

Enterprise-control system integration —

Part 1: Models and terminology

ICS 25.040; 35.240.50

National foreword

This British Standard is the UK implementation of EN 62264-1:2008. It is identical with IEC 62264-1:2003. It supersedes BS IEC 62264-1:2003, which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee GEL/65, Measurement and control, to Subcommittee GEL/65/1, System considerations.

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

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 17 January 2005

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ISBN 978 0 580 59326 0

Amendments/corrigenda issued since publication

Date	Comments
30 September 2008	This corrigendum renumbers BS IEC 62264-1:2003 as BS EN 62264-1:2008

**Enterprise-control system integration -
Part 1: Models and terminology
(IEC 62264-1:2003)**

Intégration des systèmes
entreprise-contrôle -
Partie 1: Modèles et terminologie
(CEI 62264-1:2003)

Integration von Unternehmensführungs-
und Leitsystemen -
Teil 1: Modelle und Terminologie
(IEC 62264-1:2003)

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

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of the International Standard IEC 62264-1:2003, prepared by SC 65A, System aspects, of IEC TC 65, Industrial-process measurement, control and automation, and ISO TC 184/SC 5/JWG 15, Enterprise-control system integration, was submitted to the Unique Acceptance Procedure and was approved by CENELEC as EN 62264-1 on 2007-12-01 without any modification.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 2008-12-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2010-12-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 62264-1:2003 was approved by CENELEC as a European Standard without any modification.

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INTRODUCTION

IEC 62264 is a multi-part standard that defines the interfaces between enterprise activities and control activities. This standard provides standard models and terminology for describing the interfaces between the business systems of an enterprise and its manufacturing-control systems. The models and terminology presented in this standard

- 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 capabilities of manufacturing control systems with enterprise systems; and
- c) can be applied regardless of the degree of automation.

Specifically, this standard 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. Some of the benefits produced will

- a) reduce users' times 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 costs of automating manufacturing processes;
- e) optimize supply chains; and
- f) reduce life-cycle engineering efforts.

It is not the intent of this standard to

- suggest that there is only one way of implementing integration of control systems to enterprise systems;
- force users to abandon their current methods of handling integration; or
- restrict development in the area of integration of control systems to enterprise systems.

This standard discusses the interface content between manufacturing-control functions and other enterprise functions, based upon the Purdue Reference Model for CIM (hierarchical form) as published by ISA. This standard presents a partial model or reference model as defined in ISO 15704.

The scope of this standard is limited to describing the relevant functions in the enterprise and the control domain and which objects are normally exchanged between these domains. Subsequent parts will address how these objects can be exchanged in a robust, secure, and cost-effective manner preserving the integrity of the complete system.

The intent of Clause 4 is to describe the context of the models in Clause 5 and Clause 6. It gives the criteria used to determine the scope of the manufacturing control system domain. Clause 4 does not contain the formal definitions of the models and terminology but describes the context to understand the other clauses.

The intent of Clause 5 is to describe hierarchy models of the activities involved in manufacturing-control enterprises. It presents in general terms the activities that are associated with manufacturing control and the activities that occur at the business logistics level. It also gives an equipment hierarchy model of equipment associated with manufacturing control.

The intent of Clause 6 is to describe a general model of the functions within an enterprise which are concerned with the integration of business and control. It presents, in detail, an abstract model of control functions and, in less detail, the business functions that interface to control. The purpose is to establish a common terminology for functions involved in information exchange.

The intent of Clause 7 is to state in detail the objects that make up the information streams defined in Clause 6. The purpose is to establish a common terminology for the elements of information exchanged.

Annex A defines the relationship of this standard with other related standardization work in the manufacturing area.

The intent of Annex B is to present the business reasons for the information exchange between business and control functions. The purpose is to establish a common terminology for the reason for information exchange.

Annex C discusses the rationale for multiple models.

Annex D contains selected elements from the Purdue Reference Model that may be used to place the functions described in Clauses 5 and 6 in context with the entire model.

Annex E is informative. It correlates the Purdue Reference Model to the MESA International Model.

This standard is intended for those who are

- involved in designing, building, or operating manufacturing facilities;
- responsible for specifying interfaces between manufacturing and process control systems and other systems of the business enterprise; or
- involved in designing, creating, marketing, and integrating automation products used to interface manufacturing operations and business systems.

Annex F is a discussion of systems, resources, capability, capacity, and time as used in this standard.

ENTERPRISE-CONTROL SYSTEM INTEGRATION –

Part 1: Models and terminology

1 Scope

This part of IEC 62264 describes the interface content between manufacturing control functions and other enterprise functions. The interfaces considered are the interfaces between Levels 3 and 4 of the hierarchical model defined by this standard. The goal is to reduce the risk, cost, and errors associated with implementing these interfaces.

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

The scope of this standard is limited to

- a) a presentation of the scope of the manufacturing operations and control domain;
- b) a discussion of the organization of physical assets of an enterprise involved in manufacturing;
- c) a listing of the functions associated with the interface between control functions and enterprise functions; and
- d) a description of the information that is shared between control functions and enterprise functions.

2 Normative references

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

IEC 61512-1:1997, *Batch control – Part 1: Models and terminology*

ISO/IEC 19501-1, *Information technology – Unified Modeling Language (UML) – Part 1: Specification*¹

ISO 10303-1:1994, *Industrial automation systems and integration – Product data representation and exchange – Part 1: Overview and fundamental principles*

ISO 15531-1, *Industrial automation systems and integration – Industrial manufacturing management data – Part 1: General overview*¹

ISO 15704:2000, *Industrial automation systems – Requirements for enterprise-reference architectures and methodologies*

¹ To be published.

3 Terms and definitions

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

3.1

area

physical, geographical or logical grouping determined by the site

NOTE It can contain process cells, production units, and production lines.

3.2

available capacity

portion of the production capacity that can be attained but is not committed to current or future production

3.3

bill of loading

BOL

contract or receipt for goods that a carrier agrees to transport from one place to another and to deliver to a designated person or that it assigns for compensation upon the conditions stated therein

3.4

bill of material

BOM

listing of all the subassemblies, parts, and/or materials that are used in the production of a product including the quantity of each material required to make a product

3.5

bill of resources

listing of all resources and when in the production process they are needed to produce a product

NOTE It is also a listing of the key resources required to manufacture a product, organized as segments of production and is often used to predict the impact of activity changes in the master production schedule on the supply of resources.

3.6

capability

ability to perform actions, including attributes on qualifications and measures of the ability as capacity

NOTE See Annex F for additional background on this concept.

3.7

capacity

measure of the ability to take action, a subset of a capability

NOTE See Annex F for additional background on this concept.

EXAMPLE Measures of the production rates, flow rates, mass or volume.

3.8

certificate of analysis

COA

certification of conformance to quality standards or specifications for products or materials

NOTE It can include a list or reference of analysis results and process information. It is often required for custody transfer of materials.

3.9**committed capacity**

portion of the production capacity that is currently in use or is scheduled for use

3.10**consumables**

resources that are not normally included in bills of material or are not individually accounted for in specific production requests

3.11**control domain**

in this standard, control domain is synonymous with the manufacturing operations and control domain

3.12**enterprise**

one or more organizations sharing a definite mission, goals and objectives to offer an output such as a product or service

3.13**equipment class**

means to describe a grouping of equipment with similar characteristics for purposes of scheduling and planning

3.14**finished goods**

final materials on which all processing and production are completed

3.15**finished good waivers**

approvals for deviation from normal product specifications

3.16**in-process waiver requests**

requests for waivers on normal production procedures due to deviations in materials, equipment, or quality metrics, where normal product specifications are maintained

3.17**manufacturing operations and control domain****MO&C**

domain that includes all the activities in Level 3 and information flows to and from levels 0, 1, and 2 across the boundary to Level 4

3.18**material class**

means to describe a grouping of materials with similar characteristics for purposes of scheduling and planning

3.19**material lot**

uniquely identifiable amount of a material

NOTE It describes the actual total quantity or amount of material available, its current state, and its specific property values.

3.20

material definition

definition of the properties and characteristics for a substance

3.21

material subplot

uniquely identifiable subset of a material lot, containing quantity and location

NOTE This may be a single item.

3.22

personnel class

means to describe a grouping of persons with similar characteristics for purposes of scheduling and planning

3.23

process segment

view of a collection of resources needed for a segment of production, independent of any particular product at the level of detail required to support business processes that may also be independent of any particular product

NOTE This may include material, energy, personnel, or equipment.

3.24

production capacity

ability of resources to perform production in the enterprise. The production capacity includes the capacity of those resources and represents

- a) the collection of personnel, equipment, material, and process segment capabilities;
- b) the total of the current committed, available, and unattainable capacity of the production facility;
- c) the highest sustainable output rate that could be achieved for a given product mix, raw materials, worker effort, plant, and equipment

3.25

production control

collection of functions that manages all production within a site or area

3.26

production line

series of pieces of equipment dedicated to the manufacture of a specific number of products or families

3.27

production rules

information used to instruct a manufacturing operation how to produce a product

3.28

production unit

set of production equipment that converts, separates, or reacts one or more feedstocks to produce intermediate or final products

3.29**product segments**

shared information between a bill of resources and a production rule for a specific product

NOTE A logical grouping of personnel resources, equipment resources, and material specifications required to carry out the production step.

3.30**resource**

enterprise entity that provides some or all of the capabilities required by the execution of an enterprise activity and/or business process (in the context of this standard, a collection of personnel, equipment, and/or material)

3.31**unattainable capacity**

portion of the production capacity that cannot be attained

NOTE Typically due to factors such as equipment unavailability, sub-optimal scheduling, or resource limitations.

3.32**work cell**

dissimilar machines grouped together to produce a family of parts having similar manufacturing requirements

4 Enterprise-control system integration overview**4.1 Introduction**

Successfully addressing the issue of enterprise-control system integration requires identifying the boundary between the enterprise and the manufacturing operations and control domains (MO&C). The boundary is identified using relevant models that represent functions, physical equipment, information within the MO&C domain, and information flows between the domains.

Multiple models show the functions and integration associated with control and enterprise systems.

