INTERNATIONAL STANDARD

ISO 15531-43

First edition
2006-08-15

Industrial automation systems and integration — Industrial manufacturing management data —

Part 43: Manufacturing flow management data: Data model for flow monitoring and manufacturing data exchange

Systèmes d'automatisation industrielle et intégration — Données de gestion de fabrication industrielle —

Partie 43: Données de gestion des flux de fabrication: Modèle de données pour suivi des flux et échange des données de fabrication

Reference number
ISO 15531-43:2006(E)

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Published in Switzerland

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Foreword

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

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

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ISO 15531-43 was prepared by Technical Committee ISO TC184/SC4, *Industrial automation systems and integration*, Subcommittee SC4, *Industrial data*.

A complete list of parts of ISO 15531 is available from the Internet:

http://www.tc184-sc4.org/titles

Introduction

The information generated about the manufacturing process of an industrial product is very important for the life cycle of this product, notably in a context of sustainable development. Manufacturing may be defined as the transformation of raw material or semi-finished components leading to goods production. Manufacturing management is the function of directing or regulating the flows of goods through the entire production cycle from requisitioning of raw materials to the delivery of the finished product, including the impact on resources management.

A manufacturing management system manages the flow of information and materials through the whole production chain, from suppliers, through to manufacturers, assemblers, distributors, and sometimes customers.

The relations among those partners may be identified and structured in an electronic form with a view to facilitating electronic exchanges. Information handled during these exchanges is identified, modelled and represented in such a way that may be shared by a maximum of partners through the usage of standards for product and manufacturing data modelling.

The production planning functions within the supplier plants are assumed to have strong relationships with the master production scheduling functions of the main plant, which shares information with them, on the likely pattern of the future demands to allow suppliers to plan in turn their production. On a day-to-day basis, the operational planning system of the main plant sends orders to the suppliers to ensure the availability of components, sub-assemblies and others, such as resources needed for its manufacturing and assembly process.

ISO 15531 addresses the type of information described above. It is does not standardise the model of the manufacturing process. The aim of ISO 15531 is to provide a standardised data model for representing manufacturing management data. Its purpose is to facilitate the integration between the numerous industrial applications by means of common, standardised software that is able to represent these three sets of data.

ISO 15531 is organised as a series of parts, each published separately. The parts of ISO 15531 fall into the following series: production data for external exchange, manufacturing resources usage management data, time model management and manufacturing flow management data.

This part of ISO 15531 addresses the representation of data related to manufacturing flow and process management, through the development of a data model of the manufacturing flows and processes. Particular attention has been paid in the development of this part of ISO 15531 to the relation with the other standards developed in ISO TC184/SC4, such as ISO 10303, ISO 13584, ISO 15926. In addition to the fact that this part of ISO 15531 is developed using EXPRESS language (see ISO 10303-11: 2004) Edition 2, it makes extensive use of several constructs of ISO 10303-41, and references ISO 13584 dictionaries.

Industrial automation systems and integration — Industrial manufacturing management data — Part 43: Manufacturing flow management data: Data model for flow monitoring and manufacturing data exchange

1 Scope

This part of ISO 15531 provides a data model for flow management, and a related set of building blocks, from which are specified standardized data models and representations for the planning, scheduling, controlling and monitoring of material and informational flows. This is in contrast with ISO 15531-42, which provides a time model only.

Consequently this part of ISO 15531 provides a representation of data related to flow control and management in manufacturing, through the development of a conceptual flow model.

The following are within the scope of this part of ISO 15531:

— representation of data related to the management and control of manufacturing flows.

NOTE – This information is usually provided within the main plant, and exchanged among the different machine tools, or production cells.

The following are outside the scope of this part of ISO 15531:

— modelling of information related to the external exchanges;

— modelling of information related to the resource usage made during the manufacturing processes;

— modelling of the information related to the representation of the time.

2 Normative references

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

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

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

ISO 10303-11: 2004, *Industrial automation systems and integration – Product data representation and exchange – Part 11: Description methods: The EXPRESS language reference manual*

ISO 10303-41, *Industrial automation systems and integration – Product data representation and exchange – Part 41: Integrated generic resources: Fundamentals of product description and support*

ISO 10303-49, *Industrial automation systems and integration – Product data representation and exchange – Part 49: Integrated generic resources: Process structures and properties*

ISO 13584-1, *Industrial automation systems and integration – Parts library – Part 1: Overview and fundamental principles*

ISO 13584-24, *Industrial automation systems and integration – Parts library – Part 24: Logical resource: Logical model of supplier library*

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

ISO 15531-31: 2004, *Industrial automation systems and integration – Industrial manufacturing management data – Part 31: Resource information model*

ISO 15531-32, *Industrial automation systems and integration – Industrial manufacturing management data: Resources usage management – Part 32: Conceptual model for resources usage management data*

ISO 15531-42, *Industrial automation systems and integration – Industrial manufacturing management data – Part 42 : Time model*

IEC 62264-1 : 2003, *Enterprise-control system integration ─ Part 1 : Models and terminology*

3 Terms, definitions, and abbreviations

3.1 Terms and definitions

For the purposes of this document, the following definitions apply:

3.1.1
capability
quality of being able to perform a given activity

NOTE The capability is defined by a group of characteristics that describes functional aspects of manufacturing resources or system.

[ISO 15531-1]

3.1.2
capacity
capability of a system, sub-system or resource to perform its expected function from a quantitative point of view

EXAMPLE The capacity of a system or a resource to produce a given quantity of output in a particular time period.

