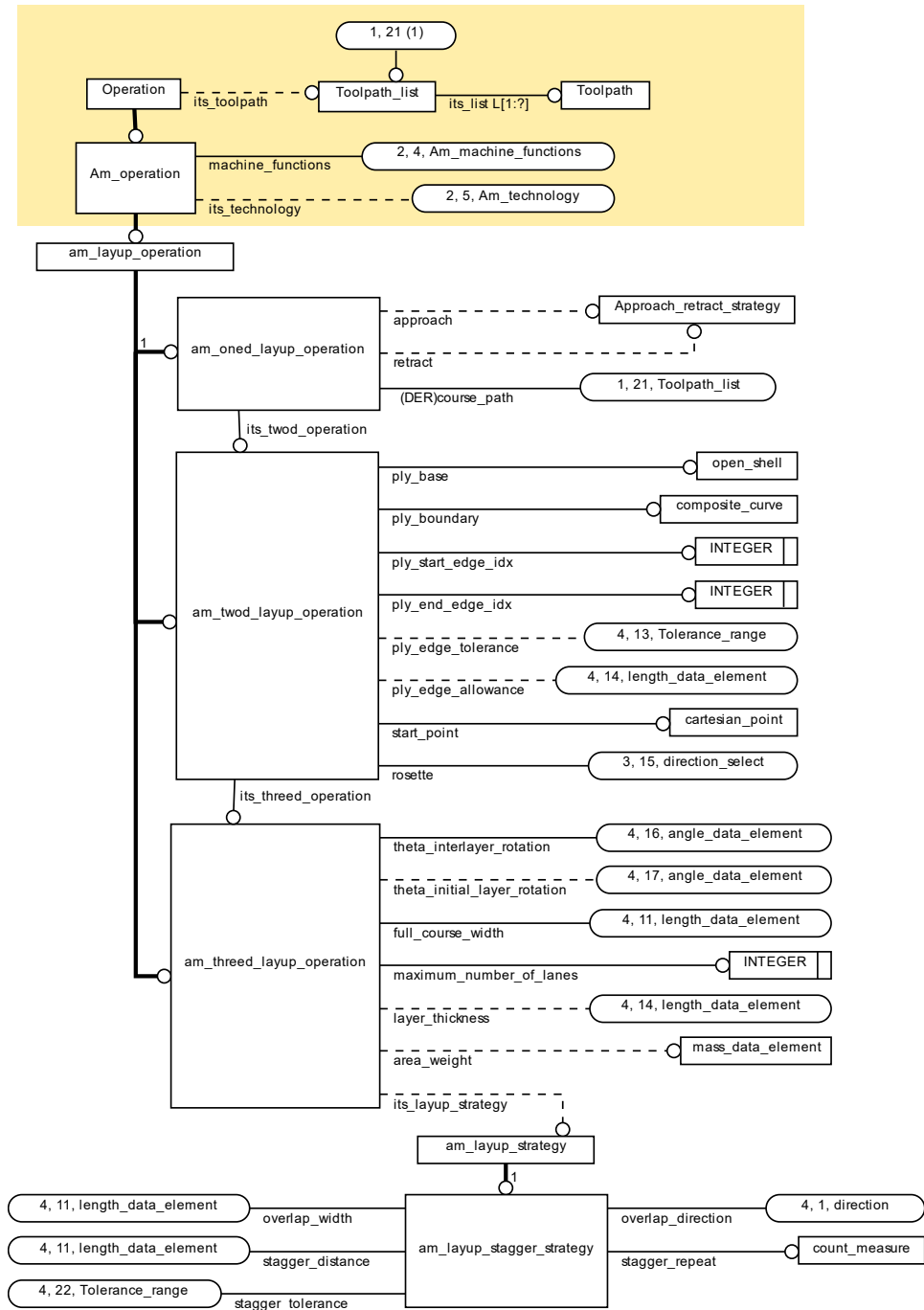


AP238 Extension for Composite Layup

1 Application Objects



Composite Operations

1.1 AM_layup_operation

The AM_layup_operation application object defines the machine functions and technology to be used in a layup operation. The Am_layup_operation application object inherits from the am_operation as defined in ISO 14649-17 [1],