- a) Hierarchy models that describe the levels of functions and domains of control associated within manufacturing organizations are presented in Clause 5. These models are based on *The Purdue Reference Model for CIM*, referenced as PRM; the MESA International Functional Model; and the equipment hierarchy model from IEC 61512-1.

NOTE 1 Selected elements of the *Purdue Reference Model for CIM* are included in Annex D.

NOTE 2 See the Bibliography for reference to the MESA white paper defining MES functionality.

- b) A data flow model that describes the functional and data flows within manufacturing organizations is given in Clause 6. This model is also based on The Purdue Reference Model for CIM.
- c) An object model that describes the information that may cross the enterprise and control system boundary is given in Clause 7.

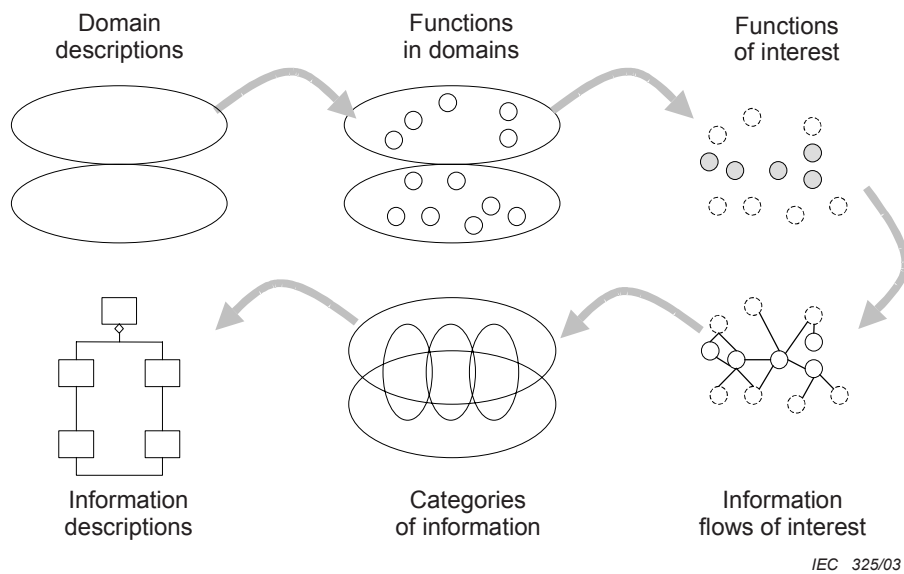


Figure 1 – Outline of models in the standard

This standard provides models and information in multiple levels of detail and abstraction. These levels are illustrated in Figure 1, which serves as a map to the rest of the document. Each model and diagram increases the level of detail presented in the previous model.

The models start with a description of the domain of control systems and the domain of enterprise systems. The domain discussion is contained in Clause 5.

Functions within the domains are presented in Clauses 5 and 6. Functions of interest that are relevant to the standard are also given a detailed description in Clause 6. The information flows of interest between the relevant functions are listed in 6.5.

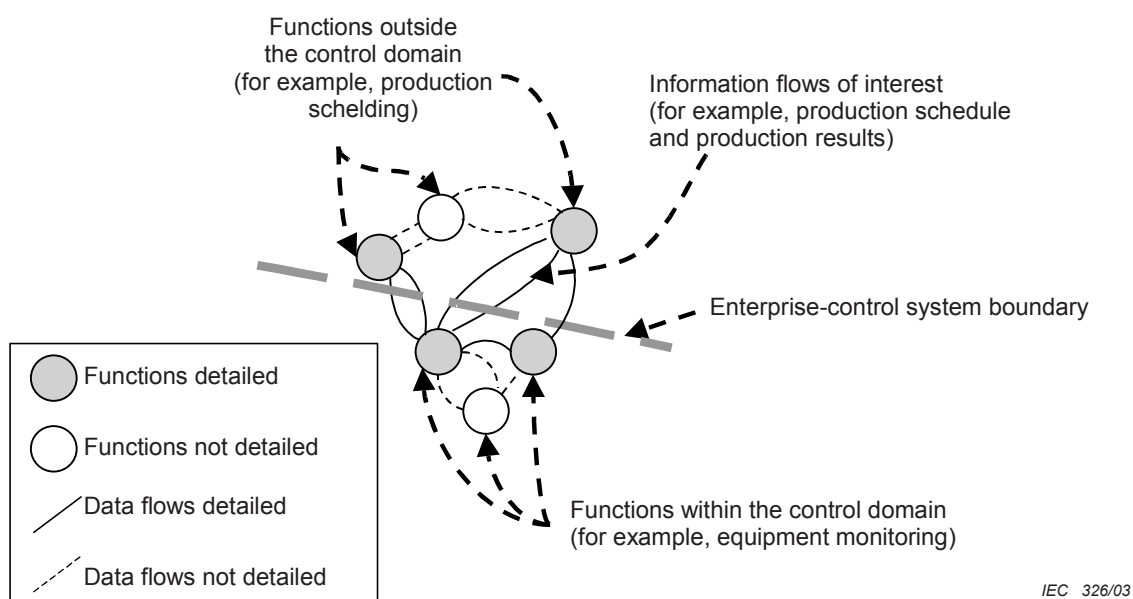
The categories of information are given in 7.2. The formal object model of the information of interest is presented in 7.5, 7.6, 7.7, and 7.8.

4.2 Criteria for inclusion in manufacturing operations and control domain

The hierarchy and data flow models describe most of the functions within a manufacturing enterprise. Only some of those functions are associated with manufacturing control and manufacturing control systems. The following list shows the criteria used to determine which functions and which information flows are included in this standard.

- a) The function is critical to maintaining regulatory compliance. This includes such factors as safety, and compliance to environmental and current good manufacturing practices.
- b) The function is critical to plant reliability.
- c) The life impacts the operation phase of the life of a facility, as opposed to the design, construction, and disposal phases of the life of a facility.
- d) The information is needed by facility operators in order to perform their jobs.

The information that flows between functions identified as being within the control domain and those outside the control domain describe the enterprise-control system boundary. Information exchanged between functions within the control domain and information exchanged between functions outside the control domain are outside the scope of this document. Figure 2 illustrates the enterprise-control system interface, as depicted in the data flow model, between control and non-control functions; the blue circles indicate functions that exchange information and are described in the data flow model. Functions depicted as white circles and data flows depicted as dashed lines are those considered as outside the scope of this standard.



IEC 326/03

Figure 2 – Enterprise-control system interface

5 Hierarchy models

5.1 Hierarchy model introduction

Clause 5 presents the hierarchy models associated with manufacturing control systems and other business systems.

5.2 Scheduling and control hierarchy

5.2.1 Hierarchy levels

Figure 3 depicts the different levels of a functional hierarchy model: business planning and logistics, manufacturing operations and control, and batch, continuous, or discrete control. The model shows the hierarchical levels at which decisions are made. The interface addressed in this standard is between Level 4 and Level 3 of the hierarchy model. This is generally the interface between plant production scheduling and operation management and plant floor coordination.

NOTE The figure is a simplified version of the Purdue Hierarchy Model, as shown in Figures D.1, D.2, D.3 and D.4 of Annex D.

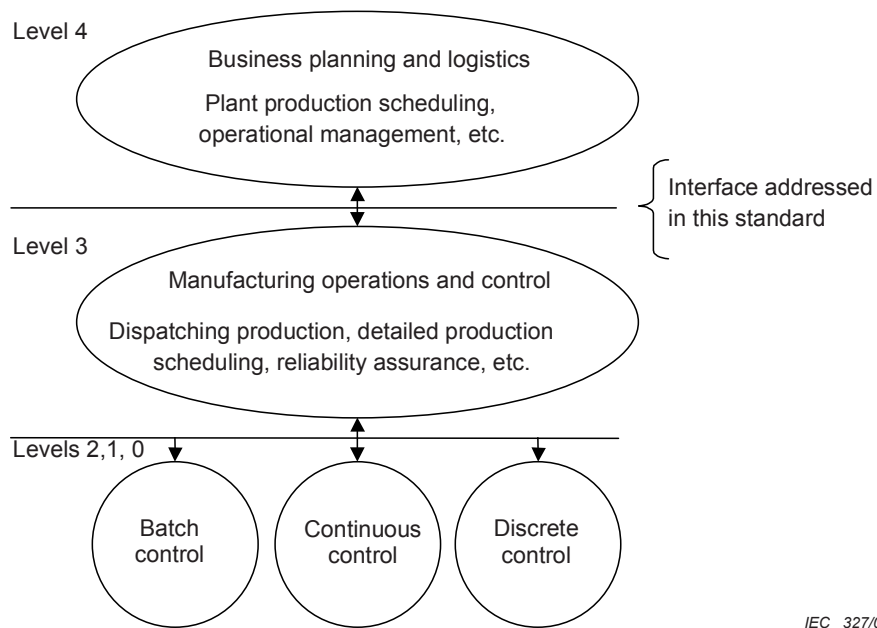


Figure 3 – Functional hierarchy

Levels 2, 1, and 0 present the cell or line supervision functions, operations functions, and process control functions and are not addressed in this standard. The discussion and labelling of levels is based on a historical description, further described in Annex D. Level 0 indicates the process, usually the manufacturing or production process. Level 1 indicates manual sensing, sensors, and actuators used to monitor and manipulate the process. Level 2 indicates the control activities, either manual or automated, that keeps the process stable or under control. There are several different models for the functions at these levels based on the actual production strategy used.

5.2.2 Level 4 activities

Level 4 activities typically include

- collecting and maintaining raw material and spare parts usage and available inventory, and providing data for purchase of raw material and spare parts;
- collecting and maintaining overall energy use and available inventory and providing data for purchase of energy source;
- collecting and maintaining overall goods in process and production inventory files;
- collecting and maintaining quality control files as they relate to customer requirements;
- collecting and maintaining machinery and equipment use and life history files necessary for preventive and predictive maintenance planning;
- collecting and maintaining manpower use data for transmittal to personnel and accounting;
- establishing the basic plant production schedule;
- modifying the basic plant production schedule for orders received, based on resource availability changes, energy sources available, power demand levels, and maintenance requirements;

- i) developing optimum preventive maintenance and equipment renovation schedules in coordination with the basic plant production schedule;
- j) determining the optimum inventory levels of raw materials, energy sources, spare parts, and goods in process at each storage point. These functions also include materials requirements planning (MRP) and spare parts procurement;
- k) modifying the basic plant production schedule as necessary whenever major production interruptions occur;
- l) capacity planning, based on all of the above activities.

