - Operator
>   Description - Operators for petrochemical plant
>   Properties
>
> >   ID - MTBE Process Certification
> >   Description - Each completed level of certification test
> >   Value - TRUE, FALSE
> >   Units of Measure -
> >
> >   Qualification Test Specification

          ID - PC-MTBE-992828
          Description - Test to determine level of MTBE certification.
          Version - 1997-04-02

     ID - PO Refining Process Certification
     Description - Each completed level of certification test
     Value - TRUE, FALSE
     Units of Measure -

        Qualification Test Specification

          ID - PC- PO-Refining -992828
          Description - Test to determine level of PO Refining certification.
          Version - 1997-04-02

     ID - Push-Up Certification
     Description - Operator is temporarily able to perform the higher up function
     Value - TRUE, FALSE
     Units of Measure -

<u>Person</u>
     ID - 999-63-8161
     Description -
     Name - John Doe
     Properties

        ID - MTBE Process Certification
        Description - Each completed level of certification test
        Value - TRUE,
        Units of Measure -

          Qualification Test results

            ID - PC-MTBE-992828-2000-10-12
            Description - Test to determine level of MTBE certification.
            Result - Passed
            Expiration - 2000-12-15

        ID - PO Refining Process Certification
        Description - Each completed level of certification test
        Value - FALSE
        Units of Measure -

        ID - Push-Up Certification
        Description - Operator is temporarily able to perform the higher up function
        Value - FALSE
        Units of Measure -
        ID - Fire Team Qualified
        Description - Operator has been trained to aid in fire-fighting
        Value - TRUE
        Units of Measure -

       Personnel Classes

         ID - Operator
         ID - Operator Level B
         ID - Fire Team Qualified

C.5   Production capability example

This is a simplified example of production capability information for a crude oil pipeline shipment system. This example illustrates the future committed definition of the capability of a crude oil pipeline segment, using a specific segment of time.

<u>Production</u> <u>Capability</u>

ID - Caspian Crude Oil Pipeline
Location - Tengiz-Atyrau Pipeline Segment
Element Type - Area
Start Time - August 1, 2011
End Time - August 31, 2011

Material Capability

    Description - Segment Throughput
    Material Class - Crude Oil - Type A
    Capability Type - Committed
    Start Time - August 1, 2001 6:00
    End Time - August 2, 2001 6:00

Material capability property

    ID - Viscosity
    Value - 104
    Unit of Measure - cp (centipoise)

Material capability property

    ID - Entry Temperature
    Value - 30
    Unit of Measure - Deg C

Material capability property

    ID - Ground Temperature
    Value - 18
    Unit of Measure - Deg C

C.6　Production performance example

This is a simplified example of production performance information for a crude oil pipeline shipment system. This example illustrates an example of a day of production for crude oil pipeline segment.

Production Performance

ID - Caspian Crude Oil Pipeline
Start Time - August 1, 2011
End Time - August 2, 2011
Location - Tengiz-Atyrau Pipeline Segment
Type - Area

Production Response

    ID - Daily Production
    Start Time - August 1, 2011 - 6:00
    End Time - August 2, 2011 - 6:00

    Segment Response

        ID - Daily Production

        Production Data

            Name - Total Pipeline Throughput
            Value - 126,000
            Unit of Measure - Metric Tons / Day

        Material Produced Actual

            Description- Crude Shipped, Shipper A
            Material Lot - SampleNumber 28883992021
            Quantity - 63,000
            Unit of Measure - Metric Tons / Day

        Material produced actual property

            ID - Average Viscosity
            Value - 103
             Unit of Measure - cp (centipoise)

        Material produced actual property

            ID - Entry Temperature
            Value - 32.3
            Unit of Measure - Deg C

Annex D
(informative)

Questions and answers about object use

D.1   General

This annex contains notes about the expected use of the object models, basically recorded as notes between committee members.

D.2   Inflow materials

Question:

In many continuous production facilities the material inflow into the process is an important element of shared information. Does the *product segment* present the material inflow into production, or can it be presented in the *product production rule*?

Answer:

There are no attributes in the *Product segment - Material Specification*, or the *Process Segment - Material Segment Specification* that detail if the material is produced or consumed.

To be consistent with the rest of the models we should be able to specify the inflow (consumed) material in either the *Process Segment,*

EXAMPLE   Running a distillation segment consumes a material.

or in the *Product segment* (producing a material also consumes a material). This information is needed for scheduling, so it should be included in the exchanged information. The information should probably be recorded as a property of either the *Product segment - Material Specification* or of the *Process Segment - Material Segment Specification*, depending on the industry needs.

D.3   Multiple products per process segment

Question:

In many continuous and batch industries a single process segment can produce multiple products. What describes the whole picture that multiple product segments are associated with a certain process segment?

EXAMPLE   In a system where materials A, B and C are used to produce products X and Y at a certain equipment in a single batch, where Y could be a by-product.

- There is only one Process Segment.
- There are two Product segments, for X and Y.
- The Product Production Rule describes that X is made from A, B and C, and Y is made from A, B and C.
- Then, what describes that the X and Y are "brother" products?
- Is it a parent Product segment, which contains Product segment X and Y?

