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20240327_ap238e4_drill_and_fill

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Description

Drill and Fill after editing in Renton

AP238 Extension for Drill and Fill

This document describes the ARM/AIM mappings for an AP238 extension for the automation of processes that drill holes into assemblies and fill them with fasteners.

1 Application Objects
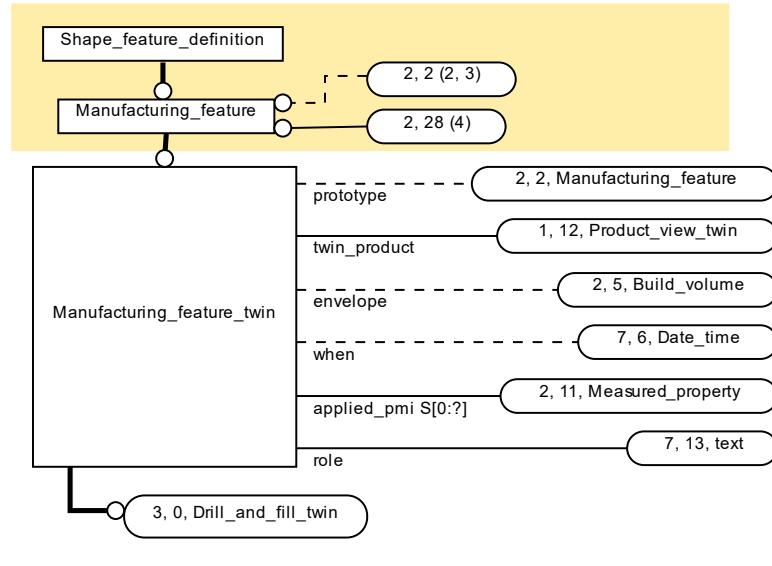
Feature Twin Definition

1.1 Manufacturing_feature_twin

The Maapplied_pmi_itemnufacturing_feature_twin application object is a type of Manufacturing_feature that describes a digital twin of a feature.

```
ENTITY Manufacturing_feature_twin
SUBTYPE OF (Manufacturing_feature);
  prototype:        OPTIONAL Manufacturing_feature;
  twin_product:     Product_view_twin;
  envelope:         OPTIONAL Build_volume;
  when:             OPTIONAL date_time;
  applied_pmi:      SET [0:?] OF measured_property;
  role: text;
END_ENTITY;
```

1.1.1 prototype

The as-designed state of the feature twin.

Note: In many cases the prototype is a feature described in AP242.

1.1.2 twin_product

The product that contains this digital twin feature.

1.1.3 envelope

A volume on the product containing the digital twin prototype. If two instances of the prototype are in the envelope, then the twin shall be the instance that has the greatest volume in the envelope.

1.1.4 when

The date and time when the twin had this status. If null then the twin describes the current status.

1.1.5 applied_pmi

The pmi that has been measured on the digital twin.

1.1.6 role

The role of the twin on the product, for example, a round hole digital twin may describe a pilot hole, a tack hole, or a fastener hole.

3, 0 (2)

3, 32 (4, 4)

3, 22 (3, 4, 4)

Drill_and_fill_twin

hole_in_place — BOOLEAN

pilot_in_place — BOOLEAN

tack_in_place — 1, 19, Product_view_twin

fastener_in_place — 1, 19, Product_view_twin

collar_in_place — 1, 19, Product_view_twin

washer_in_place — 1, 19, Product_view_twin

washer_count — 7, 20, count_measure

sealed — 1, 19, Product_view_twin

engineering_fit — hole_class

iso_fit — iso_286_hole_class

disposition — drill_and_fill_condition

measured_location — 2, 21, Measured_property

measured_size — 2, 21, Measured_property

measured_orientation — 2, 21, Measured_property

measured_form — 2, 21, Measured_property

replacement — 3, 22, Drill_and_fill_twin

stackups S[0:?]

Drill_and_fill_stackup

measurement_state — measurement_condition

outer_part — 1, 14, Product_view_definition

default_direction — direction

default_diameter — 7, 15, Length_data_element

computed_depth — 7, 15, Length_data_element

when_computed — 7, 6, Date_time

layers L[1:?]

Stack_layer

usage — 1, 14, Product_view_definition

start_dist — 7, 16, Length_data_element

end_dist — 7, 16, Length_data_element

status — stack_layer_status

layer_feature — 2, 2, Manufacturing_feature

Drill and Fill Feature Twin Definition

1.2 Drill_and_fill_twin

The Drill_and_fill_twin application object is a Manufacturing_feature_twin that describes how a stack of materials is being fastened.

```
ENTITY Drill_and_fill_twin
SUBTYPE OF (Manufacturing_feature_twin);
  stackups           : SET [0:?] OF Drill_and_fill_stackup;
  hole_in_place      : BOOLEAN;
  pilot_in_place     : OPTIONAL BOOLEAN;
  tack_in_place      : OPTIONAL Product_view_twin;
  fastener_in_place  : OPTIONAL Product_view_twin;
  collar_in_place    : OPTIONAL Product_view_twin;
  washer_in_place    : OPTIONAL Product_view_twin;
  washer_count       : OPTIONAL count_measure;
  sealed             : OPTIONAL Product_view_twin;
  engineering_fit    : OPTIONAL hole_class;
  iso_fit            : OPTIONAL iso_286_hole_class;
  disposition        : drill_and_fill_condition;
  measured_location  : OPTIONAL Measured_property;
  measured_size      : OPTIONAL Measured_property;
  measured_orientation: OPTIONAL Measured_property;
  measured_form      : OPTIONAL Measured_property;
  replacement        : OPTIONAL Drill_and_fill_twin;
WHERE
  WR1: 'POSITION_TOLERANCE' IN TYPEOF (measured_location.prototype) OR
  'PROFILE_TOLERANCE' IN TYPEOF (measured_location.prototype)
  WR2: 'DIAMETER_SIZE' IN TYPEOF (measured_size.prototype)
  WR3: 'PERPENDICULARITY_TOLERANCE' IN TYPEOF (measured_orientation.prototype) OR
  'PARALLELISM_TOLERANCE' IN TYPEOF (measured_orientation.prototype) OR
  'ANGULARITY_TOLERANCE' IN TYPEOF (measured_orientation.prototype) OR
  WR4: 'ROUNDNESS_TOLERANCE' IN TYPEOF (measured_form.prototype) OR
  'CYLINDRICITY_TOLERANCE' IN TYPEOF (measured_form.prototype)
END_ENTITY;

TYPE drill_and_fill_condition = ENUMERATION OF (pending, active, exception, hold,
completed, replaced); END_TYPE;

TYPE hole_class = ENUMERATION OF (loose_fit, free_running, easy_running, sliding_fit,
close_clearance, location_clearance, slight_interference, transition, press_fit,
medium_fit, force_fit); END_TYPE;

TYPE iso_286_hole_class = ENUMERATION OF (clearance_fit, interference_fit,
transition_fit); END_TYPE;

NOTE Table 6-1 of ISO 286-1
```

1.2.1 stackups

The stack of material layers in the feature. Different stackups can be measured for different stages of the process, for example, as-designed, as-assembled, and as_clamped.

1.2.2 hole_in_place

True if the fastener hole has been drilled.

1.2.3 pilot_hole_in_place

True if the pilot hole has been drilled.

1.2.4 tack_in_place

True if there is a tack in the hole.

1.2.5 fastener_in_place

The twin model of the fastener that has been placed into the hole.

1.2.6 collar_in_place

The twin model of the collar (or nut) that has been placed on the fastener.

1.2.7 washer_in_place

The twin model of the washers that have been placed on the fastener.

1.2.8 washer_count

The number of washers placed between the fastener and the material.

1.2.9 sealed

The twin model of the sealant.

1.2.10 disposition

The current status of the twin

- pending if no work has been performed
- active if work is currently being performed
- completed if all the planned work has been completed
- rejection_tag if there is an issue that awaits resolution
- replaced if repeated, for example with a bigger hole and fastener

1.2.11 engineering_fit

If the hole is a tight fit then force will be necessary to insert the fastener. If the hole is a loose fit then the fastener will drop into place.

NOTE: The engineering fit should not be repeated if it is described in the prototype.

1.2.12 iso_fit

The ISO 286-1 classification of the engineering fit.

NOTE: The ISO fit should not be repeated if it is described in the prototype.

1.2.13 measured_location

The as_measured location of the hole.

1.2.14 measured_size

The as_measured section size of the hole.

1.2.15 measured_orientation

The as_measured orientation of the hole.

1.2.16 measured_form

The as_measured form (roundness or cylindricity) of the hole.

1.2.17 replacement

If the physical twin had to replaced because of a manufacturing issue, then this is the replacement. For example, if the fastener did not fit beause of tolerance issues, then the hole may have been replaced by a larger one.

1.3   Drill_and_fill_stackup

The Drill_and_fill_Stackup application object describes the material layers in a feature.

```
ENTITY Drill_and_fill_stackup;
  measurement_state : measurement_condition;
  outer_part        : Product_view_definition;
  default_direction : OPTIONAL direction;
```

```
   default_diameter  : OPTIONAL Length_data_element;
   layers            : OPTIONAL LIST [1:?] OF stack_layer;
   computed_depth    : OPTIONAL Length_data_element;
   when_computed     : OPTIONAL Date_time;
END_ENTITY;

TYPE measurement_condition = ENUMERATION OF (as_designed, as_predicted, as_measured);
END_TYPE;
```

1.3.1 measurement_state

The state of the twin when the stackup was measured

- as-designed: the stackup as designed in a CAD system
- as-predicted: the stackup as predicted with as-built dimensions for all components
- as-measured: the stackup as measured on the assembled airframe after clamping

1.3.2 outer_part

The part in the assembly where the drilling begins.

NOTE: Boeing and LM have defined the hole origin at the bottom of a skin.

1.3.3 default_direction

The direction of the material removal if no feature path is given.

1.3.4 default_diameter

The diameter of the material removal if no feature profile is given.

1.3.5 layers

The list of layer depths in the stackup.

1.3.6 computed_depth

The computed depth of the stackup.

Note: The computed_depth may be the sum of the depths of the layers, or it may be the result of inspection after the fastener has been clamped.

1.3.7 when_computed

The date and time when the measurement was computed.

1.4 Stack_layer

The Stack_layer application object describes the starting and ending distance from the origin of
the feature for a path through each layer of the assembly.

```
ENTITY Stack_layer;
  usage             : Product_view_definition;
  start_dist        : Length_data_element;
  end_dist          : Length_data_element;
  status            : OPTIONAL stack_layer_status;
  layer_feature     : OPTIONAL Manufacturing_feature;
END_ENTITY;

TYPE stack_layer_status = ENUMERATION OF (air_gap, overlap); END_TYPE;
```

1.4.1 usage

The product that defines this layer of the stackup.

NOTE: A different material may be defined at each layer.

1.4.2 start_dist

The distance on the feature path from the origin to the start of this layer.

1.4.3 end_dist

The distance on the feature path from the origin to the end of this layer.

1.4.4 status

Set when there is an air gap, or overlap, between this layer and the preceding layer

NOTE: An overlap indicates that some volume of each material is inside the other

1.4.5 layer_feature

An optional description of the volume removed on this layer, for example, for a drill hole a
round hole may be described for the volume removed on each layer.
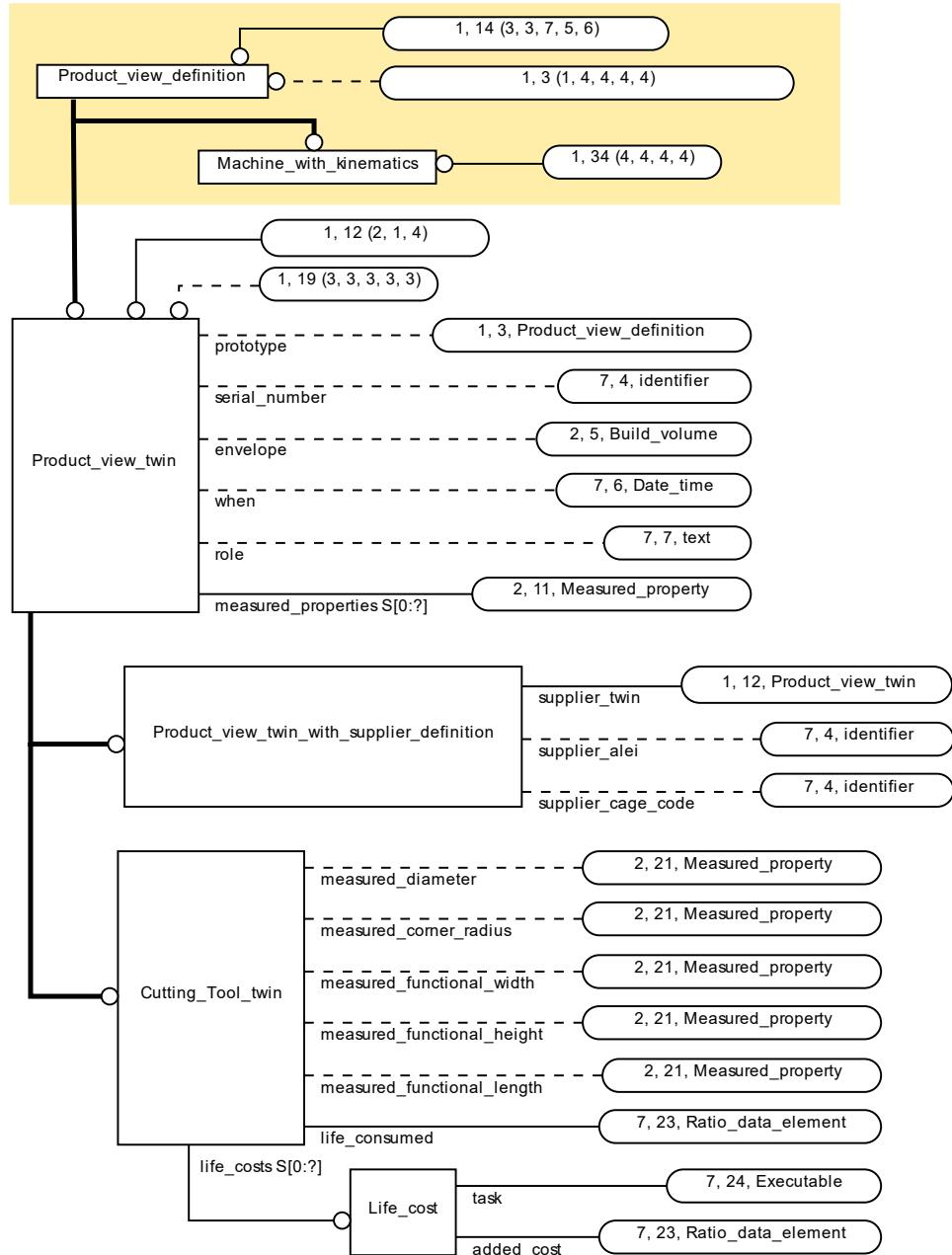
Product Twin Definitions

1.5   Product_view_twin

The product_view_twin application object is a digital twin describing as-built data for a product. If there are many digital instances of the product, for example many fasteners on a structure, then each is distinguished from the others by a serial number and/or an envelope. If this is the only instance of a product then this twin may be its own prototype.

```
ENTITY Product_view_twin
```

```
  SUBTYPE OF (Product_view_definition);
  prototype:             OPTIONAL Product_view_definition;
  serial_number:         OPTIONAL identifier;
  envelope:              OPTIONAL Build_volume;
  when:                  OPTIONAL Date_time;
  role:                  OPTIONAL text;
  measured_properties:   SET [0:?] OF Measured_property;
END_ENTITY;
```

1.5.1 prototype

The as-designed data of the product twin.

1.5.2 serial_number

An identifier that is unique to this digital twin instance with respect to the product prototype.

1.5.3 envelope

The envelope is a volume containing a prototype of the digital twin. If two instances of the prototype are in the envelope, then the twin shall be the instance that has the greatest volume in the envelope.

1.5.4 when

The date and time when the twin had this status. If null then the twin describes the current state.

1.5.5 role

The role of the twin on the product, for example, a fastener digital twin may describe a pin, a collar, a nut or a washer.