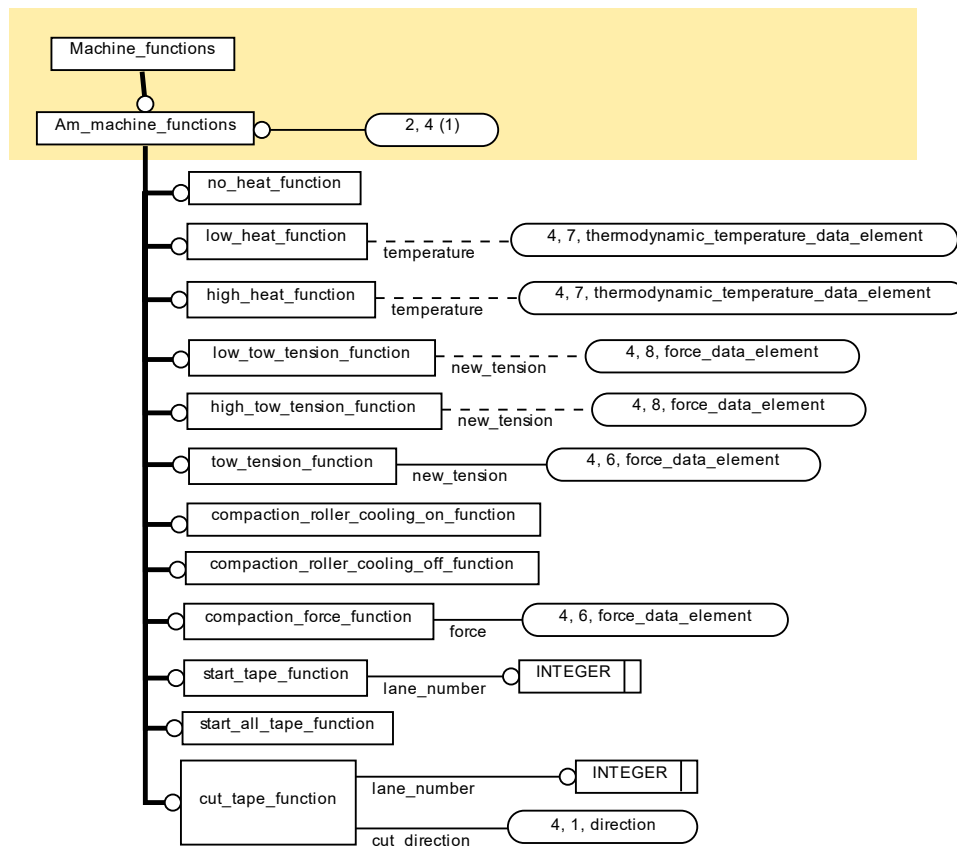
```
ENTITY am_layup_operation
ABSTRACT SUPERTYPE OF (ONEOF (am_oned_layup_operation, am_twod_layup_operation,
am_threed_layup_operation))
SUBTYPE OF (am_operation);
  -- machine_functions:          am_machine_functions;
  -- its_technology:            am_technology;
END_ENTITY;
```

1.1.1 machine_functions

the machine functions required for this operation.

1.1.2 its_technology

the processing technology to be used for this operation.