Answer:

IEC 62264-2 does not model the object relationships in IEC 62264-1, so this is a matter of implementation. The most common approach to this problem seems to be to list a Process Segment for the process of consuming (A,B,C) and generating (X,Y).

The *Process Segment - Material Segment Specifications* would contain the appropriate ratios (assuming they are constant), such as [50 % A, 30 % B, 20 % C] to produce [75 % X, 25 % Y]. There would be *Product segments* for X and Y, but they would not maintain the inflow (consumed) information in the *Product segments*.

Since the exact relationship between the amounts of material can also be equipment specific, the most common approach would be to create multiple *Process Segments* that show the consumed and produced materials in the ratios appropriate for each set of unique *equipment*.

In petrochemical refining and chemical production it is even more complicated, since the ratio of produced material can vary based on production parameters (such as temperatures of trays in distillation columns) and on the specific properties of the consumed materials (such as the sulfur content of the oil). In those cases, if the information needed to be exchanged on a regular basis, the most common approach would be to extend the *Process Segment - Material Segment Specifications* to include the mathematical relationships, such as an equation, tables, or LP, or a reference to an LP, equation, or table.

D.4 Process segments vs. product segments

Question:

What is the difference between process segments and product segments?

Answer:

A *process segment* presents a production activity and what resources are needed to execute the activity, at the level of detail required for business processes, such as planning or costing. Business segment is a synonym for process segment.

EXAMPLE 1   Making a bicycle frame necessitates the use of an assembly jig, a bending machine, and an assembler for 30 min.

The same resources can be associated with more than one process segment.

A *product segment* lists what resources are needed to make a specific product, at the level of detail required for planning or costing.

EXAMPLE 2   What is needed to make a 27-inch bicycle; 2 27-inch wheels, 1 27-inch frame, 1 seat, 15 screws, 1 h of a tall test cyclist, etc.

A product is defined by one or more product segments.

Any specific implementation can require more than one *product segment*, more than one *process segment*, or a combination of both to fully describe a planning or costing view of production.

The concept of "*process segment*" is a planning view of production describing the resources needed for production. In the continuous industries, this usually corresponds to scheduled/planned operations within production units.

EXAMPLE 3   A *process segment* in an oil refinery would be the material flowing through a catalytic cracker. The "segment" of production would be the use of the catalytic cracker. The scheduled element would be either the flow rate through the cracker, or the total amount of material through the cracker during a period of time.

In addition, when multiple products are produced from the same process, then *process segments* are generally considered a better description of production.

EXAMPLE 4   A distillation *process segment* (associated with a distillation column) could process many product segments (one per outflow).

The "*product segment*" is a planning view of production where the product definition is more descriptive than the process definition.

EXAMPLE 5   There can be many products made using a "semiconductor chip insertion process", but the product definition is the key determination of the product produced, not the process itself.

Process segments are generally considered a sufficient description when the processes are relatively generic and do not themselves define products. *Product segments* are important in flexible-discrete and batch manufacturing, where the ability to include specific characteristics for each product is possible.

Table D.1 – Definition of segment types

Description	Process Segment	Product segment
Category of Information	Production Information	Product Definition/Description
Definition	Equipment planning view of production	Product planning view of production
Dependence	Usually independent of product	Usually dependent on product

D.5   Production parameter references

Question:

Is a Production Request - Segment Request - Production Parameter a reference to a parameter of the associated Product segment or the Process Segment?

Answer:

Either, and this ambiguity was used on purpose, because the specifying committee had examples for both cases.

EXAMPLE   A *Production Parameter* can be a paint color to be used, this could be defined as being in either the *Product segment* (if each product can be painted a different color in the same production step) or in the *Process Segment* (if all products going through the production step are painted the same color).

D.6   How class name and property IDs are used to identify elements

Question:

The object models all follow the same pattern of class name, with an optional property ID. How is that used to identify elements?

Answer:

While properties can be used to contain information about resources, they can also be used to identify subsets of resources.

Resources can sometimes be described using a class name, such as "Operators," or as class names plus some differencing property, such as "Operators" with ranking of "Master," "Standard" or "Junior."   In the models where a "quantity" is needed, the models all follow the same pattern. There is always a reference to a class (such as *Personnel Capability*) that can have an optional quantity.

EXAMPLE 1   It may need 10 man-hours of operator time available for a shift. If the element described is a subset of the class, such as only "Master" operators, then a property object is used to contain the discriminating information, and the quantity information.

EXAMPLE 2   *Personnel Property Capability* would define 4 man-hours of "Master" operator time available for a shift.