1.5.6 measured_properties

The as-measured properties of the twin, for example, a cutter twin may have measured properties for its diameter, corner radius and functional length.
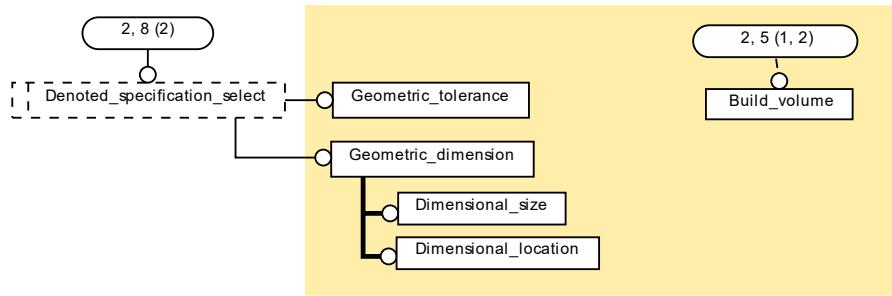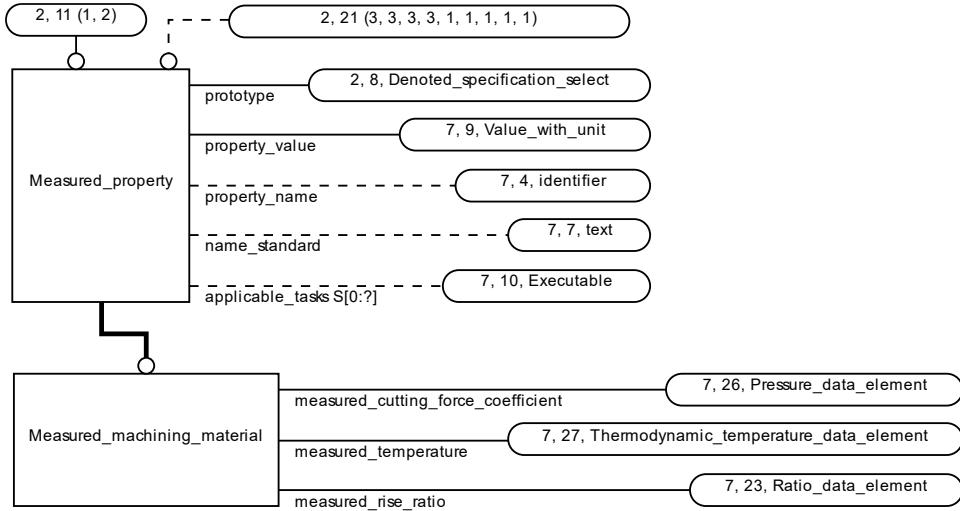
Measured Property Definition

1.6 Measured_property

The measured_property application object describes a property on a digital twin that has been measured by an external device such as a tool assembly pre-setter.

```
ENTITY Measured_property;
      prototype:      Denoted_specification_select;    // link to GD&T
      property_value:    Value_with_unit;
      property_name:     OPTIONAL identifier;                    // ISO 13399 name
      name_standard:     OPTIONAL text;
      applicable_tasks:  OPTIONAL SET [0:?] OF Executable;       // applicable tasks
END_ENTITY;
```

1.6.1 prototype

The dimension on the product that has this property.

1.6.2 property_value

The as-measured value of the property.

1.6.3 property_name

The name of the property where possible this name should be defined by a standard. For example, ISO 13399 gives standard names to properties defined for a cutter.

1.6.4 name_standard

The name of the standard that defines the property.

1.6.5 applicable_tasks

The manufacturing tasks that will use this property.

1.7 Cutting_tool_twin

The Cutting_tool_twin application object describes a digital twin of a cutter.

```
ENTITY Cutting_Tool_twin
  SUBTYPE OF (Product_view_twin);
  measured_diameter              : OPTIONAL Measured_property;
  measured_corner_radius         : OPTIONAL Measured_property;
  measured_functional_width      : OPTIONAL Measured_property;
  measured_functional_height     : OPTIONAL Measured_property;
  measured_functional_length     : OPTIONAL Measured_property;
  life_consumed                  : Ratio_data_element;
  life_costs                     : SET [0:?] OF Life_cost;
END_ENTITY;
```

1.7.1 measured_diameter

the as_measured effective_cutting_diameter as defined in ISO 13399.

1.7.2 measured_corner_radius

the as_measured corner_radius as defined in ISO 13399.

1.7.3 measured_width

the as_measured width as defined in ISO 13399.

1.7.4 measured_height

the as_measured height as defined in ISO 13399.

1.7.5 measured_functional_length

the as_measured functional length as defined in ISO 13399.

1.7.6 life_consumed

The tool life percentage consumed on the tasks performed.

NOTE The percentage starts at 0 for a new tool, and sometimes exceeds 100 if it is over used.

1.7.7 Life_costs

Life costs for using the resource on a task.

1.8 Life Cost

The Life_cost application object describes how much tool life is consumed when the tool machines an operation.

```
ENTITY Life_cost;
   task              : Executable;
   added_cost        : Ratio_data_element;
END_ENTITY;
```

1.9 Measured_machining_material

The Measured_machining_material application object describes machining characteristics of a measured material.

```
ENTITY Measured_machining_material
  SUBTYPE OF (Measured_property);
  measured_cutting_force_coefficient:  Pressure_data_element;
  measured_temperature:                Thermodynamic_temperature_data_element;
  measured_rise_ratio:                 Ratio_data_element;
END_ENTITY;
```

NOTE: The material is usually measured once by a standards authority, but maybe measured for a specific lot.

1.9.1 cutting force coefficient

Force per area for a chip thickness of 1 mm (0.0394 inch) in tangential direction. A specific material may have more than one specific cutting force coefficient.

NOTE: Material constant: specific cutting force coefficient. Traditionally named kc 1.1).

1.9.2 temperature

Shear-zone temperature applicable for the specific cutting force coefficient.

1.9.3 rise_ratio

Rise in specific cutting force as a function of reduced chip thickness.

NOTE: Can be found in the work material property from cutting data tables.

1.10 Product_view_twin_with_supplier_definition

The Product_view_twin_with_supplier_definition application object describes a supplier digital twin that has been substituted for the product_view_twin after meeting the requirements defined for the product_view_twin.

```
ENTITY Product_view_twin_with_supplier_definition
  SUBTYPE OF (Product_view_twin);
  supplier_twin:          Product_view_twin;
  supplier_alei:          OPTIONAL identifier;
  supplier_cage_code:     OPTIONAL identifier;
END_ENTITY;
```

1.10.1 supplier_twin

The digital twin made by the supplier.

1.10.2 supplier_alei

The unique ALEI (Authoritative Legal Entity Identifier) of this supplier in accordance with ISO 8000-116.

1.10.3 supplier_cage_code

The unique CAGE (Commercial and Government Entity) identifier of this supplier. CAGE identifiers are issued by the DLA Logistic in US.

NOTE A CAGE identifier is a proxy identifier according to ISO 8000-116.

1.10.4 task

The task that has been measured.

1.10.5 added_cost

When the tool is applied to this task add this cost to its life_consumed.

```
Manufacturing_feature_group ───── elements S[0:?] ───── ( 2, 28, Manufacturing_feature )

Drill_and_fill_group ───── manufacturing_stage ───── ( 7, 13, text )
                     ───── primary ───── [ BOOLEAN ]

    Escape_sequence_group ───── robot ───── ( 1, 34, Machine_with_kinematics )
                          ───── escape_moves ───── ( 7, 39, Connect_escape_stack )

    Entry_sequence_group ───── robot ───── ( 1, 34, Machine_with_kinematics )
                         ───── entry_moves ───── ( 7, 41, Connect_entry_stack )

    Fastener_group ───── maximum_grip_length ───── ( 7, 16, Length_data_element )
                   ───── minimum_grip_length ───── ( 7, 16, Length_data_element )
                   ───── fastener ───── ( 1, 3, Product_view_definition )
                   ───── collar ───── ( 1, 3, Product_view_definition )
                   ───── sealant ───── ( 1, 3, Product_view_definition )
                   ───── washer ───── ( 1, 3, Product_view_definition )
                   ───── washer_count ───── ( 7, 20, count_measure )

    Oneup_assembly_group ───── manufacturing_plan ───── ( 7, 33, Workplan )
                         ───── compatible_robots S[0:?] ───── ( 1, 34, Machine_with_kinematics )
                         ───── must_follow S[0:?]

    Preferred_robot_group ───── preferred_robot ───── ( 1, 34, Machine_with_kinematics )
                          ───── precedence ───── [ INTEGER ]

    Reference_frame_group ───── guide_verified ───── [ BOOLEAN ]
                          ───── modification ───── ( 7, 30, axis2_placement_3d )
                          ───── verification_time ───── ( 7, 31, Date_time )
                          ───── basis

        Best_fit_reference_frame_group ───── guides S[0:?] ───── ( 3, 32, Drill_and_fill_twin )

        Three_twin_reference_frame_group ───── guide_primary ───── ( 3, 32, Drill_and_fill_twin )
                                         ───── guide_secondary ───── ( 3, 22, Drill_and_fill_twin )
                                         ───── guide_tertiary ───── ( 3, 22, Drill_and_fill_twin )

    Requirement_and_property_group ───── requirements S[0:?] ───── [ requirement_assignment ]
                                   ───── properties S[0:?] ───── [ assigned_property ]
                                   ───── when_met ───── [ condition_time ]

    Same_assembly_group ───── parts_joined S[0:?] ───── ( 1, 12, Product_view_twin )
```

Drill and Fill Group Definitions

1.11 Drill_and_fill_group

The Drill_and_fill_group application object describes planning information for a group of drill and fill holes.

```
ENTITY Drill_and_fill_group
ABSTRACT SUPERTYPE
SUBTYPE OF (Manufacturing_feature_group);
  manufacturing_stage    : text;       -- phase 1, phase 2 etc.
  primary : BOOLEAN;
END_ENTITY;
```

1.11.1 manufacturing_phase

The manufacturing phase when this group contains relevant planning information. For example, a manufacturing plan may be divided into time periods called "Phase 1", "Phase 2" and "Phase 3".

1.11.2 primary

This grouping defines a primary property for this set of features. For example, the primary or preferred fastener for this hole.

1.12 Reference_frame_group

The Reference_frame_group application object describes a reference frame that can be used to correct the location and axis orientation of a group of holes.

```
ENTITY Reference_frame_group
SUBTYPE OF (Drill_and_fill_group);
  guide_verified    : BOOLEAN;
  basis             : OPTIONAL Reference_frame_group;
  modification      : OPTIONAL axis2_placement_3d;
  verification_time : Date_time; -- because stale after 12 hours
END_ENTITY;
```

1.12.1 guide_verified

The guide_verified is set to true when the guide has been checked.

1.12.2 basis

The basis to be used when computing the modification for this reference frame group. If no basis is set then the global coordinate system shall be used as the base.

1.12.3 modification

The modification against the basis necessary to correctly position and orient any drilling operations generated to make holes for the members of this group.

1.12.4 verification_time

The date and time when the guides were last checked. For example, in some enterprises a guide is considered stale after 12 hours and must be computed again.

1.13 Three_twin_reference_frame_group

The Three_twin_reference_frame_group application object describes a reference frame that is computed using three guides.

```
ENTITY Three_twin_reference_frame_group
SUBTYPE OF (reference_frame_group);
  guide_primary           : Drill_and_fill_twin;
  guide_secondary  : OPTIONAL Drill_and_fill_twin;
  guide_tertiary   : OPTIONAL Drill_and_fill_twin;
END_ENTITY;
```

1.13.1 guide primary

The primary reference point for the guide. This point is required and defines the displacement required to correctly position the group.

1.13.2 guide secondary

The secondary reference point for the guide. If set this point determines the axis of the guide.

1.13.3 guide tertiary

The tertiary reference point for the guide. If set this point determines the reference axis of the guide.

1.14 Best_fit_reference_frame_group

The Best_fit_reference_frame_group application object describes a reference frame that is computed using a set of guides.

```
ENTITY Best_fit_reference_frame_group
```

```
SUBTYPE OF (Reference_frame_group);
  guides          : SET OF Drill_and_fill_twin;
END_ENTITY;
```

1.14.1 guides

The points used to compute the best fit.

1.15 Fastener_group

The Fastener_group application object describes a fastener configuration that can be used for a group of holes.

```
-- group of holes with the same suggested fastener
ENTITY Fastener_group
SUBTYPE OF (Drill_and_fill_group);
  maximum_grip_length    : Length_data_element;
  minimum_grip_length    : Length_data_element;
  fastener               : OPTIONAL Product_view_definition;
  collar                 : OPTIONAL Product_view_definition;
  sealant                : OPTIONAL Product_view_definition;
  washer                 : OPTIONAL Product_view_definition;
  washer_count           : OPTIONAL count_measure;
END_ENTITY;
```

1.15.1 maximum_grip_length

The maximum grip length allowed for the holes in this fastener group.

1.15.2 minimum_grip_length

The minimum grip length allowed for the holes in this fastener group.

1.15.3 fastener

The recommended fastener for the holes in this fastener group.

1.15.4 collar

The recommended collar for the holes in this fastener group.

1.15.5 sealant

The recommended sealant for the holes in this fastener group.

1.15.6 washer

The recommended washer for this assembly.

1.15.7 washer count

The washer count required for this fastener assembly.

1.16 Same_assembly_group

The Same_assembly_group application object describes drill and fill holes that join the same components.

```
-- group of holes that join the same components
ENTITY Same_assembly_group
SUBTYPE OF (Drill_and_fill_group);
  parts_joined : SET OF Product_view_twin;
END_ENTITY;
```

1.16.1 parts_joined

The list of parts joined by the drill and fill holes in this group.

1.17 Oneup_assembly_group

The Oneup_assembly_group application object describes a group of holes that need to be drilled together to meet the requirements of oneup assembly.

```
-- group of holes that are drilled together
ENTITY Oneup_assembly_group
SUBTYPE OF (Drill_and_fill_group);
  manufacturing_plan:     OPTIONAL Workplan;
  compatible_robots :     SET [0:?] OF Machine_with_kinematics;
  must_follow :           SET [0:?] OF Oneup_assembly_group;
END_ENTITY;
```

1.17.1 manufacturing_plan

The recommended drilling solution.

1.17.2 compatible_robots

The robots that can run the recommended solution.

1.17.3 must_follow

The set of other one-up assembly groups that must be completed before this group begins.

1.18 Preferred_robot_group

The preferred_robot_group application object describe a robot that is the preferred choice for a group of holes.

```
-- group of holes that prefer to use the same robot
ENTITY Preferred_robot_group
SUBTYPE OF (Drill_and_fill_group);
  preferred_robot  : Machine_with_kinematics;
  precedence       : OPTIONAL INTEGER;
END_ENTITY;
```

1.18.1 preferred_robot

A robot that can be selected for this group of holes.

1.18.2 precedence

A precedence level when multiple robots can be selected

1.19 Escape_sequence_group

The Escape_sequence_group application object describes a safe escape sequence for the group of holes when the programmed sequence must be interrupted.

```
-- how to pull away for unplanned changes in sequence
ENTITY Escape_sequence_group
SUBTYPE OF (Drill_and_fill_group);
  robot                    : Machine_with_kinematics;
  escape_moves             : Connect_escape_stack;
END_ENTITY;
```

1.19.1 robot

The robot that uses this escape sequence.

1.19.2 escape_moves

The stack of escape moves for the robot.

1.20 Entry_sequence_group

The Entry_sequence_group application object describes a safe entry sequence for the group of holes when a new programmed sequence is started.

```
-- how to approach for drill and fill for unplanned changes in sequence
ENTITY Entry_sequence_group
SUBTYPE OF (Drill_and_fill_group);
  robot             : Machine_with_kinematics;
  entry_moves       : Connect_entry_stack;
END_ENTITY;
```

1.20.1 robot

The robot that uses this entry sequence.

1.20.2 entry_moves

The stack of entry moves for the robot.

