भारतीय मानक
Indian Standard

IS/ISO 15531-31 : 2004

औद्योगिक ऑटोमेशन पद्धति एवं संघटन — औद्योगिक उत्पादन प्रबंधन आँकड़े

भाग 31 संसाधन सूचना मॉडल

Industrial Automation Systems and Integration — Industrial Manufacturing Management Data

Part 31 Resource Information Model

ICS 25.040.40

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NATIONAL FOREWORD

This Indian Standard (Part 31) which is identical with ISO 15531-31 : 2004 'Industrial automation systems and integration — Industrial manufacturing management data — Part 31: Resource information model' issued by the International Organization for Standardization (ISO) was adopted by the Bureau of Indian Standards on the recommendation of the Industrial and Production Automation Systems and Robotics Sectional Committee and approval of the Production and General Engineering Division Council.

The text of ISO Standard has been approved as suitable for publication as an Indian Standard without deviations. Certain conventions and terminologies are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to the following International Standard for which Indian Standard also exists. The corresponding Indian Standard which is to be substituted in its place is listed below along with its degree of equivalence for the edition indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
ISO 13584-1 : 2001 Industrial automation systems and integration — Parts library — Part 1: Overview and fundamental principles	IS/ISO 13584-1 : 2001 Industrial automation systems and integration — Parts library : Part 1 Overview and fundamental principles	Identical

The technical committee has reviewed the provisions of the following International Standards referred in this adopted standard and has decided that they are acceptable for use in conjunction with this standard:

International Standard	*Title*
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	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 structure and properties
ISO 14258	Industrial automation systems — Concepts and rules for enterprise models
ISO 15531-1	Industrial automation systems and integration — Industrial manufacturing management data — Part 1: General overview

(*Continued on third cover*)

Indian Standard

INDUSTRIAL AUTOMATION SYSTEMS AND INTEGRATION — INDUSTRIAL MANUFACTURING MANAGEMENT DATA

PART 31 RESOURCE INFORMA TION MODEL

1. Scope

According to the scope ISO 15531-3X series that is reminded in annex A of this document, ISO 15531-31 is an introduction to the ISO 15531-3x series of part of ISO 15531. It describes the universe of discourse of this standard as well as the resources information model. It provides the main principles used in this series of parts of ISO 15531.

The following are within in the scope of this Part of ISO 15531:

— general overview of the parts 15531-3x series;

— definitions of terms used;

— fundamental principles used for conceptual model of resource usage management data;

— description of the resources information model (RIM);

— derivation process of identification and description of resources;

— structure of the standard and relationships between this series of parts and the others series of parts the standard is composed;

— use of standard (informative).

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

— detailed description of the resource information model;

— EXPRESS description of the model and related entities;

— definition of detailed level concepts and entities;

NOTE - Those three items are developed in the part 32 of ISO 15531 : *Conceptual model for resources usage management data.*

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, *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 structure and properties*

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

ISO 14258, *Industrial automation systems — Concepts and rules for enterprise models*

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

3. Terms, definitions, and abbreviations

3.1. Terms defined in ISO 10303-1

This part of ISO 15531 makes use of the following terms defined in ISO 10303-1:

— conformance testing;

— data;

— data exchange;

— information;

— product;

— product data.

3.2. Terms defined in ISO 10303-11

This part of ISO 15531 makes use of the following terms defined in ISO 10303-11:

— entity.

3.3. Terms defined in ISO 15531-1

This part of ISO 15531 makes use of the following termes defined in ISO 15531-1:

— capability;

— capacity;

— construct;

— enterprise entity;

— model ;

— process;

— resource;

— universe of discourse.

3.4. Terms defined in ISO 14258

— enterprise;

— enterprise model;

3.5. Other definitions

For the purposes of this part of ISO 15531, the following definitions apply.

3.5.1
attribute
a piece of information stating a property of an enterprise entity.

NOTE – The concept provided here to the broad concept of entity as defined in European standard ENV 12204. The term entity used in the definition provided by the ENV 12204 has been replaced here by enterprise entity as in ISO 15531-1 to avoid any confusion and inconsistency with the reserved term “entity” defined in ISO 10303. The usage of this concept has been limited to the area of concern of ISO 15531 in order to enable the use of the term “enterprise entity” instead of “entity”, and the field of application of the term attribute is restricted to enterprise entities.

3.5.2
business process
a partially ordered set of activities of an enterprise which can be executed to realise a given objective of the enterprise or a part of the enterprise to achieve some desired end-result.

3.5.3
classification
the process of arranging abstractions into a structure organised according to their distinguishing properties.

3.5.4
definition of resource characteristics
set of resources properties that are characterised by physical values.

NOTE - Those physical values may be qualitative or quantitative.

3.5.5
definition of resource views
classified set of resource views.

NOTE - Those resource view may be defined either by the user or catalogues.

3.5.6

generic resource
structure belonging to resource hierarchy and encompassing the common properties of several resources.

NOTE - The corresponding entity `generic_resource` includes a complete definition of the related attribute without link to actual value.

3.5.7
object
concept or a physical thing which may exist in the real world.

3.5.8
operation
the completion of an action or work element to realise a specific result.

3.5.9
order
a construct which represents the necessary input for a business process that co-ordinates and controls some other business process or activity.

3.5.10
property
a real world characteristic which is represented by either attributes or constraints.

3.5.11
resource characteristic
main property of a resource according to a given purpose.

NOTE 1 - In ISO 15531 resource characteristics are mainly related to the management of the manufacturing resources.

