
**Industrial automation systems and
integration — Product data
representation and exchange —**

Part 240:

**Application protocol: Process plans for
machined products**

*Systèmes d'automatisation industrielle et intégration — Représentation
et échange de données de produits —*

*Partie 240: Protocole d'application: Plan des processus pour produits
usinés*



Reference number
ISO 10303-240:2005(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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.

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

ISO 10303-240 was prepared by Technical Committee ISO TC184/SC4, *Industrial automation systems and integration*, Subcommittee SC4 *Industrial data*.

This International Standard is organized as a series of parts, each published separately. The structure of this International Standard is described in ISO 10303-1.

Each part of this International Standard is a member of one of the following series: description methods, implementation methods, conformance testing methodology and framework, integrated generic resources, integrated application resources, application protocols, abstract test suites, application interpreted constructs, and application modules. This part is a member of the 200 series.

A complete list of parts of ISO 10303 is available from the Internet:

[<http://www.tc184-sc4.org/titles/>](http://www.tc184-sc4.org/titles/)

Introduction

ISO 10303 is an International Standard for the computer-interpretable representation of product information and for the exchange of product data. The objective is to provide a neutral mechanism capable of describing products throughout their life cycle. This mechanism is suitable not only for neutral file exchange, but also as a basis for implementing and sharing product databases, and as a basis for archiving.

This part of ISO 10303 is a member of the application protocol series. This part of ISO 10303 specifies an application protocol (AP) for the exchange, archiving and sharing of computer-interpretable process plans for numerical control and manually machined parts. The intent of this AP is to allow for the exchange, archiving and sharing of data between dissimilar Computer-Aided Process Planning (CAPP) systems.

A process plan is a set of instructions. These instructions are used by programmers to generate machine tool controller programs which, when executed, drive the tool motion to remove material. Process planning takes place after the preliminary engineering design is completed but before the manufacturing process has begun, and the process plan effort requires feedback for design completeness. Design information is communicated to a process planner who identifies the manufacturing steps necessary to transform the material specified by the design into a product.

This AP specifies the data contained within a process plan as opposed to the data necessary to perform process planning functions. Included in this AP are the relationships that exist between the different process plan data items as well as the relationships that exist between these data items and the product definition data. Product definition data includes data items from design process such as geometry, surface finish and machining tolerance.

This application protocol defines the context, scope, and information requirements for digitally represented process plans for numerical control and manually machined parts and specifies the integrated resources necessary to satisfy these requirements.

Application protocols provide the basis for developing implementations of ISO 10303 and abstract test suites for the conformance testing of AP implementations.

Clause 1 defines the scope of the application protocol and summarizes the functionality and data covered by the AP. Clause 3 lists the words defined in this part of ISO 10303 and gives pointers to words defined elsewhere. An application activity model that is the basis for the definition of the scope is provided in Annex F. The information requirements of the application are specified in clause 4 using terminology appropriate to the application. A graphical representation of the information requirements, referred to as the application reference model, is given in Annex G.

Resource constructs are interpreted to meet the information requirements. This interpretation produces the application interpreted model (AIM). This interpretation, given in 5.1, shows the correspondence between the information requirements and the AIM. The short listing of the AIM specifies the interface to the integrated resources and is given in 5.2. Note that the definitions and EXPRESS provided in the integrated resources for constructs used in the AIM may include select list items and subtypes which are not imported into the AIM. The expanded listing given in Annex A contains the complete EXPRESS for the AIM without annotation. A graphical representation of the AIM is given in Annex H. Additional requirements for specific implementation methods are given in Annex C.

Figure 1 contains the data planning model that provides a high-level description of the requirements for this application protocol, as well as identifying that some relationship exists between the basic data components.

The planning model illustrates that an process plan is composed of one or more sequenced activities. The activities can be broken into several closely related sub-activities. Activities are associated with the product definition data and will be used in the production of the product shape data. Each activity describes in detail the associated processing and the type and amount of resource required with additional special instructions, if necessary. An process plan also includes administrative data pertinent to the management of the process plan.

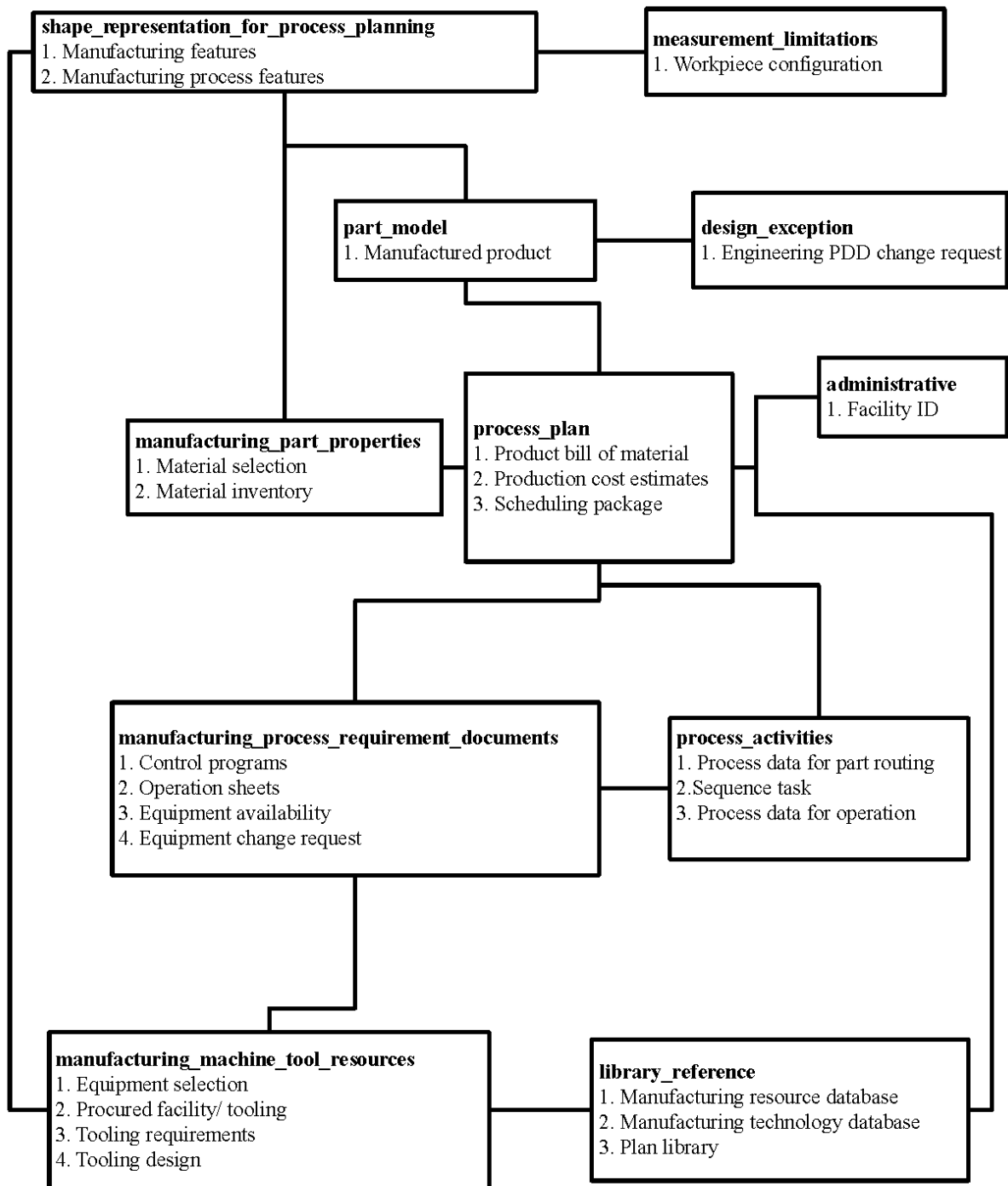


Figure 1 — Process planning data planning model

Industrial automation systems and integration — Product data representation and exchange —

Part 240:

Application protocol: Process plans for machined products

1 Scope

This part of ISO 10303 specifies the use of the integrated resources necessary for the scope and information requirements for the exchange, sharing and long term data retention of computer-interpretable process plan information for both numerical control (NC) and manually operated applications, and associated product definition data.