NOTE For a given system or resource the distinction between capacity available and capacity requested may be

useful.

[ISO 15531-1]

3.1.3
carrying process
transportation process
process that supports flows between other processes

NOTE The other processes may be manufacturing processes and/or other carrying processes. A carrying process is a specialisation of process, it may also be considered as a specialisation of manufacturing process. Nevertheless in the context of flow management a clear distinction shall be made between processes that support directly the manufacturing and process that are more logistic and facilities-oriented.

3.1.4
data
representation of information in a formal manner suitable for communication, interpretation, or processing by human beings or computers

[ISO 10303-1]

3.1.5
data exchange
storing, accessing, transferring, and archiving of data

[ISO 10303-1]

3.1.6
device
any identified physical equipment, system or subsystem that does not belong to software, data set or human resource class

NOTE A device may nevertheless include software.

[ISO 15531-1]

3.1.7
discrete manufacturing
production of discrete items

EXAMPLE Cars, appliances or computer.

[ISO 15531-1]

3.1.8
division process
carrying process that divides flows into more flows

3.1.9
entity
class of information defined by common properties

[ISO 10303-11]

3.1.10
enterprise entity
any concrete or abstract thing in the universe of discourse of an enterprise

NOTE The concept provided here belongs to the broader concept of entity as defined in ISO 15704 [2]. The concept of entity as defined in those standards has been restricted here to avoid inconsistency with the term of entity as defined in ISO 10303-11. Then excepted in the definition of universe of discourse the term entity applies in ISO 15531 with the definition provided by ISO 10303-11.

[ISO 15531-1]

3.1.11
environment
part of the universe of discourse that does not belong to the system itself

EXAMPLE Inputs and outputs of the systems, such as raw material, final products etc., belong to the environment of the system as well as constraints that apply to it or time

[ISO 15531-42]

3.1.12
flow
motion of a set of physical or informational objects in space and time

[ISO 15531-1]

3.1.13
flow control
specific production control system that is based primarily on setting production rates and feeding work into production to meet these planned rates, then monitoring and controlling production

NOTE That includes the act of checking and driving the flow according to a given purpose. The term may also apply to the function or service. Definition adapted from APICS dictionary [5].

[ISO 15531-1]

3.1.14
flow model
representation or description of manufacturing-related flows describing only the aspects relevant for its purpose

[ISO 15531-1]

3.1.15
information
facts, concepts, or instructions

[ISO 10303-1]

3.1.16
junction process
carrying process that enables the grouping of several flows into one or more other flows

3.1.17
manufacturing
function or act of converting or transforming material from raw material or semi-finished state to a state of further completion

NOTE Definition adapted from APICS dictionary [5].

[ISO 15531-1]

3.1.18
manufacturing management
function or act of directing or regulating the flows of goods through the entire production cycle from requisitioning of raw materials to the delivery of the finished product, including the impact on resources management

[ISO 15531-1]

3.1.19
manufacturing process
structured set of activities or operations performed upon material to convert it from the raw material or a semifinished state to a state of further completion

NOTE Manufacturing processes may be arranged in process layout, product layout, cellular layout or fixed position layout. Manufacturing processes may be planned to support make-to-stock, make-to-order, assemble-to-order, etc., based on strategic use and placements of inventories.

[ISO 15531-1]

3.1.20
model
representation or description of an entity or a system, describing only the aspects considered to be relevant for its purpose

NOTE Entity is not used here with the meaning provided by ISO 10303-11 but with the sense usually given in ISO 15704 [2]

[ISO 15531-1]

3.1.21
operation
job or task consisting of one or more work elements, usually done essentially in one location

NOTE Definition from APICS dictionary [5].

3.1.22
planning
analysis and design of the sequence of processes, of the resource requirements and flow management constraints needed to achieve a given operation

[ISO 10303-1]

3.1.23
process
structured set of activities involving various enterprise entities, that is designed and organised for a given purpose

NOTE The definition provided here is very close to that given in ISO 10303-49. Nevertheless ISO 15531 needs the notion of structured set of activities, without any predefined reference to the time or steps. In addition, from the point of view of flow management, some empty processes may be needed for a synchronisation purpose although they are not actually doing anything (ghost task).

[ISO 15531-1]

3.1.24
product
thing or substance produced by a natural or artificial process

[ISO 10303-1]

3.1.25
product data
representation of information about a product in a formal manner suitable for communication, interpretation, or processing by human beings or by computers

[ISO 10303-1]

3.1.26
resource
any device, tool and means, excepted raw material and final product components, at the disposal of the enterprise to produce goods or services

NOTE 1 Resources as they are defined here include human resources considered as specific means with a given capability and a given capacity. Those means are considered as being able to be involved in the manufacturing process through assigned tasks. That does not include any modelling of an individual or common behaviour of human resource excepted in their capability to perform a given task in the manufacturing process (e.g.: transformation of raw material or component provision of logistic services). That means that human resources are only considered, as the other, from the point of view of their functions, their capabilities and their status (e.g.: idle, busy). That excludes any modelling or representation of any aspect of individual or common «social» behaviour.

NOTE 2 This definition includes ISO 10303-49 definition.

[ISO 15531-1]

3.1.27
scheduling
act, function or result of planning occurrences of manufacturing activities

[ISO 15531-1]

3.1.28
unit of time
unit that is implicitly or explicitly a multiple of the internationally-defined second, to which a measure of time in a time domain refers

NOTE 1 In other words, unit of time is the quantity of time chosen as a reference, in terms of which other quantities of time may be expressed. The second is the unit of time defined in the SI system of units.