1.21 Requirement_and_property_group

The Requirement_and_property_group application object describes requirements and properties that must be met by the drill points in the group.

```
-- PMI constraints on this group
ENTITY Requirement_and_property_group
SUBTYPE OF (Drill_and_fill_group);
  requirements      : SET OF requirement_assignment;
  properties        : SET OF assigned_property;
  when_met          : condition_time;
END_ENTITY;

TYPE condition_time = ENUMERATION OF (pre_condition, post_condition,
pre_and_post_condition); END_TYPE;
```

1.21.1 requirements

A set of dimensional and tolerance constraints.

1.21.2 properties

A set of properties such as material, hardness and surface condition.

1.21.3 when_met

An indication of whether these properties should be met before the operation, after the operation. or both before and after the operation.
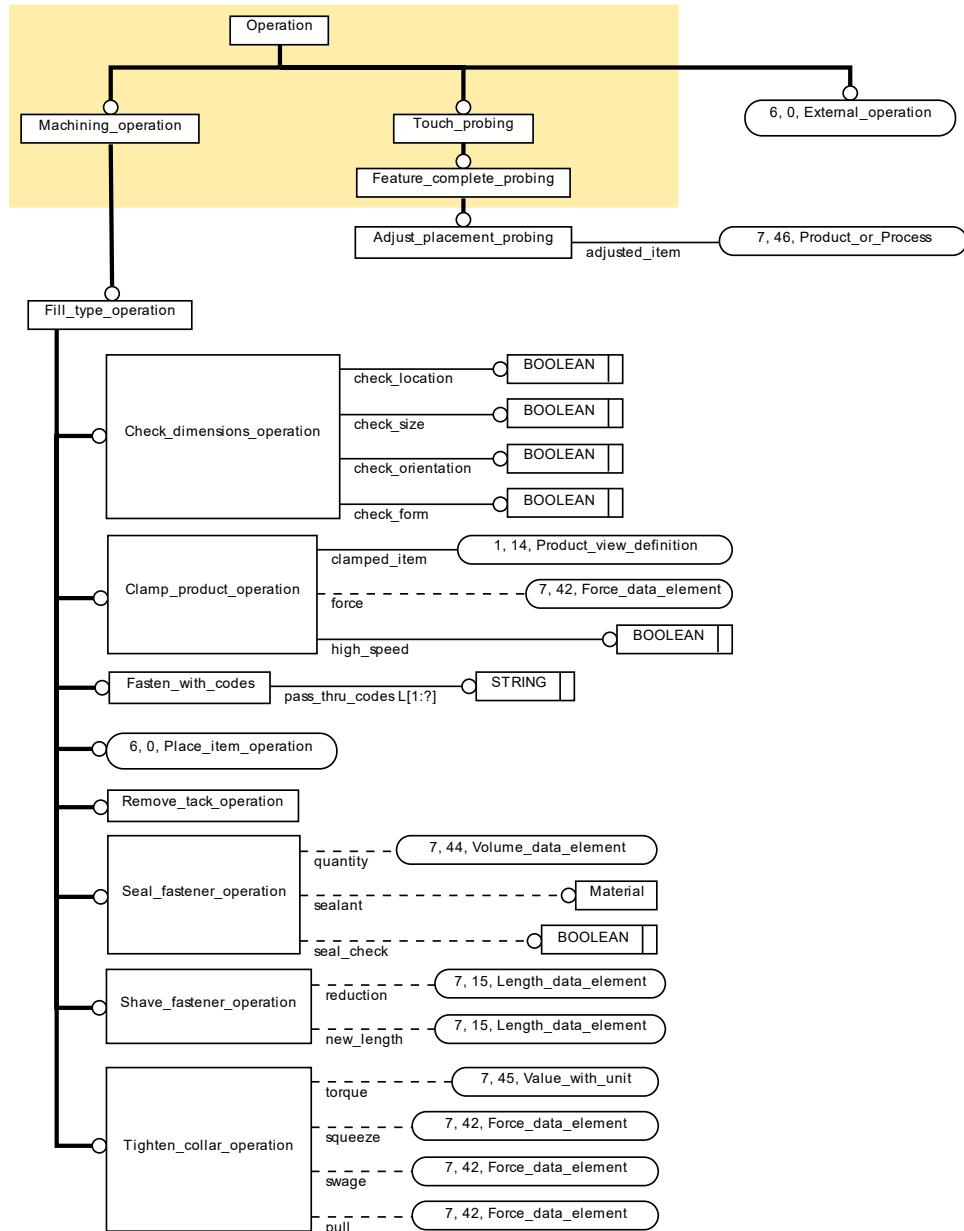
Drill and Fill Operation Definitions

1.22 Fill_type_operation

The Fill_type_operation application object is a Machining_operation that adds a product to the as_is model.

```
ENTITY Fill_type_operation
  SUBTYPE_OF (Machining_operation);
END_ENTITY
```

1.23 Clamp_product_operation

The Clamp_product_operation application object is a Fill_type_operation that clamps a structure during manufacturing.

```
ENTITY Clamp_product_operation
  SUBTYPE_OF (Fill_type_operation);
  clamped_item      : Product_view_definition;
  force             : OPTIONAL Force_data_element;
  high_speed        : BOOLEAN;
END_ENTITY;
```

1.23.1 clamped_item

The item that is to be clamped.

1.23.2 force

The force to be applied during the clamping.

1.23.3 high_speed

True if the clamping is to be done at high speed.

1.24 Fasten_with_codes

The Fasten_with_codes application object is a Fasten_operation that uses machine-specific codes to achieve its effect.

```
ENTITY Fasten_with_codes
  SUBTYPE_OF (Fill_type_operation);
  pass_thru_codes   : LIST [1:?] OF STRING;
END_ENTITY;
```

1.24.1 pass_thru_codes

The enterprise's machine/process specific codes that are to be used to control the manufacturing.
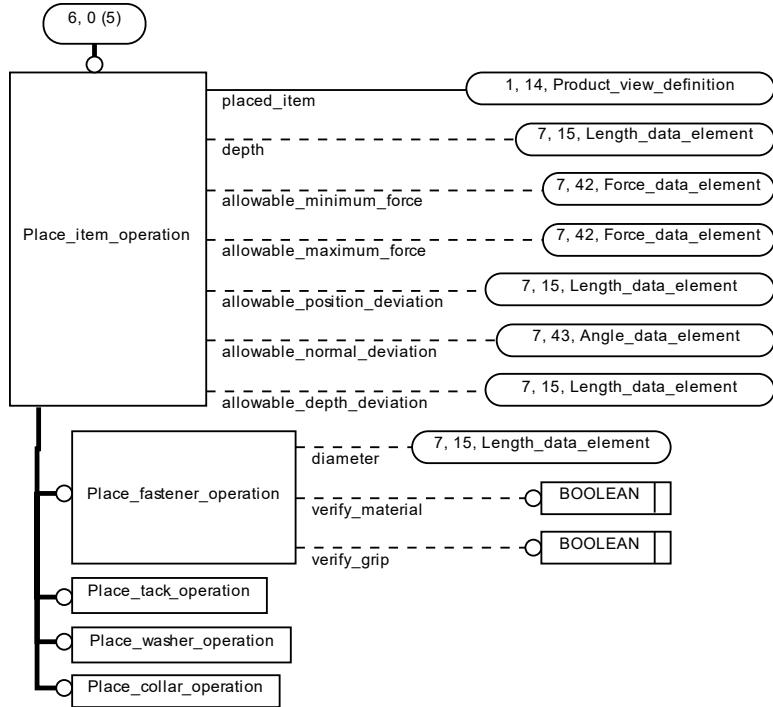
Place Item Operation Definitions

1.25 Place_item_operation

The Place_item_operation application object is a Fill_type_operation that places an item into a feature.

```
-- The as-selected fastener may be different to the as-planned
ENTITY Place_item_operation
  SUBTYPE OF (Fill_type_operation);
  placed_item                 : Product_view_definition;
  depth                       : OPTIONAL Length_data_element;
  allowable_minimum_force     : OPTIONAL Force_data_element;
  allowable_maximum_force     : OPTIONAL Force_data_element;
  allowable_position_deviation : OPTIONAL Length_data_element;
  allowable_normal_deviation  : OPTIONAL Angle_data_element;
  allowable_depth_deviation   : OPTIONAL Length_data_element;
END_ENTITY;
```

1.25.1 placed_item

Definition of the item to be placed into the feature. The digital twin selected shall use this definition as a prototype.

1.25.2 depth

The distance from the top of the feature, in the direction of the axis of the feature, where the item is to be placed.

1.25.3 allowable_minimum_force

The minimum force necessary to place the fastener, or insert a rivet, into the feature.

NOTE: If the minimum is not met then a flag can be raised.

1.25.4 allowable_maximum_force

The maximum force necessary to place the fastener, or insert a rivet, into the feature.

NOTE: If a force is exceeded then a flag can be raised.

1.25.5 allowable_position_deviation

The maximum deviation allowed for the position of the item.

NOTE: If the deviation is exceeded then a flag can be raised.

1.25.6 allowable_normal_deviation

The maximum deviation allowed for the direction of the normal.

NOTE: If an angular deviation is exceeded then a flag can be raised.

1.25.7 allowable_depth_deviation

The maximum deviation allowed for the depth of the hole.

NOTE: If the depth is exceeded then a flag can be raised.

1.26 Place_fastener_operation

The Place_fastener_operation application object is a Fill_type_operation that places a fastener.

```
ENTITY Place_fastener_operation
  SUBTYPE OF (Place_item_operation);
  diameter          : OPTIONAL Length_data_element;
  verify_material   : OPTIONAL BOOLEAN;
```

```
   verify_grip      : OPTIONAL BOOLEAN;
END_ENTITY;
```

1.26.1 diameter

The expected diameter for the placed item.

1.26.2 verify_material

Verify the material of the fastener, for example, by using a camera to inspect the color.

1.26.3 verify_grip

Verify the grip length is sufficient for the depth of the hole stack.

1.27 Place_tack_operation

The Place_tack_operation application object is a Fill_type_operation that places a temporary fastener.

```
ENTITY Place_tack_operation
  SUBTYPE OF (Place_item_operation);
END_ENTITY;
```

1.28 Place_washer_operation

The Place_washer_operation application object is a Fill_type_operation that places a washer.

```
ENTITY Place_washer_operation
  SUBTYPE OF (Place_item_operation);
END_ENTITY;
```

1.29 Place_collar_operation

The Place_collar_operation application object is a Fill_type_operation that places a collar.

```
ENTITY Place_collar_operation
  SUBTYPE OF (Place_item_operation);
END_ENTITY;
```

1.30 Remove_tack_operation

The Remove_tack_operation application object removes a temporary fastener from a feature..

```
ENTITY Remove_tack_operation
  SUBTYPE OF (Fill_type_operation);
END_ENTITY;
```

1.31 Seal_fastener_operation

The Seal_fastener_operation application object is a Fill_type_operation that seals the fastener in a feature.

```
ENTITY Seal_fastener_operation
  SUBTYPE OF (Fill_type_operation);
  quantity        : OPTIONAL Volume_data_element;
  sealant         : OPTIONAL material;
  seal_check      : OPTIONAL BOOLEAN;
END_ENTITY;
```

1.31.1 quantity

The volume of sealant to be applied.

1.31.2 sealant

The sealant material.

1.31.3 seal_check

Check the sealant, for example, using a camera.

1.32 Shave_fastener_operation

The Shave_fastener_operation application object is a Fill_type_operation that reduces the length of the fastener for a feature.

```
ENTITY Shave_fastener_operation
  SUBTYPE OF (Fill_type_operation);
  reduction  : OPTIONAL Length_data_element;
  new_length : OPTIONAL Length_data_element;
END_ENTITY;
```

1.32.1 reduction

The length of material to be removed.

1.32.2 new_length

The required length of the fastener after shaving.

1.33 Tighten_collar_operation

The Tighten_collar_operation application object is a Fill_type_operation that tightens the collar on a fastener in a feature.

```
ENTITY Tighten_collar_operation
  SUBTYPE OF (Fill_type_operation);
  torque             : OPTIONAL Value_with_unit;
  squeeze            : OPTIONAL Force_data_element;
  swage              : OPTIONAL Force_data_element;
  pull               : OPTIONAL Force_data_element;
END_ENTITY;
```

1.33.1 torque

The torque to be applied to tighten the collar

1.33.2 squeeze

The force to be applied to squeeze the rivet tight.

1.33.3 swage

The force to be applied to form the collar around the fastener.

1.33.4 pull

The force to be applied to pull the fastener, swage the collar, and break the pintail.

Pintail fastener

1.34 Check_dimensions_operation

The Check_dimensions_operation application object is a Fill_type_operation that checks the dimension of a hole before the fastener is inserted using a measurement device.

```
ENTITY Check_dimensions_operation
  SUBTYPE OF (Fill_type_operation);
  check_location    : BOOLEAN;
  check_size        : BOOLEAN;
  check_orientation : BOOLEAN;
  check_form        : BOOLEAN;
END_ENTITY;
```

1.34.1 check_location

Use the measurement device to check that the location of the hole is correct.

1.34.2 check_size

Use the measurement device to check that the size of the hole is correct.

1.34.3 check_orientation

Use the measurement device to check that the orientation of the hole is correct.

1.34.4 check_form

Use the measurement device to check that the form of the hole is correct.

1.35 Adjust_placement_probing

The Adjust_placement_probing application object is a Feature_complete_probing that adjusts the position of a product such as a fastener, or a process such as a drilling operation.

```
ENTITY Adjust_placement_probing
  SUBTYPE_OF (Feature_complete_probing);
  adjusted_item           : Product_or_Process;
END_ENTITY;

TYPE Product_or_Process = SELECT(
    Product_view_definition,
    Executable);
END_TYPE;
```

1.35.1 adjusted_item

The product or process to be adjusted.
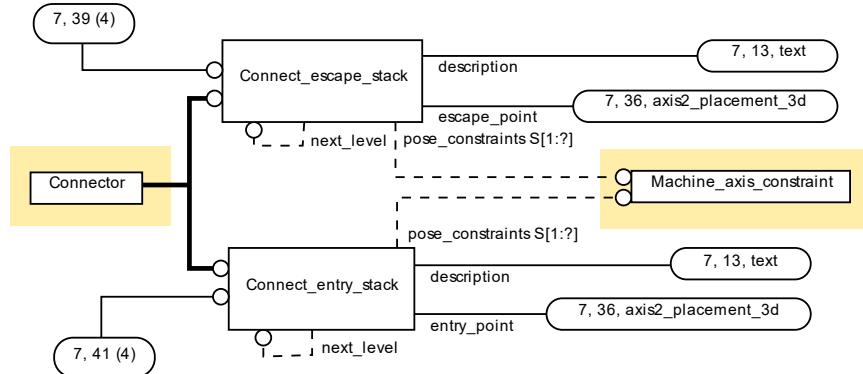
Connector Definitions

1.36 Connect_escape_stack

The Connect_escape_stack application object is a kind of Connector. It describes a safe escape when an operation completes.

```
ENTITY Connect_escape_stack
  SUBTYPE OF (Connector);
  description      : text;
  escape_point     : axis2_placement_3d;
  pose_constraints : OPTIONAL SET [1:?] OF Machine_axis_constraint;
  next_level       : OPTIONAL Connect_escape_stack;
END_ENTITY;
```

1.36.1 description

Human readable summary of the robot configuration at this point in the escape sequence, for example elbow_up, bottom_out and neck_down.

1.36.2 escape_point

The required new point and orientation for the robot when it reaches this level.

1.36.3 pose_constraints

Axis constraints that must be met when the robot reaches the new point. For example, if the robot has a wide back then it may be constrained to keep the back away from the airframe.

1.36.4 next_level

Depending on the situation a robot may need to escape over multiple levels to avoid fixtures and workpieces. For example, an escape to a new location that does not need to avoid geometry should only need one level, an escape that needs to avoid a local fixture may need two levels, and an escape that needs to reach a point on the other side of the airframe may need three levels.