NOTE 1 The application activity model in Annex F provides a graphical representation of the processes and information flows which are the basis for the definition of the scope of this part of ISO 10303.

The following are within the scope of this part of ISO 10303:

— information out of the planning activity that is contained in the process plans for machined parts which includes:

- numerical controlled machines;
- manual operations.

— the manufacture of a single piece mechanical part, and assemblies of single piece parts for manufacturing purpose which includes:

- process data for part routing which includes manufacturing process and setup sequencing;
- process data for operation.

— interface for capturing technical data out of the upstream application protocols which includes:

- product definition data, including tracking a design exception notice of a part;
- initial material definition data.

— technical data for and/or out of the process planning for machined parts which includes:

- machining features for defining shapes necessary for manufacturing;
- machining feature classification structure;
- geometric and dimensional tolerances of the parts being manufactured;

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- materials, and properties of the parts being manufactured.
- references to standards and specifications declared in the process plan;
- work instructions for the tasks required to manufacture a part, using which include:
 - references to the resources required to perform the work;
 - the sequences of the work instructions;
 - relationships of the work to the part geometry.
- information required to support NC programming of processes specified in the process plan;

NOTE 2 This includes product definition, administrative data, machine, tooling, and material requirements.

- information required to support in-process inspection specified in the process plan;

NOTE 3 In-process inspection includes such tasks as using gauge blocks or performing a probing operation to verify the dimensional constraints placed upon the part.

- shop floor information specified in the process plan;
- information for production planning specified in the process plan;

NOTE 4 Information for production planning contains items such as process data for part routing and required resource to perform the planned activity.

NOTE 5 Shop floor information contains such items as part routing, machine setup, and part loading instructions.

The following are outside the scope of this part of ISO 10303:

- NC program, source programs, and specific machine tool controller codes;
- NC process information derived from, or required for, manufacturing preplanning activities;

NOTE 6 This includes information from activities such as factory capacity planning, scheduling, producibility analysis, and statistical process control.

- continuous processes;

NOTE 7 Continuous process is the control of a process that requires feedback to determine new parameters such as those in adaptive control, real-time inspection and automatic corrections and in the manufacture of chemical and plating products.

- inspection processes that require an inspection plan;

NOTE 8 Inspection processes refer to inspection that occurs outside the context of the NC machining process, such as removing the part and remounting it on a Coordinate Measuring Machine (CMM).

- drawing and production illustration contents;

- make or buy analysis activities;
- actual costing data;
- production control and scheduling analysis;
- production planning functions;
- actual execution of the process plan or associated NC programs.

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 8824-1, *Information Technology — Abstract Syntax Notation One (ASN.1) — Specification of Basic Notation — Part 1*.

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 10303-21, *Industrial automation systems and integration — Product data representation and exchange — Part 21: Implementation methods: Clear text encoding of the exchange structure*.

ISO 10303-31, *Industrial automation systems and integration — Product data representation and exchange — Part 31: Conformance testing methodology and framework: General concepts*.

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 10303-42, *Industrial automation systems and integration — Product data representation and exchange — Part 42: Integrated generic resources: Geometric and topological representation*.

ISO 10303-43, *Industrial automation systems and integration — Product data representation and exchange — Part 43: Integrated generic resources: Representation structures*.

ISO 10303-44, *Industrial automation systems and integration — Product data representation and exchange — Part 44: Integrated generic resources: Product structure configuration*.

ISO 10303-45, *Industrial automation systems and integration — Product data representation and exchange — Part 45: Integrated generic resources: Materials*.

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ISO 10303-47, *Industrial automation systems and integration — Product data representation and exchange — Part 47: Integrated generic resources: Shape variation tolerances.*

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

ISO 10303-501, *Industrial automation systems and integration — Product data representation and exchange — Part 501: Application interpreted construct: Edge-based wireframe.*

ISO 10303-502, *Industrial automation systems and integration — Product data representation and exchange — Part 502: Application interpreted construct: Shell-based wireframe.*

ISO 10303-507, *Industrial automation systems and integration — Product data representation and exchange — Part 507: Application interpreted construct: Geometrically bounded surface.*

ISO 10303-509, *Industrial automation systems and integration — Product data representation and exchange — Part 509: Application interpreted construct: Manifold surface.*

ISO 10303-510, *Industrial automation systems and integration — Product data representation and exchange — Part 510: Application interpreted construct: Geometrically bounded wireframe.*

ISO 10303-511, *Industrial automation systems and integration — Product data representation and exchange — Part 511: Application interpreted construct: Topologically bounded surface.*

ISO 10303-512, *Industrial automation systems and integration — Product data representation and exchange — Part 512: Application interpreted construct: Faceted boundary representation.*

ISO 10303-514, *Industrial automation systems and integration — Product data representation and exchange — Part 514: Application interpreted construct: Advanced boundary representation.*

ISO 10303-519, *Industrial automation systems and integration — Product data representation and exchange — Part 519: Application interpreted construct: Geometric tolerances.*

ISO 10303-522, *Industrial automation systems and integration — Product data representation and exchange — Part 522: Application interpreted construct: Machining features.*

ISO 13584-26, *Industrial automation systems and integration — Parts library — Part 26: Logical resource: Information supplier identification.*

ISO 13584-42, *Industrial automation systems and integration — Parts library — Part 42: Description methodology: Methodology for structuring part families.*

IEC/ISO Directives, Part 2, *Rules for the structure and drafting of International Standards*, Fourth edition, 2001.

3 Terms, definitions and abbreviations

3.1 Terms defined in ISO 10303-1

For the purpose of this part of ISO 10303, the following terms defined in ISO 10303-1 apply.

- abstract test suite (ATS);
- application;
- application activity model (AAM);
- application context;
- application interpreted model (AIM);
- application object;
- application protocol (AP);
- application reference model (ARM);
- computer aided design (CAD);
- computer aided manufacture (CAM);
- conformance class;
- conformance requirement;
- data;
- data exchange;
- generic resource;
- information;
- integrated generic resource;
- integrated resource;
- interpretation;
- model;
- PICS proforma;
- product;

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- product data;
- product information model;
- resource construct;
- test purpose;
- unit of functionality (UoF);
- validation.

3.2 Terms defined in ISO 10303-21

For the purpose of this part of ISO 10303, the following terms defined in ISO 10303-21 apply.

- implementation method.

3.3 Terms defined in ISO 10303-31

For the purpose of this part of ISO 10303, the following terms defined in ISO 10303-31 apply.

- conformance class;
- conformance testing;
- postprocessor;
- preprocessor.