3.5.12
resource configuration
set of properties of resource configured for a specific manufacturing task.

3.5.13
resource hierarchy
structure designed to enable a classification of resources.

3.5.14
resources information model (RIM)
model of information addressing management of resources usage.

3.5.15
resource status
property which identifies an individual resource availability at some point in time.

3.5.16
resource view
specific set of resource characteristic associated to a given purpose.

3.5.17
structure of resource characteristics
set of classified resource characteristics.

3.6. Abbreviations

For the purpose of this part of ISO 15531, the following abbreviation applies.

RIM resources information model

4. Overview of resource management universe of discourse

This series of parts refers to the resource usage management. This clause then describes the universe of discourses of resource management, while clause 5 describes the structures of the ISO 15531-31 series of part and clause 6 provides the requirements for resources management and the basic principles of the Resource Information Model.

NOTE 1 The description of the universe of discourse of resource usage (see the definition of this term in ISO FDIS 15531-1 clause 3-6-50) and requirements for a model of resource usage management data are different. For example the universe of discourse of resources may include their description or their maintenance process, while the usage management model may not address this topics. The requirements for such a model will be described in clause 6 of this standard.

Resources usage management includes resource configuration, capabilities and capacities as well as operation management, installation management and facilities management. It also includes quality features, maintenance features, and safety features.

NOTE 2 maintenance features are exclusively considered regarding the point of view of the resource management (e.g. availability).

Three different aspects must be considered about the resources:

— their description, their usage and their maintenance;

— the description of the functionality a resource is able to provide, its capacity and capability;

— the information model used to trigger, estimate and monitor the resource.

This series of parts clearly do not address the first item whether it is considered as raw material or intermediate product. That means that ISO 15531-3x series of parts do not address resources in term of product description as it could be made using ISO 10303. Resource information model described in this part includes neither the modelling of the resource shape nor the description of its usage in the meaning of its way of working (operations instructions).

NOTE 3 ISO 15531 does not describe the way of working of a drilling machine excepted in term of capability and capacity. The milling machine modelling in term of its component description is the domain of ISO 10303, ISO 13584 or "cutting tools" standards. ISO 15531-31 addresses only the management data of the milling machine.

The description of capacities and capabilities of the resources (the functionality) is modelled at a very generic level. That allows any modeller to use this generic model, eventually in conjunction with other standards (e.g. ISO 10303, ISO 13584), to make up a more precise resource model aimed at a specific industrial activity, or a specific function.

This series of parts of ISO 15531 deal with model, and attributes of data capable of being stored in an industrial company's resource database for the purpose of manufacturing management. They address the following data:

— performance metrics;

— input and output resources definition;

— capacity and capability;

— tools and application software needed in conjunction with specific activities;

— capacity of internal controls and intelligence;

— information input and output capability and capacity;

— standard references for resources;

— maintenance scheduling and monitoring;

— cost elements.

5. Structure of ISO 15531-3x series

ISO 15531-3x series of part on manufacturing resource usage management data is divided into three parts. Although they are strongly connected and related, this series of parts address specific concerns and are developed separately. A general overview provides principles and concepts to preserve consistency and to describe the relationships between them.

The numbering of the standard is the following:

— ISO 15531-31: Resources information model basic principles;

— ISO 15531-32: Conceptual model for resources usage management data.

Some of the information to be represented in ISO 15531-2x series of parts comes from the outside of the enterprise, and is used throughout the entire production cycle to be ultimately returned to the environment. In any case, data exchanged during the production cycle are strongly related to system management and to time and flow models as described. Part 31 describes the fundamental principles and gives an overview of the 15531-3x series. Part 32 describes the conceptual model for resource usage management data based on a special modelling concept and constructs and provides a resource information model (RIM). Part 33 describes the conformance testing procedure and results.

EXAMPLE – Environment includes suppliers, customers, subsidiaries, and others partners.

6. Fundamental principles

The conceptual model of resource management is a way for modelling resource management activities and the information required to perform these activities. Its objective is to provide a method for describing the usage management of resources in business processes and all related information.

Planning and managing resources relating business process to resource usage management require:

— a representation of the information needed by the business process;

— a representation of the information about management activities necessary for planning and controlling the resources;

— a representation of the resource information and attributes;

Conceptual models of resource usage management require:

— the modelling elements;

— the modelling of information needed for processes and information about the processes required for performing the resource management activities.

NOTE - Modelling elements includes resources

EXAMPLE –. Machines, software, data set, human, information

The following sections describe modelling concepts and constructs to represent these requirements and provide an outline of the structure and elements of a resource information model, which enable resource usage management.

6.1. Modelling Concept and Constructs

The representation of manufacturing business processes and related complex structures in a model requires a modelling language, which adequately represents the information, attributes, structures and processes needed for resource management.

A business activity is a purpose-driven change of one or more objects. These changes require direct or indirect planning and scheduling and are executed by resources, which own the needed capability.
Objects which are transformed by a resource are objects of the generic classes product (Product Development, Production,...), Order (Order Processing, Order Decomposition,...), Resource (Resource Planning, Resource Management, Maintenance,..) or their respective subclasses. An order, electronic software or human control does ordering and controlling resources.

The enabling information for a resource to execute the transformation is part of the resource description [3].

Each resource within a business process can be considered in the following manner (see Figure1):

— the first stage is the description of the object(s) (material or information, orders, products or other resources) to be transformed within the resource;

— the second stage describes the transformation during which the task itself is achieved;

— the third stage is of the description of the object(s), which have been transformed by the resource.