1.37 Connect_entry_stack

The Connect_entry_stack application object is a kind of Connector. It describes a safe entry procedure to postion the robot and tool before the operation starts.

```
ENTITY Connect_entry_stack
  SUBTYPE OF (Connector);
  description      : text;
  entry_point      : axis2_placement_3d;
  pose_constraints : OPTIONAL SET [1:?] OF Machine_axis_constraint;
  next_level       : OPTIONAL Connect_entry_stack;
END_ENTITY;
```

1.37.1 description

Human readable summary of the robot configuration at this point in the escape sequence, for example elbow_up, bottom_out and neck_down.

1.37.2 entry_point

The required new point and orientation for the robot when it reaches this level.

1.37.3 pose_constraints

Axis constraints that must be met when the robot reaches the new point. For example, if the robot has a wide back then it may be constrained to keep the back away from the airframe.

1.37.4 next_level

Depending on the situation a robot may need to approach over multiple levels. For example, an approach that does not need to avoid geometry should only need one level, an approach that needs to avoid a local fixture may need two levels, and an approach that needs to reach a point on the other side of the airframe may need three levels.
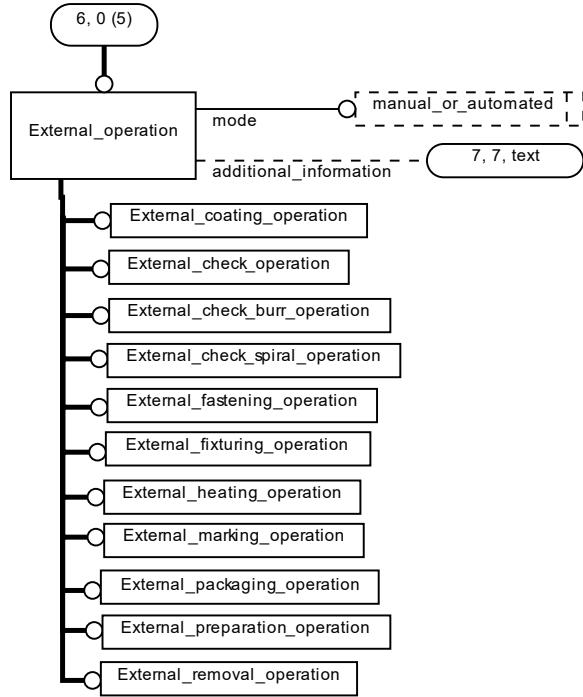
External Operation Definitions

1.38 External_operation

The External_operation application object is an operation performed by an external system that is beyond the scope of the automation defined in this project.

```
ENTITY External_operation
  SUBTYPE OF (operation);
  mode                   : manual_or_automated;
  additional_information  : OPTIONAL Text;
END_ENTITY;

TYPE manual_or_automated = ENUMERATION OF (manual, automated); END_TYPE;
```

1.38.1 mode

the external operation is manual or automated.

1.38.2 additional_information

additional information about the operation such as "cooling", or "laser heating".

1.39 External_heating_operation

```
ENTITY External_heating_operation
  SUBTYPE OF (External_operation);
END_ENTITY;
```

The External_heating_operation application object documents that an operation has heated the part.

1.40 External_marking_operation

```
ENTITY External_marking_operation
  SUBTYPE OF (External_operation);
END_ENTITY;
```

The External_marking_operation application object documents that an operation has marked the part.

1.41 External_coating_operation

```
ENTITY External_coating_operation
  SUBTYPE OF (External_operation);
END_ENTITY;
```

The External_coating_operation application object documents that an operation has coated the part.

1.42 External_packaging_operation

```
ENTITY External_packaging_operation
  SUBTYPE OF (External_operation);
END_ENTITY;
```

The External_packaging_operation application object documents that an operation has packaged the part.

1.43 External_fastening_operation

```
ENTITY External_fastening_operation
  SUBTYPE OF (External_operation);
END_ENTITY;
```

The External_fastening_operation application object documents that an operation has fastened the part.

1.44 External_fixturing_operation

```
ENTITY External_fixturing_operation
  SUBTYPE OF (External_operation);
END_ENTITY;
```

The External_fixturing_operation application object documents that an operation has fixtured the part.

1.45 External_preparation_operation

```
ENTITY External_preparation_operation
  SUBTYPE OF (External_operation);
END_ENTITY;
```

The External_preparation_operation application object documents that an operation has prepared the part.

1.46 External_removal_operation

```
ENTITY External_removal_operation
  SUBTYPE OF (External_operation);
END_ENTITY;
```

The External_removal_operation application object documents that an operation has removed material from the part.

Note: If desirable the before and after state of the part can be documented using as_is and to_be workpieces attached to the workingstep.

1.47 External_check_operation

```
ENTITY External_check_operation
  SUBTYPE OF (External_operation);
END_ENTITY;
```

The External_check_operation application object documents that an operation has checked the part.

1.48 External_check_burr_operation

```
ENTITY External_check_burr_operation
  SUBTYPE OF (External_operation);
END_ENTITY;
```

The External_check_burr_operation application object documents that a feature has been checked for burrs.

1.49 External_check_spiral_operation

```
ENTITY External_check_spiral_operation
  SUBTYPE OF (External_operation);
END_ENTITY;
```

The External_check_spiral_operation application object documents that a hole has been checked for sprials.

2 Features Mapping specification

2.1 MANUFACTURING_FEATURE_TWIN

```
AIM element: twin_feature
Source:      10303-238
Reference path:
twin_feature <=
instanced_feature <=
[shape_aspect]
[ feature_definition <=
characterized_object]
```


2.1.1 manufacturing_feature_twin to manufacturing_feature (as prototype)

```
AIM element: PATH
Reference path:
twin_feature <=
instanced_feature <=
shape_aspect <-
shape_aspect_relationship.relating_shape_aspect
shape_aspect_relationship =>
{shape_aspect_relationship.name ='prototype'}
shape_aspect_relationship.related_shape_aspect ->
shape_aspect =>
instanced_feature
```


2.1.2 manufacturing_feature_twin to product_view_twin (as twin_product)

```
AIM element: PATH
Reference path:
twin_feature <=
instanced_feature <=
```

```
shape_aspect
shape_aspect.of_shape ->
product_definition_shape <=
property_definition
property_definition.definition ->
characterized_definition
characterized_definition = characterized_product_definition
characterized_product_definition
characterized_product_definition = product_definition
product_definition
```

2.1.3 envelope

```
AIM element: shape_representation_with_parameters
Source:       10303-47
Reference path:
twin_feature <=
instanced_feature <=
shape_aspect
shape_definition = shape_aspect
shape_definition
characterized_definition = shape_definition
characterized_definition <-
property_definition.definition
{property_definition =>
product_definition_shape}
property_definition <-
represented_definition = property_definition
represented_definition <-
property_definition_representation.definition
{property_definition_representation =>
shape_definition_representation}
property_definition_representation
property_definition_representation.used_representation ->
representation =>
shape_representation =>
shape_representation_with_parameters
```

2.1.4 when

```
AIM element: date_and_time
Source:       10303-41
Reference path:
twin_feature <=
instanced_feature <=
characterized_object
date_and_time_item = characterized_object
date_and_time_item <-
applied_date_and_time_assignment.items[i]
applied_date_and_time_assignment <=
date_and_time_assignment
{ date_and_time_assignment.role ->
date_time_role
```

```
date_time_role.name = 'measured' }
date_and_time_assignment.assigned_date_and_time ->
date_and_time
```

2.1.5 manufacturing_feature_twin to measured_property (as applied_pmi)

```
Reference path:
twin_feature <=
instanced_feature <=
shape_aspect
shape_definition = shape_aspect
shape_definition
characterized_definition = shape_definition
characterized_definition <-
property_definition.definition
property_definition =>
twin_measured_property
```

2.1.6 role

```
AIM element: descriptive_representation_item.description
Source:      10303-45
Reference path:
twin_feature <=
instanced_feature <=
shape_aspect
shape_definition = shape_aspect
shape_definition
characterized_definition = shape_definition
characterized_definition <-
property_definition.definition
property_definition
{property_definition.name = 'role'}
represented_definition = property_definition
represented_definition <-
property_definition_representation.definition
property_definition_representation
property_definition_representation.used_representation ->
representation
representation.items[i] ->
representation_item =>
descriptive_representation_item
descriptive_representation_item.description
```

2.2 DRILL_AND_FILL_TWIN

```
AIM element: twin_feature
Source:      10303-238
Reference path:
twin_feature <=
instanced_feature <=
```

```
feature_definition <=
characterized_object]
{characterized_object
characterized_object.description = 'drill and fill'}
```

2.2.1 drill_and_fill_twin to stack_up (as stackups)

```
AIM element: PATH
Reference path:
twin_feature <=
instanced_feature <=
shape_aspect
action_method_items = shape_aspect
action_method_items <-
applied_action_method_assignment.items[i]
applied_action_method_assignment <=
action_method_assignment
{ action_method_assignment.role ->
action_method_role
action_method_role.name = 'stack up' }
action_method_assignment.assigned_action_method ->
action_method =>
machining_stack
```

2.2.2 hole_in_place

#1: if value is true

#2: if value is false (mapping may be omitted if value is false)

```
AIM element: descriptive_representation_item.description
Source:        10303-45
Reference path:
twin_feature <=
instanced_feature <=
shape_aspect
shape_definition = shape_aspect
shape_definition
characterized_definition = shape_definition
characterized_definition <-
property_definition.definition
property_definition
{property_definition.name = 'hole present'}
represented_definition = property_definition
represented_definition <-
property_definition_representation.definition
property_definition_representation
property_definition_representation.used_representation ->
representation
representation.items[i] ->
representation_item =>
descriptive_representation_item
```

```
descriptive_representation_item.description
{ #1: (descriptive_representation_item.description = 'hole present' )
#2: (descriptive_representation_item.description = 'hole not present' ) }
```

2.2.3 pilot_in_place

#1: if value is true

#2: if value is false (mapping may be omitted if value is false)

```
AIM element: descriptive_representation_item.description
Source:       10303-45
Reference path:
twin_feature <=
instanced_feature <=
shape_aspect
shape_definition = shape_aspect
shape_definition
characterized_definition = shape_definition
characterized_definition <-
property_definition.definition
property_definition
{property_definition.name = 'pilot present'}
represented_definition = property_definition
represented_definition <-
property_definition_representation.definition
property_definition_representation
property_definition_representation.used_representation ->
representation
representation.items[i] ->
representation_item =>
descriptive_representation_item
descriptive_representation_item.description
{ #1: (descriptive_representation_item.description = 'pilot present' )
#2: (descriptive_representation_item.description = 'pilot not present' ) }
```

2.2.4 drill_and_fill_twin to product_view_twin (as tack_in_place)

```
AIM element: PATH
Reference path:
twin_feature <=
instanced_feature <=
shape_aspect <-
shape_aspect_relationship.relating_shape_aspect
{shape_aspect_relationship.name = 'tack'}
{shape_aspect_relationship.description = 'product usage'}
shape_aspect_relationship
shape_aspect_relationship.related_shape_aspect ->
shape_aspect
{shape_aspect.description = 'product occurrence'}
shape_aspect.of_shape ->
product_definition_shape <=
```

```
property_definition
property_definition.definition ->
characterized_definition
characterized_definition = characterized_product_definition
characterized_product_definition
characterized_product_definition = product_definition
product_definition
```

2.2.5 drill_and_fill_twin to product_view_twin (as fastener_in_place)

```
AIM element: PATH
Reference path:
twin_feature <=
instanced_feature <=
shape_aspect <-
shape_aspect_relationship.relating_shape_aspect
{shape_aspect_relationship.name = 'fastener'}
{shape_aspect_relationship.description = 'product usage'}
shape_aspect_relationship
shape_aspect_relationship.related_shape_aspect ->
shape_aspect
{shape_aspect.description = 'product occurrence'}
shape_aspect.of_shape ->
product_definition_shape <=
property_definition
property_definition.definition ->
characterized_definition
characterized_definition = characterized_product_definition
characterized_product_definition
characterized_product_definition = product_definition
product_definition
```

2.2.6 drill_and_fill_twin to product_view_twin (as collar_in_place)

```
AIM element: PATH
Reference path:
twin_feature <=
instanced_feature <=
shape_aspect <-
shape_aspect_relationship.relating_shape_aspect
{shape_aspect_relationship.name = 'collar'}
{shape_aspect_relationship.description = 'product usage'}
shape_aspect_relationship
shape_aspect_relationship.related_shape_aspect ->
shape_aspect
{shape_aspect.description = 'product occurrence'}
shape_aspect.of_shape ->
product_definition_shape <=
property_definition
property_definition.definition ->
characterized_definition
characterized_definition = characterized_product_definition
characterized_product_definition
```

```
characterized_product_definition = product_definition
product_definition
```

2.2.7 drill_and_fill_twin to product_view_twin (as washer_in_place)

```
AIM element: PATH
Reference path:
twin_feature <=
instanced_feature <=
shape_aspect <-
shape_aspect_relationship.relating_shape_aspect
{shape_aspect_relationship.name = 'washer'}
{shape_aspect_relationship.description = 'product usage'}
shape_aspect_relationship
shape_aspect_relationship.related_shape_aspect ->
shape_aspect
{shape_aspect.description = 'product occurrence'}
shape_aspect.of_shape ->
product_definition_shape <=
property_definition
property_definition.definition ->
characterized_definition
characterized_definition = characterized_product_definition
characterized_product_definition
characterized_product_definition = product_definition
product_definition
```

2.2.8 washer_count

```
AIM element: count_measure
Source:       10303-41
Reference path:
twin_feature <=
instanced_feature <=
shape_aspect
shape_definition = shape_aspect
shape_definition
characterized_definition = shape_definition
characterized_definition <-
property_definition.definition
property_definition
{property_definition.name = 'washer count'}
represented_definition = property_definition
represented_definition <-
property_definition_representation.definition
property_definition_representation
property_definition_representation.used_representation ->
representation
representation.items[i] ->
representation_item =>
measure_representation_item <=
measure_with_unit =>
measure_with_unit.value_component ->
```

```
measure_value
measure_value = count_measure
count_measure
```

2.2.9 drill_and_fill_twin to product_view_twin (as sealed)

```
AIM element: PATH
Reference path:
twin_feature <=
instanced_feature <=
shape_aspect <-
shape_aspect_relationship.relating_shape_aspect
{shape_aspect_relationship.name = 'sealed'}
{shape_aspect_relationship.description = 'product usage'}
shape_aspect_relationship
shape_aspect_relationship.related_shape_aspect ->
shape_aspect
{shape_aspect.description = 'product occurrence'}
shape_aspect.of_shape ->
product_definition_shape <=
property_definition
property_definition.definition ->
characterized_definition
characterized_definition = characterized_product_definition
characterized_product_definition
characterized_product_definition = product_definition
product_definition
```

2.2.10 engineering_fit

```
AIM element: class.name
Source:           ISO 10303-54
Reference path:
twin_feature <=
instanced_feature <=
shape_aspect
classification_item = shape_aspect
classification_item
applied_classification_assignment.items[i] ->
applied_classification_assignment <=
classification_assignment
classification_assignment.role ->
classification_role
{ classification_role.name = 'engineering fit' }
classification_assignment.assigned_class ->
group =>
class
class.name
{ (class.name = 'loose fit')
(class.name = 'free running')
(class.name = 'easy running')
(class.name = 'sliding fit')
(class.name = 'close clearance')
```

```
(class.name = 'location clearance')
(class.name = 'slight interference')
(class.name = 'transition')
(class.name = 'press fit')
(class.name = 'medium fit')
(class.name = 'force fit') }
```

2.2.11 iso_fit

```
AIM element: class.name
Source:              ISO 10303-54
Reference path:
twin_feature <=
instanced_feature <=
shape_aspect
classification_item = shape_aspect
classification_item
applied_classification_assignment.items[i] ->
applied_classification_assignment <=
classification_assignment
classification_assignment.role ->
classification_role
{ classification_role.name = 'iso 286 fit' }
classification_assignment.assigned_class ->
group =>
class
class.name
{ (class.name = 'clearance fit')
(class.name = 'interference fit')
(class.name = 'transition fit') }
```