3.4 Other definitions

For the purposes of this part of ISO 10303, the following definitions apply:

3.4.1

computer-aided process planning (CAPP) system

a commercial or proprietary software application used to assist process planners in making a process plan.

3.4.2

direct numerical control (DNC) system

a computer system that transmits machine-tool controller codes directly from a host computer to the machine-tool controller. The machine-tool controller transmits back its status to the host system.

3.4.3

engineering bill of materials (EBOM)

the list of part numbers and assemblies that make up the design engineering configuration that contains the raw stock size and the material specification.

3.4.4**engineering change notice (ECN)**

a document released by design engineering to production that informs production of pending changes to a specific design.

3.4.5**engineering change order (ECO)**

an authorization to implement changes to a specific engineering design.

3.4.6**fixture coordinate system**

a coordinate system on a fixture for the location and orientation of the fixture in a machine tool coordinate system.

3.4.7**group technology (GT)**

a manufacturing philosophy in which similar parts are identified and grouped together to take advantage of their similarities in manufacturing and design.

3.4.8**inventory item**

a tangible object that must be accounted for on an inventory manifest.

3.4.9**machine coordinate system**

three mutually perpendicular planes which define the axis and origin for a machine location.

3.4.10**machined part (MP)**

a product shaped by removing material using one or more machine tools.

3.4.11**manufacturing bill of materials**

a list of materials required for the machining process plan.

EXAMPLE A product has an engineering bill of materials of: left hinge, right holder, bolt, washer, locknut, bearing washer. The left hinge, right holder, and bearing washer need to have a hole machined as a loose assembly, they are then separated. The bearing washer is returned to stores and the left hinge, right holder have other machining work done prior to being sent off to another site for heat treatment and plating. The engineering and product build will show six items but our machining process plan needs a separate bill of materials with just left hinge, right holder, and bearing washer.

3.4.12**material resource planning (MRP) system**

a software application that controls and schedules the flow of materials as required by production.

3.4.13**numerical control (NC)**

a machine tool controlled by a programmable computerized system.

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3.4.14

part coordinate system

three mutually perpendicular planes which define the axis and origin for a part location.

3.4.15

part program

a set of instructions used to transform the part specification from an engineering drawing or 3D model to a sequence of processing steps to be performed on an NC machine.

3.4.16

process plan (PP)

the detailed method for the machining of a part. It includes a sequence of steps to be executed that call out the selected machines, fabrication, operation steps, setups, routings, and in-process inspection requirements for the manufacturing of a machined part.

3.4.17

product definition data (PDD)

the data that pertains to the design description

3.5 Abbreviations

For purposes of this part of ISO 10303, the following abbreviations apply:

AAM	application activity model
AIC	application interpreted construct
AIM	application interpreted model
AP	application protocol
ARM	application reference model
ATS	abstract test suite
B-rep	boundary representation
CAD	computer aided design
CAPP	computer-aided process planning
DBMS	database management system
DNC	direct numerical control
EBOM	engineering bill of materials
ECN	engineering change notice
ECO	engineering change order

GT	group technology
ID	identification
IDEF0	ICAM definition language 0
IDEF1X	ICAM definition language 1 - extended
MP	machined part
MRP	material resource planning
NC	numerical control
PDD	product definition data
PICS	protocol implementation conformance statement
PP	process plan
UoF	units of functionality

4 Information requirements

This clause specifies the information required for manual or numerical control process plans for machined parts.

The information requirements are specified as a set of units of functionality, application objects, and application assertions. These assertions pertain to individual application objects and to relationships between application objects. The information requirements are defined using the terminology of the subject area of this application protocol.

NOTE 1 A graphical representation of the information requirements is given in Annex G.

NOTE 2 The information requirements correspond to those of the activities identified as being within the scope of this application protocol in Annex F.

NOTE 3 The mapping table specified in 5.1 shows how the integrated resources and application interpreted constructs are used to meet the information requirements of this application protocol.

4.1 Units of functionality

This subclause specifies the units of functionality for the process planning application protocol. This part of ISO 10303 specifies the following units of functionality:

- administrative;
- design_exception;
- library_reference;
- manufacturing_machine_tool_resources;
- manufacturing_process_requirement_documents;
- manufacturing_part_properties;
- measurement_limitations;
- part_model;
- process_activities;
- process_plan;
- shape_representation_for_process_planning.

The units of functionality and a description of the functions that each UoF supports are given below. The application objects included in the UoFs are defined in 4.2.

4.1.1 administrative

The administrative UoF contains the information required for the management of process plan. This information contains sufficient detail to allow for the identification, release and revision of the process plan.

The following application objects are used by the administrative UoF:

- Company;
- Company_contract_assignment;
- Organization;
- Planning_group_member;
- Status_authority.

4.1.2 design_exception

The design_exception UoF contains the application objects used for documentation required for issuing an error report for a problem that was discovered in the creation of a process plan, and a solution to the problem as it pertains to the regeneration of input data for further process planning.

The following application objects are used by the design_exception UoF:

- Design_exception_notice;
- Engineering_change_order;
- Engineering_change_proposal.

4.1.3 library_reference

The library_reference UoF provides the capability and mechanisms by which references can be made to information in external libraries.

NOTE A supplier library of part information is a type of library that may be referenced.

The following application objects are used by the library_reference UoF:

- BSU;
- Class_BSU;
- Externally_defined_representation;
- Library_part_assignment;
- Property_BSU;
- Property_value;
- Supplier_BSU.

4.1.4 manufacturing_machine_tool_resources

The manufacturing_machine_tool_resources UoF contains the definitions of tools, fixtures, and jigs used to accomplish the fabrication of a part.

The following application objects are used by the manufacturing_machine_tool_resources UoF:

- Controller;
- Fixture_assembly;
- Fixture_assembly_element;

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- Generic_manufacturing_resource;
- In_facility_location;
- Machine;
- Pallet;
- Part_holding_position;
- Resource_with_material;
- Resource_with_representation;
- Tool_assembly;
- Tool_assembly_element;
- Tool_body;
- Tool_magazine_turret_carousel;
- Work_cell;
- Workstation.

4.1.5 manufacturing_part_properties

The manufacturing_part_properties UoF contains the description of characteristics of the part that is being defined. These characteristics specify requirements for manufacturing that apply to either the state of the part at a particular time prior to or after the manufacture of the part, or a process that is required to be executed during the manufacture of the part.

The following application objects are used by the manufacturing_part_properties UoF:

- Alternate_material;
- Descriptive_parameter;
- Hardness;
- Material;
- Material_property;
- Numeric_parameter;
- Numeric_parameter_with_tolerance;
- Part_property;

- Process_property;
- Property;
- Property_parameter;
- Surface_property.

4.1.6 manufacturing_process_requirement_documents

The manufacturing_process_requirement_documents UoF contains information that identifies product data for control documents. These documents include contracts, drawings, additional data for process plans, and other supporting documentation for process plans. These documents may be in either digital or hardcopy format.

The following application objects are used by the manufacturing_process_requirement_documents UoF:

- Contract;
- Controller_program;
- Digital_file;
- Document_assignment;
- Document_file;
- Document_file_properties;
- Document_file_relationship;
- Design_reference;
- Executable;
- External_file_identification;
- External_schema_definition;
- Fixture_contract;
- Hardcopy;
- Illustration;
- Material_specification;
- Partial_document_assignment;

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- Part_dimensioning_standard;
- Special_capability;
- Special_instruction;
- Specification;
- Supplemental_document;
- Tool_contract;
- Tool_placement_instruction;
- View_reference.