NOTE 2 The multiplication ratio may be either greater or smaller than one.

[ISO 15531-42]

3.1.29
universe of discourse
the collection of concrete or abstract things that belong to an area of the real world, selected according to its interest for the system to be modelled and for its corresponding environment.

NOTE Definition adapted from ISO 19439 [3]

[ISO 15531-1]

3.2 Abbreviations

For the purposes of this part of ISO 15531, the following abbreviations applies:

MANDATE	MANufacturing management DATa Exchange
STEP	STandard for the Exchange of Product model data

4 General purpose and scope of ISO 15531

ISO 15531, also known as MANDATE, specifies the characteristics for a representation of manufacturing management information over the entire industrial process, with the necessary mechanisms and definitions to enable manufacturing management data to be shared and exchanged within the factory, with other plants or with companies.

Exchanges are made through different computer systems and environments associated with the complete industrial process. ISO 15531 focuses on discrete manufacturing but is not limited to it. Nevertheless, any extension to industrial processes which does not belong to discrete manufacturing is always under consideration when it does not imply any contradiction or inconsistency with the initial objective of ISO 15531.

The following are within the scope of ISO 15531:

— the representation of production and resources information, including capability, capacity, monitoring, maintenance constraints and control;

NOTE - Maintenance constraints and relevant maintenance management data are taken into account from the

point of view of their impact on the flow control.

— the exchange and sharing of production information and resources information, including storing, transferring, accessing and archiving.

The following are outside the scope of ISO 15531:

— enterprise modelling;

NOTE - That means that tools, architecture and methodologies for the modelling of an enterprise as a whole are not within the scope of ISO 15531.

— product data (representation and exchange of product information);

— component data (parts library: representation and exchange of computer-interpretable parts library information);

— cutting tools (electronic representation for exchange of cutting tool data);

— technical maintenance information (technical information such as those included in devices repair, operation and maintenance manuals).

5 Manufacturing flow management data

5.1 Management of manufacturing flows

This part of ISO 15531 addresses the modelling of data for the management of manufacturing flows as well as flow control in a shop floor or factory. This manufacturing flow model is provided in the context of various processes that run simultaneously and/or sequentially, providing one or more products and/or components and involving numerous resources as indicated in Figure 1.

In this context one component may be the input of several processes, one process may provide different components and/or product simultaneously or successively, different processes may make use of the same resource successively.

EXAMPLE 1 In the Figure 1 the same component (or raw material) C2 is an input of processes A and F, as well as component (or raw material) C3 for processes F and L.

EXAMPLE 2 In the Figure 1 process A provides components for both processes B and D ; process F provides components for process C, K and G ; process L provides components for processes H and M, etc. that may occur simultaneously or successively.

EXAMPLE 3 In the Figure 1 process E gets components from processes D and C and provides products (or components) P2 and P3; process D provides, product (or component) P1 and a component for process E as well as process N gets components from processes H and M to provide products (or components) P7 and P8. All these operations may occur simultaneously or successively.

EXAMPLE 4 Processes B and C make, successively, use of the same resources, as well as processes G and H with another resource.

This part of ISO 15531 provides a way to model the data needed to manage the multiple complex

flows that have to be taken into account between the different manufacturing processes that run simultaneously or successively in a factory. That includes, products, components or raw material flows as well as services flow such as information flows.