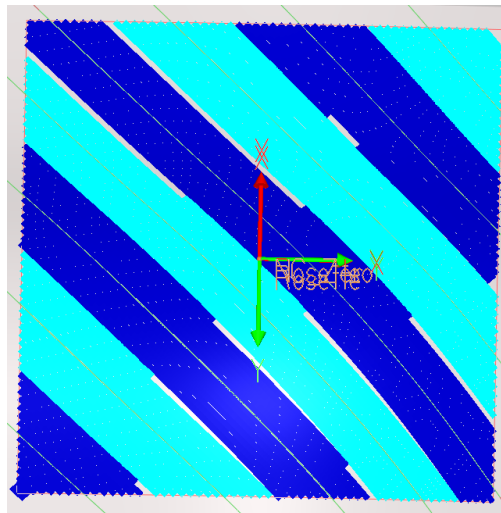


1.2 Cut_tape_function

The cut tape application object is an AM machine function that cuts a tape during a layup.

```
ENTITY cut_tape_function
SUBTYPE OF (am_machine_functions);
  lane_number:      INTEGER;
END_ENTITY;
```

NOTE: For example, in the middle of a course the first or last tape may need to be cut avoid overlaps.



Cut tapes in courses

1.2.1 lane_number

The lane number of the tow that is to be cut.

NOTE: The lane number is an index into the maximum_number_of_lanes as defined in the thread_layup_operation.

1.3 start_tape_function

The start tape application object is an AM machine function that starts tape laying in a lane.

```
ENTITY start_tape_function
```

```
SUBTYPE OF (am_machine_functions);
  lane_number:          INTEGER;
END_ENTITY;
```

1.3.1 lane_number

The lane number of the tow that is to be started or restarted.

NOTE: The lane number is an index into the maximum_number_of_lanes as defined in the threed_layup_operation.

1.4 start_all_tape_function

The start all tape application object is an AM machine function that starts tape laying in all the lanes of the course

```
ENTITY start_all_tape_function
SUBTYPE OF (am_machine_functions);
END_ENTITY;
```

NOTE: The number of lanes in a course is set in the oned_layup_operation and may not be the same as the maximum number of tapes allowed in the tow.

1.5 Compaction_roller_cooling_on_function

The compaction_roller_cooling_on application object is an AM machine function that turns cooling on for the compaction roller.

```
ENTITY compaction_roller_cooling_on_function
SUBTYPE OF (am_machine_functions);
END_ENTITY;
```

1.6 Compaction_roller_cooling_off_function

The compaction_roller_cooling_off application object is an AM machine function that turns cooling off for the compaction roller.

```
ENTITY compaction_roller_cooling_off_function
SUBTYPE OF (am_machine_functions);
END_ENTITY;
```

1.7 Compaction_force_function

The compaction_force application object is an AM machine function that defines a force for the compaction roller.

```
ENTITY compaction_force_function
SUBTYPE OF (am_machine_functions);
force:          force_data_element;
END_ENTITY;
```

1.7.1 force

the force to be applied for compaction

1.8 High_heat_function

The high heat application object is an AM machine function that sets the tape heater to high.

```
ENTITY high_heat_function
SUBTYPE OF (am_machine_functions);
  temperature:          OPTIONAL thermodynamic_temperature_data_element;
END_ENTITY;
```

1.8.1 temperature

the desired temperature for the heater.

1.9 Low_heat_function

The low heat application object is an AM machine function that sets the tape heater to low.

```
ENTITY low_heat_function
SUBTYPE OF (am_machine_functions);
  temperature:          OPTIONAL thermodynamic_temperature_data_element;
END_ENTITY;
```

1.9.1 temperature

the desired temperature for the heater.

1.10 No_heat_function

The no_heat application object is an AM machine function that turns the heater off.

```
ENTITY no_heat_function
SUBTYPE OF (am_machine_functions);
END_ENTITY;
```

1.11 Tow_tension_function

The tow_tension application object is an AM machine function that sets the tension of the tape.

```
ENTITY tow_tension_function
SUBTYPE OF (am_machine_functions);
  new_tension: force_data_element;
END_ENTITY;
```

1.11.1 New_tension

the new tow tension.