2.2.12 disposition

```
AIM element: class.name
Source:              ISO 10303-54
Reference path:
twin_feature <=
instanced_feature <=
shape_aspect
classification_item = shape_aspect
classification_item
applied_classification_assignment.items[i] ->
applied_classification_assignment <=
classification_assignment
classification_assignment.role ->
classification_role
{ classification_role.name = 'disposition' }
classification_assignment.assigned_class ->
group =>
class
class.name
{ (class.name = 'pending')
(class.name = 'active')
```

```
(class.name = 'exception')
(class.name = 'hold')
(class.name = 'completed')
(class.name = 'replaced') }
```

2.2.13 drill_and_fill_twin to measured_property (as measured_location)

```
Reference path:
twin_feature <=
instanced_feature <=
shape_aspect
shape_definition = shape_aspect
shape_definition
characterized_definition = shape_definition
characterized_definition <-
property_definition.definition
{ property_definition.definition = 'measured location' }
property_definition =>
twin_measured_property
```

2.2.14 drill_and_fill_twin to measured_property (as measured_size)

```
Reference path:
twin_feature <=
instanced_feature <=
shape_aspect
shape_definition = shape_aspect
shape_definition
characterized_definition = shape_definition
characterized_definition <-
property_definition.definition
{ property_definition.definition = 'measured size' }
property_definition =>
twin_measured_property
```

2.2.15 drill_and_fill_twin to measured_property (as measured_orientation)

```
Reference path:
twin_feature <=
instanced_feature <=
shape_aspect
shape_definition = shape_aspect
shape_definition
characterized_definition = shape_definition
characterized_definition <-
property_definition.definition
{ property_definition.definition = 'measured orientation' }
property_definition =>
twin_measured_property
```

2.2.16 drill_and_fill_twin to measured_property (as measured_form)

```
Reference path:
twin_feature <=
instanced_feature <=
shape_aspect
shape_definition = shape_aspect
shape_definition
characterized_definition = shape_definition
characterized_definition <-
property_definition.definition
{ property_definition.definition = 'measured form' }
property_definition =>
twin_measured_property
```

2.2.17 drill_and_fill_twin to product_view_twin (as replacement)

```
AIM element: PATH
Reference path:
twin_feature <=
instanced_feature <=
shape_aspect <-
shape_aspect_relationship.relating_shape_aspect
{shape_aspect_relationship.name = 'replacement'}
{shape_aspect_relationship.description = 'product usage'}
shape_aspect_relationship
shape_aspect_relationship.related_shape_aspect ->
shape_aspect
{shape_aspect.description = 'product occurrence'}
shape_aspect.of_shape ->
product_definition_shape <=
property_definition
property_definition.definition ->
characterized_definition
characterized_definition = characterized_product_definition
characterized_product_definition
characterized_product_definition = product_definition
product_definition
```

2.3 DRILL_AND_FILL_STACKUP

```
AIM element: machining_stack
Source:       10303-238
Reference path:
machining_stack <=
action_method
```

2.3.1 Measurement_state

```
AIM element: descriptive_representation_item.description
Source:    10303-45
```

```
Reference path:
filling_type_operation <=
machining_operation <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'measurement state' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation representation.items[i] ->
representation_item =>
descriptive_representation_item
descriptive_representation_item.description
{ (descriptive_representation_item.description = 'designed' )
(descriptive_representation_item.description = 'predicted' )
(descriptive_representation_item.description = 'measured' ) }
```

2.3.2 drill_and_fill_stackup to product_view_definition (as outer_part)

```
AIM element: PATH
Reference path:
machining_stack <=
action_method <-
action_method_assignment.assigned_action_method
{ action_method_assignment.role ->
action_method_role
action_method_role.name = 'outer part' }
action_method_assignment =>
applied_action_method_assignment
applied_action_method_assignment.items[i] ->
action_method_items
action_method_items = product_definition
product_definition
```

2.3.3 default_direction

```
AIM element: direction
Source:      10303-42
Reference path:
machining_stack <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'direction' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation
```

```
representation.items[i] ->
representation_item =>
geometric_representation_item =>
direction
```

2.3.4 default_diameter

```
AIM element: length_measure_with_unit
Source:        10303-41
Reference path:
machining_stack <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'diameter' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation
representation.items[i] ->
representation_item =>
measure_representation_item <=
measure_with_unit =>
length_measure_with_unit
```

2.3.5 drill_and_fill_stackup to stack_layer (as layers)

```
AIM element: PATH
Reference path:
machining_stack <=
action_method <-
action_method_relationship.relating_method
action_method_relationship
{ action_method_relationship =>
sequential_method }
action_method_relationship.related_method ->
action_method =>
machining_stack_element
```

2.3.6 computed_depth

```
AIM element: length_measure_with_unit
Source:        10303-41
Reference path:
machining_stack <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'computed depth' }
```

```
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation
representation.items[i] ->
representation_item =>
measure_representation_item <=
measure_with_unit =>
length_measure_with_unit
```

2.3.7   when_computed

```
AIM element: date_and_time
Source:       10303-41
Reference path:
machining_stack <=
action_method
date_and_time_item = action_method
date_and_time_item <-
applied_date_and_time_assignment.items[i]
applied_date_and_time_assignment <=
date_and_time_assignment
{ date_and_time_assignment.role ->
date_time_role
date_time_role.name = 'when computed' }
date_and_time_assignment.assigned_date_and_time ->
date_and_time
```

2.4   STACK_LAYER

```
AIM element: machining_stack_element
Source:       10303-238
Reference path:
machining_stack_element <=
action_method
```

2.4.1   stack_layer to product_view_definition (as usage)

```
AIM element: PATH
Reference path:
machining_stack_element <=
action_method <-
action_method_assignment.assigned_action_method
{ action_method_assignment.role ->
action_method_role
action_method_role.name = 'usage' }
action_method_assignment =>
applied_action_method_assignment
applied_action_method_assignment.items[i] ->
action_method_items
```

```
action_method_items = product_definition
product_definition
```

2.4.2 start_dist

```
AIM element: length_measure_with_unit
Source:       10303-41
Reference path:
machining_stack_element <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = ' start distance' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation
representation.items[i] ->
representation_item =>
measure_representation_item` <=
measure_with_unit =>
length_measure_with_unit
```

2.4.3 end_dist

```
AIM element: length_measure_with_unit
Source:       10303-41
Reference path:
machining_stack_element <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'end distance' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation
representation.items[i] ->
representation_item =>
measure_representation_item <=
measure_with_unit =>
length_measure_with_unit
```

2.4.4 status

```
AIM element: descriptive_representation_item.description
Source:       10303-45
Reference path:
```

```
machining_stack_element <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'status' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation
representation.items[i] ->
representation_item =>
descriptive_representation_item
descriptive_representation_item.description
{ (descriptive_representation_item.description = 'air gap')
(descriptive_representation_item.description = 'overlap') }
```

2.4.5 stack_layer to manufacturing_feature (as layer_feature)

```
AIM element: PATH
Reference path:
machining_stack_element <=
action_method <-
action_method_assignment.assigned_action_method
{ action_method_assignment.role ->
action_method_role
action_method_role.name = 'layer feature' }
action_method_assignment =>
applied_action_method_assignment
applied_action_method_assignment.items[i] ->
action_method_items
action_method_items = shape_aspect
shape_aspect =>
instanced_feature <=
feature_definition
```

3   Product and Tolerance Twin Mapping specification

3.1   PRODUCT_VIEW_TWIN

```
AIM element: product_definition
Source:        10303-41
Reference path:
product_definition
product_definition.formation ->
product_definition_formation
product_definition_formation.of_product ->
product <-
```

```
{ product_related_product_category.products[i]
product_related_product_category <=
product_category
product_category.name='twin model' }
```

3.1.1 product_view_twin to product_view_definition (as prototype)

```
AIM element: PATH
Reference path:
product_definition
characterized_product_definition = product_definition
characterized_product_definition
characterized_definition = characterized_product_definition
characterized_definition <-
property_definition.definition
{ property_definition =>
product_definition_shape }
property_definition <-
property_definition_relationship.relating_property_definition
property_definition_relationship
{ property_definition_relationship.name = 'prototype' }
{ property_definition_relationship =>
twin_prototype_relationship }
property_definition_relationship.related_property_definition ->
property_definition
{ property_definition =>
product_definition_shape }
property_definition.definition -
characterized_definition
characterized_definition = characterized_product_definition
characterized_product_definition
characterized_product_definition = product_definition
product_definition
```

3.1.2 serial_number

```
AIM element: product_definition.id
Source:        10303-41
Reference path:
product_definition
product_definition.id
```

3.1.3 envelope

```
AIM element: shape_representation_with_parameters
Source:        10303-47
Reference path:
product_definition
characterized_product_definition = product_definition
characterized_product_definition
characterized_definition = characterized_product_definition
characterized_definition <-
```

```
property_definition.definition
{property_definition =>
product_definition_shape}
property_definition <-
represented_definition = property_definition
represented_definition <-
property_definition_representation.definition
{property_definition_representation =>
shape_definition_representation}
property_definition_representation
property_definition_representation.used_representation ->
representation =>
shape_representation =>
shape_representation_with_parameters
```

3.1.4 when

```
AIM element: date_and_time
Source:      10303-41
Reference path:
product_definition
date_and_time_item = product_definition
date_and_time_item <-
applied_date_and_time_assignment.items[i]
applied_date_and_time_assignment <=
date_and_time_assignment
{ date_and_time_assignment.role ->
date_time_role
date_time_role.name = 'measured' }
date_and_time_assignment.assigned_date_and_time ->
date_and_time
```

3.1.5 role

```
AIM element: descriptive_representation_item.description
Source:      10303-45
Reference path:
product_definition
characterized_product_definition = product_definition
characterized_product_definition
characterized_definition = characterized_product_definition
characterized_definition <-
property_definition.definition
property_definition <-
{property_definition.name = 'role'}
represented_definition = property_definition
represented_definition <-
property_definition_representation.definition
property_definition_representation
property_definition_representation.used_representation ->
representation
representation.items[i] ->
representation_item =>
```

```
descriptive_representation_item
descriptive_representation_item.description
```

3.1.6   product_view_twin to measured_property (as measured_properties)

```
AIM element: PATH
Reference path:
product_definition
characterized_product_definition = product_definition
characterized_product_definition
characterized_definition = characterized_product_definition
characterized_definition <-
property_definition.definition
property_definition =>
twin_measured_property
```

3.2   MEASURED_PROPERTY

```
AIM element: twin_measured_property
Source:        10303-238
Reference path:
twin_measured_property <=
property_definition
```

3.2.1   prototype

```
AIM element: PATH
Reference path:
twin_measured_property <=
property_definition
generic_property_definition_select = property_definition
generic_property_definition_select <-
generic_property_relationship.related
generic_property_relationship
{ generic_property_relationship.name =  'prototype' }
generic_property_relationship.relating ->
( generic_property_definition_select = dimensional_location )
( generic_property_definition_select = dimensional_size )
( generic_property_definition_select = geometric_tolerance )
```

3.2.2   property_value

```
AIM element: measure_representation_item
Source:        10303-45
Reference path:
twin_measured_property <=
property_definition <-
property_definition_representation.definition
{property_definition_representation =>
shape_definition_representation}
```

```
property_definition_representation
property_definition_representation.used_representation ->
representation
representation.items[i] ->
representation_item =>
measure_representation_item
```

3.2.3 property_name

```
AIM element: property_definition.name
Source:      10303-41
Reference path:
twin_measured_property <=
property_definition
property_definition.name
```

3.2.4 name_standard

```
AIM element: property_definition.description
Source:      10303-41
Reference path:
twin_measured_property <=
property_definition
property_definition.description
```

3.2.5 measured_property to executable (as applicable_tasks)

```
AIM element: PATH
Reference path:
twin_measured_property <=
property_definition
action_method_items = property_definition
action_method_items <-
applied_action_method_assignment.items[i]
applied_action_method_assignment <=
action_method_assignment
{ action_method_assignment.role ->
action_method_role
action_method_role.name = 'applicable tasks' }
action_method_assignment.assigned_action_method ->
action_method =>
machining_process_executable
```

3.3 CUTTING_TOOL_TWIN

```
AIM element: product_definition
Source:      10303-41
Reference path:
```

```
product_definition
product_definition.formation ->
product_definition_formation
product_definition_formation.of_product ->
product <-
{ product_related_product_category.products[i]
product_related_product_category <=
product_category
product_category.name='cutting tool' }
```

3.3.1 cutting_tool_twin to measured_property (as measured_diameter)

```
AIM element: PATH
Reference path:
product_definition
characterized_product_definition = product_definition
characterized_product_definition
characterized_definition = characterized_product_definition
characterized_definition <-
property_definition.definition
{ property_definition.name = 'diameter' }
property_definition =>
twin_measured_property
```

3.3.2 cutting_tool_twin to measured_property (as measured_corner_radius)

```
AIM element: PATH
Reference path:
product_definition
characterized_product_definition = product_definition
characterized_product_definition
characterized_definition = characterized_product_definition
characterized_definition <-
property_definition.definition
{ property_definition.name = 'corner radius' }
property_definition =>
twin_measured_property
```

3.3.3 cutting_tool_twin to measured_property (as measured_functional_width)

```
AIM element: PATH
Reference path:
product_definition
characterized_product_definition = product_definition
characterized_product_definition
characterized_definition = characterized_product_definition
characterized_definition <-
property_definition.definition
{ property_definition.name = 'functional width' }
property_definition =>
twin_measured_property
```

3.3.4 cutting_tool_twin to measured_property (as measured_functional_height)

```
AIM element: PATH
Reference path:
product_definition
characterized_product_definition = product_definition
characterized_product_definition
characterized_definition = characterized_product_definition
characterized_definition <-
property_definition.definition
{ property_definition.name = 'functional height' }
property_definition =>
twin_measured_property
```

3.3.5 cutting_tool_twin to measured_property (as measured_functional_length)

```
AIM element: PATH
Reference path:
product_definition
characterized_product_definition = product_definition
characterized_product_definition
characterized_definition = characterized_product_definition
characterized_definition <-
property_definition.definition
{ property_definition.name = 'functional length' }
property_definition =>
twin_measured_property
```

3.3.6 life_consumed

```
AIM element: ratio_measure_with_unit
Source:       10303-41
Reference path:
product_definition
characterized_product_definition = product_definition
characterized_product_definition
characterized_definition = characterized_product_definition
characterized_definition <-
property_definition.definition
{ property_definition.name = 'life consumed' }
property_definition <-
property_definition_representation.definition
{property_definition_representation =>
shape_definition_representation}
property_definition_representation
property_definition_representation.used_representation ->
representation
representation.items[i] ->
representation_item =>
measure_representation_item
measure_representation_item <=
measure_with_unit =>
```

```
ratio_measure_with_unit
```

3.3.7 cutting_tool_twin to life_cost (as life_costs)

```
AIM element: PATH
Reference path:
product_definition
characterized_product_definition = product_definition
characterized_product_definition
characterized_definition = characterized_product_definition
characterized_definition <-
property_definition.definition
{ property_definition.name = 'life costs' }
property_definition <-
property_definition_representation.definition
{property_definition_representation =>
shape_definition_representation}
property_definition_representation
property_definition_representation.used_representation ->
representation
representation.items[i] ->
representation_item =>
measure_representation_item
measure_representation_item <=
measure_with_unit =>
ratio_measure_with_unit
```

3.4 LIFE_COST

```
AIM element: ratio_measure_with_unit
Source:        10303-41
Reference path:
ratio_measure_with_unit <=
measure_with_unit =>
measure_representation_item <=
representation_item
{ representation_item. name = 'life cost' }
measure_representation_item
```

3.4.1 life_cost to executable (as task)

```
AIM element: PATH
Reference path:
ratio_measure_with_unit <=
measure_with_unit =>
measure_representation_item <=
representation_item
action_method_items = representation_item
action_method_items <-
applied_action_method_assignment.items[i]
applied_action_method_assignment <=
```

```
action_method_assignment
{ action_method_assignment.role ->
action_method_role
action_method_role.name = 'life cost task' }
action_method_assignment.assigned_action_method ->
action_method =>
machining_process_executable
```

3.4.2 added_cost

```
AIM element: ratio_measure_with_unit
Source:       10303-41
Reference path:    IDENTICAL MAPPING
```