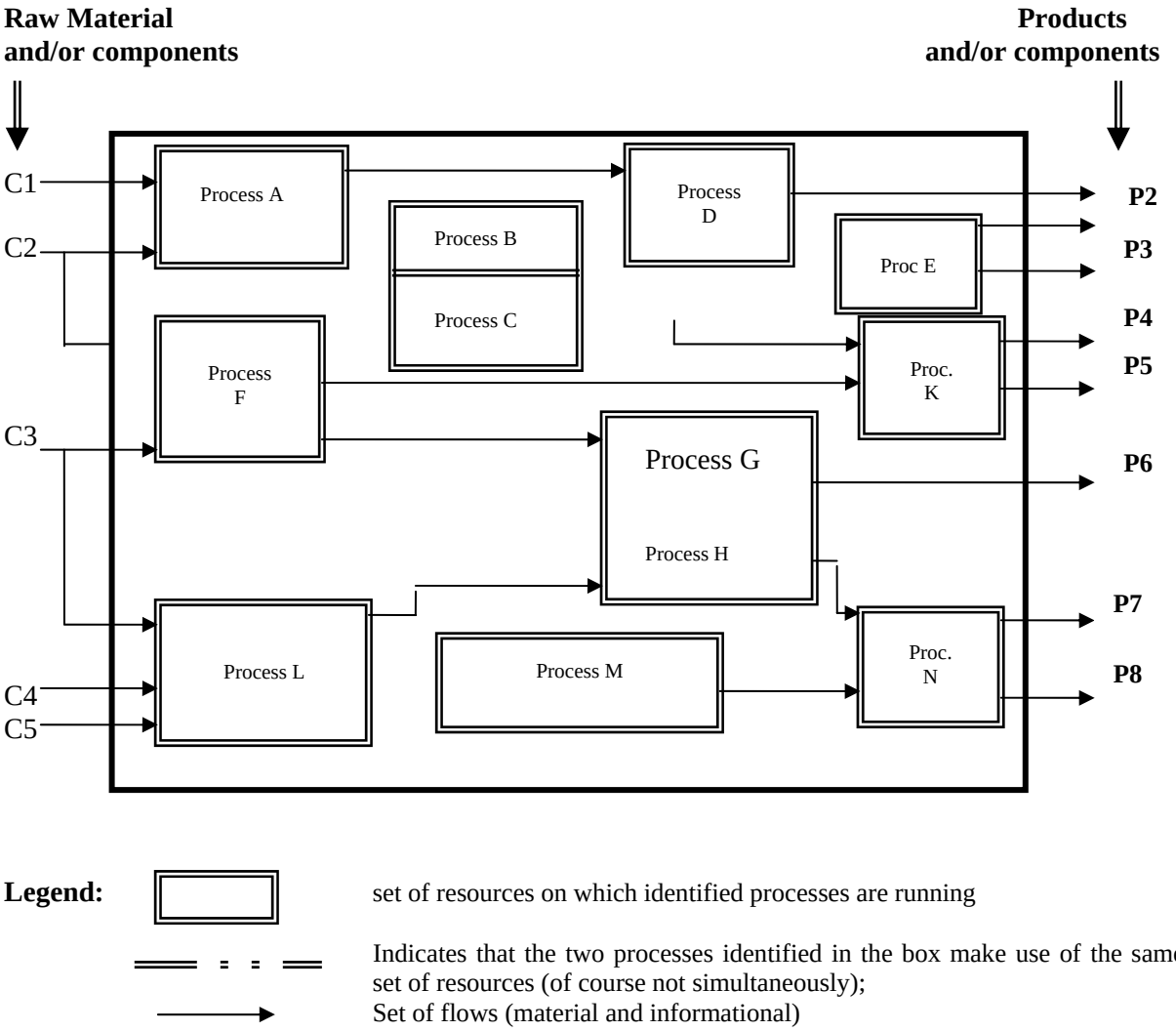


Figure 1 — Multiple manufacturing processes in a factory

Since the universe of discourse of this part of ISO 15531 is the complete manufacturing processes in a factory , the flows management data under consideration also includes the data used to manage the flows that are coming from the environment of the factory (considered as a system) as well as those that are going to this environment.

EXAMPLE 5 Data that are needed to manage the flow of components that are coming from other factories of the company or from suppliers.

According to these requirements, this part of ISO 15531 defines in 5.2 the fundamental concepts and principles for the **manufacturing_flow_management_data_schema**. 5.3 specifies this schema that provides the structural aspects of manufacturing flows processes in the context of planning, scheduling, monitoring and control. In the following clauses of this part of ISO 15531, the EXPRESS

constructs, which conform to ISO 10303-11 of this schema, allow for the representation of constraints relevant for planning, scheduling, monitoring and controlling of manufacturing processes.

NOTE Though this part of ISO 15531 has been set up for discrete part manufacturing flow management data, all the schema may be used for continuous processes.

5.2 Fundamental concepts and assumptions

Two kinds of independent concepts or enterprise entities are needed to model a flow of material or informational objects between two processes A and B.

EXAMPLE 1 Material and informational flows between a milling machine that performs the process A and a drilling machine that performs the process B.

The first one addresses the modelling of the physical process that performs the carrying of the concerned objects between the process A and the process B. This physical process that is called carrying process, or transportation process in order to distinguish it from purely manufacturing or machining processes, is a system, as any other processes. It has input (from process A) and output (to process B) it includes a physical system (its resources) and a control system as described in ISO 15531-31 : 2004, Annex D and IEC 62264-1 : 2003, Annex F. Figure 2 provides a basic representation of the relationship between process A and process B through arrows that represent the overall flows between the two processes, while Figure 3 details the representation of the flows through the representation of a carrying process.

The second kind of concepts is more abstract. It specifies the characteristics of the transfer of objects between process A and process B in term of flow content identification, flow logical origin and flow logical destination, but also in term of the quantity of objects to be transferred per unit of time. All these information are flow management data, their modelling is the purpose of this part of ISO 15531.