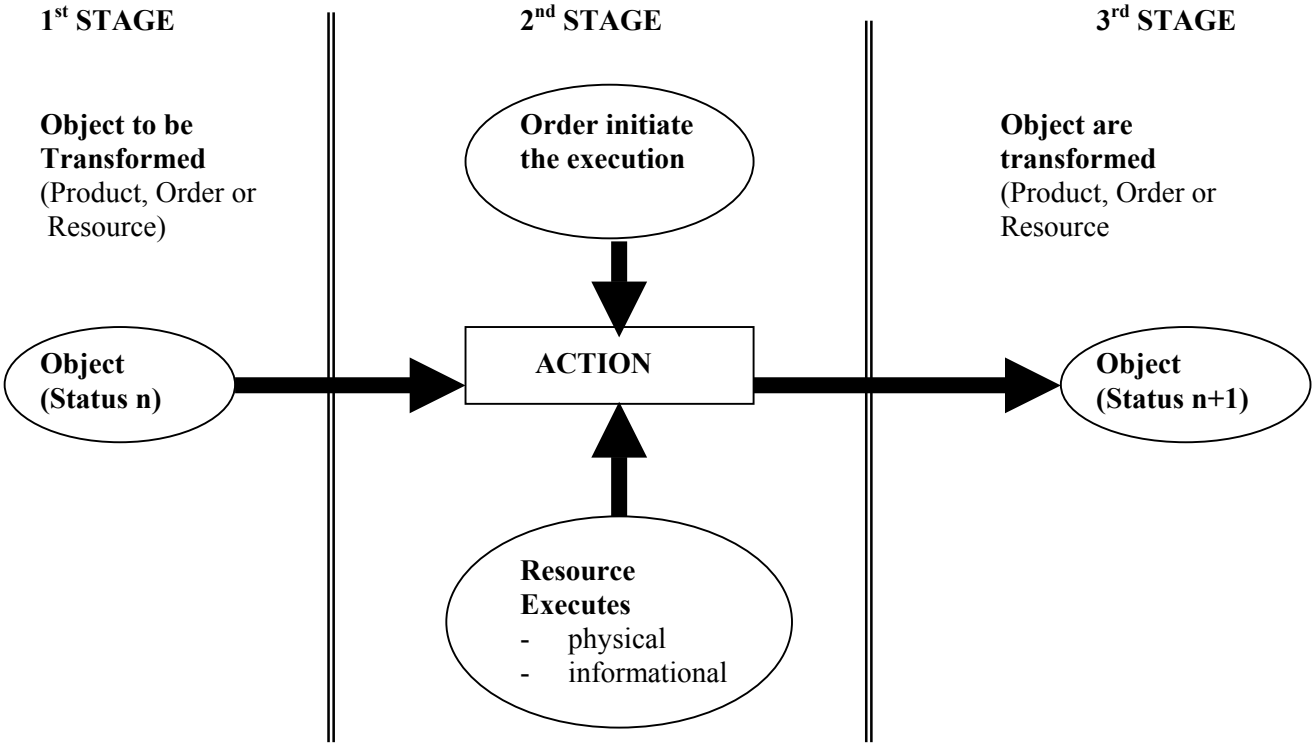

Figure 1 - Model for representation of business processes and structures [1]

6.2. Object and Resource Change State Sections

6.2.1 Input Section

Objects are subject to constraints prior to transformation. The input section, before transformation occurs, defines the format of object entries.

NOTE - Usually there is more than one possibility accepted by the resource and, as a result, the definition of the constraints and attributes will be a list or a generic definition.

6.2.2 Transformation Section

This section represents the transformation capabilities and the capacity the resource is able to provide to the outside.

6.2.3 Output Section

Objects released from the resource are also subject to constraints. The output section relates transformed objects is defining under which form and with which support, the objects have to leave the resource (see 6.2.1 Input Section).

Representing the related and affected processes of resource usage management with the above described concept and constructs leads to the elements of a Resource Information Model enabling and supporting resource usage management.

6.2.4 Resource Information Model (RIM)

A complete representation of manufacturing resources, e.g. shape aspects, is not within scope of ISO15531-3X series. Only data relevant for decision-making regarding to the usage of resources, e.g. within process planning or job scheduling, are considered. In order to meet all tasks, the information model is structured in a modular way (see Figure 2).

The entity `resource` forms the central element within the schema. Each further description classifying or detailing a resource's characteristics is related to `resource`. The schema's entities can be clustered into logical units including:

— resource hierarchy ;

— structure of resource characteristics ;

— resource status;

— definition of resource views ;

— definition of resource characteristics

— resource configuration.

"A resource hierarchy can be represented by instantiating a resource group. A generic resource captures generic characteristics of a resource type. A specific resource is the specialisation of a generic resource and captures a set of characteristics which represent a resource which can or does exist. The individual resource represents the occurrences of manufacturing resources within the business.