This model allows significant flexibility by allowing a single class definition (e.g., Operators), without a quantity listing, and multiple property descriptions (e.g., Master, Standard, and Junior operators) each with their own property definition. The left part of Figure D.1 illustrates how a *Personnel Capability* would describe a capability of 8 operators. The right part illustrates how the capability of different ranking of operators would be defined. The *Personnel Capability Property*, Ranking, is used to differentiate the capability of different types of operators.
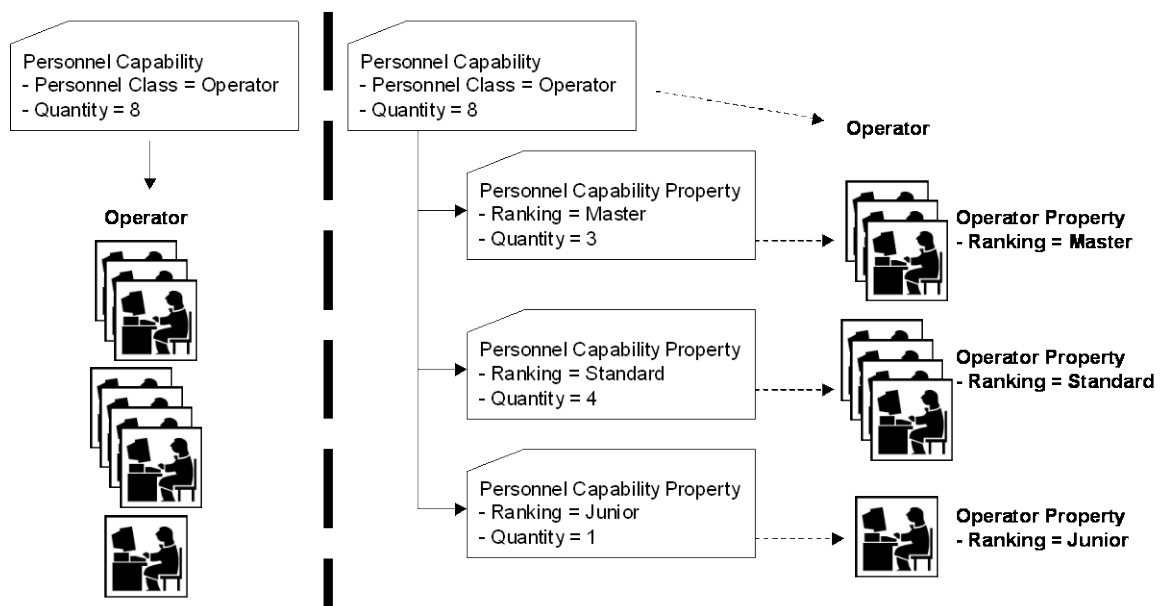
Figure D.1 – Class and property IDs used to identify elements

This concept applies to the following objects:

— *personnel capability*
— *material capability*
— *physical asset capability*
— *equipment segment capability*
— *personnel segment specification*
— *material segment specification*
— *equipment specification*
— *physical asset specification*
— *personnel requirement*
— *material produced requirement*
— *consumable expected*
— *equipment actual*
— *material consumed actual*
— *physical asset actual*

— *equipment capability*
— *personnel segment capability*
— *physical asset segment capability*
— *material segment capability*
— *equipment segment specification*
— *personnel specification*
— *material specification*
— *physical asset requirement*
— *equipment requirement*
— *material consumed requirement*
— *personnel actual*
— *material produced actual*
— *consumable actual*

D.7   Possible capability over-counts

Question:

What does the statement about over-counts in capabilities mean?

Answer:

The statements, such as: Where persons are members of multiple personnel classes, then the personnel capability information presented by personnel class should be used carefully because of possible double counts, and personnel resources should be managed at the instance level, are given because when a property is used to show overlapping subsets of a capability, then the same capability can be double scheduled unless this situation is recognized. Figure D.2 shows an example where a property of ReactorType presents how many reactors are available. The total amount of capability is 5, but the sum of all reactors subsets is 6, because 1 reactor can be qualified as a heating and a mixing type. In this situation the mixing and heating resources should be scheduled at the instance level in order not to overuse the available resources.
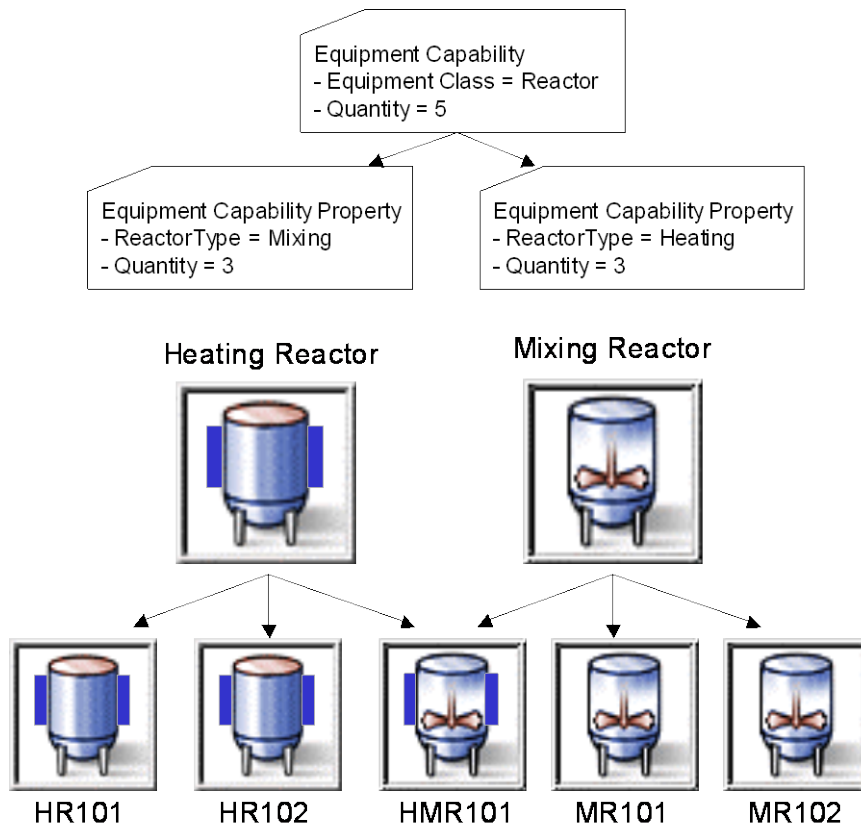
Figure D.2 – A property defining overlapping subsets of the capability

D.8 Routing and process capability

Question:

How are routing information and processing capabilities represented in the models?