1.12 High_tow_tension_function

The tow_tension application object is an AM machine function sets the tension of the tape to high with an optional value.

```
ENTITY high_tow_tension_function
SUBTYPE OF (am_machine_functions);
  new_tension: OPTIONAL force_data_element;
END_ENTITY;
```

1.12.1 New_tension

the new tow tension.

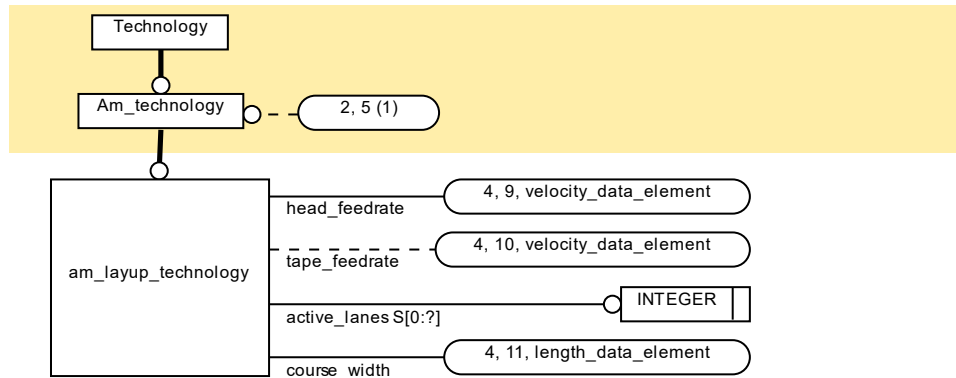
1.13 Low_tow_tension_function

The low_tow_tension application object is an AM machine function that sets the tension of the tape to low with an optional value.

```
ENTITY low_tow_tension_function
SUBTYPE OF (am_machine_functions);
  new_tension: OPTIONAL force_data_element;
END_ENTITY;
```

1.13.1 New_tension

the new tow tension.



Technology

1.14 Am_layup_technology

The am_layup technology defines the speed of the layup and the width of the course.

```
ENTITY am_layup_technology
SUBTYPE OF (am_technology);
  head_feedrate:      velocity_data_element;
  tape_feedrate:     OPTIONAL velocity_data_element;
  active_lanes:      SET [0:?] OF INTEGER;
  tape_width:        length_measure;
  course_direction:  OPTIONAL forward_or_backward;
END_ENTITY;
```

```
TYPE forward_or_backward = ENUMERATION OF (forward, backward); END_TYPE;
```

1.14.1 head_feedrate

the speed of the head as it moves on the course.

1.14.2 tape_feedrate

the speed of the tape as it is fed through the head.

NOTE: The tape feedrate needs to be higher than the head feedrate when the distance between the head and the surface is growing.

1.14.3 active_lanes

the lane numbers of the active tows.

1.14.4 tape_width

the width of tape being laid in this course.

1.14.5 course_direction

the direction of the course classified as forward when in the direction of rosette, and backward when in direction opposite to the rosette.

NOTE: In most situations consecutive courses are laid in opposite directions.

1.15 AM_oned_layup_operation

The AM_oned_layup_operation application object defines a tow path for the tape.

```
ENTITY am_oned_layup_operation
SUBTYPE OF (am_layup_operation);
  approach:          OPTIONAL approach_retract_strategy;
  retract:           OPTIONAL approach_retract_strategy;
  its_twod_operation: am_twod_layup_operation;
DERIVE
  course_path: toolpath_list :=
    SELF\Operation.its_toolpath;
END_ENTITY;
```

1.15.1 approach

the strategy used to approach the course before tape laying begins.

1.15.2 retract

the strategy used to exit the course after tape laying ends.

1.15.3 its_twod_operation

the twod_layup_operation used to generate this oned_layup_operation.

1.15.4 course_path

the centerline of the path followed by the tape head.