For resource usage management purposes a resource characteristic comprises information about a resource. The assignment of a resource characteristic classification to a resource characteristic enables this information to be distinguished into:

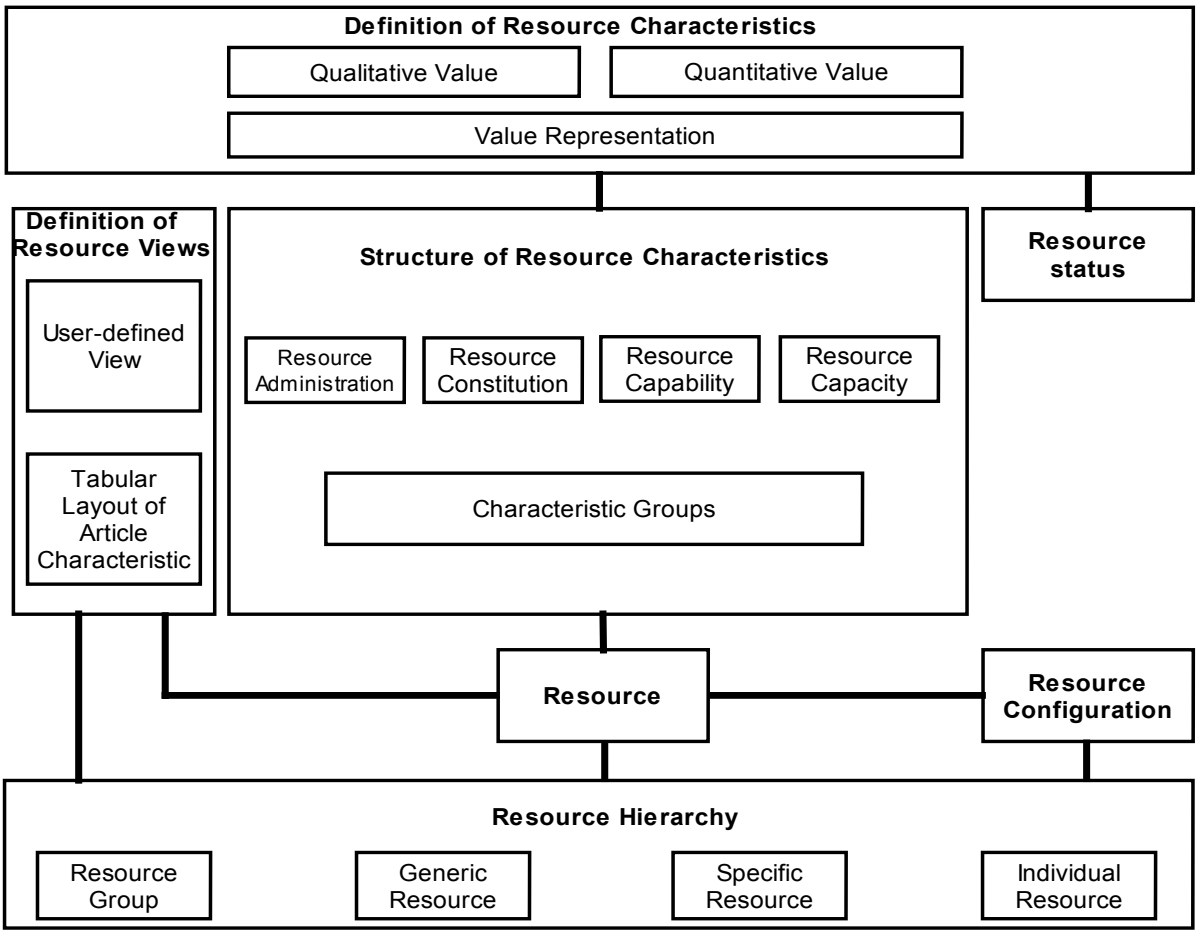

Figure 2 - Structure of resource information model [5]

— resource_administration ;

— resource_capability ;

— resource_constitution;

— resource_capacity.

A resource_administration represents a group of characteristics describing administrative information on manufacturing resources.

EXAMPLE 1: the fact that a machine is available or not, that it shall be stopped for maintenance, or send to another plant may be resource_administration information.

A resource_capability defines a group of characteristics specifying manufacturing resources under functional aspects. In particular this comprises the specification of resource-specific manufacturing processes.

A resource_constitution represents a group of characteristics describing the constitution of manufacturing resources.

A resource_capacity defines a group of characteristics dealing with job scheduling related resource data

EXAMPLE 2 The workload an individual_resource is able to provide. ISO 15531-1 provides some more explanation on capability and capacity concepts in its annex B.

A definition of a resource_view is derived by a specific aggregation of resource_characteristics. A resource_view is assigned to a generic_resource and can either be represented by a resource_tabular_layout_of_article_characteristic, e.g. regarding to DIN 4000, or by a resource_user_defined_view.

Representing a resource hierarchy and defining a resource view form the first instantiation level of the generic model. A partial model has to be derived in order to configure the model regarding to user-specific demands. Instantiating resource_group and generic_resource, including the definition of a resource_view generate it. The actual instantiation of the model with physical resource data is based on the partial model. Physical values of manufacturing resource characteristics are represented by resource_representation which can either be qualitative or quantitative values.
A resource_status is assigned to each individual_resource. A status is defined by a resource_status_type which provides feedback information on the state of manufacturing resources. Moreover a resource_status has a time_reference to date which is represented in the date_time_schema of ISO10303-41.

NOTE In an other way resource status provides information on the availability of the resource for a future activity as a result and consolidation of other definition relevant for the describing this availability.

EXAMPLE Resource administration describe any information that may contribute to define the administrative availability of the resource such approval of its usage, maintenance planning,… These information contribute with other ones to determine the status of the resource.

7. Relation to ISO 15531-2x series and ISO 15531-4x series

Some of the information to be represented in the ISO 15531-3x series comes from the environment of the enterprise addressed by ISO 15531-21 and is linked to information represented in resource characteristics.

EXAMPLE - Information exchanged with suppliers on resource maintenance, with customers or suppliers on resource administration.