Answer:

Routing information can be represented in product segment dependencies, in process segment dependencies, or in both.

In some industries the routing is product specific, such as the route shown in Figure D.3. The left side of the figure illustrates the assembly of a specific electronic product, with multiple assembly operations (at G and H). The routing, for a single product (or class of products), is represented by the *product segment dependencies* illustrated in the center of Figure D.3. The capability of the system, for a specific product, can be represented in a set of *product segment dependencies*, as illustrated on the right side of Figure D.3.

In this example there could be multiple product routings given, one for each class of products. A scheduling system would use the product demand, product routing, and process segment capabilities to generate production schedules.

Product Routing for Product X	Product X Segment Dependencies	Process Segment Capabilities
A → B → G → H C → D E → F (D → G, F → H)	B must follow A D must follow C F must follow E G must follow B G must follow D H must follow G H must follow F	500 boards/hour of Product X on Process Segment A 450 boards/hour of Product X on Process Segment B 300 front-panels/hour of Product X on Process Segment C 300 front-panels/hour of Product X on Process Segment D 500 power-supplies/hour of Product X on Process Segment E 500 power-supplies/hour of Product X on Process Segment F 350 boxes/hour of Product X on Process Segment G 450 boxes/hour of Product X on Process Segment H

Figure D.3 – Routing for a product

In some industries, such as continuous production with byproducts, the routing can be dependent on the processes. In Figure D.4 the routing contains material dependencies information. The routing information is then used for scheduling. The route in the left side of Figure D.4 can be represented in a set of process segment definitions (center table in Figure D.4) and process segment dependency definitions (right table in Figure D.4). The process segment definitions contain the material production and consumption information. The consumption and production information within the process segments present additional constraints and dependencies required for scheduling of material B1, C1, and F1.

**Routings and
Material Dependencies**

A1

A — B → B1

A2

A3

A4 C → C1

E1

C2

E — D — F

E2   D1   F1

Process Segment

Process Segment A
    produces material A1
    produces material A2
    produces material A3
    produces material A4
Process Segment B
    consumes material A1
    consumes material A2
    produces product B1
Process Segment C
    consumes material A3
    consumes material E1
    produces product C1
    produces material C2
Process Segment D
    consumes material A4
    consumes material E2
    produces material D1
Process Segment E
    produces material E1
    produces material E2
Process Segment F
    consumes material C2
    consumes material D1
    produced product F1

**Process Segment
Dependencies**

B must follow A
C must follow A
C must follow E
D must follow A
D must follow E
F must follow C
F must follow D

Figure D.4 – Routing with co-products and material dependencies

D.9   Product and process capability dependencies

Question:

How is the information represented for complex scheduling problems, such as where there is a complex relationship between equipment and products? An example of this is a paint plant, where particular products can only be manufactured on specific equipment and yield varies based on product and equipment.

Answer:

There can be a mapping of equipment to *process segments*. The example shown in Figure D.5 shows sets of equipment A, B, C, and D that correspond to *process segments*. There might be multiple elements of equipment (process cells, production lines, production units) associated with each *process segment*, or it could correspond to a single piece of equipment.