5.2.3 Level 3

5.2.3.1 Level 3 activities

Level 3 activities typically include

- a) reporting on area production including variable manufacturing costs;
- b) collecting and maintaining area data on production, inventory, manpower, raw materials, spare parts and energy usage;
- c) the performance of data collection and off-line analysis as required by engineering functions. This may include statistical quality analysis and related control functions;
- d) carrying out needed personnel functions such as: work period statistics (for example, time, task), vacation schedule, work force schedules, union line of progression, and in-house training and personnel qualification;
- e) establishing the immediate detailed production schedule for its own area including maintenance, transportation and other production-related needs;
- f) locally optimizing the costs for its individual production area while carrying out the production schedule established by the Level 4 functions;
- g) modification of production schedules to compensate for plant production interruptions that may occur in its area of responsibility.

Descriptions of the major functionalities associated with these various activities are given in 5.2.3.2 through 5.2.3.12. The standard assumes all activities not explicitly presented as part of the Level 3 control domain to be part of the enterprise domain. See Annex E for a correlation of the activities to the MESA International Model.

5.2.3.2 Resource allocation and control

The control domain includes the functionality of managing resources directly associated with control and manufacturing. The resources include machines, tools, labour skills, materials, other equipment, documents, and other entities that are required for work to start and to be completed. The management of these resources may include local resource reservation to meet production-scheduling objectives.

The control domain also ensures that equipment is properly set up for processing, including any allocation needed for set-up. The control domain is also responsible for providing real-time statuses of the resources and a detailed history of resource use.

5.2.3.3 Dispatching production

The control domain includes the functionality of managing the flow of production in the form of jobs, orders, batches, lots, and work orders, by dispatching production to specific equipment and personnel. Dispatch information is typically presented in the sequence in which the work needs to be done and may change in real time as events occur on the factory floor.

The control domain may alter the prescribed schedules, within agreed limits, based on local availability and current conditions. Dispatching of production includes the ability to control the amount of work in process at any point through buffer management and management of rework and salvage processes.

5.2.3.4 Data collection and acquisition

The control domain includes the functionality of obtaining the operational production and parametric data that are associated with the production equipment and production processes.

The control domain also is responsible for providing real-time statuses of the production equipment and production processes and a history of production and parametric data.

5.2.3.5 Quality management

The control domain includes the functionality of providing real-time measurements collected from manufacturing and analysis in order to assure proper product quality control and to identify problems requiring attention. It may recommend actions to correct the problem, including correlating the symptoms, actions and results to determine the cause.

It includes statistical process control/statistical quality control (SPC/SQC), tracking and management of off-line inspection operations, and analysis in laboratory information management systems.

5.2.3.6 Process management

The control domain includes the functionality of monitoring production and either automatically corrects or provides decision support to operators for correcting and improving in-process functions. These functions may be intra-operational and focus specifically on machines or equipment being monitored and controlled, as well as inter-operational, tracking the process from one operation to the next.

It may include alarm management to make sure factory persons are aware of process changes that are outside acceptable tolerances.

5.2.3.7 Production tracking

The control domain includes the functionality of providing the status of production and the disposition of work. Status information may include personnel assigned to the work; component materials used in production; current production conditions; and any alarms, rework, or other exceptions related to the product. The functionality includes the capability of recording the production information to allow forward and backward traceability of components and their use within each end product.

5.2.3.8 Performance analysis

The control domain includes the functionality of providing up-to-the-minute reporting of actual manufacturing operations results along with comparisons to past history and expected results. Performance results include such measurements as resource utilization, resource availability, product unit cycle time, conformance to schedule, and performance to standards. Performance analysis may include SPC/SQC analysis and may draw from information gathered by different control functions that measure operating parameters.

5.2.3.9 Operations and detailed scheduling

The control domain includes the functionality of providing sequencing based on priorities, attributes, characteristics, and production rules associated with specific production equipment and specific product characteristics, such as shape, colour sequencing or other characteristics that, when scheduled in sequence properly, minimize set-up. Operations and detailed scheduling takes into account finite capacity of resources and recognizes alternative and overlapping/parallel operations in order to calculate in detail the exact time of equipment loading and adjustment to shift patterns.

5.2.3.10 Document control

The control domain includes some of the functionality of controlling records and forms that are maintained with the production unit. The records and forms include work instructions, recipes, drawings, standard operation procedures, part programmes, batch records, engineering change notices, shift-to-shift communication, as well as the ability to edit “as planned” and “as built” information. It sends instructions down to the operations, including providing data to operators or recipes to device controls. It would also include the control and integrity of regulatory documentation, environmental, health and safety regulations, and SOP information such as corrective action procedures.

5.2.3.11 Labour management

The control domain includes some of the functionality of providing status of personnel in an up-to-the minute time frame. The functions include time and attendance reporting, certification tracking, as well as the ability to track indirect functions such as material preparation or tool room work as a basis for activity-based costing. Labour management may interact with resource allocation to determine optimal assignments.

5.2.3.12 Maintenance management

The control domain includes some of the functionality of maintaining equipment and tools. The functions ensure the equipment and tools availability for manufacturing. They also may include scheduling for periodic or preventive maintenance as well as responding to immediate problems. Maintenance management maintains a history of past events or problems to aid in diagnosing problems.

5.3 Equipment hierarchy

5.3.1 Equipment model

The physical assets of an enterprise involved in manufacturing are usually organized in a hierarchical fashion as described in Figure 4. This is an expansion of the model described in IEC 61512-1 and includes the definition of assets for discrete and continuous manufacturing. Lower-level groupings are combined to form higher levels in the hierarchy. In some cases, a grouping within one level may be incorporated into another grouping at that same level.

This model shows the areas of responsibility for the different function levels defined in the scheduling and control hierarchical model of Figure 3. The equipment hierarchy model additionally gives some of the objects utilized in information exchange between functions. This corresponds to a resource model for equipment, as defined in ISO 15704 and ISO 15531-1.

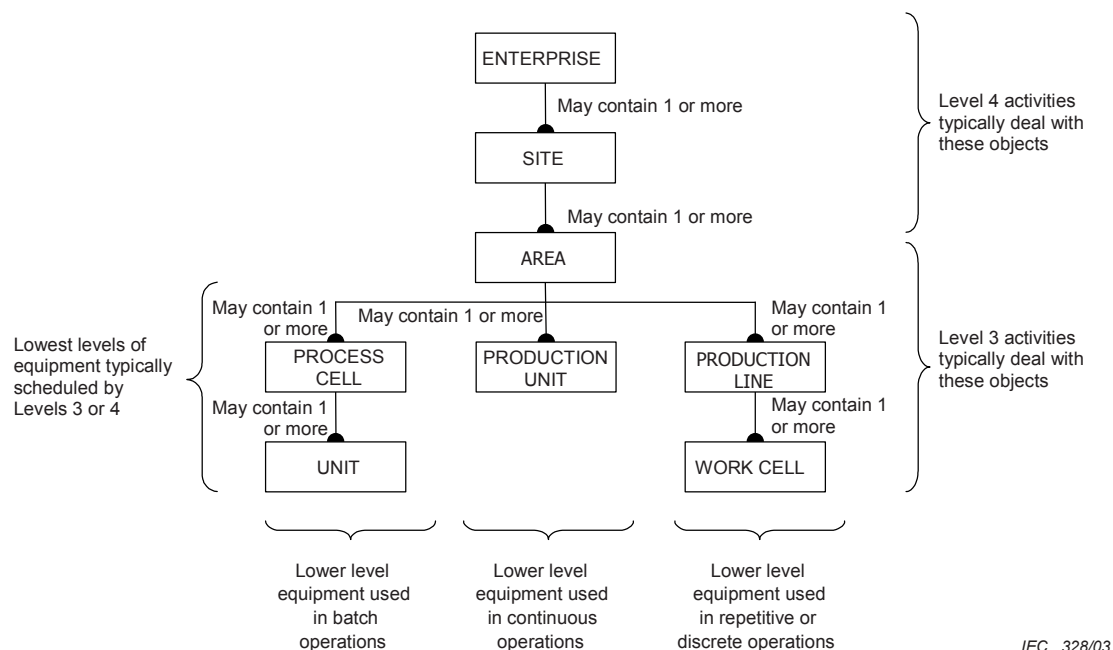


Figure 4 – Equipment hierarchy

5.3.2 Enterprise

An enterprise is a collection of one or more sites and may contain sites and areas. The enterprise is responsible for determining what products will be manufactured, at which sites they will be manufactured, and in general how they will be manufactured.

Level 4 functions are generally concerned with the enterprise and site levels. However, enterprise planning and scheduling may involve areas, cells, lines, or units within an area.

5.3.3 Site

A site is a physical, geographical, or logical grouping determined by the enterprise. It may contain areas, production lines, process cells, and production units. The Level 4 functions at a site are involved in local site management and optimization. Site planning and scheduling may involve cells, lines, or units within the areas.

A geographical location and main production capability usually identifies a site. Sites generally have well-defined manufacturing capabilities.

NOTE For example, site identifiers from various industries are Dallas Expressway Plant, Deer Park Olefins Plant and Johnson City Manufacturing Facility. Sites are often used for rough-cut planning and scheduling.

5.3.4 Area

An area is a physical, geographical, or logical grouping determined by the site. It may contain process cells, production units, and production lines. Most Level 3 functions occur within the area. The main production capability and geographical location within a site usually identify areas.

NOTE For example, area identifiers from various industries are CMOS Facility, North End Tank Farm and Building 2 Electronic Assembly.

Areas generally have well-defined manufacturing capabilities and capacities. The capabilities and capacities are used for Level 3 and Level 4 planning and scheduling.