Data exchanges during the production cycle are strongly related to system management and to time and flow models addressed by ISO 15531-4x series of parts. Direct linkages from the Resource Information Model of ISO 15531-32 to resource status and time schemas in ISO 15531-4x series of parts are established.

In that way, information on internal system management as described in ISO 15531-4x series of parts, information on resources usage management, as in the parts of ISO 15531-3x series as well as those to be exchanged outside of the company (part ISO 15531-21), are fully consistent.

Annex A
(normative)
ASN.1 Identifier of ISO 15531-31

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

```
iso standard 15531 part 31 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
(normative)
Scope of ISO 15531-3x series

The scope of ISO 15531-3X series of ISO 15531 is to develop the models, and attributes capable of residing in an industrial manufacturing company's resource database which are to be used by manufacturing management for the purpose of resource usage management.

The following are within the scope of ISO 15531-3x series:

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

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

The following are outside the scope of ISO 15531-3x series:

— representation and exchange of product information;

— representation and exchange of computer-interpretable parts library information;

— electronic representation for exchange of cutting tool data;

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

Annex C
(informative)
Relation of ISO 15531-3x series of parts with other related standards

C.1 Relation to other standards

Appropriate related standards as well as standardisation efforts have been considered in this standard. That concerns ISO 10303, ISO 13584, EDIFACT, and standards or efforts dealing with enterprise modelling such as ISO FDIS 14258, CEN/CENELEC ENV 40003, CEN/CENELEC ENV 12204. Have also been taken in account works in progress within the ISO TC184/SC5/WG1 and CEN TC310/WG1, as well as other related standardisation work such as work in progress in the ISO TC29/WG34 on "Cutting tools" data exchange. ISO 15531-3x series of parts supports this related work.

During manufacturing processes, people use data defined by the designers, and they do not have to redefine work already done. Raw material, or intermediate products, clearly product-related, are within the scope of ISO 10303. These items are out of the scope of ISO 15531-3x series. Some data about components has to be exchanged during the production process inside the factory and/or outside the factory (i.e. through the purchasing department). This is within the scope of ISO 13584. Moreover many other kinds of data, which are defined in other standardisation group are used, shared or exchanged during the production process inside the company.

EXAMPLE - Work in progress in ISO TC29/WG34 on "Cutting Tools" (ISO 13399 Cutting tool representation and exchange), ISO TC184 SC1/WG7 (ISO 14649 Data model for CNC controllers).

The models, constructs and data representations provided by 15531-3x series are checked to be consistent with those provided by ISO 10303 and ISO 13584 in order to make integration in manufacturing easier and to ensure interoperability all over the production process. This means, in particular, that this standards using EXPRESS language, is fully compliant with the ISO 10303 architecture.

Moreover, resource usage management will be one of the tools of the manufacturing integration process and is checked to be compliant with upper level integration tools such as those developed in the field of Enterprise Modelling by the ISO TC184/SC5/WG1 (ISO 14258) CEN TC 310 WG1 (ENV 12204).

Specific portions of the 15531-3x series address aspects that may be different from that adopted in other standards. ISO 15531-3x series of parts may use enterprise entity that are required for the optimal description of information and processes and may be proposed as "common resources" to ISO TC 184/SC4:

— Most of the time, parts lists are re-built by the manufacturing management. This is due to the top-down approach of the design function, from the whole product to assemblies and spare parts,

while manufacturing management has a bottom-up approach, based on production in pulled flow which takes a given level of inventories and resources availability into account.

— The process plan is a specific way to use ISO 10303 to define products undergoing transformation during manufacturing. The link with the product to be made (thus with ISO 10303) is obvious (see ISO 10303-49). Available resources and tools, and their capabilities and capacities are integrally linked and therefore common to both activities.

Except for very specific cases of prototypes, or unique parts, most of the data used during manufacturing cannot be defined at the product design stage, because the data is determined by situations evolving with time, and also by variable characteristics and capabilities.

ISO 10303, and ISO 15531-3x series assesses items common to both in different ways and from different viewpoints. As a result, the ISO 15531-3x series, Enterprise Modelling standards and ISO TC29 standards do not overlap. There is a very strong relationship between these standardisation efforts and a need for close co-ordination.

The following are specific references and relationships:

— ISO 13399 can be used for the initial parts of ISO 15531-32,

— ISO 10303 (AP 214 and AP 224) could reference entities of ISO 15531-32,

— ISO 14649 could reference to ISO 15531-32 entities.

C.2 Use of the standard

This standard will pay special attention to the description of the resource usage management, and the configuration of resources. Selection of resource activities would use the data that are described by the data modelling method presented by this standard. The resource manager has to be supplied with all necessary information at all times to fulfil its tasks. The standard is allows access to this information under a standardised form independent of the kind of resources or processes.