In this example there can be specific rules for each product, or rules for classes of products. The *product segments* for each product would show which *process segments* are valid. The capability of each process segment and product combination can be represented in *process segment capability* objects. This information can then be used to fill in the information needed by a scheduling system, such as in a cost/throughput matrix illustrated in the lower right of Figure D.5. The costing information, and demand information required to determine the optimal throughput, do not cross the boundary addressed by this standard, but the capacity information does.
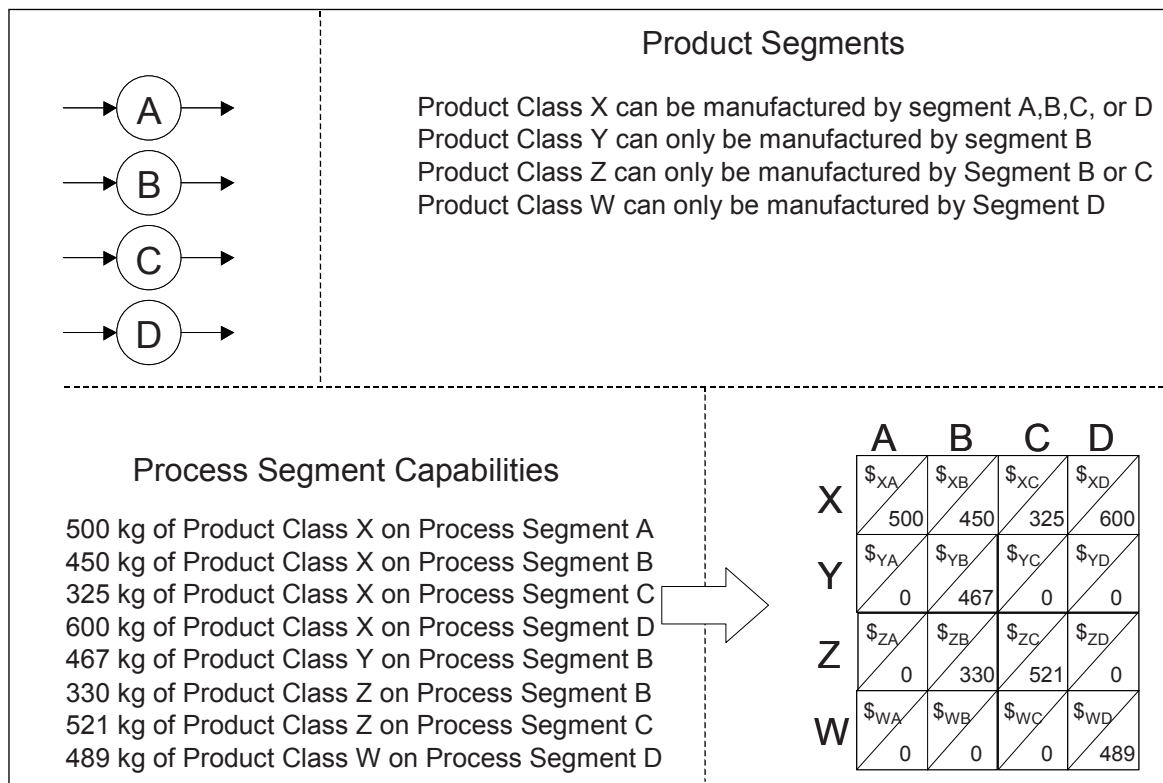
Figure D.5 – Product and process capability relationships

D.10   Representation of dependencies

Question:

How are process or product dependencies represented?

Answer:

The *Dependency Type* attribute in the *process segment dependency* and the *product segment dependency* objects can be used to show the dependency. These can be simple dependencies, such as:

a) one segment follows another segment;

b) one segment cannot follow another segment;

c) two segments can run in parallel;

d) one segment starts when another segment starts;

e) one segment starts when another segment ends;

f) one segment starts any time after another segment starts;

g) one segment starts any time after another segment ends.

These dependencies can include physical constraints (because of production line layout), or constraints based on safety (such as prohibiting a "water add" after an "acid fill"), or constraints based on the chemical or physical processing required to make a product (bicycle wheels have to be assembled before the bicycle final assembly).

More complicated constraints based on timing or other dependencies can also be defined using the *Dependency Factor* attribute.

EXAMPLE 1 The longer a semiconductor wafer is kept unprocessed the more defects are introduced, so there is a maximum delay allowed between segments of production.

EXAMPLE 2 A material (like cheese or wine) ages between processing segments so there is a minimum time allowed between segments of production.

Figure D.6 illustrates some of the possible dependencies using timing constraints associated with *product segment dependencies* or *process segment dependencies.* The left side of Figure D.6 illustrates possible dependencies where overlapped execution of the segment is allowed or required. The right side of Figure D.6 illustrates dependencies where non-overlapped execution is allowed or required.

B may run in parallel to A
Start B at A start
Start B after A start
Start B no later than T time after A start
Start B no earlier than T time after A start

B may not run in parallel to A
Start B at A end
Start B after A end
Start B no later than T time after A end
Start B no earlier than T time after A end
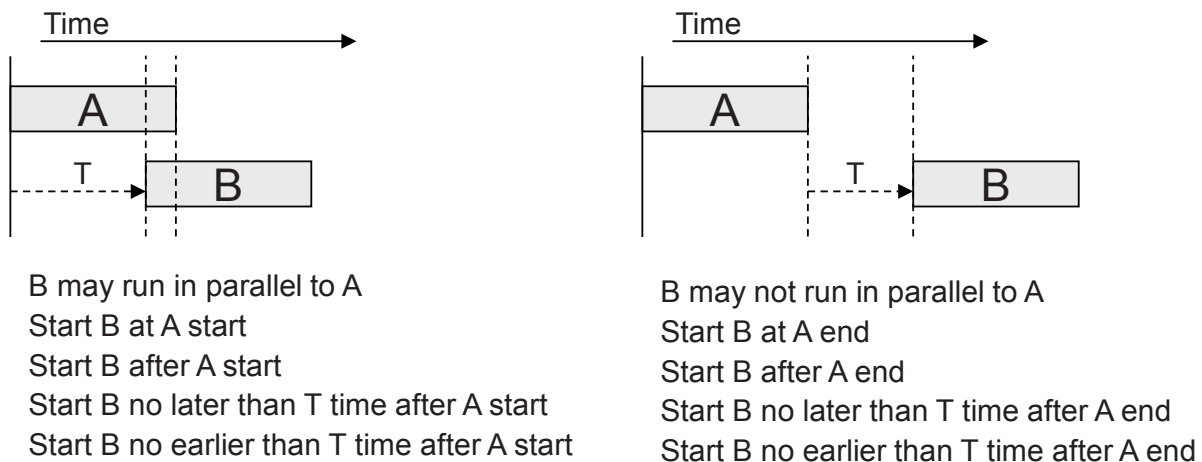
Figure D.6 – Time-based dependencies

The dependency type cannot only be related to time, but also to other unit of measures. For example, in Discrete Industry it can be common to specify a dependency between two work task segments that is based on the amount of product produced rather than on the time elapsed. The idea is to be able to express a dependency like "Start B after A has started and at least 50 % of product quantity has been produced".