4.1.7 measurement_limitations

The measurement_limitations UoF contains the information necessary to identify the important sizes of the measured relationships between aspects of a part's shape or between an aspect of a part's shape and a reference shape that does not comprise the shape of the part, and the acceptable deviation from that size or relationship for the purpose of manufacturing.

The following application objects are used by the measurement_limitations UoF:

- Angular_dimension_tolerance;
- Angular_size_dimension_tolerance;
- Curved_dimension_tolerance;
- Diameter_dimension_tolerance;
- Dimensional_tolerance;
- Distance_along_curve_tolerance;
- Externally_defined_size_dimension;
- Height_dimension;
- Geometric_tolerance;
- Length_dimension;
- Limits_and_fits;
- Location_dimension_tolerance;
- Location_tolerance;

- Machining_tolerance;
- Plus_minus_value;
- Radial_dimension_tolerance;
- Size_tolerance;
- Thickness_tolerance;
- Tolerance_limit;
- Tolerance_range;
- Tolerance_value.
- Width_dimension.

4.1.8 part_model

The `part_model` UoF contains the information necessary to identify the part that is to be input to the process planning function and identify the association of properties with that part. Additionally, information pertaining to feedback about the quality or necessary revisions to the product data is represented by this UoF.

The following application objects are used by the `part_model` UoF:

- Manufactured_assembly;
- Manufactured_assembly_relationship;
- Mating_definition;
- Mating_definition_relationship;
- Mating_relationship;
- Part_version;
- Single_piece_part.

4.1.9 process_activities

The `process_activities` UoF contains the information which defines a specific manufacturing action. Manufacturing actions deal with the transformation and inspection that takes place in the sequential process of machining a source material into a final part. These manufacturing actions include processes, operations and tasks associated with material removal by numerically controlled machine tools.

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The following application objects are used by the process_activities UoF:

- Activity;
- Allowed_time;
- Alternate_activity;
- Ancillary_activity;
- Ancillary_setup;
- Continuous_process;
- Fixture_machine_mounting;
- Fixture_machine_unmounting;
- Fixture_pallet_mounting;
- Fixture_pallet_unmounting;
- Fixture_setup;
- Machine_parameters;
- Machine_setup;
- Machine_usage;
- Machining_process;
- Manufacturing_activity;
- Manufacturing_process;
- Mounting_position;
- Non_machining_process;
- Pallet_machine_mounting;
- Pallet_machine_unmounting;
- Part_fixture_mounting;
- Part_fixture_unmounting;
- Part_machine_mounting;

- Part_machine_unmounting;
- Part_mounting;
- Part_routing;
- Part_unmounting;
- Performance_rate;
- Process_activity;
- Production_rate;
- Setup_activity;
- Tool_setup;
- Validation.

4.1.10 process_plan

The process_plan UoF contains the application objects used for defining a process plan, revisions of the process plan, machining feature classification structure and manufacturing process and setup sequencing.

The following application objects are used by the process_plan UoF:

- Alternate_process_plan;
- Feature_dependency;
- Feature_identification_item;
- Feature_interaction;
- Feature_process;
- Process_plan_security;
- Process_plan_version;
- Range_of_parts;
- Revision.

4.1.11 shape_representation_for_process_planning

The shape_representation_for_process_planning UoF contains the physical definition of initial and final form of the part. This definition is given via a parametric method for features, and additional geometric and topological definitions.

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The following application objects are used by the shape_representation_for_process_planning UoF:

- Base_shape;
- Block_base_shape;
- Cylindrical_base_shape;
- Explicit_base_shape_representation;
- Geometric_model;
- Implicit_base_shape_representation;
- Intermediate_shape;
- Manufacturing_process_feature;
- Model_element;
- Ngon_base_shape;
- Object_element_shape_representation;
- Orientation;
- Part_placement;
- Part_shape;
- Shape_aspect;
- Shape_aspect_representation;
- Shape_representation_type.

4.2 Application objects

This subclause specifies the application objects for them mechanical product definition for process planning using machining features application protocol. Each application object is an atomic element that embodies a unique application concept and contains attributes specifying the data elements of the object. The application objects and their definitions are given below.

4.2.1 Activity

An Activity is a discrete task, or set of tasks, that is executed in the manufacturing of a product. Each Activity is either an Manufacturing_activity (see 4.2.76), Setup_activity (see 4.2.128), or Alternate_activity (see 4.2.3). The data associated with an Activity are the following:

- activity_information;
- activity_number;
- constrained_by;
- description;
- duration;
- frequency;
- graphics_representation;
- name;
- organization_id;
- references;
- resources.

4.2.1.1 activity_information

The activity_information specifies the Special_instruction (see 4.2.135) for the purpose of planning a machining activity. The activity_information need not be specified for a particular Special_instruction. There may be more than one activity_information for a Special_instruction. See 4.3.6 for the application assertion.

4.2.1.2 activity_number

The activity_number specifies the unique identifier for an operation, task, or step, within an process_plan_version.

4.2.1.3 constrained_by

The constrained_by specifies Supplemental_document (see 4.2.138) that is the additional documentation that may be referenced to further define the activity. The constrained_by need not be specified for a particular Activity. See 4.3.7 for the application assertion.

4.2.1.4 description

The description specifies the word, or group of words, that provide either instructions for the Activity to be performed or state the objective to be achieved by the Activity.

EXAMPLE These descriptions might contain:

- drill and ream all four 3" diameter through holes;
- fabricate hub mounting holes;
- fixture the shaft per diagram "A1234" and machine per NC Program "XYZ".

4.2.1.5 duration

The duration specifies the Performance_rate (see 4.2.111) which is the amount of time necessary to complete the task. See 4.3.5 for the application assertion.

4.2.1.6 frequency

The frequency specifies the number of repetitions a process plan is performed for a particular part. Frequency need not be specified for a particular Activity.

4.2.1.7 graphics_representation

The graphics_representation specifies the visual representation of information necessary for the activity. There may be more than one graphics_representation for a Design_reference (See 4.2.24), Illustration (see 4.2.59), or View_reference (see 4.2.153). The graphics_representation need not be specified for a particular Activity. See 4.3.1, 4.3.3, and 4.3.8 for the application assertion.

4.2.1.8 name

The name specifies the word, or group of words that make up the unique designation of an Activity.

4.2.1.9 organization_id

The organization_id specifies the unique identifier for the organization responsible for performing the Activity.

4.2.1.10 references

The references specifies the Material (see 4.2.79) of the Part_version (see 4.2.109) necessary to perform the activity. References need not be specified for a particular Activity. See 4.3.4 for the application assertion.

4.2.1.11 resources

The resources specifies the Generic_manufacturing_resource (see 4.2.53) that defines the additional resources that may be necessary to perform the activity. The resources need not be specified for a particular Activity (see 4.2.79). See 4.3.2 for the application assertion.

4.2.2 Allowed_time

An Allowed_time is the total time allocated for the completion of an activity. An Allowed_time is a type of Performance_rate (see 4.2.111).

EXAMPLE The Allowed_time equals the allowance_factor multiplied by the standard_time. If the standard_time takes 3 minutes to drill a hole, and the allowance_factor for the job is 1.2, the Allowed_time for the job would be 3.6 minutes.

The data associated with an Allowed_time are the following:

- allowance_factor;
- standard_time.