The above-described model serves as a basis for a standard but is shown in only two dimensions. It corresponds to only one aspect, resource usage management. By building a generic schema dedicated to specific viewpoints such as cost elements, maintenance, and quality, a specialised set of application oriented standards or application protocols can be developed.

Annex D
(informative)
Systems, resources, capability, capacity and time

The annex C of ISO 15531-1 provides some guidance on the usage of the terms capability and capacity in the approach of ISO 15531. This annex is an very close adaptation of annex F of ISO/IEC FDIS 62264-1. Since this annex describe systems, resources, capability, capacity and time in a very close way from which ISO 15531 does (Annex F of ISO/IEC 62264-1 has been build on the principles adopted by MANDATE), in order to increase the self understanding of the standard the whole annex of ISO/IEC 62264 has been reproduced below and slightly adapted to improve conformance to SC4 directives.

D.1 Introduction

The "General System theory" has been built up in 1937 by Ludwig Von Bertalanffy although the concept of isolated (or closed) systems has been implicitly or explicitly used in mechanics, physics, chemical sciences for centuries. Star and planet movements are all explained first from isolated system models, as well as the atomic model and Schrödinger equations. It is the same for the second principle of thermodynamics, or black box temperature. There are many other examples.

The "General system theory" is, implicitly or explicitly, the back-ground of the analysis or design of complex systems or entities in biology, physical sciences or chemical sciences, in cybernetics, engineer sciences, economy, quality (ISO 9000 standard are based on the systemic approach), organisation sciences, business re-engineering, electronics, and computer sciences.

Hundred of books have been written about "general system theory" and its use in complexity management and in various disciplines. A selection of the major publications are listed in the bibliography.

"General System Theory" is also the implicit or explicit background of most analysis, design and modelling methods such as IDEF0, Merise, etc, and also of object oriented methods or languages (especially UML).

Therefore this annex, after a short reminder of "System theory" concepts, provides an overview and explanation on the concepts of capacity and capability in relation to system theory and to related manufacturing standards that already exist or are in progress.

D.2 Definition of a system

Three types of definition are provided below:

D.2.1 From Larousse encyclopædia

There is more then height definitions of system in this kind of encyclopaedia, the following has been chosen for their closeness with the domain of manufacturing:

— Complex of organised elements, considered from the point of view of their relations inside a whole that works in an unitary manner.

— Set of means arranged to achieve a given purpose.

— Equipment, arrangement built up from various elements, that achieve a given function.

D.2.2 From "General System theory" specialists

The background definition is that of Ludwig Von Bertalanffy, the other are inferred to be closer of organisations, manufactory, or enterprises:

— Complex of elements that are in interrelations (Ludwig Von Bertalanffy, see [1])

— Set of elements in dynamic interrelation that are organised for a given purpose (J. de Rosnay mentioned by C.W. Churchman, see)

— Set of parts that are co-ordinated to fulfil a collection of objectives (C. West Churchman)

NOTE Complex has to be understood as a set of several elements (very often a lot) in contrast with a simple element

D.2.3 From standards

— A collection of real-world items organised for a given purpose (ISO 15704)

For this annex we keep the last definition.

D.3 Some definitions related to "System Theory"

D.3.1 Definitions of "Universe of discourse"

The following definitions are extracted from standards

— All those of real-world objects that are of potential interest. (ISO 10303-12)

— The collection of concrete or abstract things that belong to an area of the real-world, selected according to its interest for the system. (Adapted from ISO 15531-1)

— The collection of entities that ever have been, are, or ever will be in a selected portion of real-word or postulated world of interest that being described by the model (CEN ENV 12204)

The three definitions are quite identical. In particular the ISO 15531-1 definition is already adapted from the third to take into account the fact that ISO 15531 refers to ISO 10303 whereas the term "entity" does not address in ISO 10303 the same concept as in CEN ENV 12204. Another point is that the first two definitions seem not to address what is called "postulated world" in the third definition. In fact the precision provided in the third definition is important to emphasise that modelling is used for expected systems as well as for existing systems . Nevertheless during the development of a new system the real-world includes both actually existing things and those things that are expected to become part of the real-world a soon as the new system turns to be operational.

The second definition (and the third) emphasises the fact that the universe of discourse is the result of a voluntary action of selection from the modeller or the developer.

D.3.2 Definitions of "Environment" of a system

The following definition are the most often used:

— All those universes of discourse that do not belong to the system itself

— The part of the real world that is outside the system and which consequently can not be totally controlled by the system (or its control system)

— The part of the real-world that the system can not control, but which may have an impact on it or that the system may itself impact or transform (including the result of this transformation).