D.11   Representation of material produced and consumed

Question:

Why are there two different models for representing the material produced and material consumed, as attributes in some objects (production capability model and product definition model), and as separate objects in the production schedule and production performance models?

Answer:

In the production schedule and production performance model, typical implementations had used these as separate objects, and this information was of major importance. In the other models the material information usually refers to material consumed, and only rarely seems to be used to represent produced material. The attribute model was used in these cases so that the object models would be less complex.

D.12   Material produced and the capability model

Question:

Why is there a *material produced* type in the capability model?

Answer:

In some processes, there are materials that are produced as a side effect of production, such as wastewater, or recycled materials. These materials can be used in other parts of production, and their availability can have to be considered in schedules.

D.13   How a material transfer is handled?

Question:

How is a material transfer handled? It is not a request for production, just a request to move material from one location to another.

Answer:

A material transfer can be handled using the production schedule and production performance models. There are multiple methods; one is to have a process segment defined for a "TRANSFER." The material to be transferred could be identified in the *material consumed requirement* object. The actual amount of material transferred could be identified in a *material produced actual* object. In some processes the two amounts can differ due to losses during transfer. The material locations for the movements could be identified in the material consumed sublot and material produced sublot information.

If the movement of material is initiated from the manufacturing operations level but has to be known by the logistics level, then a production response could be generated that defined a "TRANSFER" segment. There is no requirement in this standard that there is a production request for a production response, but corresponding business processes have to be in place to support the exchange of information.

D.14   How to extend the standard when properties cannot be used

Properties are the standard method for extensions, however, where required information cannot be added using the property model, additional information, including industry- and application-specific information, can have to be added as non-standard attributes and objects. However, in order to achieve integration, these extensions have to be documented and explicitly shared among interoperating partners. A documentation method should be to define a new industry or application specific standard, referencing this part of IEC 62264 and documenting the extensions.

D.15   Modeling of tools

Question:

Are tools modeled as equipment or materials?

Answer:

Depending on the purpose of the tool, a tool can be modelled as either equipment or as materials. Tools can be used in different ways, for example tools used in the process of manufacturing versus tools included in the assembly of the product. Tools that can be

consumed or need to be lot traceable would be modelled as material. Other tools could be modelled as equipment. Some examples are shown in Table D.2:

Table D.2 – Examples of materials and equipment

Equipment	Material
Electric drill	Bit
Sanding machine	Sandpaper
Screw driver	Screw
Hammer	Nail

D.16   What is equipment and what is a physical asset?

Question:

Does there need to be a one-to-one relationship between physical asset and equipment?

Answer:

There are cases of one-to-one relationships, and one-to-many relationships in each direction. One item that is scheduled as a single piece of equipment can be tracked as multiple physical assets for maintenance purposes. Likewise a single physical asset can be scheduled as multiple pieces of equipment. The relationship with these many to many roles is accomplished using the mapping of the role based equipment hierarchy to the physical asset hierarchy. One element in the equipment role hierarchy is a collection of assets in the physical asset hierarchy. Examples are shown in Table D.3.

Table D.3 – Equipment and physical assets

Equipment	Physical Asset	Relationship
TT-101 (temperature sensor)	1212-RTD-R21 (temperature probe)	1 to 1
P-1000 (palletizer)	Robot Labeller Bar code verifier / scanner Conveyer Servo Motor	1 to 4
CP-1001 (capper) F-1001 (sanitary filter)	453212-121-09FEB2006 (capper machine)	2 to 1

D.17   How should dependencies in the production/operations schedule and production/operations response be handled?

Question:

How should dependencies in the production/operations schedule and production/operations response be 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 production/operations requests.

For example, an MRP/ERP at level 4 can generate 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 can start only 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 implemented at level 4 or level 3, but represented in the production schedule or production/operations schedule request.

D.18   How are "mixed" operations types used?

Question:

How are "mixed" operations types to be used?

Answer:

The operation schedule model can handle mixed types of operations. The operation schedule, operation request and segment requirement can be specialized or mixed:

- a "mixed" operation schedule can hold mixed or specialized operation requests,
- a "mixed" operation request can hold mixed or specialized segment requirements,
- a "mixed" segment requirement can handle multiple resource specifications that would normally appear in specialized segment.