4.2.2.1 allowance_factor

The allowance_factor specifies the percentage of the standard time which compensates for unavoidable delays.

EXAMPLE Unavoidable delays include such thing as: making minor tool repairs, equipment repairs, operator fatigue, and human factors.

4.2.2.2 standard_time

The standard_time specifies a time value for the accomplishment of a work task as determined by the proper application of appropriate work measurement techniques.

NOTE The standard_time is not influenced by operator fatigue, weather conditions, or other variables.

4.2.3 Alternate_activity

An Alternate_activity is the identification of a separate activity that can be used to replace the current activity within the same process plan. The data associated with an Alternate_activity is the following:

- primary_activity.

4.2.3.1 primary_activity

The primary_activity specifies the Activity (see 4.2.1) of the primary activity for which this activity is the Alternate_activity. See 4.3.9 for the application assertion.

4.2.4 Alternate_material

An Alternate_material is the identification of a secondary material that may be used when the primary material choice is not available. The data associated with an Alternate_material are the following:

EXAMPLE Figure 14 illustrates a note block for a part with Alternate_material.

NOTE The Alternate_material definition is derived from clause 4.2.1 of ISO 10303-224.

- alternate_ranking;
- material_substitute.

4.2.4.1 alternate_ranking

The alternate_ranking specifies the order for selecting Alternate_material objects in the event the primary Material is not available.

4.2.4.2 material_substitute

The material_substitute specifies the material to be used as the substitute. See 4.3.10 for the application assertion.

4.2.5 Alternate_process_plan

An Alternate_process_plan is the identification of a secondary process plan that may be used when the primary process plan choice is not available. The data associated with an Alternate_process_plan are the following:

- alternate_ranking;
- plan_substitute.

4.2.5.1 alternate_ranking

The alternate_ranking specifies the order for selecting Alternate_process_plan objects in the event the primary Process_plan_version (see 4.2.116) is not available.

4.2.5.2 plan_substitute

The plan_substitute specifies Process_plan_version (see 4.2.116) that is to be used as a substitute process plan. See 4.3.11 for the application assertion.

4.2.6 Ancillary_activity

An `Ancillary_setup` is a type of `Manufacturing_activities` (see 4.2.76) that defines an ancillary action. The data associated with an `Ancillary_activity` are the following:

— `method`.

4.2.6.1 method

A `method` specifies the descriptive ancillary action being performed. The `method` need not be specified for a particular `Ancillary_setup`.

4.2.7 Ancillary_setup

An `Ancillary_setup` is a type of `Setup_activity` (see 4.2.128) that defines the setup for a an ancillary action Activity (see 4.2.1). The data associated with an `Ancillary_setup` are the following:

— `setup_type`.

4.2.7.1 setup_type

A `setup_type` specifies the descriptive placement and location information for an ancillary activity.

4.2.8 Angular_dimension_tolerance

An `Angular_dimension_tolerance` is a type of `Location_tolerance` (see 4.2.67) that defines the allowable variation in the angle between two elements of the shape of a part. Each `Angular_dimension_tolerance` shall have an origin shape and a termination shape.

NOTE 1 The `Angular_dimension_tolerance` definition is derived from clause 4.2.3 of ISO 10303-224.

NOTE 2 Figure 2 illustrates the `Angular_dimension_tolerance`.

The data associated with an `Angular_dimension_tolerance` are the following:

— `plane_and_direction`.

4.2.8.1 plane_and_direction

The `plane_and_direction` specifies a plane that contains the geometry for the `Angular_dimension_tolerance` and a direction that is the location of the plane that contains the `Angular_dimension_tolerance`. The `plane_and_direction` need not be specified for a particular `Angular_dimension_tolerance`. See 4.3.12 for the application assertion.

EXAMPLE A part might be viewed in a front view for defining a `location_dimension_tolerance`.

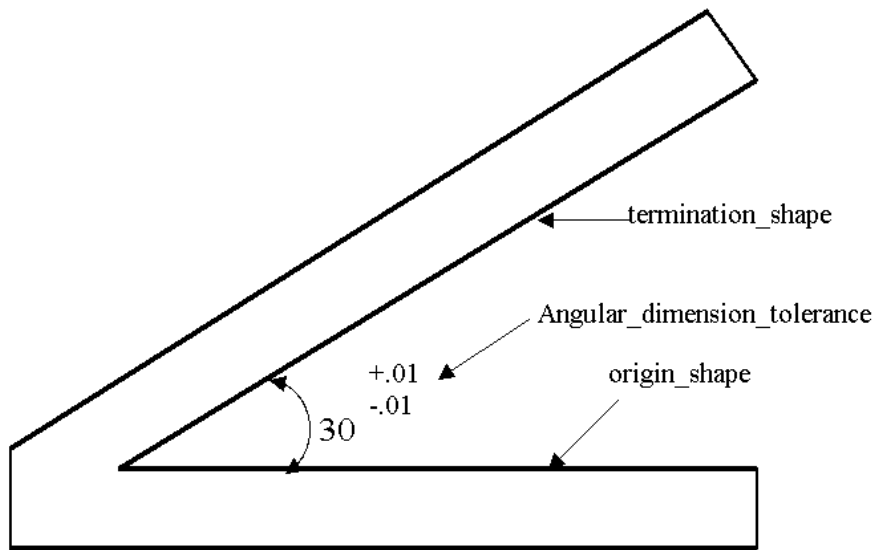


Figure 2 — Angular_dimension_tolerance

4.2.9 Angular_size_dimension_tolerance

An Angular_size_dimension_tolerance is a type of Size_tolerance (see 4.2.133) that specifies the allowable variation on the size or gap formed by two angular elements of the shape of a part.

NOTE 1 The Angular_size_dimension_tolerance definition is derived from clause 4.2.4 of ISO 10303-224.

NOTE 2 Figure 3 illustrates the Angular_size_dimension_tolerance.

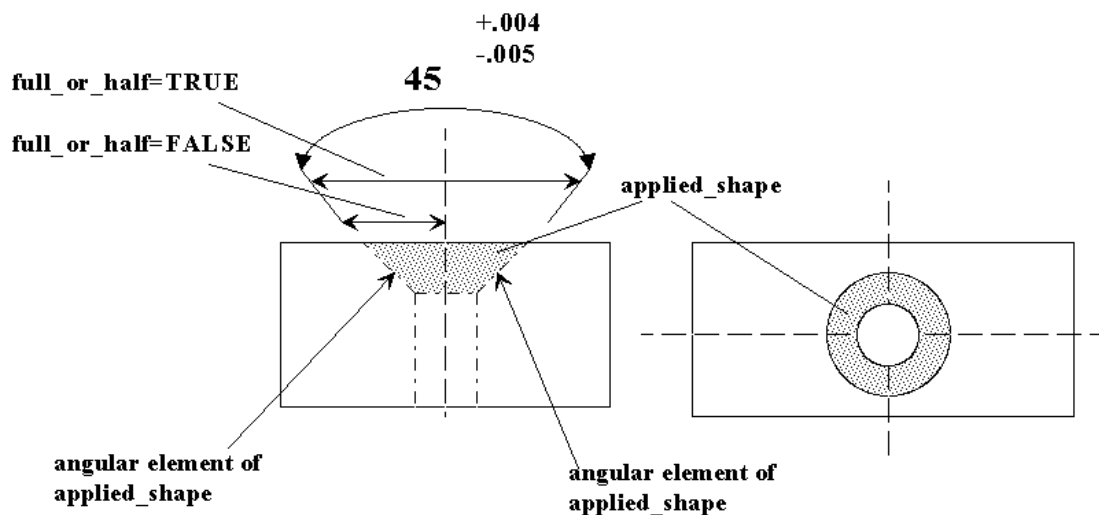


Figure 3 — Angular_size_dimension_tolerance

The data associated with an `Angular_size_dimension_tolerance` are the following:

- `full_or_half`;
- `major_angle`.