NOTE System Theory specialists often use the term "driving system" instead of "control system"

The first definition is the simplest one. The two others emphasise the fact that the environment may have an impact on it (see later the notion of constraints) and the system itself may have an impact on its environment in particular by the transformation of a part of it (e.g. transformation of raw material, and/or component into products and/or other components). See open system.

D.3.3 Definition of an "isolated system" ("closed system")

— A system that is supposed to not have any interaction with its environment.

The term "isolated" instead of "closed" is coming from physical sciences. In fact, a totally isolated system is a pure abstraction without any actual existence (i.e. such a system can not be observed. Nevertheless this concept of isolated system is the support of many models in physical sciences such as, the black object theory, the second principle of thermodynamics, the quantum model of the atom (Schrödinger equations), the star and planets mechanics, etc.

D.3.4 Definition of an open system

— A system that undergoes the impact of its environment through constraints and act on the environment by modifying it (transformation of inputs into outputs).

The only systems that have any interest for an enterprise, or in manufacturing are the open systems. Obviously production, manufacturing systems do not have any significance if they are not open system. Isolated system can not have any production. We will now omit the term “open” that we will consider as implicit for our purpose.

D.3.5 Objectives, purpose, constraints

The following definitions are also used in system theory:

— A system is subject to constraints from its environment (except isolated systems).

— Furthermore, any system is endowed with a purpose (ISO 15704 definition) or mission. This purpose is most often transformed into objectives

— Those objectives may be provided internally (e.g. by the decisional sub-system) or imposed by the environment (or both). Either way, from the moment they are defined and formulated, they become data on which the system has no control. They are part of the constraints.

D.4 Elements (components) of a system

A system is generally (from the highest to the most elementary level) composed of numerous elements that may be:

— Its resources

— Other sub-systems that may be of different types and may themselves include other sub-systems for which the upper level system become the environment

— The relations between sub-systems

— ….

EXAMPLE : Physical (or operational) system, driving system, decisional system, information system, control system, purchasing system, maintenance system, regulation system.

Two sub-system are required:

— The physical (or operational) system

— The driving system (the driver)

Any system or sub-system is strictly obliged to include, till the elementary level, at least a physical system and a driving system (some time called operated and operating system).

Each of these physical and driving systems may themselves be eventually decomposed into another physical and driving system,…

At the lowest level of decomposition (elementary level) the physical system includes the operational resources needed for the achievement of the activity concerned, and the driving system includes the resource dedicated to control and monitor the physical system

EXAMPLE: For a given level of detailing and some given choices of modelling, a milling machine may be considered as the physical system and its operator as the driving system of a milling system. Other modelling choices and level of detail may be envisioned.

D.5 Schema of a production system and mapping to IDEF0.

D.5.1 Schema of a production system

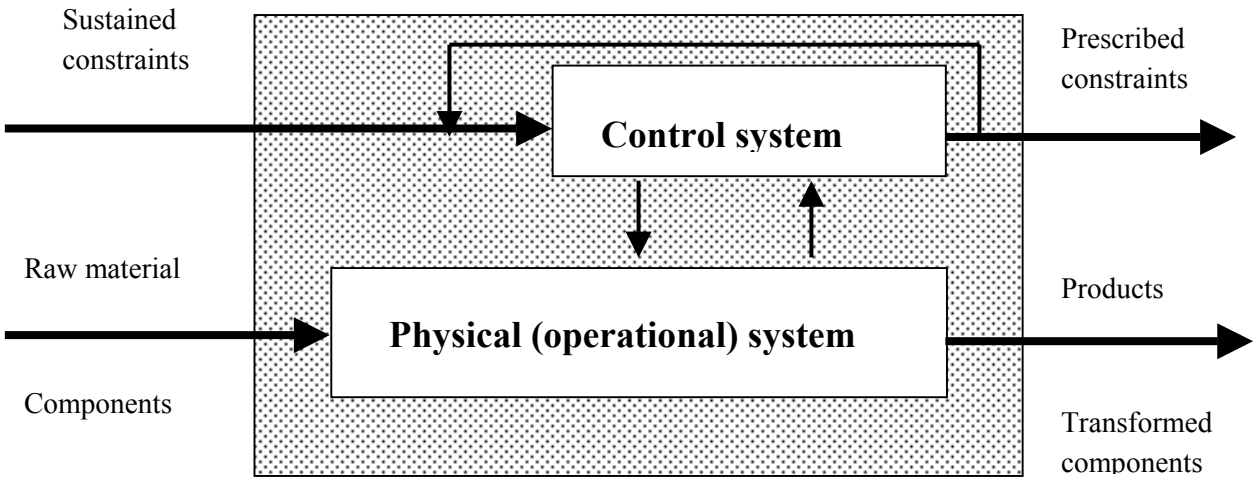

Figure D.1: Production or manufacturing system

Under the control of the control system, the resources transform raw material and/or components into new components and/or finished products.

NOTE On “Control system” and “driving system” see note of clause D.3.2

A production system is then characterised by a set of activities that are performed on its environment by its resources (that are themselves controlled by the driving system) in order to transform this

environment (products and components provided, prescribed constraints) that itself impact (sustained constraints) on the system concerned.

The transformation provided by the system to its environment is one of the characteristic elements of its behaviour.

D.5.2 IDEF0 and the systemic approach

The IDEF0 actigrams are just the representation of some activities of the system and/or of some of its sub-systems:

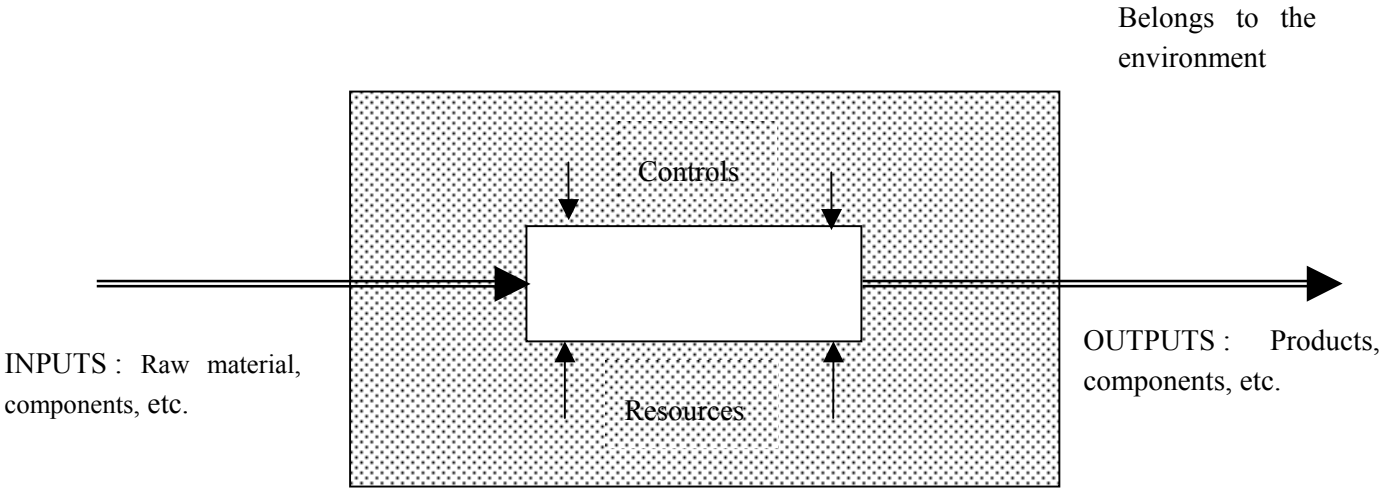

Figure D.2 : IDEF0 actigram

The behaviour of the system is described by the set of activities that its resources perform to transform its environment.

D.6 Resources

D.6.1 General definition of resource

— An entity (human or technical) that may play a role in the achievement in a given class of task when it is available (François Vernadat see [6]).

A resource is characterised by its:

— Capability

— Capacity

— Availability

D.6.2 ISO 15531-1 definition of resource

— Any device, tool and means at the disposal of the enterprise to produce goods and services.

This definition that is included in the general definition applies to the universe of discourse of MANDATE (ISO 15531-1), concerning production and manufacturing systems.

D.7 Capability, capacity

D.7.1 Capability

Capability is essentially a functional and qualitative concept, with two aspects:

— Provided capability (by a resource)

— Required capability (by an activity)

The following definitions are most often use in system theory:

— The quality of being able to perform a given activity (ISO 15531-1)

— Ability to do a certain task (F. Vernadat)

D.7.2 Capacity

Capacity is strictly a quantitative concept with two aspects:

— Provided capacity (by a resource)