In the figure, the segment requirement specifies:

- the material movements needed to fulfill the corresponding operation (inventory operation category);
- the resources for the production; the material information should include the dispensed material and other material those transfer would not need to be specified (liquid substance available from fixed pipes);
- the quality related resources that are involved during or at the end of the production operation.
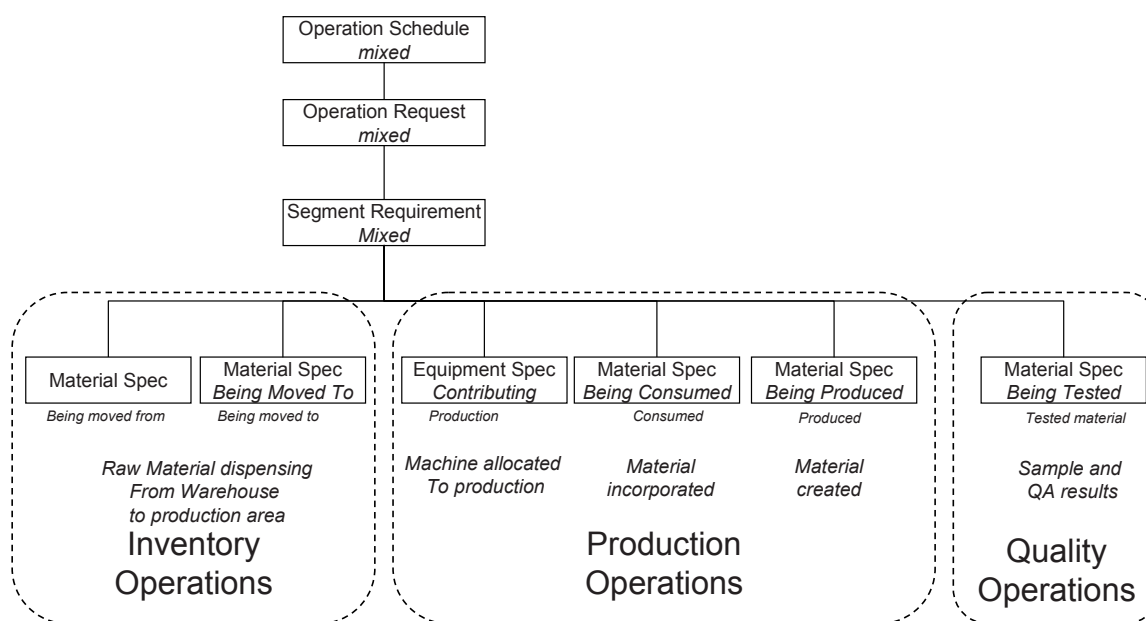
Figure D.7 – Mixed operation example

D.19   What is the relationship between this standard and MESA's B2MML?

Question:

What is the relationship between this standard and MESA's B2MML?

Answer:

B2MML is an implementation of the standard that is based on XML technology and was developed by and is the property of MESA (ref: www.mesa.org). B2MML includes a compliance statement (as defined in Clause 9.)

The B2MML implementation includes additional information (elements) than are defined in this standard, usually for consistency of type definitions or to make use of the implementation easier when using standard programming languages.

B2MML is not the only way to implement this standard, but B2MML can be used as a reference implementation of the standard.

The committee developing the B2MML standard also sends comments on this standard to the committee developing this standard.

D.20   Unique objects

Question:

There appears to be common attributes, structure and usage to the objects *Qualification Test Specification* (Personnel), *Equipment Capability Test Specification* (Role based Equipment), *Physical Asset Capability Test Specification* (Asset), and *Material Test Specification* (Material). Why have these objects been presented as unique entities rather than utilizing a common "resource" test specification?

Answer:

The standard presents each of these objects with a unique namespace to clarify to the reader of the standard that these objects represent specific tests and test results, dependent on the context of usage within each resource model. Representing the models in this way clearly conveys to the reader the purpose and usage of each of the models within the standard.

Modern data modeling tools can yield multiple levels of optimization; however, these abstracted data models are not helpful to convey an understanding of how this standard represents information in this specific problem space. The models have been developed along the lines of other standards, such as OAGIS and EDI standards, which have proven to be useful standards for similar reasons.

While the committee members recognize that the models can be represented with a more optimized view, the purpose of this standard is not to present the most optimized data model. By further optimizing the data models represented in the standard, the committee feels that the meaning of these data models and their significance to the standard will be lost leading to misunderstandings or impractical implementations of the standard. The committee members also realize that implementations of this standard can employ advanced data modeling techniques that seek to optimize the representation of certain objects (i.e. using a common resource model in XML with an element to distinguish its type and maintain its unique namespace).

Annex E
(informative)

Logical information flows

The personnel model, equipment model, physical asset model, material model, and process segment model are collectively referred to as the resource models.

Systems communicating using the product capability, product definition, production schedule, and production performance models have to agree on the meaning of data values.

EXAMPLE 1   Property IDs.

The objects in the resource models document the agreed upon values.

The assumption is that the resource model information is shared among communicating systems. The resource model information can be embedded as part of an information flow for other objects, can be exchanged as separate objects, or can be part of a common or distributed data store.

The IEC 62264-1 object model does not assume a one-to-one relationship between enterprise systems and manufacturing control systems. These can be one-to-many, many-to-one, or many-to-many relationships.

EXAMPLE 2   Examples of the exchanges include contract manufacturing being performed for multiple customers (many-to-one), and a single company with multiple different manufacturing control systems (one-to-many).