An area is made up of lower-level elements that perform the manufacturing functions. There are three types of elements defined that correspond to continuous manufacturing models, discrete (repetitive and non-repetitive) manufacturing models, and batch manufacturing models. An area may have one or more of any of the lower-level elements depending upon the manufacturing requirements. Many areas will have a combination of production lines for the discrete operations, production units for the continuous processes, and process cells for batch processes. For example, a beverage manufacturer may have an area with continuous mixing in a production unit, which feeds a batch process cell for batch processing, feeding a bottling line for a discrete bottling process.

Depending on the planning and scheduling strategy selected, the Level 4 functions may stop at the area level, or they may schedule the functions of the lower-level elements within the areas.

5.3.5 Production unit

Production units are the lowest level of equipment typically scheduled by the Level 4 or Level 3 functions for continuous manufacturing processes. Production units are composed of lower level elements, such as equipment modules, sensors, and actuators, but definitions of these are outside the scope of this standard. A production unit generally encompasses all of the equipment required for a segment of continuous production that operates in a relatively autonomous manner. It generally converts, separates, or reacts one or more feed stocks to produce intermediate or final products.

The major processing activity or product generated often identifies the production unit.

NOTE For example, production unit identifiers from various industries are Catalytic Cracker #1, Steam Cracker #59 and Alkylation Unit 2.

Production units have well-defined processing capabilities and throughput capacities and these are used for Level 3 functions. The capacities and capabilities are also often used as input to Level 4 scheduling, even if the production units are not scheduled by the Level 4 functions.

5.3.6 Production line and work cell

Production lines and work cells are the lowest levels of equipment typically scheduled by the Level 4 or Level 3 functions for discrete manufacturing processes. Work cells are usually only identified when there is flexibility in the routing of work within a production line. Production lines and work cells may be composed of lower-level elements, but definitions of these are outside the scope of this document.

The major processing activity often identifies the production line.

NOTE For example, production line identifiers from various industries are Bottling Line #1, Capping Line #15, CMOS Line #2 and Water Pump Assembly Line #4.

Production line and work cells have well-defined manufacturing capabilities and throughput capacities and these are used for Level 3 functions. The capacities and capabilities are also often used as input to Level 4 scheduling, even if the production lines and work cells are not scheduled by the Level 4 functions.

5.3.7 Process cell and unit

Process cells and units are the lowest level of equipment typically scheduled by the Level 4 and Level 3 functions for batch manufacturing processes. Units are usually only identified at Level 3 and 4 if there is flexibility in the routing of the product within a process cell. The definitions for process cells and units are contained in IEC 61512-1.

The major processing capability or family of products produced often identifies the process cell.

NOTE For example, process cell identifiers from various industries are Mixing Line #5, West Side Glue Line and Detergent Line 13.

Process cells and units have well-defined manufacturing capabilities and batch capacities and these are used for Level 3 functions. The capacities and capabilities may also be used as input data for Level 4 scheduling, even if the process cells or units are not scheduled by the Level 4 functions.

5.4 Decision hierarchy

5.4.1 Introduction

In addition to the hierarchy of activities, there is also a hierarchy of decision-making and associated scheduling involved in enterprise-to-control integration. The following subclauses cover the rationale for such a hierarchy, and the categories and time horizons of such decisions. This hierarchy of decision-making and a mapping to manufacturing operations will be discussed in a later part of this standard.

5.4.2 Integrated decision making

An enterprise is organized by functions and in levels, and decisions are made within multiple functions and multiple levels. Integrated decision-making means that the (different categories of) decisions made within various functions are consistent in the sense that they contribute to the achievement of the global objectives of the enterprise. This also means that the time horizons in which various decisions are made are coordinated. In relationship to production, this means that the correct raw materials and products are available at the correct time, on the correct machine and processed by the correct personnel. Decisions to execute the production are made in multiple time horizons.

5.4.3 Categories of decision-making

Decision-making activities deal with products, resources and time. The different combinations of these lead to a categorization into three basic types of decisions.

- Manage products: This is concerned with the management of products and time without regard to resources. Major decisions are concerned with what products, what quantity, and when those products are to be produced or procured.
- Manage resources: This is concerned with the management of resources and time. Major decisions of this category are concerned with the management of capacity of the resources.
- Plan production: This is concerned with the production planning that synchronizes the flow of products, resources, and time.

5.4.4 Time horizons

Decisions can be classified into three general basic time horizons.

- Long term and broad scope: These are long-term decisions that are concerned with the presentation of the objectives consistent with the global objectives of the enterprise.
- Medium term and intermediate scope: These are medium-term decisions that deal with the allocation of resources to meet the objectives defined in the long-term time horizon.
- Short term and limited scope: This is a short-term time horizon associated with the planning and execution of actions, using the means presented at the medium-term time horizon, to reach the objectives of the long-term time horizon.

6 Functional data flow model

6.1 Functional data flow model contents

This clause presents

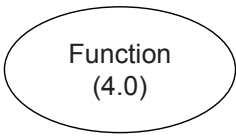
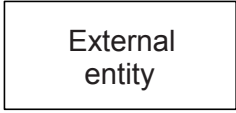
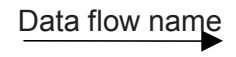
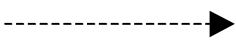
- a) the functions of an enterprise involved with manufacturing;
- b) the information flows between the functions that cross the enterprise-control interface.

6.2 Functional data flow model notation

The enterprise-control interface is described using a data flow model. The model uses the Yourdon-DeMarco notational methodology (see Bibliography).

Table 1 shows the Yourdon notation used in the functional model.

Table 1 – Yourdon notation used

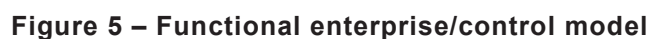
Symbol	Definition
	A function is represented as a labelled ellipse. A function is a group of tasks that are classified as having a common objective. Functions are organized in a hierarchical manner and are identified with a name and a number. The number represents an identification of the data model hierarchy level.
	An external entity is represented as a labelled rectangle. An external entity is a component outside the model boundaries that sends data to, and/or receives data from, the functions.
	A solid line with an arrow represents a grouping of data that flows between functions, data stores, or external entities. The data are defined in the enterprise-control integration model. All solid lines have a name for the data flows. A data flow at one level of the functional hierarchy may be represented by one or more flows at the lower level of the hierarchy.
	A dashed line with an arrow represents a grouping of data that flows between functions, data stores, or external entities. The data are not pertinent to the enterprise-control integration model but are shown to illustrate the context of functions. Dashed-line data flows without names are not identified in this model but are defined in Annex D.
	A persistent data storage is represented as the name of the data store with a line above and a line below the name. A persistent data store maintains information defined in a data flow, so that it is usable in a potentially non-synchronous manner with the original data source.

6.3 Functional enterprise-control model

The functional model is depicted in Figure 5. The wide dotted line illustrates the boundary of the enterprise-control interface. The line is equivalent to the Level 3/Level 4 interface presented in 5.1. The manufacturing control side of the interface includes most of the functions in production control and some of the activities in the other major functions. The labelled lines indicate information flows of importance to manufacturing control. The wide dotted line intersects functions that have sub-functions that may fall into the control domain or the enterprise domain depending on organizational policies. This is a combination of a function view and an information view of the enterprise, as defined in ISO 15704.

The model structure does not reflect an organizational structure within a company but an organizational structure of functions. Different companies will place the functions in different organizational groups.

The detailed information in the information flows is presented in Clause 7.



6.4.1 Order processing (1.0)

There is generally no direct interface between the functions of order processing and the manufacturing control functions.

- ### 6.4.2 Production scheduling (2.0)

Detailed scheduling, within an area, is considered to be a control function.

The general functions of production scheduling typically include

- a) the determination of production schedule;
- b) the identification of long-term raw material requirements;
- c) the determination of the pack-out schedule for end-products;
- d) the determination of the available product for sales.

The information generated or modified by the production scheduling functions includes

- 1) the production schedule;
- 2) the actual production versus the planned production;
- 3) the production capacity and resource availability;
- 4) the current order status.

6.4.3 Production control (3.0)

6.4.3.1 Production control main functions

The production control functions encompass most of the functions associated with manufacturing control. The functions of production control typically include

- a) controlling the transformation of raw materials into the end-product in accordance with the production schedule and production standards;
- b) performing plant engineering activities and updating of process plans;
- c) issuing requirements for raw materials;
- d) producing reports of performance and costs;
- e) evaluating constraints to capacity and quality;
- f) self-testing and diagnosis of production and control equipment;
- g) creating production standards and instructions for SOPs (standard operating procedures), recipes, and equipment handling for specific processing equipment.

The main functions in production control include process support engineering, operations control, and operations planning.

6.4.3.2 Process support engineering

The functions of process support engineering typically include

- a) issuing requests for modification or maintenance;
- b) coordinating maintenance and engineering functions;
- c) providing technical standards and methods to operations and maintenance functions;
- d) following up on equipment and process performance;
- e) providing technical support to operators;
- f) following up on technological developments.

The functions of process support engineering generate or modify the following information for use in other control functions.

- 1) Minor equipment and process modifications; this may include new design drawings.
- 2) Instructions on how to handle equipment; this may include standard operating procedures.
- 3) Instructions on how to make products; this includes production rules and the standard materials, equipment, and other resources used.
- 4) Material safety data sheets (MSDS).
- 5) Instructions on how to install equipment; this may include vendor equipment.
- 6) Environmental and safety operating limits and constraints.
- 7) Engineering standards for process equipment design techniques and process operational methods, and online operating instructions.

6.4.3.3 Operations control

Operations control is the collection of functions that manages all production within a site or area.

The functions of production control typically include

- a) producing the product according to the schedule and specifications;
- b) reporting production, process, and resource information;
- c) monitoring equipment, validating operational measurements, and determining the need for maintenance;
- d) preparing equipment for maintenance and returning it to service after maintenance;
- e) performing diagnostics and self-check of production and control equipment;
- f) balancing and optimizing production within the site or area;
- g) possible local site or area labour management and document management.

The functions of production control typically generate or modify the following information for use in other control functions.

- 1) Status of production requests.
- 2) Selected production data, such as data to calculate production cost and performance.
- 3) Selected process data, such as equipment performance feedback.
- 4) Status of resources.
- 5) Status of maintenance work order requests.
- 6) Requests for maintenance.
- 7) Diagnostic and self-test results.
- 8) Process history.
- 9) Requests for process support engineering support.
- 10) Requests for analysis of material.