— Required capacity (by an activity)

In addition to ISO 15531 the following definition are encountered:

— Measure of the quantity of product (or component) a resource can process per unit of time (adapted from F. Vernadat)

— Measure of the performance of a resource regarding the quantity of product (or component) the resource is able to provide or the quantity of raw material (or component) the resource is able to process.

D.7.3 Capability versus capacity

Capability is essentially a functional concept. It may sometimes include quantitative properties or attributes. In that case the quantitative aspect solely addresses some needed precision on capability.

EXAMPLE: The characteristics in term of size of the parts or in term of precision for the milling capability of a milling machine

Capacity is strictly a quantitative concept that characterises the performance of the resource in the achievement of its activity.

EXAMPLE: Quantity of product provided by the resource per unit of time.

It is possible to consider for certain modelling purposes that the capacity of a resource may be one of the characteristics of the capability of a resource. Nevertheless this must be avoided, in order to prevent any confusion. But it is never possible to consider the opposite (Capability as a characteristic of capacity).

D.7.4 Provided capability (resp. capacity) versus requested capability (resp. capacity)

Each statement of the following paragraph applies either to capability or capacity, even if capability only is mentioned.

The set of capabilities provided by a resource is a characteristic of the resource (an a priori data). At the starting point this capability is not associated with any activity. In the same way the set of capabilities required by an activity is also a characteristic of this activity At the start point there is no resource associated to this required activity.

It is the association of a resource with an activity with the corresponding control in the context of a specific application (e.g. production or scheduling application) that constitutes the system.

EXAMPLE:

A painting robot that is idle is only a resource, possibly available. It nevertheless exists and its existence (with all its capabilities and its capacity) may potentially be taken in account in a scheduling application. The painting activity without any resource (human or robot) to achieve this function is a concept that will only become actual when this activity is associated with a resource in a painting operation. The scheduling application enables the association of this concept with a given resource in the context of an operational system. The resource “painting robot” is not a system. The activity “painting” is a concept only. A painting robot that is actually painting under the ad-hoc control is a painting system.

In most cases the panel of capabilities required by a given activity is only a subset of the panel of capabilities provided by the resource that is associated with this activity in the system. When the difference is too big the resource is under employed.

On the other hand, if the resource is unable to provide all the capabilities required by the activity, there is no possible production, no possible manufacturing (The resource has to be replaced with a more convenient one). The system therefore does not exist and cannot run.

Some times the capacity provided by a resource is bigger than that required by the activity with which the resource is associated. In most cases both capacities are comparable. Nevertheless if for any reason (failure or anything else) the resource associated with a given activity is not able to provide all the capacity required by the activity, the production is most often reduced. The system runs in a decreased mode (the question is : is this decreased mode acceptable?).

D.8 Time

Time includes at least two main concepts:

— Duration that is useful to express any expected or passed consumption of time;

— Point in time that is used to locate or mark any passed, present or expected event;

Time theoretically fits the definition provided in clause V.1 for any resource. For example some duration may be envisioned as “a means at the disposal of the enterprise to produce goods and services”. Nevertheless the time concept considerably differs from the concept of resource by the following aspects:

— Time is a component of the environment of the system. The system may probably control some internal duration of certain of its activities. But the system is unable to control points in time, or external duration in its environment. The system can not control time. Time is a sustained constraint

— Time is also an element of the interrelation between the different components and/or sub-systems of the system under consideration. In particular some point in time that marks the end of an activity of the system may be associated to trigger the starts or ends some other activities within the system.

For these reasons time can not be processed as a resource. It has to be processed as a constraint and/or a relation that contribute to the association between different components of the system (for example one resource with an activity).

D.9 How to deal with the facilities in a system

This term generally includes compressed air, electricity, energy, lubricants, etc.

— The equipment that provides these facilities may be considered as systems or sub-systems with their own inputs, outputs, their own resources and driving systems

— On the other hand these facilities may be considered as input or output of the different systems, or as components of the resources they contribute to operate (the consumption is then an element of the life, maintenance and usage of the resource).

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(*Continued from second cover*)

Annexes A and B are normative and Annexes C and D of this standard are for information only.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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