Figure E.1 illustrates some possible logical information flows between enterprise systems and manufacturing control systems.
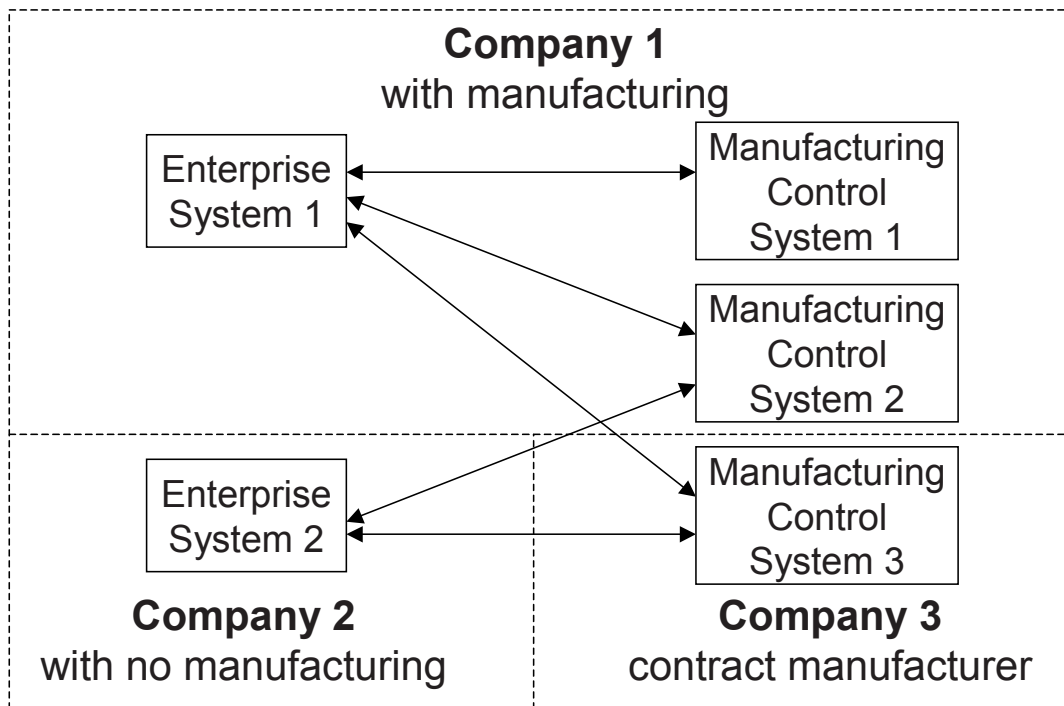
Figure E.1 – Enterprise to manufacturing system logical information flows

The information in this part of IEC 6 2264 is independent of any communication protocol. Part 2 makes no assumption about the agents that create the information and the agents that use the information. Different implementations of the information model can describe different communication protocols and will often require additional attributes and objects.

EXAMPLE 3 An SQL implementation will have to identify primary keys and can identify index attributes.

Additionally, the information model does not assume a one-to-one relationship between external systems and manufacturing control systems. There can be one-to-many, many-to-one, or many-to-many relationships.

EXAMPLE 4 Examples of the many-to-many exchanges include multiple maintenance systems or quality systems.

Figure E.2 illustrates examples of manufacturing control system connections.
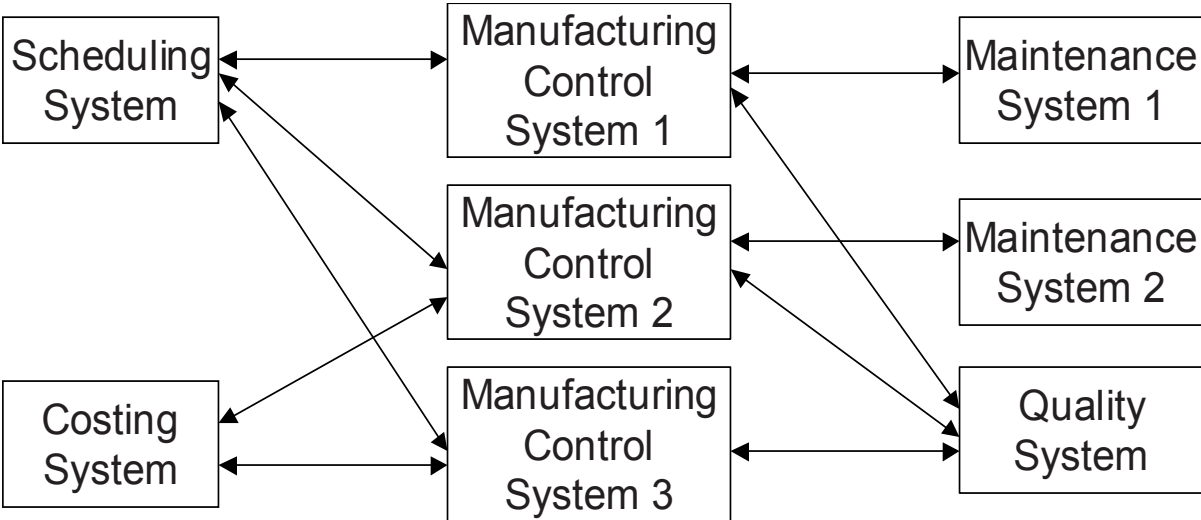
Figure E.2 – Logical information flows among multiple systems

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