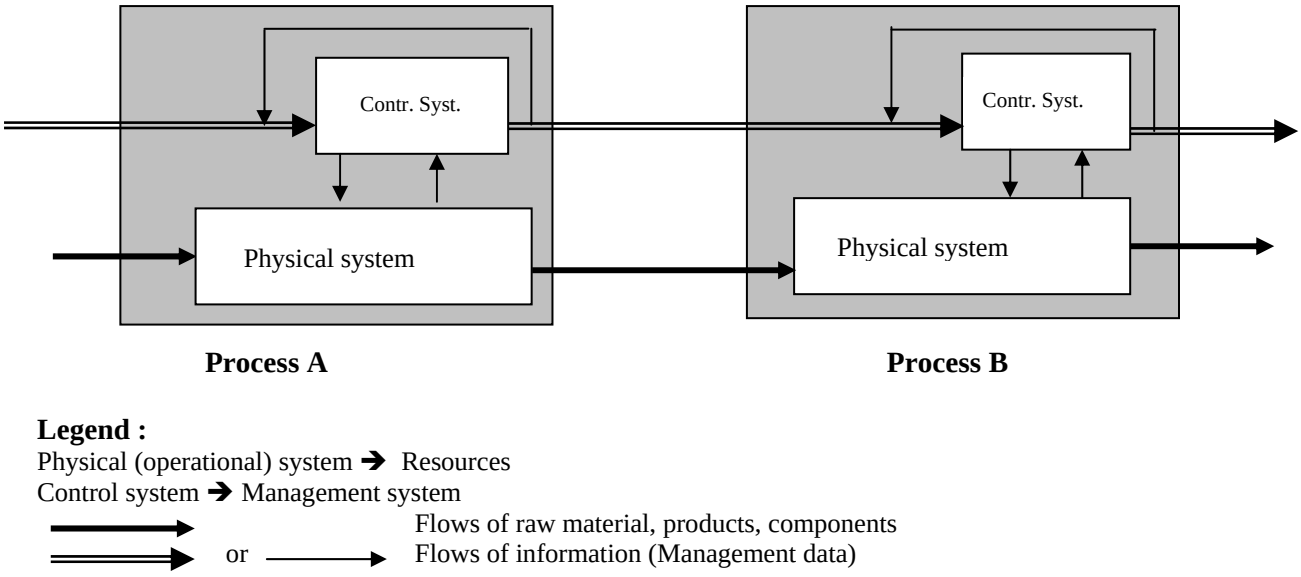


Figure 2 — Relationships between two manufacturing processes in a factory

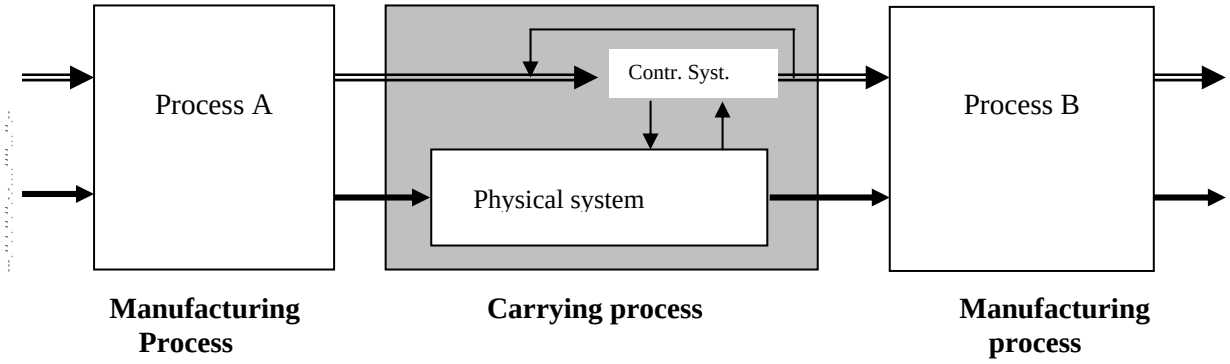
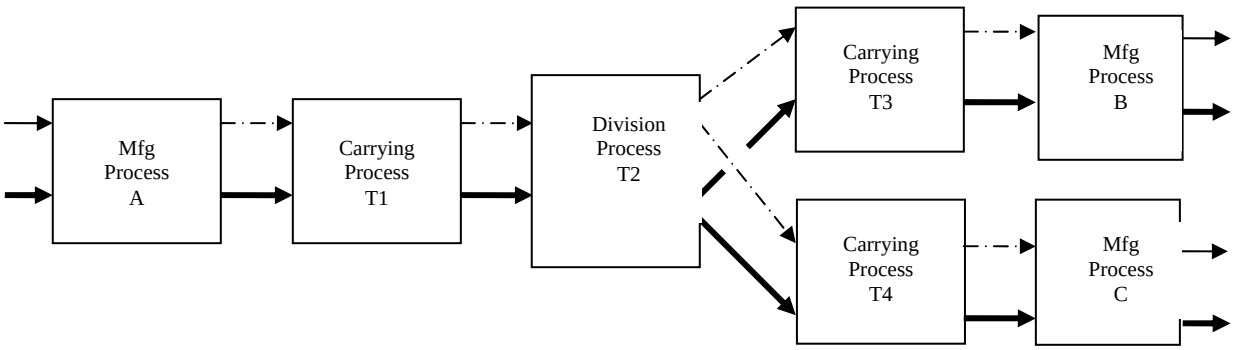


Figure 3 — Process that supports the flows between manufacturing processes A and B

With this separation between the two kinds of enterprise entities needed by manufacturing flows, the data needed to manage them are modelled independently of any kind of processes and/or resources that support these manufacturing flows. All these physical characteristics of manufacturing flows, including topological characteristics, are described separately thru the modelling of processes, resources and other first kinds of enterprise entities that support the carrying process.

EXAMPLE 2 : These carrying resources may include travelling bands (including the description of their topology), automatic trolleys, fork-lift truck driver (including the way of using it to go from process A location to process B location), network cable etc.

Any kind of topological characteristic of the manufacturing flows is modelled thru the modelling of a combination of various carrying processes. Figure 4 provides the representation of flow separation and the corresponding carrying processes. The junction of two flows into one is represented in the same way and supported by a junction process instead of a division process. The corresponding figure would be symmetric to Figure 4.



Legend :

A,B, and C are manufacturing or machining processes
T1, T2, T3, and T4 are transportation processes that support the flows between process A and B and/or C
Information flows
Material flows

Figure 4 —Example of flow separation

EXAMPLE 3 in the Figure 4, the process A may be a milling process while process B may be a quality control process and process C a drilling process. In the same way process T1 may be a transportation process making use of a travelling band while process T2 may be a picking process that put aside some components to the carrying process T3 that may be supported by the worker who carries on the component to quality control. The components that are not picked up will continue on their travelling band that supports the carrying process T4.

As this fundamental principle for the modelling of manufacturing management data provides a very generic model of these data, its specialisation into a particular model is obtained through the description of processes, resources, and the usage of catalogues based on ISO 13584-1 technology as specified in the following clauses.