3.5 MEASURED_MACHINING_MATERIAL

```
AIM element: twin_measured_property
Source:       10303-238
Reference path:
twin_measured_property <=
property_definition
{ property_definition.name = 'machining material' }
```

3.5.1 measured_cutting_force_coefficient

```
AIM element: measure_representation_item
Source:       10303-45
Reference path:
twin_measured_property <=
property_definition <-
property_definition_representation.definition
{property_definition_representation =>
shape_definition_representation}
property_definition_representation
property_definition_representation.used_representation ->
representation
representation.items[i] ->
representation_item =>
measure_representation_item
```

3.5.2 measured_temperature

```
AIM element: measure_representation_item
Source:       10303-45
Reference path:
twin_measured_property <=
property_definition <-
property_definition_representation.definition
{property_definition_representation =>
shape_definition_representation}
```

```
property_definition_representation
property_definition_representation.used_representation ->
representation
representation.items[i] ->
representation_item =>
measure_representation_item
```

3.5.3 measured_rise_ratio

```
AIM element: ratio_measure_with_unit
Source:       10303-41
Reference path:
twin_measured_property <=
property_definition <-
property_definition_representation.definition
{property_definition_representation =>
shape_definition_representation}
property_definition_representation
property_definition_representation.used_representation ->
representation
representation.items[i] ->
representation_item =>
measure_representation_item
measure_representation_item <=
measure_with_unit =>
ratio_measure_with_unit
```

3.6 PRODUCT_VIEW_TWIN_WITH_SUPPLIER_DEFINITION

```
AIM element: product_definition
Source:       10303-41
product_definition
characterized_product_definition = product_definition
characterized_product_definition
characterized_definition = characterized_product_definition
characterized_definition <-
property_definition.definition
{ property_definition =>
product_definition_shape }
property_definition <-
property_definition_relationship.relating_property_definition
property_definition_relationship
{ property_definition_relationship.name = 'supplier' }
{ property_definition_relationship =>
twin_prototype_relationship }
```

3.6.1 product_view_twin_with_supplier_definition to product_view_twin (as supplier_twin)

```
AIM element: PATH
Reference path:
```

```
product_definition
characterized_product_definition = product_definition
characterized_product_definition
characterized_definition = characterized_product_definition
characterized_definition <-
property_definition.definition
{ property_definition =>
product_definition_shape }
property_definition <-
property_definition_relationship.relating_property_definition
property_definition_relationship
{ property_definition_relationship.name = 'supplier' }
{ property_definition_relationship =>
twin_prototype_relationship }
property_definition_relationship.related_property_definition ->
property_definition
{ property_definition =>
product_definition_shape }
property_definition.definition -
characterized_definition
characterized_definition = characterized_product_definition
characterized_product_definition
characterized_product_definition = product_definition
product_definition
```

3.6.2 supplier_alei

```
AIM element: identification_assignment.assigned_id
Source:       10303-41
Reference path:
product_definition
organization_item = product_definition
organization_item <-
applied_organization_assignment.items[i]
applied_organization_assignment <=
organization_assignment
{ organization_assignment.role ->
organization_role
organization_role.name = 'supplier' }
organization_assignment.assigned_organization ->
organization
organization.id
identification_item = organization
identification_item <-
applied_identification_assignment.items[i]
applied_identification_assignment <=
identification_assignment
{ identification_assignment.role ->
identification_role
identification_role.name = 'authoritative legal entity identifier' }
identification_assignment.assigned_id
```

3.6.3 supplier_cage_code

```
AIM element: identification_assignment.assigned_id
Source:      10303-41
Reference path:
product_definition
organization_item = product_definition
organization_item <-
applied_organization_assignment.items[i]
applied_organization_assignment <=
organization_assignment
{ organization_assignment.role ->
organization_role
organization_role.name = 'supplier' }
organization_assignment.assigned_organization ->
organization
organization.id
identification_item = organization
identification_item <-
applied_identification_assignment.items[i]
applied_identification_assignment <=
identification_assignment
{ identification_assignment.role ->
identification_role
identification_role.name = 'cage code' }
identification_assignment.assigned_id
```

4   Groups Mapping specification

4.1   DRILL_AND_FILL_GROUP

```
AIM element: filling_type_group
Source:      10303-238
Reference path:
filling_type_group <=
machining_group <=
[group]
[characterized_object]
```

4.1.1 manufacturing_stage

```
AIM element: descriptive_representation_item.description
Source:      10303-45
Reference path:
filling_type_group <=
machining_group <=
characterized_object
characterized_definition = characterized_object
characterized_definition <-
```

```
property_definition.definition
property_definition
{property_definition.name = 'manufacturing stage'}
represented_definition = property_definition
represented_definition <-
property_definition_representation.definition
property_definition_representation
property_definition_representation.used_representation ->
representation
representation.items[i]->
representation_item =>
descriptive_representation_item
descriptive_representation_item.description
```

4.1.2 primary

#1: if value is true

#2: if value is false (mapping may be omitted if value is false)

```
AIM element: descriptive_representation_item.description
Source:        10303-45
Reference path:
filling_type_group <=
machining_group <=
characterized_object
characterized_definition = characterized_object
characterized_definition <-
property_definition.definition
property_definition
{property_definition.name = 'manufacturing stage'}
represented_definition = property_definition
represented_definition <-
property_definition_representation.definition
property_definition_representation
property_definition_representation.used_representation ->
representation
representation.items[i]->
representation_item =>
descriptive_representation_item
descriptive_representation_item.description
 { #1: (descriptive_representation_item.description = 'primary' )
 #2: (descriptive_representation_item.description = 'secondary' ) }
```

4.2 REFERENCE_FRAME_GROUP

```
AIM element: filling_type_group
Source:        10303-238
Reference path:
filling_type_group <=
machining_group <=
```

```
[group]
[characterized_object]
```

4.2.1 guide_verified

#1: if value is true

#2: if value is false (mapping may be omitted if value is false)

```
AIM element: descriptive_representation_item.description
Source:       10303-45
Reference path:
filling_type_group <=
machining_group <=
characterized_object
characterized_definition = characterized_object
characterized_definition <-
property_definition.definition
property_definition
{property_definition.name = 'guide verified'}
represented_definition = property_definition
represented_definition <-
property_definition_representation.definition
property_definition_representation
property_definition_representation.used_representation ->
representation
representation.items[i]->
representation_item =>
descriptive_representation_item
descriptive_representation_item.description
{ #1: (descriptive_representation_item.description = 'verified' )
#2: (descriptive_representation_item.description = 'not verified' ) }
```

4.2.2 reference_frame_group to reference_frame_group (as basis)

```
AIM element: PATH
Reference path:
filling_type_group <=
machining_group <=
group <-
group_relationship.relating_group
group_relationship
{ group_relationship.name = 'basis' }
group_relationship.related_group ->
group =>
machining_group =>
filling_type_group
```

4.2.3 modification

```
AIM element: axis2_placement_3d
Source:       10303-42
Reference path:
filling_type_group <=
machining_group <=
characterized_object
characterized_definition = characterized_object
characterized_definition <-
property_definition.definition
property_definition
{property_definition.name = 'modification'}
represented_definition = property_definition
represented_definition <-
property_definition_representation.definition
property_definition_representation
property_definition_representation.used_representation ->
representation
representation.items[i]->
representation_item =>
geometric_representation_item =>
placement =>
axis2_placement_3d
```

4.2.4 verification_time

```
AIM element: date_and_time
Source:       10303-41
Reference path:
filling_type_group <=
machining_group
date_and_time_item = machining_group
date_and_time_item <-
applied_date_and_time_assignment.items[i]
applied_date_and_time_assignment <=
date_and_time_assignment
{ date_and_time_assignment.role ->
date_time_role
date_time_role.name = 'verification time' }
date_and_time_assignment.assigned_date_and_time ->
date_and_time
```

4.3 THREE_TWIN_REFERENCE_FRAME_GROUP

```
AIM element: filling_type_group
Source:       10303-238
Reference path:
filling_type_group <=
machining_group <=
group
group.description
```

```
{ group.description = 'three twin reference frame' }
```

4.3.1 three_twin_reference_frame_group to drill_and_fill_twin (as guide_primary)

```
AIM element: PATH
Reference path:
filling_type_group <=
machining_group <=
group <-
group_assignment.assigned_group
{ group_assignment <-
role_select = group_assignment
role_select <-
role_association.item_with_role
role_association
role_association.role ->
object_role
object_role.name = 'primary guide' }
group_assignment =>
applied_group_assignment
applied_group_assignment.items[i] ->
groupable_item
groupable_item = shape_aspect
shape_aspect =>
instanced_feature =>
twin_feature
```

4.3.2 three_twin_reference_frame_group to drill_and_fill_twin (as guide_secondary)

```
AIM element: PATH
Reference path:
filling_type_group <=
machining_group <=
group <-
group_assignment.assigned_group
{ group_assignment <-
role_select = group_assignment
role_select <-
role_association.item_with_role
role_association
role_association.role ->
object_role
object_role.name = 'secondary guide' }
group_assignment =>
applied_group_assignment
applied_group_assignment.items[i] ->
groupable_item
groupable_item = shape_aspect
shape_aspect =>
instanced_feature =>
twin_feature
```

4.3.3 three_twin_reference_frame_group to drill_and_fill_twin (as guide_tertiary)

```
AIM element: PATH
Reference path:
filling_type_group <=
machining_group <=
group <-
group_assignment.assigned_group
{ group_assignment <-
role_select = group_assignment
role_select <-
role_association.item_with_role
role_association
role_association.role ->
object_role
object_role.name = 'tertiary guide' }
group_assignment =>
applied_group_assignment
applied_group_assignment.items[i] ->
groupable_item
groupable_item = shape_aspect
shape_aspect =>
instanced_feature =>
twin_feature
```

4.4 BEST_FIT_REFERENCE_FRAME_GROUP

```
AIM element: filling_type_group
Source:        10303-238
Reference path:
filling_type_group <=
machining_group <=
group
group.description
{ group.description = 'best fit reference frame' }
```

4.4.1 best_fit_reference_frame_group to drill_and_fill_twin (as guides)

```
AIM element: PATH
Reference path:
filling_type_group <=
machining_group <=
group <-
group_assignment.assigned_group
{ group_assignment <-
role_select = group_assignment
role_select <-
role_association.item_with_role
role_association
role_association.role ->
object_role
object_role.name = 'guides' }
```

```
group_assignment =>
applied_group_assignment
applied_group_assignment.items[i] ->
groupable_item
groupable_item = shape_aspect
shape_aspect =>
instanced_feature =>
twin_feature
```

4.5 FASTENER_GROUP

```
AIM element: filling_type_group
Source:        10303-238
Reference path:
filling_type_group <=
machining_group <=
group
group.description
{ group.description = 'fastener' }
```

4.5.1 maximum_grip_length

```
AIM element: length_measure_with_unit
Source:        10303-41
Reference path:
filling_type_group <=
machining_group <=
characterized_object
characterized_definition = characterized_object
characterized_definition <-
property_definition.definition
property_definition
{property_definition.name = 'maximum grip length'}
represented_definition = property_definition
represented_definition <-
property_definition_representation.definition
property_definition_representation
property_definition_representation.used_representation ->
representation
representation.items[i]->
representation_item =>
measure_representation_item <=
measure_with_unit =>
length_measure_with_unit
```

4.5.2 minimum_grip_length

```
AIM element: length_measure_with_unit
Source:        10303-41
Reference path:
filling_type_group <=
```

```
machining_group <=
characterized_object
characterized_definition = characterized_object
characterized_definition <-
property_definition.definition
property_definition
{property_definition.name = 'minimum grip length'}
represented_definition = property_definition
represented_definition <-
property_definition_representation.definition
property_definition_representation
property_definition_representation.used_representation ->
representation
representation.items[i]->
representation_item =>
measure_representation_item <=
measure_with_unit =>
length_measure_with_unit
```

4.5.3 fastener_group to product_view_definition (as fastener)

```
AIM element: PATH
Reference path:
filling_type_group <=
machining_group <=
group <-
group_assignment.assigned_group
{ group_assignment <-
role_select = group_assignment
role_select <-
role_association.item_with_role
role_association
role_association.role ->
object_role
object_role.name = 'fastener' }
group_assignment =>
applied_group_assignment
applied_group_assignment.items[i] ->
groupable_item
groupable_item = product_definition
product_definition
```

4.5.4 fastener_group to product_view_definition (as collar)

```
AIM element: PATH
Reference path:
filling_type_group <=
machining_group <=
group <-
group_assignment.assigned_group
{ group_assignment <-
role_select = group_assignment
role_select <-
```

```
role_association.item_with_role
role_association
role_association.role ->
object_role
object_role.name = 'collar' }
group_assignment =>
applied_group_assignment
applied_group_assignment.items[i] ->
groupable_item
groupable_item = product_definition
product_definition
```

4.5.5 fastener_group to product_view_definition (as sealant)

```
AIM element: PATH
Reference path:
filling_type_group <=
machining_group <=
group <-
group_assignment.assigned_group
{ group_assignment <-
role_select = group_assignment
role_select <-
role_association.item_with_role
role_association
role_association.role ->
object_role
object_role.name = 'sealant' }
group_assignment =>
applied_group_assignment
applied_group_assignment.items[i] ->
groupable_item
groupable_item = product_definition
product_definition
```

4.5.6 fastener_group to product_view_definition (as washer)

```
AIM element: PATH
Reference path:
filling_type_group <=
machining_group <=
group <-
group_assignment.assigned_group
{ group_assignment <-
role_select = group_assignment
role_select <-
role_association.item_with_role
role_association
role_association.role ->
object_role
object_role.name = 'washer' }
group_assignment =>
applied_group_assignment
```

```
applied_group_assignment.items[i] ->
groupable_item
groupable_item = product_definition
product_definition
```

4.5.7 washer_count

```
AIM element: count_measure
Source:        10303-41
Reference path:
filling_type_group <=
machining_group <=
characterized_object
characterized_definition = characterized_object
characterized_definition <-
property_definition.definition
property_definition
{property_definition.name = 'washer count'}
represented_definition = property_definition
represented_definition <-
property_definition_representation.definition
property_definition_representation
property_definition_representation.used_representation ->
representation
representation.items[i] ->
representation_item =>
measure_representation_item <=
measure_with_unit =>
measure_with_unit.value_component ->
measure_value
measure_value = count_measure
count_measure
```

4.6 SAME_ASSEMBLY_GROUP

```
AIM element: filling_type_group
Source:        10303-238
Reference path:
filling_type_group <=
machining_group <=
group
group.description
{ group.description = 'same assembly' }
```

4.6.1 same_assembly_group to product_view_twin (as parts_joined)

```
AIM element: PATH
Reference path:
filling_type_group <=
machining_group <=
group <-
```

```
group_assignment.assigned_group
{ group_assignment <-
role_select = group_assignment
role_select <-
role_association.item_with_role
role_association
role_association.role ->
object_role
object_role.name = 'joined' }
group_assignment =>
applied_group_assignment
applied_group_assignment.items[i] ->
groupable_item
groupable_item = product_definition
product_definition
```

4.7 ONEUP_ASSEMBLY_GROUP

```
AIM element: filling_type_group
Source:      10303-238
Reference path:
filling_type_group <=
machining_group <=
group
group.description
{ group.description = 'oneup assembly' }
```

4.7.1 oneup_assembly_group to workplan (as manufacturing_plan)

```
AIM element: PATH
Reference path:
filling_type_group <=
machining_group <=
characterized_object
action_method_items = characterized_object
action_method_items <-
applied_action_method_assignment.items[i]
applied_action_method_assignment <=
action_method_assignment
{ action_method_assignment.role ->
action_method_role
action_method_role.name = 'plan' }
action_method_assignment.assigned_action_method ->
action_method =>
machining_process_executable =>
machining_workplan
```

4.7.2 oneup_assembly_group to machine_with_kinematics (as compatible_robots)

```
AIM element: PATH
Reference path:
```

```
filling_type_group <=
machining_group <=
group <-
group_assignment.assigned_group
{ group_assignment <-
role_select = group_assignment
role_select <-
role_association.item_with_role
role_association
role_association.role ->
object_role
object_role.name = 'compatible robot' }
group_assignment =>
applied_group_assignment
applied_group_assignment.items[i] ->
groupable_item
groupable_item = product_definition
product_definition
```