6.4.3.4 Operations planning

The functions of operations planning typically include

- a) setting up a short-term production plan based on the production schedule;
- b) checking the schedule against raw material availability and product storage capacity;
- c) checking the schedule against equipment and personnel availability;
- d) determining the per cent of capacity status;
- e) modifying the production plan hourly to account for equipment outage, manpower and raw materials availability.

The functions of operations planning typically generate or modify the following information for use in other control functions.

- 1) Material and energy inventory report.
- 2) Material and energy requirements required to meet the production plan.
- 3) Site or area production plan for operations control.
- 4) Available capability of the production resources.

6.4.4 Material and energy control (4.0)

The functions of materials and energy control typically include

- a) managing inventory, transfers, and quality of material and energy;
- b) generating requests for purchasing of materials and energy based on short- and long-term requirements;
- c) calculating and reporting inventory balance and losses of raw material and energy utilization;
- d) receiving incoming material and energy supplies and requesting quality assurance tests;
- e) notifying purchasing of accepted material and energy supplies.

The functions of materials and energy control typically generate or modify the following information for use in other control functions.

- 1) Material and energy order requests.
- 2) Incoming confirmation of received materials and energy.
- 3) Material and energy inventory report.
- 4) Manual and automated transfer instructions for operations control.

Some of the functions within material and energy control may be inside the control domain, based on local organizational structures. Therefore, selected data flows into and out of material and energy control are presented because they may cross the enterprise-control system boundary.

6.4.5 Procurement (5.0)

The functions of procuring resources typically include

- a) placing orders with suppliers for raw materials, supplies, spare parts, tools, equipment and other required materials;
- b) monitoring progress of purchases and reporting to requisitioners;
- c) releasing incoming invoices for payment after arrival and approval of goods;
- d) collecting and processing of unit requests for raw materials, spare parts, etc., for order placement to vendors.

The functions of procurement typically generate or modify the expected material and energy delivery schedules for use in other control functions.

6.4.6 Quality assurance (6.0)

The functions of quality assurance typically include

- a) testing and classification of materials;
- b) setting standards for material quality;
- c) issuing standards to manufacturing and testing laboratories in accordance with requirements from technology, marketing and customer services;
- d) collecting and maintaining material quality data;
- e) releasing material for further use (delivery or further processing);
- f) certifying that the product was produced according to standard process conditions;
- g) checking of product data versus customer's requirements and statistical quality control routines to assure adequate quality before shipment.
- h) relaying material deviations to process engineering for re-evaluation to upgrade processes.

The functions of quality assurance typically generate or modify the following information for use in other control functions.

- 1) Quality assurance test results.
- 2) Approval to release materials or waivers on compliance.
- 3) Applicable standards and customer requirements for material quality.

Some of the functions within quality assurance may be inside the control domain, based on local organizational structures; for example, quality assurance requests. Therefore, selected data flows into and out of quality assurance are addressed because they may cross the enterprise-control system boundary.

6.4.7 Product inventory control (7.0)

The functions of product inventory control typically include

- a) managing the inventory of finished products;
- b) making reservations for specific product in accordance with product selling directives;
- c) generating the pack-out end product in accordance with delivery schedule;

- d) reporting on inventory to production scheduling;
- e) reporting on balance and losses to product cost accounting;
- f) arranging physical loading/shipment of goods in coordination with product shipping administration.

The functions of product inventory control typically generate or modify the following information for use in other control functions.

- 1) Finished goods inventory.
- 2) Inventory balances.
- 3) Pack-out schedule.
- 4) Release to ship.
- 5) Confirm to ship.
- 6) Requirements.

Some of the functions within product inventory control may be inside the control domain, based on local organizational structures. Therefore, selected data flows into and out of product inventory control are used because they may cross the enterprise-control system boundary.

6.4.8 Product cost accounting (8.0)

The functions of cost accounting typically include

- a) calculating and reporting on total product cost;
- b) reporting cost results to production for adjustment;
- c) setting cost objectives for production;
- d) collecting raw material, labour, energy and other costs for transmission to accounting;
- e) calculating and reporting on total production cost, reporting cost results to production for adjustment;
- f) setting cost objectives for materials and energy supply and distribution.

The functions of cost accounting typically generate or modify the following information for use in other control functions.

- 1) Cost objectives to production.
- 2) Performance and costs from production.
- 3) Parts and energy incoming to accounting from material and energy control.

6.4.9 Product shipping administration (9.0)

The functions of product shipping administration typically include

- a) organizing transport for product shipment in accordance with accepted orders requirements;
- b) negotiating and placing orders with transport companies;
- c) accepting freight items on site and releasing material for shipment;
- d) preparing accompanying documents for shipment (BOL, customs clearance);

- e) confirming shipment and releasing for invoicing to general accounting;
- f) reporting on shipping costs to product cost accounting.

6.4.10 Maintenance management (10.0)

The functions of maintenance management typically include

- a) providing maintenance for existing installations;
- b) providing a preventative maintenance programme;
- c) providing equipment monitoring to anticipate failure, including self-check and diagnostic programmes;
- d) placing purchase order requests for materials and spare parts;
- e) developing maintenance cost reports, and coordinating outside contract work effort;
- f) providing status and technical feedback on performance and reliability to process support engineering.

The functions of maintenance management typically generate or modify the following information for use in other control functions.

- 1) Maintenance schedules that specify the plan for future work orders.
- 2) Maintenance work orders that specify specific equipment to be taken out of service and made available for maintenance functions.
- 3) Diagnostic and self-test requests to be performed on the equipment.

Some of the functions within maintenance management may be inside the control domain, based on local organizational structures. Therefore, selected data flows into and out of maintenance management are shown because they may cross the enterprise-control system boundary.

6.4.11 Research, development, and engineering

The general functions of research, development and engineering typically include

- a) development of new products;
- b) definition of process requirements;
- c) definition of product requirements, as related to the production of the products.

6.4.12 Marketing and sales

The general functions of marketing and sales typically include

- a) generating sales plans;
- b) generating marketing plans;
- c) determining customer requirements for products;
- d) determining requirements and standards for products;
- e) interacting with customers.

6.5 Information flows

6.5.1 Information flow descriptions

The information flows between the functions that are labelled in Figure 5 are listed below.

6.5.2 Schedule

The schedule information flows from the production scheduling (2.0) functions to the production control (3.0) functions.

This typically contains the information, to production, on what product is to be made, how much is to be made, and when it is to be made. Elements of the schedule information are presented in 7.8 and are shown in Figure 22.

6.5.3 Production from plan

The production-from-plan information flows from the production control (3.0) functions to the production scheduling (2.0) functions.

This contains information about the current and completed production results from execution of the plan. It typically contains what was made, how much was made, how it was made, and when it was made. Elements of the production-from-plan information are presented in 7.8 and shown in Figure 23.

6.5.4 Production capability

The production capability information flows from the production control (3.0) functions to the production scheduling (2.0) functions.

Production capability information is the current committed, available, and unattainable capacity of the production facility. This typically includes materials, equipment, labour, and energy. Elements of the production capability information are listed in 7.6 and shown in Figure 18.

6.5.5 Material and energy order requirements

The material and energy order requirement information flows from the material and energy control (4.0) functions to the procurement (5.0) functions.

Material and energy order requirements define future requirements for materials and energy required to meet short-term and long-term requirements based on the current availability.

There are no object models for the material and energy order requirements, but the information may use the definitions relating to material and energy detailed in the Clause 7 object model.

6.5.6 Incoming order confirmation

The incoming order confirmation information flows from the material and energy control (4.0) functions to the procurement (5.0) functions.

Incoming order confirmations are the notification that the material or energy has been received.

This information is not detailed in the Clause 7 object model because it does not cross the interface between the enterprise and control domains.

6.5.7 Long-term material and energy requirements

The long-term material and energy requirements information flows from the production scheduling (2.0) functions to the material and energy control (4.0) functions.

The long-term material and energy requirements are typically time-sequenced definitions of material and energy resources that will be needed for planned production.

There are no object models for the long-term material and energy requirements, but the information may use the definitions relating to material and energy detailed in the Clause 7 object model.

6.5.8 Short-term material and energy requirements

The short-term material and energy requirements information flows from the production control (3.0) functions to the material and energy control (4.0) functions.

The short-term material and energy requirements are requirements for resources that are needed for currently scheduled or executing production. These typically include

- a) requests for materials that may include deadlines;
- b) reservations for materials;
- c) indications of actual consumption;
- d) release of reservations;
- e) adjustments to consumption.

Material is represented in Figure 16 in 7.5 and the material and energy requirements are represented in Figure 22 in 7.8.

6.5.9 Material and energy inventory

The material and energy inventory information flows from the material and energy control (4.0) functions to the production control (3.0) functions.

The material and energy inventory information flows are the currently available material and energy that is used for short-term planning and for production. This information typically deals with raw materials. Material and energy inventory information is given in 7.5.

6.5.10 Production cost objectives

The production cost objectives information flows from the product cost accounting (8.0) functions to the production control (3.0) functions.

Production cost objectives are the production performance targets in terms of resources. This could be related to a product or to a process. This typically includes materials, labour hours, energy, equipment usage, or actual costs. Elements of the production cost objectives are presented in 7.7 and shown in Figure 21.

6.5.11 Production performance and costs

The production performance and costs information flows from the production control (3.0) functions to the product cost accounting (8.0) functions.

Production performance and costs are the actual use and results associated with specific production activities. This typically includes materials, labour hours, energy, and equipment usage. Results are typically identified by products, by-products, co-products, and scrap. This information would be in sufficient detail to identify all costs by product, co-products, and scrap.

6.5.12 Incoming material and energy receipt

The incoming material and energy receipt information flows from the material and energy control (4.0) functions to the product cost accounting (8.0) functions.

Incoming material and energy receipt is the notification that the material or energy has been received and additional information needed for cost accounting. This may include the BOL, material safety data sheet (MSDS), and COA. This information is coordinated with the incoming order confirmation (6.5.6) information flow.

This information is not detailed in the Clause 7 object model because it generally does not cross the interface between the enterprise and control domains.