NOTE Using this technique each enterprise may set up catalogues that describe with the adapted level of detail the different processes, resources and flows (including the layout of their manufacturing and transportation equipment), they have to model.

5.3 Manufacturing flow management data schema definition

The following EXPRESS declaration begins the **manufacturing_flow_management_data_schema** and identifies the necessary external references.

EXPRESS specification:

```
*)
SCHEMA manufacturing_flow_management_dataschema;

REFERENCE FROM support_resource_schema
(identifier,                          -- ISO 10303-41
label,
text);
(*
```

NOTE 1 The schema referred to above can be found in the following part of ISO 10303-41;

support_resource_schema: clause 20

NOTE 2 See Annex C for a graphical presentation of this schema using the EXPRESS-G notation.

```
*)
REFERENCE FROM product_definition_schema
(product);                      -- ISO 10303-41
(*
```

NOTE 3 The schema referred to above can be found in the following part of ISO 10303-41;

product_definition_schema: clause 5

```
*)
REFERENCE FROM resource_usage_management_schema
(resource);                           -- ISO 15531-32
(*
```

NOTE 4 The schema referred to above can be found in the following part of ISO 15531-32;

resource_usage_management_schema: clause 4

```
*)
REFERENCE FROM time_domain_schema
(interval_of_time,                    -- ISO 15531-42
point_in_time);
(*
```

NOTE 5 The schema referred to above can be found in the following part of ISO 15531-42;

time_domain_schema: clause 5

```
*)
REFERENCE FROM IEC61360-2_dictionary_schema
(property_bsu);
(*
```

NOTE 6 The schema referred to above can be found in IEC 61360-2 (an informative copy is also published in ISO 13584-42).

```
*)
REFERENCE FROM ISO13584_instance_resource_schema
(primitive_value);
(*
```

NOTE 7 The schema referred to above can be found in the following part of ISO 13584-24.

instance_resource_schema: clause 6

5.4 manufacturing flow management data type definitions

5.4.1 type_of_flow

A **type_of_flow** is an alphanumeric string which may be used for a **flow** to be identified. It does not need to understandable through the natural language.

EXPRESS specification:

```
*)
TYPE type_of_flow = STRING;
END_TYPE;
(*
```

5.4.2 type_of_material_flow

A **type_of_material_flow** is an alphanumeric string which may be used to classify a **material_flow**. It does not need to understandable through the natural language.

EXPRESS specification:

```
*)
TYPE type_of_material_flow = STRING;
END_TYPE;
(*
```

5.5 Manufacturing flow management data subtype constraint definitions

5.5.1 material_information

A **material_information** is the subtype constraint used to define subtypes of **flow** for which a classification is needed.

EXPRESS specification:

```
*)
SUBTYPE_CONSTRAINT material_information FOR flow;
     ONEOF (material_flow, information_flow);
END_SUBTYPE_CONSTRAINT;
(*
```

5.5.2 rawmat_component

A **rawmat_component** is the subtype constraint used to define subtypes of **material_flow** for which a classification is needed.

EXPRESS specification:

```
*)
SUBTYPE_CONSTRAINT rawmat_component FOR material_flow;
     ONEOF (raw_material, component);
END_SUBTYPE_CONSTRAINT;
(*
```

5.6 Manufacturing flow management dataentity definitions

5.6.1 process

A **process** is a structured set of activities involving various enterprise entities, that is designed and organised for a given purpose.

NOTE – The definition provided here is taken from the ISO 15531-1 standard.

EXAMPLE – A manufacturing process may consist in drilling operations, assembly operations.

EXPRESS specification:

```
*)
ENTITY process;
     id: identifier;
     name: label;
     description: text;
     operates_on: process_flow_assignment;
     process_characterised_by: process_property_value;
```



```
      starts_at: point_in_time;                    -- ISO 15531-42
      corresponds_to: interval_of_time;            -- ISO 15531-42
      uses: resource;                              -- ISO 15531-32
      decomposes_into: SET [0:?] OF process;

UNIQUE
      UR1: id;

END_ENTITY;
(*
```

Attribute definitions:

id: allows a **process** to be identified**.**
name: the label by which the **process** is known.
description: the main characteristics of a **process**.
operates_on: the **flow**s dealt with by the **process**.
process_characterised_by: the **process_property_value** characterising the **process**.
starts_at: the **point_in_time** characterising the beginning of the **process**.

corresponds_to: the **interval_of_time** characterising the **duration** of the **process**

uses: the **resource** necessary for the **process**.
decomposes_into: the set of **process**es the **process** is composed of.

Formal proposition:

UR1: the identification of the process **shall be unique.**

5.6.2 flow

A **flow** is a motion of a set of physical or informational objects in space and time.

NOTE – The definition provided here comes from the ISO 15531-1 standard.

EXAMPLE – the motion of components from a milling machine to a drilling machine or the motion of data set from one computer to another.

EXPRESS specification:

```
*)
ENTITY flow;
      id: identifier;
      name: label;
      description: text;
      corresponds_to: process_flow_assignment;
      flow_characterised_by: flow_property_value;
      classification: type_of_flow;
      decomposes_into: SET [0:?] OF flow;

UNIQUE
      UR1: id;
```

```
END_ENTITY;
(*
```

Attribute definitions:

id: allows a **flow** to be identified**.**
name: the label by which the **flow** is known.
description: the main characteristics of a **flow**.
corresponds_to: the **process**es to which the **flow** corresponds.
flow_characterised_by: the **flow_property_value** characterising the **flow**.
classification: the **type_of_flow** provides a way of classifying different **flow**s**.**
decomposes_into: the set of **flow**s the **flow** is composed of.