4.7.3 oneup_assembly_group to oneup_assembly_group (as must_follow)

```
AIM element: PATH
Reference path:
filling_type_group <=
machining_group <=
group <-
group_relationship.relating_group
group_relationship
{ group_relationship.name = 'must follow' }
group_relationship.related_group ->
group =>
machining_group =>
filling_type_group
```

4.8 PREFERRED_ROBOT_GROUP

```
AIM element: filling_type_group
Source:       10303-238
Reference path:
filling_type_group <=
machining_group <=
group
group.description
{ group.description = 'preferred robot' }
```

4.8.1 preferred_robot_group to machine_with_kinematics (as preferred_robot)

```
AIM element: PATH
Reference path:
filling_type_group <=
machining_group <=
```

```
group <-
group_assignment.assigned_group
{ group_assignment <-
role_select = group_assignment
role_select <-
role_association.item_with_role
role_association
role_association.role ->
object_role
object_role.name = 'preferred robot' }
group_assignment =>
applied_group_assignment
applied_group_assignment.items[i] ->
groupable_item
groupable_item = product_definition
product_definition
```

4.8.2 precedence

```
AIM element: count_measure
Source:        10303-41
Reference path:
filling_type_group <=
machining_group <=
characterized_object
characterized_definition = characterized_object
characterized_definition <-
property_definition.definition
property_definition
{property_definition.name = 'precedence'}
represented_definition = property_definition
represented_definition <-
property_definition_representation.definition
property_definition_representation
property_definition_representation.used_representation ->
representation
representation.items[i] ->
representation_item =>
measure_representation_item <=
measure_with_unit =>
measure_with_unit.value_component ->
measure_value
measure_value = count_measure
count_measure
```

4.9 ESCAPE_SEQUENCE_GROUP

```
AIM element: filling_type_group
Source:        10303-238
Reference path:
filling_type_group <=
machining_group <=
```

```
group
group.description
{ group.description = 'escape' }
```

4.9.1 escape_sequence_group to machine_with_kinematics (as robot)

```
AIM element: PATH
Reference path:
filling_type_group <=
machining_group <=
group <-
group_assignment.assigned_group
{ group_assignment <-
role_select = group_assignment
role_select <-
role_association.item_with_role
role_association
role_association.role ->
object_role
object_role.name = 'robot' }
group_assignment =>
applied_group_assignment
applied_group_assignment.items[i] ->
groupable_item
groupable_item = product_definition
product_definition
```

4.9.2 escape_sequence_group to connect_escape_stack (as escape_moves)

```
AIM element: PATH
Reference path:
filling_type_group <=
machining_group <=
group <-
group_assignment.assigned_group
{ group_assignment <-
role_select = group_assignment
role_select <-
role_association.item_with_role
role_association
role_association.role ->
object_role
object_role.name = 'moves' }
group_assignment =>
applied_group_assignment
applied_group_assignment.items[i] ->
groupable_item
groupable_item = action_method
action_method =>
machining_toolpath
```

4.10 ENTRY_SEQUENCE_GROUP

```
AIM element: filling_type_group
Source:         10303-238
Reference path:
filling_type_group <=
machining_group <=
group
group.description
{ group.description = 'escape' }
```

4.10.1 entry_sequence_group to machine_with_kinematics (as robot)

```
AIM element: PATH
Reference path:
filling_type_group <=
machining_group <=
group <-
group_assignment.assigned_group
{ group_assignment <-
role_select = group_assignment
role_select <-
role_association.item_with_role
role_association
role_association.role ->
object_role
object_role.name = 'robot' }
group_assignment =>
applied_group_assignment
applied_group_assignment.items[i] ->
groupable_item
groupable_item = product_definition
product_definition
```

4.10.2 entry_sequence_group to connect_entry_stack (as entry_moves)

```
AIM element: PATH
Reference path:
filling_type_group <=
machining_group <=
group <-
group_assignment.assigned_group
{ group_assignment <-
role_select = group_assignment
role_select <-
role_association.item_with_role
role_association
role_association.role ->
object_role
object_role.name = 'moves' }
group_assignment =>
applied_group_assignment
```

```
applied_group_assignment.items[i] ->
groupable_item
groupable_item = action_method
action_method =>
machining_toolpath
```

4.11 REQUIREMENT_AND_PROPERTY_GROUP

```
AIM element: filling_type_group
Source:       10303-238
Reference path:
filling_type_group <=
machining_group <=
group
group.description
{ group.description = 'requirement' }
```

4.11.1 requirement_and_property_group to requirement_assignment (as requirements)

```
AIM element: PATH
Reference path:
filling_type_group <=
machining_group <=
group <-
group_assignment.assigned_group
{ group_assignment <-
role_select = group_assignment
role_select <-
role_association.item_with_role
role_association
role_association.role ->
object_role
object_role.name = 'required' }
group_assignment =>
applied_group_assignment
applied_group_assignment.items[i] ->
groupable_item
groupable_item = requirement_assignment
requirement_assignment
```

4.11.2 requirement_and_property_group to assigned_property (as properties)

```
AIM element: PATH
Reference path:
filling_type_group <=
machining_group <=
group <-
group_assignment.assigned_group
{ group_assignment <-
role_select = group_assignment
role_select <-
```

```
role_association.item_with_role
role_association
role_association.role ->
object_role
object_role.name = 'properties' }
group_assignment =>
applied_group_assignment
applied_group_assignment.items[i] ->
groupable_item
groupable_item = property_definition
property_definition
```

4.11.3 when_met

```
AIM element: descriptive_representation_item.description
Source:      10303-45
Reference path:
filling_type_group <=
machining_group <=
characterized_object
characterized_definition = characterized_object
characterized_definition <-
property_definition.definition
property_definition
{property_definition.name = 'maximum grip length'}
represented_definition = property_definition
represented_definition <-
property_definition_representation.definition
property_definition_representation
property_definition_representation.used_representation ->
representation
representation.items[i]->
representation_item =>
measure_representation_item <=
measure_with_unit =>
(descriptive_representation_item.description = 'pre condition' )
(descriptive_representation_item.description = 'post condition' )
(descriptive_representation_item.description = 'pre and post condition' )
```

5 Operations Mapping specification

5.1 FILL_TYPE_OPERATION

```
AIM element: filling_type_operation
Source:      10303-238
Reference path:
filling_type_operation <=
machining_operation <=
action_method
```

5.2 CLAMP_PRODUCT_OPERATION

```
AIM element: filling_type_operation
Source:       10303-238
Reference path:
filling_type_operation <=
machining_operation <=
action_method
{ action_method.description = 'clamp product' }
```

5.2.1 clamp_product_operation to product_view_definition (as clamped_item)

```
AIM element: PATH
Reference path:
filling_type_operation <=
machining_operation <=
action_method <-
action_method_assignment.assigned_action_method
{ action_method_assignment.role ->
action_method_role
action_method_role.name = 'clamped item' }
action_method_assignment =>
applied_action_method_assignment
applied_action_method_assignment.items[i] ->
action_method_items
action_method_items = product_definition
product_definition
```

5.2.2 force

```
AIM element: measure_with_unit
Source:    10303-41
Reference path:
filling_type_operation <=
machining_operation <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'clamp force' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation
representation.items[i] ->
representation_item =>
measure_representation_item <=
measure_with_unit
{ measure_with_unit.value_component ->
measure_value
measure_value = numeric_measure
```

```
  numeric_measure }
```

5.2.3 high_speed

#1: if value is true

#2: if value is false (mapping may be omitted if value is false)

```
AIM element: descriptive_representation_item.description
Source:    10303-45
Reference path:
filling_type_operation <=
machining_operation <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'clamp speed' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation representation.items[i] ->
representation_item =>
descriptive_representation_item
descriptive_representation_item.description
{ #1: (descriptive_representation_item.description = 'high' )
#2: (descriptive_representation_item.description = 'normal' ) }
```

5.3 FASTEN_WITH_CODES

```
AIM element: filling_type_operation
Source:       10303-238
Reference path:
filling_type_operation <=
machining_operation <=
action_method
{ action_method.description = 'codes' }
```

5.3.1 pass_thru_codes

```
AIM element: descriptive_representation_item.description
Source:    10303-45
Reference path:
filling_type_operation <=
machining_operation <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
```

```
{ action_property.name = 'codes' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation
representation.items[i] ->
representation_item =>
compound_representation_item
compound_representation_item.item_element ->
compound_item_definition
compound_item_definition = list_representation_item
list_representation_item[i] ->
representation_item =>
descriptive_representation_item
descriptive_representation_item.description
```

5.4 PLACE_ITEM_OPERATION

```
AIM element: filling_type_operation
Source:        10303-238
Reference path:
filling_type_operation <=
machining_operation <=
action_method
{ (action_method.description = 'place fastener')
(action_method.description = 'place tack')
(action_method.description = 'place washer')
(action_method.description = 'place collar') }
```

5.4.1 place_item_operation to product_view_definition (as placed_item)

```
AIM element: PATH
Reference path:
filling_type_operation <=
machining_operation <=
action_method <-
action_method_assignment.assigned_action_method
{ action_method_assignment.role ->
action_method_role
action_method_role.name = 'placed item' }
action_method_assignment =>
applied_action_method_assignment
applied_action_method_assignment.items[i] ->
action_method_items
action_method_items = product_definition
product_definition
```

5.4.2 depth

```
AIM element: length_measure_with_unit
```

```
Source:    10303-41
Reference path:
filling_type_operation <=
machining_operation <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'depth' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation
representation.items[i] ->
representation_item =>
measure_representation_item <=
measure_with_unit =>
length_measure_with_unit
```

5.4.3 allowable_minimum_force

```
AIM element: measure_with_unit
Source:    10303-41
Reference path:
filling_type_operation <=
machining_operation <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'allowable minimum force' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation
representation.items[i] ->
representation_item =>
measure_representation_item <=
measure_with_unit
{ measure_with_unit.value_component ->
measure_value
measure_value = numeric_measure
numeric_measure }
```

5.4.4 allowable_maximum_force

```
AIM element: measure_with_unit
Source:       10303-41
Reference path:
filling_type_operation <=
machining_operation <=
```

```
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = ' allowable maximum force' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation
representation.items[i] ->
representation_item =>
measure_representation_item <=
measure_with_unit
{ measure_with_unit.value_component ->
measure_value
measure_value = numeric_measure
numeric_measure }
```

5.4.5 allowable_position_deviation

```
AIM element: length_measure_with_unit
Source:        10303-41
Reference path:
filling_type_operation <=
machining_operation <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = ' allowable position deviation' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation
representation.items[i] ->
representation_item =>
measure_representation_item` <=
measure_with_unit =>
length_measure_with_unit
```

5.4.6 allowable_normal_deviation

```
AIM element: plane_angle_measure_with_unit
Source:        10303-41
Reference path:
filling_type_operation <=
machining_operation <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
```

```
{ action_property.name = ' allowable normal deviation' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation
representation.items[i] ->
representation_item =>
measure_representation_item` <=
measure_with_unit =>
plane_angle_measure_with_unit
```

5.4.7 allowable_depth_deviation

```
AIM element: length_measure_with_unit
Source:      10303-41
Reference path:
filling_type_operation <=
machining_operation <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = ' allowable depth deviation' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation
representation.items[i] ->
representation_item =>
measure_representation_item` <=
measure_with_unit =>
length_measure_with_unit
```

5.5 PLACE_FASTENER_OPERATION

```
AIM element: filling_type_operation
Source:      10303-238
Reference path:
filling_type_operation <=
machining_operation <=
action_method
{ action_method.description = 'place fastener' }
```

5.5.1 diameter

```
AIM element: length_measure_with_unit
Source:   10303-41
Reference path:
filling_type_operation <=
```

```
machining_operation <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'diameter' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation
representation.items[i] ->
representation_item =>
measure_representation_item <=
measure_with_unit =>
length_measure_with_unit
```

5.5.2 verify_material

#1: if value is true

#2: if value is false (mapping may be omitted if value is false)

```
AIM element: descriptive_representation_item.description
Source:    10303-45
Reference path:
filling_type_operation <=
machining_operation <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'verify material' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation representation.items[i] ->
representation_item =>
descriptive_representation_item
descriptive_representation_item.description
{ #1: (descriptive_representation_item.description = 'verify material' )
#2: (descriptive_representation_item. description = 'no verify material' ) }
```

5.5.3 verify_grip

#1: if value is true

#2: if value is false (mapping may be omitted if value is false)

```
AIM element: descriptive_representation_item.description
```

```
Source:    10303-45
Reference path:
filling_type_operation <=
machining_operation <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'verify grip' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation representation.items[i] ->
representation_item =>
descriptive_representation_item
descriptive_representation_item.description
{ #1: (descriptive_representation_item.description = 'verify grip' )
#2: (descriptive_representation_item. description = 'no verify grip' ) }
```

5.6 PLACE_TACK_OPERATION

```
AIM element: filling_type_operation
Source:       10303-238
Reference path:
filling_type_operation <=
machining_operation <=
action_method
{ action_method.description = 'place tack' }
```

5.7 PLACE_WASHER_OPERATION

```
AIM element: filling_type_operation
Source:       10303-238
Reference path:
filling_type_operation <=
machining_operation <=
action_method
{ action_method.description = 'place washer' }
```

5.8 PLACE_COLLAR_OPERATION

```
AIM element: filling_type_operation
Source:       10303-238
Reference path:
filling_type_operation <=
machining_operation <=
action_method
{ action_method.description = 'place collar' }
```

5.9 REMOVE_TACK_OPERATION

AIM element: filling_type_operation
Source: 10303-238
Reference path:
filling_type_operation <=
machining_operation <=
action_method
{ action_method.description = 'remove tack' }

5.10 SEAL_FASTENER_OPERATION

AIM element: filling_type_operation
Source: 10303-238
Reference path:
filling_type_operation <=
machining_operation <=
action_method
{ action_method.description = 'seal fastener' }

5.10.1 quantity

AIM element: measure_with_unit
Source: 10303-41
Reference path:
filling_type_operation <=
machining_operation <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'quantity' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation
representation.items[i] ->
representation_item =>
measure_representation_item <=
measure_with_unit
{ measure_with_unit.value_component ->
measure_value measure_value = Volume_data_element
Volume_data_element }

5.10.2 seal_product_operation to material (as sealant)

AIM element: PATH
Reference path:
filling_type_operation <=
machining_operation <=

```
action_method <-
action_method_assignment.assigned_action_method
{ action_method_assignment.role ->
action_method_role
action_method_role.name = 'sealant' }
action_method_assignment =>
applied_action_method_assignment
applied_action_method_assignment.items[i] ->
action_method_items
action_method_items = product_definition
product_definition
characterized_definition = product_definition
characterized_definition <-
material_designation.definitions[i]
material_designation
```

5.10.3 seal_check

#1: if value is true

#2: if value is false (mapping may be omitted if value is false)

```
AIM element: descriptive_representation_item.description
Source:    10303-45
Reference path:
filling_type_operation <=
machining_operation <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'verify seal' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation representation.items[i] ->
representation_item =>
descriptive_representation_item
descriptive_representation_item.description
{ #1: (descriptive_representation_item.description = 'verify seal' )
#2: (descriptive_representation_item. description = 'no verify seal' ) }
```

5.11 SHAVE_FASTENER_OPERATION

```
AIM element: filling_type_operation
Source:        10303-238
Reference path:
filling_type_operation <=
machining_operation <=
action_method
```

```
{ action_method.description = 'shave fastener' }
```

5.11.1 reduction

```
AIM element: length_measure_with_unit
Source:     10303-41
Reference path:
filling_type_operation <=
machining_operation <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'reduction' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation
representation.items[i] ->
representation_item =>
measure_representation_item <=
measure_with_unit =>
length_measure_with_unit
```

5.11.2 new_length

```
AIM element: length_measure_with_unit
Source:     10303-41
Reference path:
filling_type_operation <=
machining_operation <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'new length' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation
representation.items[i] ->
representation_item =>
measure_representation_item <=
measure_with_unit =>
length_measure_with_unit
```