6.5.13 Quality assurance results

The quality assurance (QA) results information flows from the quality assurance (6.0) functions to the product inventory control (7.0) functions, material and energy control (4.0) functions, and the production control, operations control (3.2) functions.

Quality assurance results are typically the results from QA tests performed on raw materials, in-process materials, or products. Quality assurance results may concern tests performed in the product or in-process tests performed in a particular segment of production. Quality assurance results may include granting of in-process waivers.

A positive QA result may be required before product inventory management may ship a product. A positive QA result may be required before production control transfers product-to-product inventory control.

6.5.14 Standards and customer requirements

The standards and customer requirements information flows from the marketing and sales functions to the quality assurance (6.0) functions, and from quality assurance to production control (3.0).

Standards and customer requirements are the specific values for attributes of the product that satisfy the customer needs. This typically includes specific processing specifications as well as material properties. This information may result in changes in or additions to material, equipment, and personnel properties and associated tests (see 7.7).

6.5.15 Product and process requirements

The product and process requirements information flows from the research, development and engineering (RD&E) functions to the production control (3.0) functions and the quality assurance (6.0) functions.

The product and process requirements define how to make a product. This typically corresponds to general or site recipes in batch manufacturing, assembly instructions and drawings in discrete manufacturing, and process descriptions in continuous manufacturing. Information about specific equipment, personnel, and material requirements may be specified according to the models in 7.7.

6.5.16 Finished goods waiver

Finished goods waiver information flows from the order processing (1.0) functions to the quality assurance (6.0) functions.

Finished goods waivers are approvals for deviation from normal product specifications. Finished goods waivers may be negotiated customer deviations from specifications defined in the standards and customer requirements (6.5.14).

6.5.17 In-process waiver request

In-process waiver request information flows from production control (3.0) to the quality assurance (6.0) functions.

In-process waiver requests are requests for waivers on normal production procedures due to deviations in materials, equipment, or quality metrics, where normal product specifications are maintained. The response to the request is in the quality assurance results.

6.5.18 Finished goods inventory

The finished goods inventory information flows from the product inventory control (7.0) functions to the production scheduling (2.0) functions.

The finished goods inventory is information on the current inventory of finished goods that is maintained by product inventory control. This typically includes quantity, quality, and location information that is used for the scheduling of new production, and as feedback on previously scheduled production. This is the total finished product available for distribution or shipment. This information is described in 7.8.

6.5.19 Process data

The process data information flows from the production control (3.0) functions to the product inventory control (7.0) functions and the quality assurance (6.0) functions.

Process data is information about production processes, as related to specific products and production requests, and is described in 7.8. Typical uses of process data are by quality assurance as part of the QA functions, and by product inventory control where this information is needed as part of the finished product deliverables.

6.5.20 Pack-out schedule

The pack-out schedule information flows from the production scheduling (2.0) functions to the product inventory control (7.0) functions.

A pack-out schedule is the consolidation of produced items of one or more stock-keeping unit for delivery to customers, inventory, or others.

6.5.21 Product and process know-how

The product and process know-how information flows from the research, development and engineering (RD&E) functions to the production control (3.0) functions.

Product and process know-how typically includes standard operating procedures, recipes, critical safety limits, and analytical methods. This may be generated in response to operations requests or originated by RD&E for new products and processes.

Elements of the product and process know-how information are presented in 7.6 and 7.7 and in Figures 20 and 21.

6.5.22 Product and process information request

The product and process information request flows from the production control (3.0) functions to the RD&E functions.

A product and process information request is a request for new or modified product definitions and process definitions.

6.5.23 Maintenance requests

The maintenance request information flows from the production control (3.0) functions to the maintenance management (10.0) functions.

Maintenance requests are requests for a maintenance function. This may be a planned request or an unplanned request due to an unplanned event, such as a lightning strike on a transformer.

6.5.24 Maintenance responses

The maintenance response information flows from the maintenance management (10.0) functions to the production control (3.0) functions.

Maintenance responses are the logged status or completion of routine, scheduled, or unplanned maintenance.

6.5.25 Maintenance standards and methods

Maintenance standards and methods information flows from the production control (3.0) functions to the maintenance management (10.0) functions.

Maintenance standards and methods are typically accepted practices and procedures that maintenance uses in performing its functions.

6.5.26 Maintenance technical feedback

Maintenance technical feedback information flows from the maintenance management (10.0) functions to the production control (3.0) functions.

Maintenance technical feedback is typically information about the performance and reliability of production equipment and may include reporting on performed maintenance. Reports on maintenance may include scheduled, preventive, or predictive.

6.5.27 Product and process technical feedback

Product and process technical feedback information flows from the production control (3.0) functions to the RD&E functions.

Product and process technical feedback is information about the performance of production equipment and product. This information generally results from performance tests and study requests to operations control.

6.5.28 Maintenance purchase order requirements

Maintenance purchase order requirements information flows from the maintenance management (10.0) functions to the procurement (5.0) functions.

Maintenance purchase order requirements are information about materials and supplies required to perform maintenance tasks.

6.5.29 Production order

Production order information flows from order processing (1.0) functions to production scheduling (2.0) functions.

Production order is information about accepted customer orders that defines work for the plant.

6.5.30 Availability

Availability information flows from the production scheduling (2.0) functions to the order processing (1.0) functions.

Availability is information about the plant's ability to fulfil the order.

6.5.31 Release to ship

Release to ship information flows from the product shipping administration (9.0) functions to the product inventory control (7.0) functions.

Release to ship is information about the permission to ship the product.

6.5.32 Confirm to ship

Confirm to ship information flows from the product inventory control (7.0) functions to the product shipping administration (9.0).

Confirm to ship is information about the actual shipment of product.

7 Object model**7.1 Model explanation**

Subclause 7.2.1 is an overview of the information contained in the object model and provides a context for the object models. It includes the general categories of information given in extra detail in 7.2.2, 7.2.3, and 7.2.4.

7.2 Categories of information

7.2.1 Information areas

Most of the information described in the Clause 6 model falls into the following three main areas.

- a) Information about the capability to produce a product.
- b) Information required to produce a product.
- c) Information about actual production of the product.

Some information in each of these three areas is shared between the manufacturing control systems and the other business systems, as illustrated in Figure 6. Venn diagrams are used to illustrate the overlap of information. This standard is only concerned with the overlapping information in the Venn diagrams, and with presenting a model and common terminology for that information.

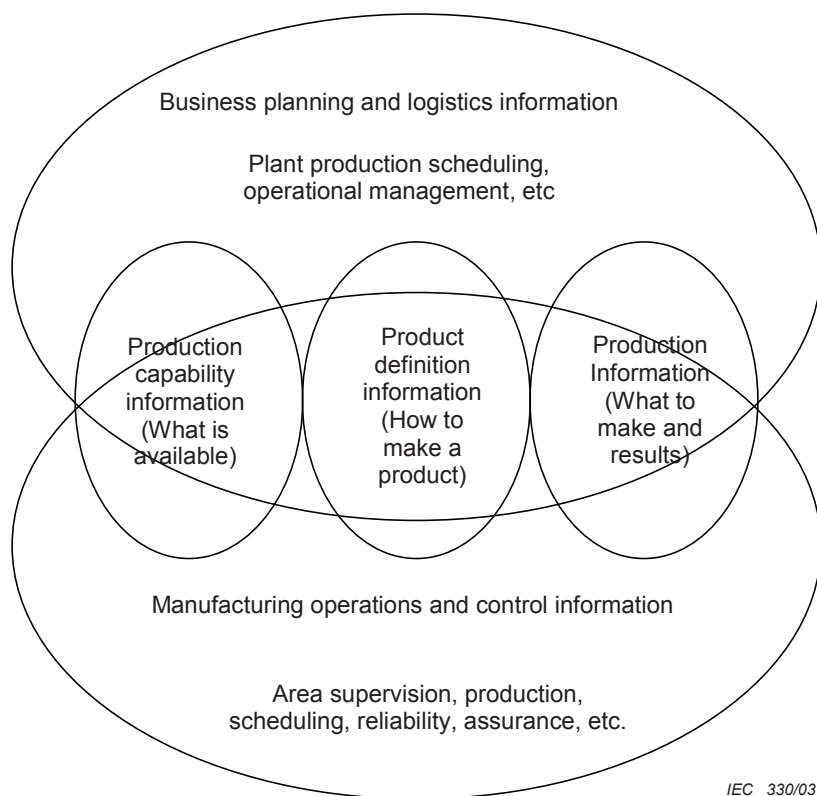
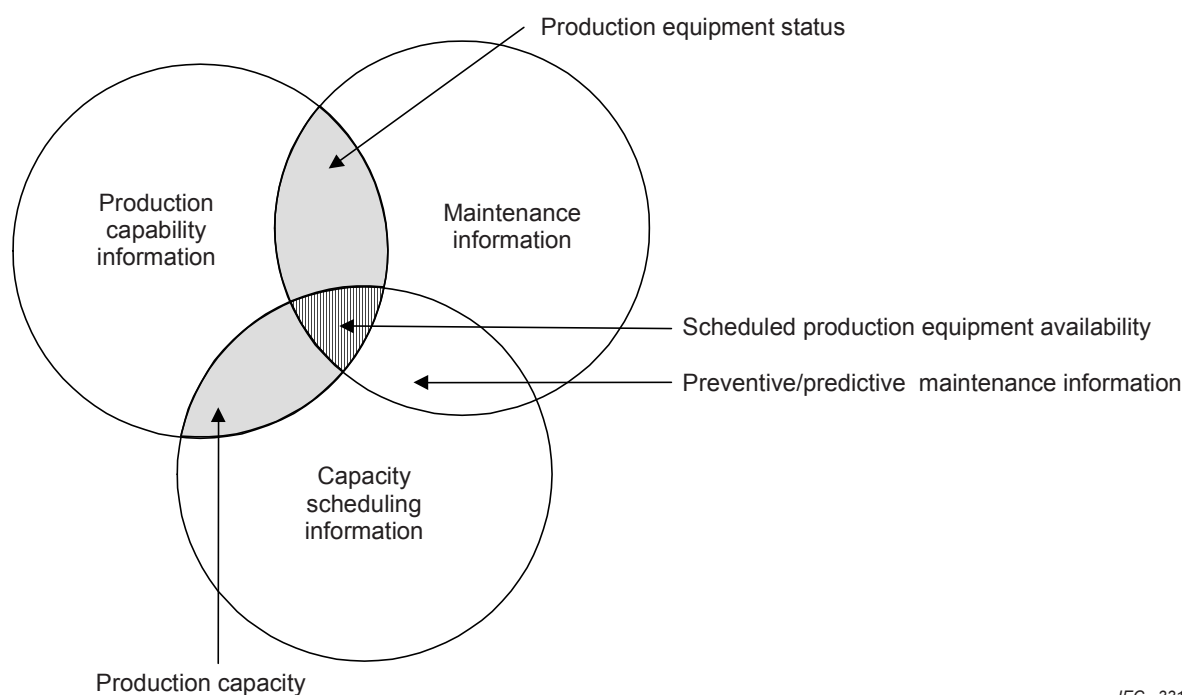


Figure 6 – Areas of information exchange

7.2.2 Production capability information

7.2.2.1 Production capability information categories

There are three main areas of information about the production capability that have significant overlap. The three areas of information are production capability information, maintenance information, and capacity scheduling information. Figure 7 illustrates the overlapping information.