Formal proposition:

UR1: the identification of the flow **shall be unique.**

5.6.3 Process flow assignment

A **process_flow_assignment** defines the representation of an association between **process** and **flow** entities.

EXPRESS specification:

```
*)
ENTITY process_flow_assignment;
END_ENTITY;
(*
```

5.6.4 process_property_value

A **process_property_value** defines the properties of a **process**, by links to the corresponding entities of the ISO13584 standard.

EXPRESS specification:

```
*)
ENTITY process_property_value;
     val: primitive_value;
     is_described_by: property_bsu;
END_ENTITY;
(*
```

Attribute definitions:

value: the **primitive_value** of the property, as provided by the external reference to ISO 13584.
is_described_by: the reference to the external dictionary of properties.

5.6.5 flow_property_value

A **flow_property_value** defines the properties of a **flow**, by connections to the corresponding entities of the ISO 13584 standard.

EXPRESS specification:

```
*)
ENTITY flow_property_value;
     val: primitive_value;
     is_described_by: property_bsu;
END_ENTITY;
(*
```

Attribute definitions:

value: the **primitive_value** of the property, as provided by the external reference to ISO 13584.
is_described_by: the reference to the external dictionary of properties.

5.6.6 material_flow

A **material_flow** is a motion of a set of physical objects in space and time.

NOTE – The definition provided here comes from the ISO 15531-1 standard.

EXAMPLE – the motion of a drill from a drilling machine to a sharpener

EXPRESS specification:

```
*)
ENTITY material_flow
SUBTYPE OF (flow);
     classification: type_of_material_flow;
END_ENTITY;
(*
```

Attribute definitions:

classification: the **type_of_material_flow** provides a way of classifying different **material_flow**s.

5.6.7 information_flow

An **information_flow** is a motion of a set of informational objects in space and time.

NOTE – The definition provided here comes from the ISO 15531-1 standard.

EXAMPLE – the transfer of a data set from a computer to another computer, or the transfer of information thru a telephon call.

EXPRESS specification:

```
*)
ENTITY information_flow
SUBTYPE OF (flow);
END_ENTITY;
```

```
(*
```

5.6.8 raw_material

A **raw_material** is a subtype of **material_flow** characterised by the motion of unrefined or untreated materials.

EXAMPLE – rubber and steel tyres are raw materials for a company making tyres.

EXPRESS specification:

```
*)
ENTITY raw_material
SUBTYPE OF (material_flow);
     refers_to: product;
END_ENTITY;
(*
```

Attribute definition:
product: the identification of the raw material.

5.6.9 component

A **component** is a subtype of **material_flow** characterised by the motion of sub-assemblies before they are incorporated into more complex structures.

EXPRESS specification:

```
*)
ENTITY component
SUBTYPE OF (material_flow);
     refers_to: product;
END_ENTITY;
(*
```

Attribute definition:

product: the identification of the component.

```
END_SCHEMA; -- manufacturing_flow_management_data_schema
(*
```

Annex A
(normative)
Use of ASN.1 Identifiers in SC4 standards

To provide for unambiguous identification of an information object in an open system, the object identifier

```
iso standard 15531 part 43 version (1)
```

is assigned to this part of ISO 15531. The meaning of this value is defined in ISO/IEC 8824-1 and is described in ISO 15531-1.

Annex B
(informative)
EXPRESS listing

This annex provides a listing of the EXPRESS specified in this part of ISO 15531. No text or annotation is included. The computer interpretable form of this annex is provided in the file ISO TC184/SC4/JWG8 N462.

```
(*
     TC184/SC4/JWG 8  N462  2005-02-15
     EXPRESS DECLARATIONS FOR ISO 15531-43
*)

SCHEMA manufacturing_flow_management_data_schema;

REFERENCE FROM support_resource_schema
(identifier,                          -- ISO 10303-41
label,
text);

REFERENCE FROM product_definition_schema
(product);                       -- ISO 10303-41

REFERENCE FROM resource_usage_management_schema
(resource);                           -- ISO 15531-32

REFERENCE FROM time_domain_schema
(interval_of_time,                    -- ISO 15531-42
point_in_time);

REFERENCE FROM ISO13584_IEC61360_dictionary_schema
(property_bsu);

REFERENCE FROM ISO13584_IEC61360_instance_resource_schema
(primitive_value);


TYPE type_of_flow = STRING;
END_TYPE;

TYPE type_of_material_flow = STRING;
END_TYPE;


SUBTYPE_CONSTRAINT material_information FOR flow;
     ONEOF (material_flow, information_flow);
END_SUBTYPE_CONSTRAINT;

SUBTYPE_CONSTRAINT rawmat_component FOR material_flow;
     ONEOF (raw_material, component);
END_SUBTYPE_CONSTRAINT;


ENTITY process;
```



```
      id: identifier;
      name: label;
      description: text;
      operates_on: process_flow_assignment;
      starts_at: point_in_time;                    -- ISO 15531-42
      corresponds_to: interval_of_time;            -- ISO 15531-42
      uses: resource;                              -- ISO 15531-32
      decomposes_into: SET [0:?] OF process;
UNIQUE
      UR1: id;
END_ENTITY;


ENTITY flow;
      id: identifier;
      name: label;
      description: text;
      corresponds_to: process_flow_assignment;
      classification: type_of_flow;
      decomposes_into: SET [0:?] OF flow;

UNIQUE
      UR1: id;

END_ENTITY;


ENTITY process_flow_assignment;
END_ENTITY;


ENTITY process_property_value;
      val: primitive_value;
      is_described_by: property_bsu;
END_ENTITY;


ENTITY flow_property_value;
      val: primitive_value;
      is_described_by: property_bsu;
END_ENTITY;

ENTITY material_flow
SUBTYPE OF (flow);
      classification: type_of_material_flow;
END_ENTITY;

ENTITY information_flow
SUBTYPE OF (flow);
END_ENTITY;


ENTITY raw_material
SUBTYPE OF (material_flow);
      refers_to: product;
END_ENTITY;
```

```
ENTITY component
SUBTYPE OF (material_flow);
      refers_to: product;
END_ENTITY;

END_SCHEMA; -- manufacturing_flow_management_data_schema
```