4.2.9.1 `full_or_half`

The `full_or_half` indicates the method used to establish the `Angular_size_dimension_tolerance` angle. The angle is either established between the two sides of an angular element or a center line datum and an angular element.

4.2.9.2 `major_angle`

The `major_angle` specifies the size of the angle for defining the variation. The angle is either the largest or the smallest of the two angles formed by the two elements of the part's shape that are related to the `Angular_size_dimension_tolerance`.

4.2.10 `Base_shape`

A `Base_shape` is the initial shape of the material before machining of the features. Each `Base_shape` is either an `Explicit_base_shape_representation` (see 4.2.36) or an `Implicit_base_shape_representation` (see 4.2.60).

NOTE The `Base_shape` definition is derived from clause 4.2.7 of ISO 10303-224.

4.2.11 `Block_base_shape`

A `Block_base_shape` is a type of `Implicit_base_shape_representation` (see 4.2.60) that describes the initial shape of the material as a rectangular cross section of some determined length.

NOTE 1 The `Block_base_shape` definition is derived from clause 4.2.10 of ISO 10303-224.

NOTE 2 Figure 4 illustrates a `Block_base_shape` and the associated attributes.

The data associated with a `Block_base_shape` are the following:

- `height`;
- `width`.

4.2.11.1 `height`

The `height` specifies the size of the side of a `Block_base_shape` along the Y-axis. See 4.3.13 for the application assertion.

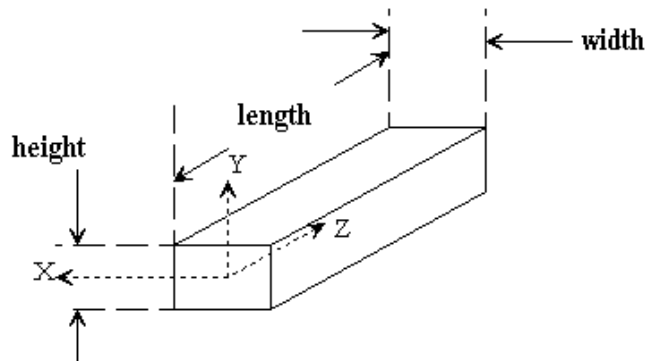


Figure 4 — Block_base_shape

4.2.11.2 width

The width specifies the size of the side of a Block_base_shape along the X-axis. See 4.3.13 for the application assertion.

4.2.12 BSU

A BSU is the identification of a piece of information, that can be a supplier, a class or a property, by specifying a code and a version. Each BSU is either a Supplier_BSU (see 4.2.139), a Class_BSU (see 4.2.13), or a Property_BSU (see 4.2.120).

NOTE The BSU definition is derived from clause 4.2.17 of ISO 10303-224.

The data associated with a BSU are the following:

— code.

4.2.12.1 code

The code specifies the designation of the identification of the information piece.

4.2.13 Class_BSU

A Class_BSU is a type of BSU (see 4.2.12) that identifies a class in a parts library.

NOTE 1 BSU is an acronym for “basic semantical unit”.

NOTE 2 The combination of supplier identification, code, and version of a class shall be unique.

NOTE 3 The Class_BSU definition is derived from clause 4.2.34 of ISO 10303-224.

The data associated with a Class_BSU are the following:

- defined_by;
- version.

4.2.13.1 defined_by

The defined_by specifies the library supplier who defines the library class. See 4.3.14 for the application assertion.

4.2.13.2 version

The version specifies the designation of the version of the information piece.

4.2.14 Company

A Company is an organization which is responsible for the process plans and products. The data associated with a Company are the following:

- address;
- name.

4.2.14.1 address

The address specifies where the Company is located.

4.2.14.2 name

The name specifies the word, or group of words, that make up the unique designation of a Company.

4.2.15 Company_contract_assignment

A Company_contract_assignment is a mechanism to associate a company with a contract, where the assigned company provides information about the contract it is associated to. The data associated with a Company_contract_assignment are the following:

- assigned_company;
- role.

4.2.15.1 assigned_company

The assigned_company specifies the company that is used to provide information to the contract. See 4.3.15 for the application assertion.

4.2.15.2 role

The assigned_company specifies the purpose for a company fulfilling the role with contracts.

4.2.16 Continuous_process

A Continuous_process is the organization of Manufacturing_processes (see 4.2.77) in a sequential order for a specific machine with a specific machine setup of a process plan. The value of the Continuous_process shall be one of the following:

- process_type;
- related_process;
- relating_process.

4.2.16.1 process_type

The process_type specifies the kind or kinds of continuous process is being done. The values of the content_geometry_type may be one of the following:

- batch;
- serial;
- serial and batch.

NOTE See 4.2.16.1.1 to 4.2.16.1.3 for the definition of each allowable value for process_type.

4.2.16.1.1 batch: the related process and the relating process are executed for each lot size.

4.2.16.1.2 serial: the related process and the relating process are executed for each part.

4.2.16.1.3 serial and batch: the related and relating process are both batch and serial.

4.2.16.2 related_process

The related_process specifies the sequence of process to be processed for a a specific machine with a specific machine setup by the process plan. The sequencing is achieved through chaining together the Manufacturing_process objects (see 4.2.77) The related_process references the next Manufacturing_process. See 4.3.16 for the application assertion.

4.2.16.3 relating_process

The relating_process specifies the sequence of process to be processed for a a specific machine with a specific machine setup by the process plan. The sequencing is achieved through chaining together the Manufacturing_process objects (see 4.2.77) The relating_process references the previous Manufacturing_process. See 4.3.16 for the application assertion.

4.2.17 Contract

A Contract is the binding agreement between two parties for the procurement and delivery of goods or services. This agreement is a legally enforceable business arrangement for the supply of certain goods or services by the contractee to the contractor. The data associated with a Contract are the following:

- acquires;
- binding_agreement;
- contract_document;
- contract_number;
- project_number.

4.2.17.1 acquires

The acquires specifies the product that is to be manufactured for this contract. See 4.3.19 for the application assertion.

4.2.17.2 binding_agreement

The binding_agreement specifies the company supplying the contract to manufacture a product. A Company_contract_assignment need not be specified for a particular Contract. See 4.3.17 for the application assertion.

4.2.17.3 contract_document

The contract_document specifies the hardcopy or digital document that details information about the contract. The contract_document need not be specified for a particular Contract. See 4.3.18 for the application assertion.

4.2.17.4 contract_number

The contract_number specifies the unique identification of a Contract within an organization.

4.2.17.5 project_number

The project_number specifies the unique identification, within an organization, that relates the work authorization back to the Contract.

4.2.18 Controller

The Controller is the computerized numerical controller that give instructions to a machine for the purpose of creating a product. The data associated with a Controller are the following:

- company_model;
- company_name;
- controller_specification.

4.2.18.1 company_model

The company_model specifies the descriptive model identification of the controller.

4.2.18.2 company_name

The company_name specifies the descriptive name for the controller.