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Figure 7 – Production capability information

7.2.2.2 Production capability information

For each site, area, and element within the area there is a presentation of the production capability of the personnel, equipment, and materials.

The production capability information includes the current state of what is available as updated by the production capability model in Figure 18.

7.2.2.3 Maintenance information

For each site, area, and element within the area there is a listing of the equipment as required for maintenance. This includes maintenance records and other information that is not part of the production capability model.

The maintenance information includes the current maintenance state of the equipment, as shown by information in the production capability model shown in Figure 18.

7.2.2.4 Capacity scheduling information

The capacity scheduling information contains the process segments available for the product unit, process cell, or production line.

For each site, area, and equipment element within the area there is a presentation of the production capacity of the personnel, equipment, and materials needed for scheduling of production.

7.2.2.5 Production equipment status

Production equipment status is information shared between the capability model of the equipment and the maintenance model. This includes the listing of the equipment, the current status of the equipment, and the usage history of the equipment.

7.2.2.6 Production capacity

Production capacity is defined as the information shared between the production capability model and the capacity scheduling model. This includes the listing of the capacity and current status of the personnel, equipment, and materials.

7.2.2.7 Scheduled production equipment availability

Scheduled production equipment availability is a dynamic interaction of production capability information, maintenance information, and capacity scheduling information that allows forecasting of scheduled production equipment availability.

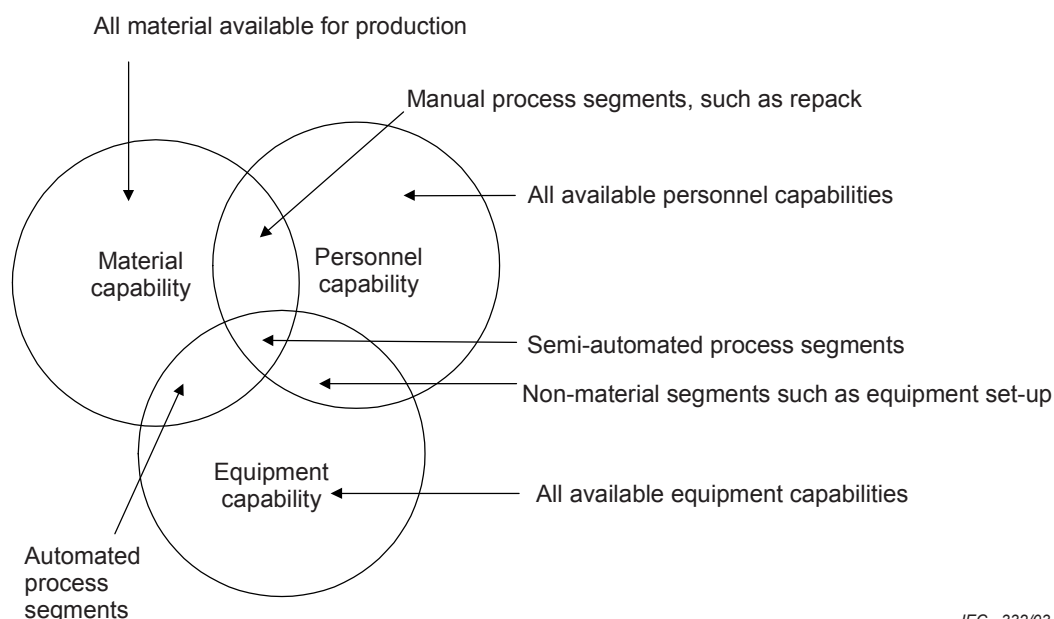
7.2.2.8 Preventive/predictive maintenance information

Preventive/predictive maintenance information is the correlation of equipment health and maintenance requirements with capacity scheduling information so as to align maintenance processes and adjust the capacity scheduling information during the maintenance processes.

7.2.2.9 Process segment capability

A capability may be given in terms of a process segment. Process segments show the business view of a part of the manufacturing process. The capabilities may specify specific capabilities or the class of capability (such as class of equipment) needed for the process segment. Figure 8 illustrates how capabilities relate to process segments.

- A manual process segment may define the class of materials and class of personnel needed for production.
- A semi-automated process segment may define the class of materials, personnel, and equipment needed.
- A non-material process segment, such as an equipment set-up segment, may define the class of equipment and personnel used.
- An automated process segment may only define the material and equipment classes needed.



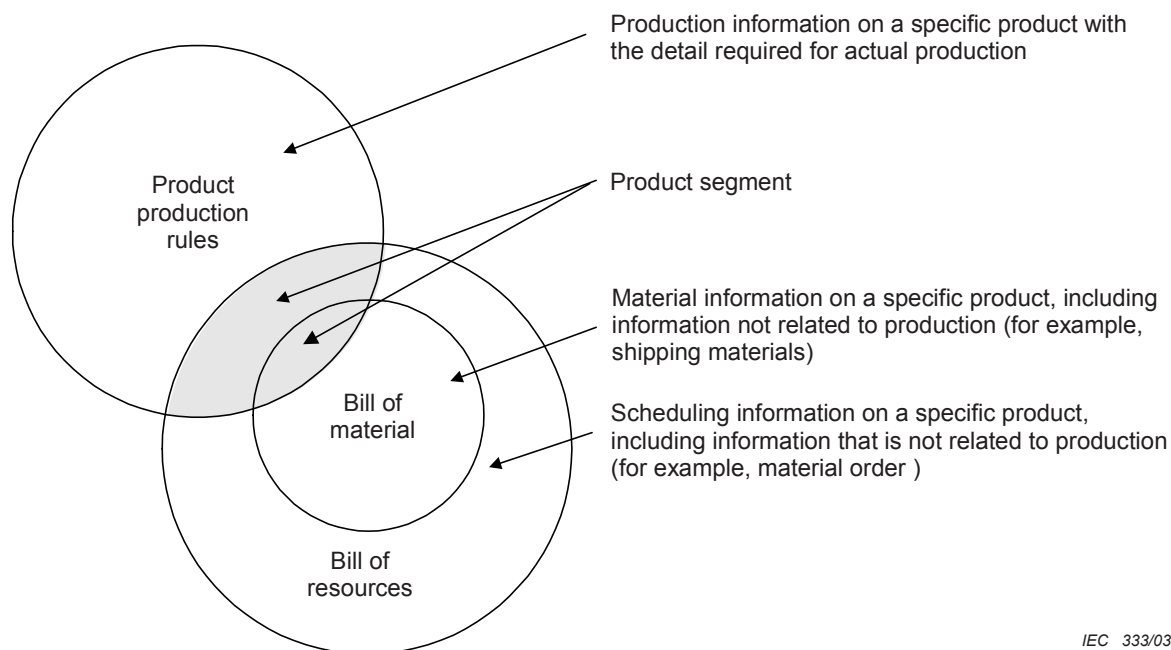
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Figure 8 – Process segment capabilities

7.2.3 Product definition information

7.2.3.1 Product definition information categories

There are three main areas of information required for the production of a specific product that have significant overlap. The three areas are information for scheduling, material information, and production rules. Figure 9 illustrates the overlapping information.



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Figure 9 – Production information definition

7.2.3.2 Product production rules

Product production rules are the information used to instruct a manufacturing operation how to produce a product. This may be called a general site or master recipe (IEC 61512-1 definitions), product data AP (application protocol) as defined in ISO 10303-1, standard operating procedure (SOP), standard operating conditions (SOC), routing, or assembly steps based on the production strategy used.

7.2.3.3 Bill of material

The bill of material is a list of all materials required to produce a product showing the quantity of each required. These may be raw materials, intermediate materials, subassemblies, parts, and consumables. This list does not contain the breakdown of where the materials are used or when they are needed, but it may be organized in a hierarchical manner that maps to some of the production steps. The bill of material often includes material that is not related to production of the product, such as shipping materials or included documentation. The bill of material is a subset of the bill of resources.

The manufacturing bill is the subset of the bill of material that is related to production.

7.2.3.4 Bill of resources

The bill of resources is the list of all resources required to produce a product. Resources may include materials, personnel, equipment, energy, and consumables. The bill of resources does not contain the specific production steps, but it may be organized in a hierarchical manner that maps to some of the production steps.

7.2.3.5 Product segment

Product segment is the overlap of information between product production rules and the bill of resources. It describes a job or task consisting of one or more work elements, usually carried out essentially in one location. A product segment is the most detailed process view for the business system to control material, labour, resource usage, cost, and quality in order to control the production.