Annex C
(informative)
EXPRESS-G diagram

Figure C.1 corresponds to the EXPRESS listing given in Annex B. The diagram uses the EXPRESS-G graphical notation for the EXPRESS language. EXPRESS-G is defined in ISO 10303-11: 2004, Annex A.

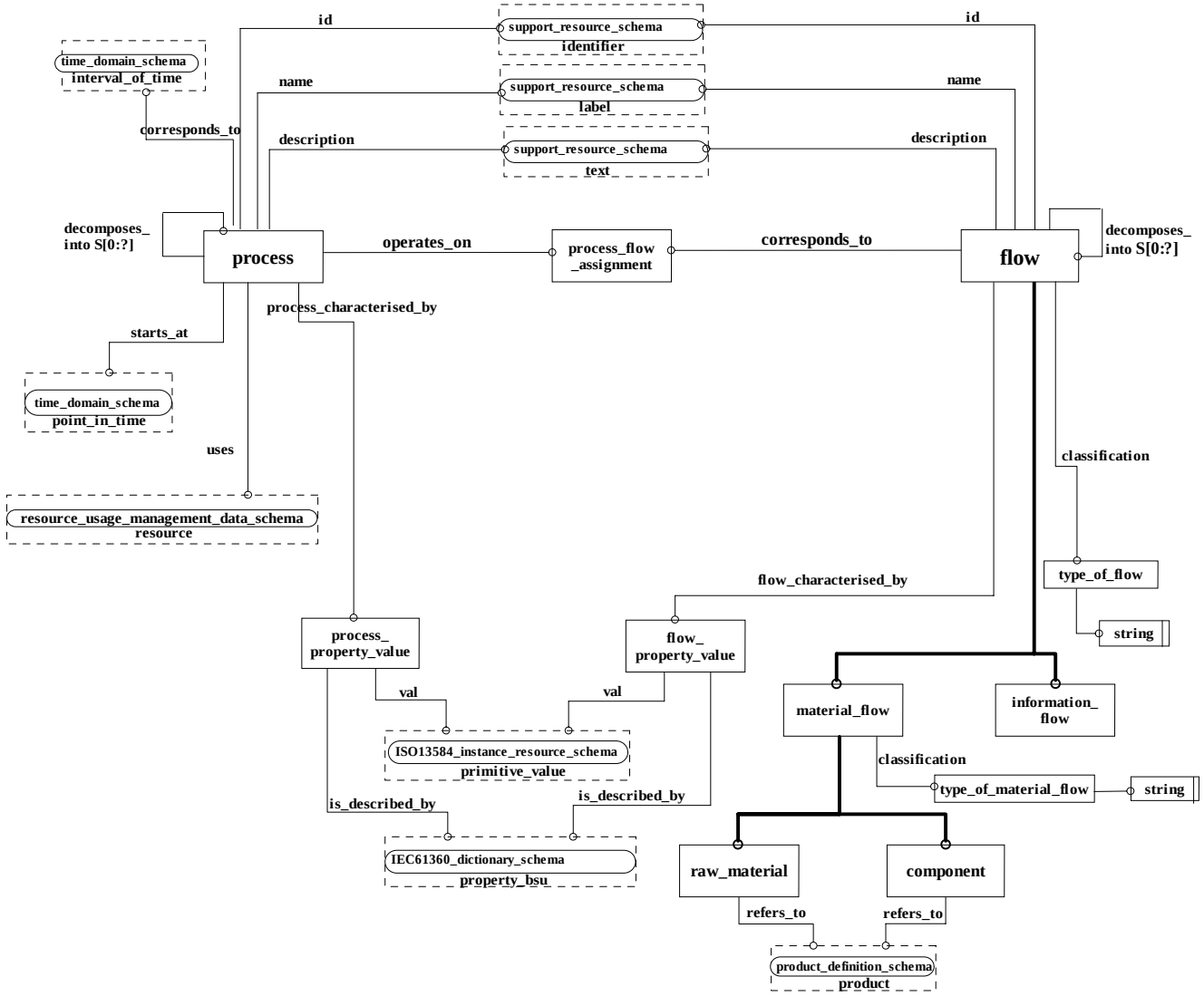


Figure C.1 — Manufacturing_flow_management_data_schema

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[3] ISO 19439, *Enterprise integration — Framework for enterprise modelling*

[4] IEC 61360-2, *Standard data element types with associated classification scheme for electric components — Part 2: EXPRESS dictionary schema*

[5] APICS dictionary; 8th Edition (Website: http: //www.apics.org).

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ICS 25.040.40

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