4.2.18.3 controller_specification

The controller_specification specifies the hardcopy or digital document that details information about the controller. See 4.3.20 for the application assertion.

4.2.19 Controller_program

An Controller_program is the collection of information, which identifies a specific set of instructions to create a product.

NOTE A program can be stored as a computer file or stored on other media. Program in this context refers to the collection of controller codes necessary to control the machine tools spindle speeds, axis feed rates, and other needed controller functions.

The data associated with an Controller_program are the following:

- accomplished_by;
- controller_data_file;
- controller_type;
- covers;
- id;
- identified_on;
- program_format;

- references;
- revision;
- validation_date;
- validation_time.

4.2.19.1 accomplished_by

The `accomplished_by` specifies the process planning activity achieved by the completion of this controller program. The `accomplishes` need not be specified for a particular `Controller_program`. See 4.3.23 for the application assertion.

4.2.19.2 controller_data_file

The `controller_data_file` specifies the hardcopy or digital document that is the controller program. The `controller_data_file` need not be specified for a particular `Controller_program`. See 4.3.21 for the application assertion.

4.2.19.3 controller_type

The `controller_type` specifies the identification of the manufacturer and model number of the controller attached to the machine tool for which the controller program is written.

4.2.19.4 covers

The `covers` specifies the sequential organization of the process planning activities covered by the controller program. The `covers` need not be specified for a particular `Controller_program`. See 4.3.24 for the application assertion.

4.2.19.5 id

The `id` specifies the unique identification, within an organization, of the controller program used for a specific machining sequence specified on the `Process_plan_version` (see 4.2.116).

4.2.19.6 identified_on

The `identified_on` specifies the product that is having the part shape modified by this controller program. See 4.3.22 for the application assertion.

4.2.19.7 program_format

The `program_format` specifies the identification of the standard used in the data encoding of the controller program.

4.2.19.8 references

The references specifies the tooling referenced by the controller program. The references need not be specified for a particular Controller_program See 4.3.25 for the application assertion.

4.2.19.9 revision

The revision specifies the unique identification, within an organization, of the change level of the controller program.

4.2.19.10 validation_date

The validation_date specifies a calendar date on which the controller program was tested and found to be suitable for production use.

4.2.19.11 validation_time

The validation_time specifies the clock time on which the controller program was tested and found to be suitable for production use. The validation_time need not be specified for a particular controller program.

4.2.20 Curved_dimension_tolerance

A Curved_dimension_tolerance is a type of Size_tolerance (see 4.2.133) that is the tolerance on a dimension for a curve measured along the entire path of the curve.

NOTE 1The Curved_dimension_tolerance definition is derived from clause 4.2.47 of ISO 10303-224.

NOTE 2 Figure 5 illustrates the Curved_dimension_tolerance.

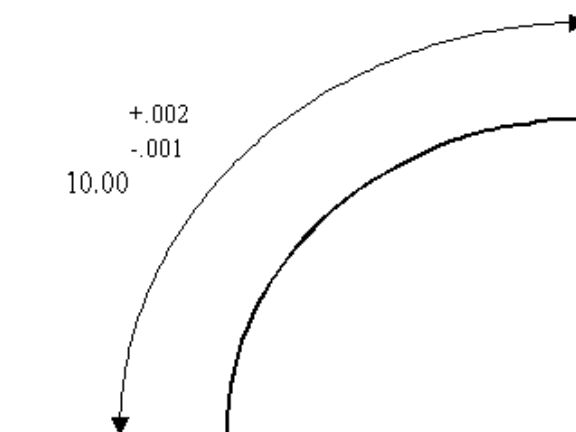


Figure 5 — Curved_dimension_tolerance

4.2.21 Cylindrical_base_shape

A Cylindrical_base_shape is a type of Implicit_base_shape_representation (see 4.2.60) that is the initial shape of the material which is cylindrical.

NOTE 1 The Cylindrical_base_shape definition is derived from clause 4.2.51 of ISO 10303-224.

NOTE 2 Figure 6 illustrates a Cylindrical_base_shape.

The data associated with a Cylindrical_base_shape are the following:

— diameter.

4.2.21.1 diameter

The diameter specifies the distance across a Cylindrical_base_shape. See 4.3.26 for the application assertion.

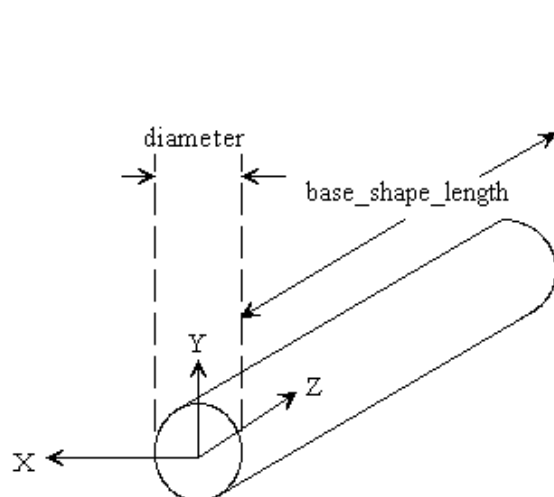


Figure 6 — Cylindrical_base_shape

4.2.22 Descriptive_parameter

A Descriptive_parameter is a type of Property_parameter (see 4.2.121) that is an explanation of the property being defined by a specification.

NOTE The Descriptive_parameter definition is derived from clause 4.2.61 of ISO 10303-224.

The data associated with a Descriptive_parameter are the following:

— descriptive_string.

4.2.22.1 descriptive_string

The descriptive_string specifies a word or group of words by which a Descriptive_parameter is explained.

4.2.23 Design_exception_notice

A Design_exception_notice is a notification of a design discrepancy discovered during the creation of the process plan for a given part such that process planning cannot continue until a technical recommendation is made to correct the problem.

NOTE The Design_exception_notice definition is derived from clause 4.2.62 of ISO 10303-224.

The data associated with a Design_exception_notice are the following:

- discrepant_part;
- issues;
- issuing_date;
- notice_description;
- notice_number;
- technical_recommendation.

4.2.23.1 discrepant_part

The discrepant_part specifies the part that has a design discrepancy. There may be more than one discrepant_part for a Design_exception_notice. See 4.3.28 for the application assertion.

4.2.23.2 issues

The issues specifies the change proposal to modify a Part. The issues need not be specified for a particular Design_exception_notice. There may be more than one issues for a Design_exception_notice. See 4.3.27 for the application assertion.

4.2.23.3 issuing_date

The issuing_date specifies the year, month and day when the design_exception_notice was created.

4.2.23.4 notice_description

The notice_description specifies the kind of problem or non-conformance machining condition causing a rejection of a part.

EXAMPLE If two holes were drilled simultaneously and the drill bits would run together, a recommendation would be needed to either change the depth of the hole or change the machining process.

4.2.23.5 notice_number

The notice_number specifies a unique identification for each Design_exception_notice.

4.2.23.6 technical_recommendation

The technical_recommendation specifies a recommended resolution to a design problem discovered during the creation of the process plan for a part. The technical_recommendation need not be specified for a particular Design_exception_notice.

4.2.24 Design_reference

A Design_reference is the identification of a graphic representation used to communicate the design. It identifies a version of a document that depicts the physical and functional data for a product, or some characteristic thereof, by means of pictorial and text presentations.

NOTE A Design_reference may be of type DXF, CAD, or other representation type.