5.12 TIGHTEN_COLLAR_OPERATION

```
AIM element: filling_type_operation
```

```
Source:        10303-238
Reference path:
filling_type_operation <=
machining_operation <=
action_method
{ action_method.description = 'tighten collar' }
```

5.12.1 torque

```
AIM element: measure_with_unit
Source:     10303-41
Reference path:
filling_type_operation <=
machining_operation <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'torque' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation
representation.items[i] ->
representation_item =>
measure_representation_item <=
measure_with_unit
{ measure_with_unit.value_component ->
measure_value
measure_value = numeric_measure
numeric_measure }
```

5.12.2 squeeze

```
AIM element: measure_with_unit
Source:     10303-41
Reference path:
filling_type_operation <=
machining_operation <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'squeeze' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation
representation.items[i] ->
representation_item =>
measure_representation_item <=
```

```
measure_with_unit
{ measure_with_unit.value_component ->
measure_value
measure_value = numeric_measure
numeric_measure }
```

5.12.3 swage

```
AIM element: measure_with_unit
Source:    10303-41
Reference path:
filling_type_operation <=
machining_operation <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'swage' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation
representation.items[i] ->
representation_item =>
measure_representation_item <=
measure_with_unit
{ measure_with_unit.value_component ->
measure_value
measure_value = numeric_measure
numeric_measure }
```

5.12.4 pull

```
AIM element: measure_with_unit
Source:    10303-41
Reference path:
filling_type_operation <=
machining_operation <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'pull' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation
representation.items[i] ->
representation_item =>
measure_representation_item <=
measure_with_unit
```

```
{ measure_with_unit.value_component ->
measure_value
measure_value = numeric_measure
numeric_measure }
```

5.13 CHECK_DIMENSIONS_OPERATION

```
AIM element: filling_type_operation
Source:       10303-238
Reference path:
filling_type_operation <=
machining_operation <=
action_method
{ action_method.description = 'check dimensions' }
```

5.13.1 check_location

#1: if value is true

#2: if value is false (mapping may be omitted if value is false)

```
AIM element: descriptive_representation_item.description
Source:    10303-45
Reference path:
filling_type_operation <=
machining_operation <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'verify location' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation representation.items[i] ->
representation_item =>
descriptive_representation_item
descriptive_representation_item.description
{ #1: (descriptive_representation_item.description = 'verify location' )
#2: (descriptive_representation_item. description = 'no verify location' ) }
```

5.13.2 check_size

#1: if value is true

#2: if value is false (mapping may be omitted if value is false)

```
AIM element: descriptive_representation_item.description
Source:    10303-45
```

```
Reference path:
filling_type_operation <=
machining_operation <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'verify size' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation representation.items[i] ->
representation_item =>
descriptive_representation_item
descriptive_representation_item.description
{ #1: (descriptive_representation_item.description = 'verify size' )
#2: (descriptive_representation_item. description = 'no verify size' ) }
```

5.13.3 check_orientation

#1: if value is true

#2: if value is false (mapping may be omitted if value is false)

```
AIM element: descriptive_representation_item.description
Source:    10303-45
Reference path:
filling_type_operation <=
machining_operation <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'verify orientation' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation representation.items[i] ->
representation_item =>
descriptive_representation_item
descriptive_representation_item.description
{ #1: (descriptive_representation_item.description = 'verify orientation' )
#2: (descriptive_representation_item. description = 'no verify orientation' ) }
```

5.13.4 check_form

#1: if value is true

#2: if value is false (mapping may be omitted if value is false)

```
AIM element: descriptive_representation_item.description
Source:    10303-45
Reference path:
filling_type_operation <=
machining_operation <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'verify form' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation representation.items[i] ->
representation_item =>
descriptive_representation_item
descriptive_representation_item.description
{ #1: (descriptive_representation_item.description = 'verify form' )
#2: (descriptive_representation_item. description = 'no verify form' ) }
```

5.14 ADJUST_PLACEMENT_PROBING

```
AIM element: machining_touch_probing
Source:    10303-238
Reference path:
machining_touch_probing <=
machining_operation <=
action_method
{ action_method.description = 'adjust placement probing' }
NOTE: adjust mapping for feature complete probing to allow this string
```

5.14.1 adjusted_item

#1: if value is a product_definition

#2: if value is a machining_product_executable

```
AIM element: PATH
Reference path:
machining_touch_probing <=
machining_operation <=
action_method <-
action_method_assignment.assigned_action_method
{ action_method_assignment.role ->
action_method_role
action_method_role.name = 'adjusted item' }
action_method_assignment =>
applied_action_method_assignment
applied_action_method_assignment.items[i] ->
action_method_items
```

```
#1: (action_method_items = product_definition
product_definition)
#2: (action_method_items = action_method
action_method =>
machining_process_executable)
```

5.15 CONNECT_ESCAPE_STACK

```
AIM element: machining_toolpath
Source:        10303-238
Reference path:
machining_toolpath <=
action_method
{ action_method.description = 'connect escape' }
```

5.15.1 description

```
AIM element: descriptive_representation_item.description
Source:        10303-45
Reference path:
machining_toolpath <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'description' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation representation.items[i] ->
representation_item =>
descriptive_representation_item
descriptive_representation_item.description
```

5.15.2 escape_point

```
AIM element: cartesian_point
Source:        10303-42
Reference path:
machining_toolpath <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'escape point' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation
```

```
representation.items[i] ->
representation_item =>
geometric_representation_item =>
point =>
cartesian_point
```

5.15.3 pose_constraints

```
AIM element: value_range
Source:       10303-1106
Reference path:
machining_toolpath <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'axis constraint' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation
representation.items[i] ->
representation_item =>
compound_representation_item =>
value_range
```

5.15.4 connect_escape_point to connect_escape_point (as next_level)

```
AIM element: PATH
Reference path:
machining_toolpath <=
action_method <-
action_method_relationship.relating_method
action_method_relationship
{ action_method_relationship.name = 'next level' }
action_method_relationship.related_method ->
action_method =>
machining_toolpath
```

5.16 CONNECT_ENTRY_STACK

```
AIM element: machining_toolpath
Source:       10303-238
Reference path:
machining_toolpath <=
action_method
{ action_method.description = 'connect entry' }
```

5.16.1 description

```
AIM element: descriptive_representation_item.description
Source:       10303-45
Reference path:
machining_toolpath <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'description' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation representation.items[i] ->
representation_item =>
descriptive_representation_item
descriptive_representation_item.description
```

5.16.2 escape_point

```
AIM element: cartesian_point
Source:       10303-42
Reference path:
machining_toolpath <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'escape point' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation
representation.items[i] ->
representation_item =>
geometric_representation_item =>
point =>
cartesian_point
```

5.16.3 pose_constraints

```
AIM element: value_range
Source:       10303-1106
Reference path:
machining_toolpath <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
```

```
{ action_property.name = 'axis constraint' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation
representation.items[i] ->
representation_item =>
compound_representation_item =>
value_range
```

5.16.4 connect_entry_point to connect_entry_point (as next_level)

```
AIM element: PATH
Reference path:
machining_toolpath <=
action_method <-
action_method_relationship.relating_method
action_method_relationship
{ action_method_relationship.name = 'next level' }
action_method_relationship.related_method ->
action_method =>
machining_toolpath
```

5.17 EXTERNAL_OPERATION

```
AIM element: external_type_operation
Source:       10303-238
Reference path:
external_type_operation <=
machining_operation <=
action_method
```

5.17.1 mode

```
AIM element: descriptive_representation_item.description
Source:   10303-45
Reference path:
filling_type_operation <=
machining_operation <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'mode' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation representation.items[i] ->
representation_item =>
```

```
descriptive_representation_item
descriptive_representation_item.description
{ (descriptive_representation_item.description = 'manual' )
  (descriptive_representation_item.description = 'automated' ) }
```

5.17.2 additional_information

```
AIM element: descriptive_representation_item.description
Source:    10303-45
Reference path:
filling_type_operation <=
machining_operation <=
action_method
characterized_action_definition = action_method
characterized_action_definition <-
action_property.definition
{ action_property.name = 'additional information' }
action_property <-
action_property_representation.property
action_property_representation
action_property_representation.representation ->
representation representation.items[i] ->
representation_item =>
descriptive_representation_item
descriptive_representation_item.description
```

5.18 EXTERNAL_HEATING_OPERATION

```
AIM element: external_type_operation
Source:        10303-238
Reference path:
external_type_operation <=
machining_operation <=
action_method
{ action_method.description = 'heating' }
```

5.19 EXTERNAL_MARKING_OPERATION

```
AIM element: external_type_operation
Source:        10303-238
Reference path:
external_type_operation <=
machining_operation <=
action_method
{ action_method.description = 'marking' }
```

5.20 EXTERNAL_COATING_OPERATION

```
AIM element: external_type_operation
```

```
Source:        10303-238
Reference path:
external_type_operation <=
machining_operation <=
action_method
{ action_method.description = 'coating' }
```

5.21 EXTERNAL_PACKAGING_OPERATION

```
AIM element: external_type_operation
Source:        10303-238
Reference path:
external_type_operation <=
machining_operation <=
action_method
{ action_method.description = 'packaging' }
```

5.22 EXTERNAL_FASTENING_OPERATION

```
AIM element: external_type_operation
Source:        10303-238
Reference path:
external_type_operation <=
machining_operation <=
action_method
{ action_method.description = 'fastening' }
```

5.23 EXTERNAL_FIXTURING_OPERATION

```
AIM element: external_type_operation
Source:        10303-238
Reference path:
external_type_operation <=
machining_operation <=
action_method
{ action_method.description = 'fixturing' }
```

5.24 EXTERNAL_PREPARATION_OPERATION

```
AIM element: external_type_operation
Source:        10303-238
Reference path:
external_type_operation <=
machining_operation <=
action_method
{ action_method.description = 'preparation' }
```

5.25 EXTERNAL_REMOVAL_OPERATION

```
AIM element: external_type_operation
Source:         10303-238
Reference path:
external_type_operation <=
machining_operation <=
action_method
{ action_method.description = 'removal' }
```

5.26 EXTERNAL_CHECK_OPERATION

```
AIM element: external_type_operation
Source:         10303-238
Reference path:
external_type_operation <=
machining_operation <=
action_method
{ action_method.description = 'check' }
```

5.27 EXTERNAL_CHECK_BURR_OPERATION

```
AIM element: external_type_operation
Source:         10303-238
Reference path:
external_type_operation <=
machining_operation <=
action_method
{ action_method.description = 'check burr' }
```

5.28 EXTERNAL_CHECK_SPIRAL_OPERATION

```
AIM element: external_type_operation
Source:         10303-238
Reference path:
external_type_operation <=
machining_operation <=
action_method
{ action_method.description = 'check spiral' }
```

6 AIM EXPRESS Additions

6.1 external_type_operation

An **external_type_operation** is a type of **machining_operation** that represents the details of an operation performed by an external system that is beyond the scope of the automation defined in this document. See the ARM definitions for External_operation and subtypes for more information.

6.1.1 EXPRESS specification:

```
*)
ENTITY external_type_operation
  SUBTYPE OF (machining_operation);
END_ENTITY;
(*
```

6.2 filling_type_operation

A **filling_type_operation** is a type of **machining_operation** that represents the details of a machining step in which an existing hole or void is filled with a fastener. See the ARM definitions for Filling_type_operation and subtypes for more information.

6.2.1 EXPRESS specification:

```
*)
ENTITY filling_type_operation
  SUBTYPE OF (machining_operation);
END_ENTITY;
(*
```

6.3 filling_type_group

A **filling_type_group** is a type of **machining_group** that collects manufacturing features within a process where holes are drilled and filled. See the ARM definitions for Drill_and_fill_group and subtypes for more information.

6.3.1 EXPRESS specification:

```
*)
ENTITY filling_type_group
  SUBTYPE OF (machining_group);
END_ENTITY;
(*
```

6.4 machining_group

A **machining_group** is a type of **group** and **characterized_object** that collects elements of a manufacturing description.

6.4.1 EXPRESS specification:

```
*)
ENTITY machining_group
  SUBTYPE OF (group, characterized_object);
END_ENTITY;
(*
```

6.5 machining_stack

A **machining_stack** is a type of **action_method** that represents the ordering of elements in a drilling operation.

6.5.1 EXPRESS specification:

```
*)
ENTITY machining_stack
  SUBTYPE OF (action_method);
END_ENTITY;
(*
```

6.6 machining_stack_element

A **machining_stack_element** is a type of **action_method** that represents one element in a drilling operation.

6.6.1 EXPRESS specification:

```
*)
ENTITY machining_stack_element
  SUBTYPE OF (action_method);
END_ENTITY;
(*
```

6.7 mbmfg_date_and_time_item

EXTEND EXISTING AP238E3 DEFINITION

The **mbmfg_date_and_time_item** type is an extension of the **date_and_time_item** type. It adds the data types **characterized_object**, **machining_operation**, **machining_process_executable**, **machining_toolpath**, **product**, **product_definition**, and **product_definition_formation** to which a referenced **date_and_time** can be assigned.

6.7.1 EXPRESS specification:

```
*)
TYPE mbmfg_date_and_time_item = SELECT BASED_ON date_and_time_item WITH (
  characterized_object,    -- ADD
  machining_group,
  machining_operation,
  machining_process_executable,
  machining_toolpath,
  product,
  product_definition,
  product_definition_formation
  );
END_TYPE;
(*
```

6.8 mbmfg_generic_property_definition_select

The **mbmfg_generic_property_definition_select** type is an extension of the **generic_property_definition_select type**. It adds the data types **geometric_tolerance** to which a **generic_property_relationship** can be associated.

6.8.1 EXPRESS specification:

```
*)
TYPE mbmfg_generic_property_definition_select = SELECT BASED_ON
generic_property_definition_select WITH (
  geometric_tolerance
  );
END_TYPE;
(*
```

6.9 twin_feature

A **twin_feature** is a type of **instanced_feature** that represents the as-made result of a manufacturing operation on a digital twin. See the ARM definitions for Manufacturing_feature_twin and subtypes for more information.

6.9.1 EXPRESS specification:

```
*)
ENTITY twin_feature
  SUBTYPE OF (instanced_feature);
END_ENTITY;
(*
```

6.10 twin_measured_property

A **twin_measured_property** is a type of **property_definition** that represents the as-measured result of a property on a digital twin. See the ARM definitions for Measured_property and subtypes for more information.

6.10.1 EXPRESS specification:

```
*)
ENTITY twin_measured_property
  SUBTYPE OF (property_definition);
END_ENTITY;
(*
```

6.11 twin_prototype_relationship

A **twin_prototype_relationship** is a type of **property_definition_relationship** that associates the digital twin description of an as-made concept with its as-designed description. See the ARM definitions for Product_view_twin, Geometric_tolerance_twin, Dimensional_size_twin, and Dimensional_location_twin for more information.

6.11.1 EXPRESS specification:

```
*)
ENTITY twin_prototype_relationship
  SUBTYPE OF (property_definition_relationship);
END_ENTITY;
(*
```

6.12 twin_substitute_relationship

A **twin_substitute_relationship** is a type of **property_definition_relationship** that associates the digital twin description of an as-made concept with a substitute description. See the ARM definitions for Product_view_twin_with_substitute for more information.

6.12.1 EXPRESS specification:

```
*)
ENTITY twin_substitute_relationship
  SUBTYPE OF (property_definition_relationship);
END_ENTITY;
(*
```

7 Change Log

2024-03-27 – Updated for model revisions made at WG15 Renton meeting in preparation for CIB review.

1. Measured_property replaces geometric_tolerance and dimension twins.
2. Measured_machining_material added to measure machining properties of a material.
3. Cutting_tool_twin replaces product_view_with_manufacturing twins.
4. Verification properties added to drill and fill operations.

2023-09-01 – updating to new drill/fill twin feature, group model, more specific operations, plus mappings.

2023-04-11 – updating to version M.   In progress.

2023-04-07 – updated to version L. Removed fasten_operation, identify_operation, serialize_operation, and load_nose.