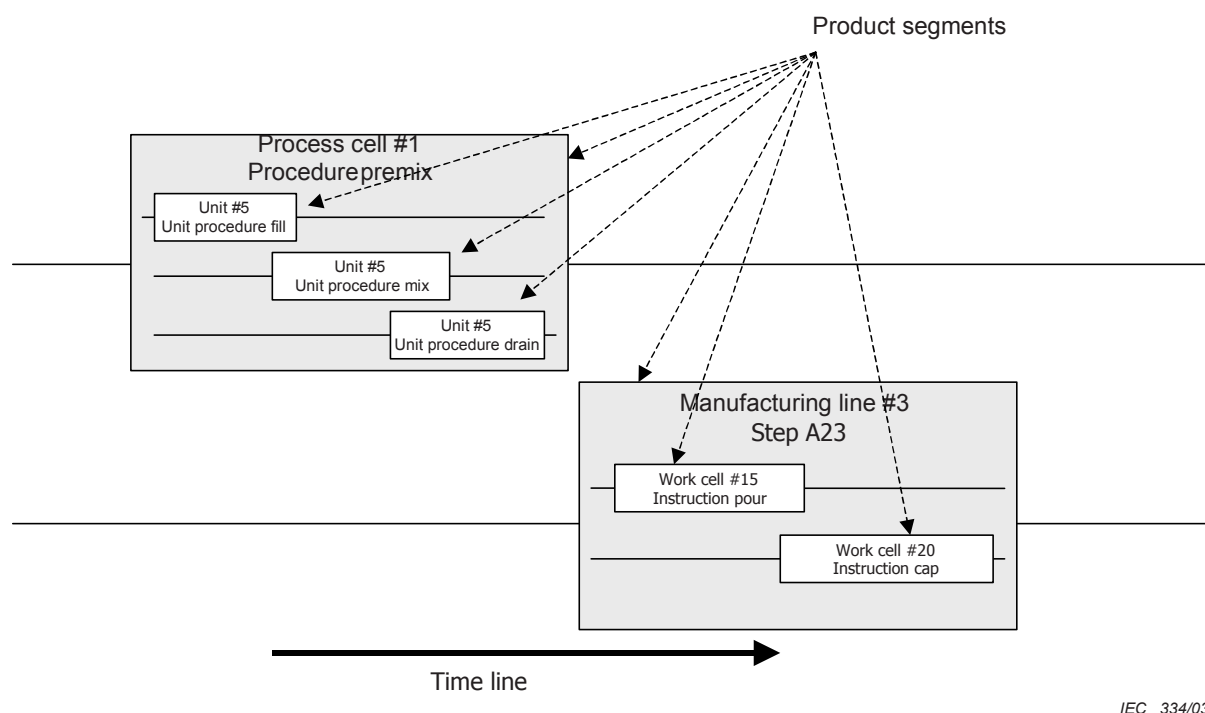
Product segments may correspond to

- a) IEC 61512-1 process stages, process operations, unit procedures, or operations for batch manufacturing;
- b) production unit operations for continuous manufacturing;
- c) assembly steps and assembly actions for discrete manufacturing;
- d) other types of identifiable time spans for other types of manufacturing.

The example in Figure 10 illustrates product segments in a Gantt-type chart with time on the horizontal axis and each box corresponding to a different product segment.

Production routing is the overlap of information between the product production rule information and bill of resources information without the bill of material information. It represents all of the non-material aspects of production such as equipment, labour, and energy. Production routings include an ordered sequence of product segments.

Material routing is the overlap of information between the production rule information and the bill of material information. It represents both the production material inputs and where they are used in product segments.

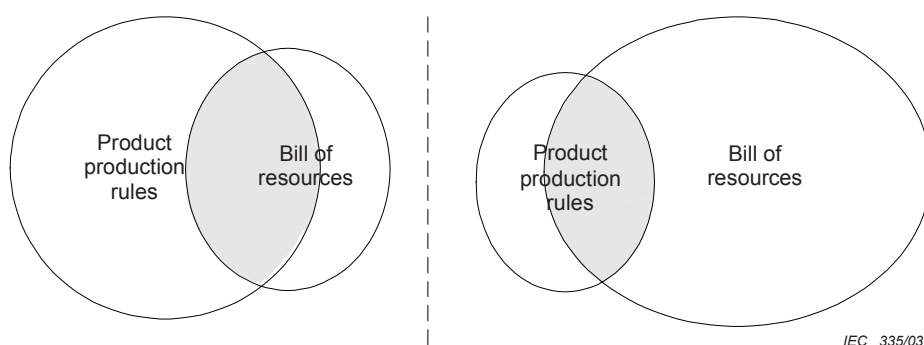


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Figure 10 – Example of process segments

7.2.3.6 Overlapping areas

Figure 9 illustrates the overlap of information between different areas but is not meant to represent the amount or importance of the information. Different manufacturing and business strategies will have different amounts of information shared between the different areas. Figure 11 illustrates the amount of information in two examples. The left side of the figure shows an example where the manufacturing systems maintain most of the information required for a product. The right side of the figure shows an example where the business systems maintain most of the information.



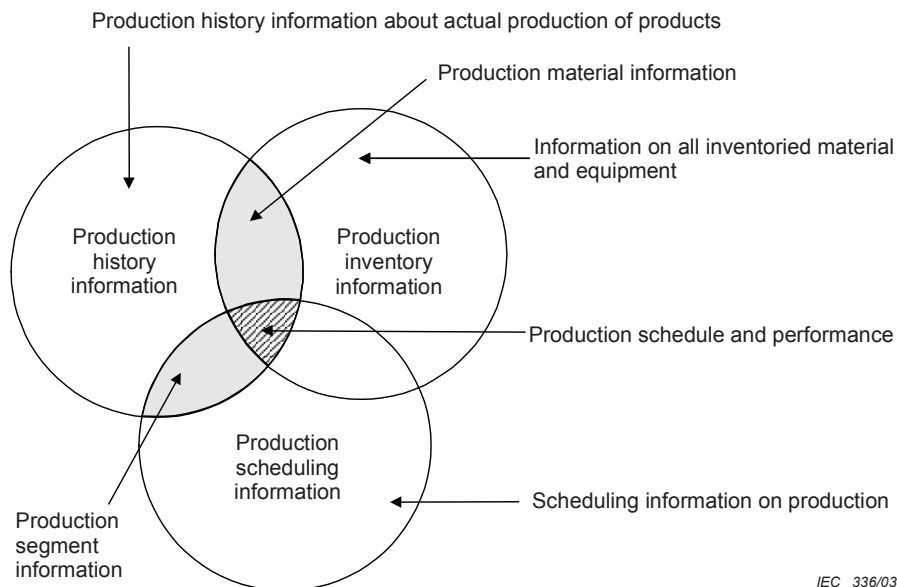
IEC 335/03

Figure 11 – Possible information overlaps

7.2.4 Production information

7.2.4.1 Production information categories

There are three main areas of information about actual production that have significant overlap. These three areas are production information, inventory information, and the production scheduling information. Figure 12 shows the overlap between the areas of information.



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Figure 12 – Production information

7.2.4.2 Production history information

Production history information is all of the information recorded about production of a product. This may be called by many names, such as the batch journal, product log, or traveller.

7.2.4.3 Production inventory information

Production inventory information is all of the information about inventoried materials, including the current status of the materials. Typically all consumed and produced materials are maintained in the production inventory information, and sometimes intermediates are maintained if they are needed for financial evaluation. In some industries this may include energy information.

7.2.4.4 Production scheduling information

The scheduling model contains all of the information about the execution of scheduled production runs.

7.2.4.5 Production segment information

The production segment information is the part of the production history information that contains information on the segments of production and is used for scheduling.

7.2.4.6 Production material information

The production material information is the part of the production history information that contains information on material that is used by inventory.

7.2.4.7 Production schedule and performance

Production schedule and performance information is shared among production information, inventory information, and scheduling information. This includes the listing of the raw materials consumed, materials produced, and materials scrapped. It also includes the discussion of how long segments of production actually took and how much material was produced and consumed by specific segments of production. This information is generally used to track actual production against production requests and as feedback to the scheduling cycle.

7.2.5 Process segment

Given the previous definitions, a process segment is the collection of capabilities needed for a segment of production, independent of any particular product. This may include material, energy, personnel, or equipment capabilities as presented in 7.6.1.

There is a relationship among the collection of process segments, the product segment listings for each product, and the segment requirements for any specific production request. This concept is illustrated in Figure 13. A product segment references a process segment known to production, and a segment requirement references a known product segment of the product being manufactured.

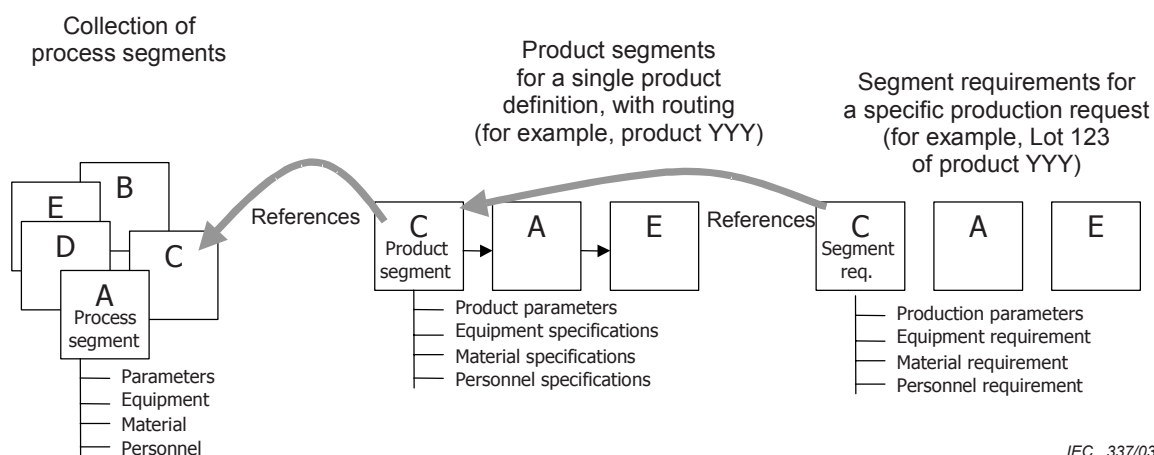


Figure 13 – Segment relationships

7.3 Object model structure

The object models are depicted using the unified modelling language (UML) notational methodology, as defined in ISO/IEC 19501-1. The diagrams have been kept simple and as a result a single object may appear on multiple diagrams.

Table 2 defines the UML notations used in the object diagrams.