The data associated with a Design_reference are the following:

- drawing_data_file;
- drawing_type;
- id;
- identifies;
- revision_level.

4.2.24.1 drawing_data_file

The drawing_data_file specifies the hardcopy or digital document that is the drawing. See 4.3.29 for the application assertion.

4.2.24.2 drawing_type

The drawing_type specifies the word, or group of words, that identify the item within the category of Drawings.

EXAMPLE A drawing_type may include such word groups as a tool design drawing, an engineering drawing, or a manufacturing drawing.

4.2.24.3 id

The id specifies the unique identification for a Design_reference within an organization.

4.2.24.4 identifies

The identifies specifies the activity that requires a Design_reference for additional information. The identifies need not be specified for a particular Design_reference. See 4.3.30 for the application assertion.

4.2.24.5 revision_level

The revision_level specifies the Design_reference release level. A Design_reference release level corresponds to a particular product version reflecting an approved engineering change.

4.2.25 Diameter_dimension_tolerance

A Diameter_dimension_tolerance is a type of Size_tolerance (see 4.2.133) that is the allowable variation of the size of a hole in a surface.

NOTE 1 The Design_exception_notice definition is derived from clause 4.2.64 of ISO 10303-224.

NOTE 2 Figure 7 illustrates the Diameter_dimension_tolerance.

4.2.26 Digital_file

A Digital_file is the computer interpretable data. A Digital_file is a type of Document_file (see 4.2.30).

4.2.27 Dimensional_tolerance

A Dimensional_tolerance is the total amount a specific dimension is permitted to vary, which is the difference between maximum and minimum permitted limits of size. Each Dimensional_tolerance is either a Location_tolerance (see 4.2.67) or a Size_tolerance (see 4.2.133).

NOTE The Dimensional_tolerance definition is derived from clause 4.2.68 of ISO 10303-224.

EXAMPLE A dimension given as $1.624 + .002 / -.002$ means it may be 1.626 or 1.622, or anywhere between these limit dimensions.

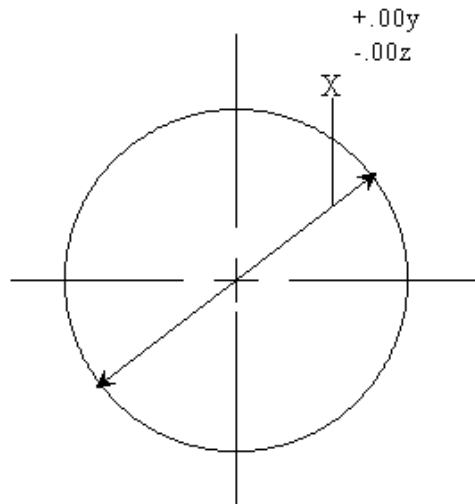


Figure 7 — Diameter_dimension_tolerance

The data associated with a Dimensional_tolerance are the following:

- dimension_description;
- dimension_note;
- dimension_value;
- limit;
- significant_digits;
- unit_of_measure.

4.2.27.1 dimension_description

The dimension_description specifies a textual description of any conditions which may affect the interpretation of the tolerance information that is defined. There may be more than one dimension_description for a Dimensional_tolerance. The dimension_description need not be specified for a particular Dimensional_tolerance.

EXAMPLE A Dimension_tolerance may apply in two places.

4.2.27.2 dimension_note

The dimension_note specifies a qualifying note. There may be more than one dimension_note for a Dimensional_tolerance. The dimension_note need not be specified for a particular Dimensional_tolerance. The values of the dimension_note may be one of the following:

- auxiliary;
- theoretical;
- user defined.

NOTE See 4.2.27.2.1 to 4.2.27.2.3 for the definition of each allowable value for limit_qualifier.

4.2.27.2.1 auxiliary: Restrict auxiliary dimension to be a nominal value with no value limitation.

4.2.27.2.2 theoretical: Restrict theoretically to be a nominal value with no value limitation.

4.2.27.2.3 user defined: a description specified by the user.

4.2.27.3 dimension_value

The dimension_value specifies the total amount by which a specific dimension is permitted to vary.

4.2.27.4 limit

The limit specifies the tolerance value applied to the Dimension_tolerance. The limit need not be specified for a particular Dimension_tolerance. See 4.3.31 for the application assertion.

4.2.27.5 significant_digits

The significant_digits specifies the number of decimal places indicating the accuracy of dimension or tolerance. The Significant_digits need not be specified for a particular Dimensional_tolerance.

4.2.27.6 unit_of_measure

The unit_of_measure specifies the unit in which the quantity is expressed.

4.2.28 Distance_along_curve_tolerance

A Distance_along_curve_tolerance is a type of Location_tolerance (see 4.2.67) that is the distance calculated between two elements along a path defined by a third element of geometry.

NOTE 1 The Distance_along_curve_tolerance definition is derived from clause 4.2.71 of ISO 10303-224.

NOTE 2 Figure 8 illustrates the Distance_along_curve_tolerance.

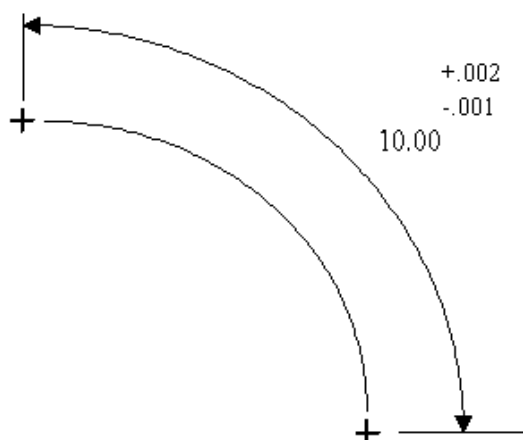


Figure 8 — Distance_along_curve_tolerance

The data associated with a Distance_along_curve_tolerance are the following:

- path;
- with_curve_direction.

4.2.28.1 path

The path specifies the shape that the tolerance applies to. See 4.3.32 for the application assertion.

4.2.28.2 with_curve_direction

The with_curve_direction specifies the direction along the element to apply the tolerance. The tolerance value is either applied from the start point of the curve to the end point of the curve, or the direction does not matter.

4.2.29 Document_assignment

A Document_assignment is a mechanism to associate a document with an object, where the assigned document provides information about the object it is associated to. Each Document_assignment may be a Partial_document_assignment (see 4.2.110). The data associated with a Document_assignment are the following:

- assigned_document;
- role.

4.2.29.1 assigned_document

The assigned_document specifies the Document_file (see 4.2.30) that is used to provide information. See 4.3.33 for the application assertion.

4.2.29.2 role

The role specifies the meaning of the Document_assignment.

4.2.30 Document_file

A Document_file is a file on a computer system or a paper document that make up a document representation. Each Document_file is a Hardcopy (see 4.2.56) or a Digital_file (see 4.2.26). The data associated with a Document_file are the following:

- document_properties;
- document_type;
- file_id;
- file_location;
- version_id.

4.2.30.1 document_properties

The document_properties specifies the characteristics of the Document_file that relate to the format of the object. See 4.3.34 for the application assertion. The document_properties need not be specified for a particular Document_file (see 4.2.30).

4.2.30.2 document_type

The document_type specifies the word or the group of words that describe the kind of object the characteristics are provided for. The document_type need not be specified for a particular Document_file.

The values of the document_type may be one of the following:

- check plan;
- design_reference;
- geometry;
- NC data;
- process plan;
- sample data.