NOTE: the course path is inherited from operation and shown here for clarity

1.16 Am_twod_layup_operation

The AM_twod_layup_operation application object defines information for generating AM_oned_layup operations.

```
// operation is defined for the ply_piece in a workingstep
ENTITY am_twod_layup_operation
SUBTYPE OF (am_layup_operation);
  manufacturing_ply_base:      OPTIONAL open_shell;
  manufacturing_outer_boundary: OPTIONAL composite_curve;
  manufacturing_inner_boundaries: OPTIONAL LIST [1:?] OF composite_curve;
  manufacturing_rosette:      OPTIONAL Direction_select;
  ply_thickness:              OPTIONAL Length_data_element;
  ply_edge_tolerance:         OPTIONAL Tolerance_range;
  ply_edge_allowance:         Length_data_element;
  start_point:                OPTIONAL cartesian_point;
  its_threed_operation:       am_threed_layup_operation;
END_ENTITY;
```

1.16.1 Manufacturing_ply_base

the surface to be laid laid during manufacturing.

NOTE: if not given the surface is the base surface defined by the composite ply table referenced by the threed_operation. The manufacturing ply base enables modeling of changes to the base surface as layers are built up.

1.16.2 manufacturing_outer_boundary

the manufacturing boundary on the surface to lay the tape. No tape shall be laid beyond this boundary.

NOTE: if not given the boundary is the same as the edge of the ply surface

1.16.3 manufacturing_inner_boundaries

the manufacturing boundaries of any voids in the surface. No tape shall be laid within this boundary.

NOTE: if not given excess tape may be laid anywhere within the void.

1.16.4 Manufacturing rosette

manufacturing specific advice for the direction of the course. The x direction defines the direction of the course, the y direction defines the direction to find the start point for the next course.

NOTE: if not given the rosette is as defined by the composite ply table.

1.16.5 ply_edge_tolerance

the range allowed for the distance between the start of the tape and the edge.

1.16.6 ply_edge_allowance

course distance before the tape starts and after the tape ends.

1.16.7 ply_thickness

the thickness of the layer.

NOTE: if not given the thickness is defined by the material of the ply.

1.16.8 start_point

the point on the surface to start laying the first course.

1.16.9 its_threed_operation

the threed_layup operation for this twod_layup operation.

1.17 AM_threed_layup_operation

The AM_threed_layup_operation application object describes process parameters for generating AM_twod_layup_operation application objects.

```
ENTITY am_threed_layup_operation
SUBTYPE OF (am_layup_operation);
  ply_table:                Composite_assembly_table;
  full_course_width:        length_data_element;
  maximum_number_of_lanes:  INTEGER;
  layer_thickness:          OPTIONAL length_data_element;
  its_layup_strategy:       OPTIONAL am_layup_strategy;
END_ENTITY;
```

1.17.1 ply table

the composite ply table defining the plys to be laid.

1.17.2 full_course_width

the width of the course if all the lanes are active.

1.17.3 maximum_number_of_lanes

the maximum number of lanes allowed in the tow.

NOTE: The number of active lanes is varied between courses to manage stagger. The maximum defines how lanes are addressed when tapes are cut and restarted.

1.17.4 its_layup_strategy

strategy information for planning am_twod_layup_operations.

1.18 AM_layup_strategy

The AM_layup_strategy application object defines a strategy for generating layup paths on each layer.

```
Entity am_layup_strategy  
ABSTRACT SUPERTYPE OF (ONEOF (am_layup_stagger_strategy));  
END_ENTITY;
```



Stagger Strategy for a sequence of layers

1.19 AM_stagger_strategy

The AM_layup_stagger_strategy application object defines how many layers are required before a start point can repeat.

```
Entity am_layup_stagger_strategy  
SUBTYPE OF (am_layup_strategy);  
  overlap_width:          length_data_element;
```

```
overlap_direction:    direction;  
stagger_distance:    length_data_element;  
stagger_repeat:      count_measure;  
stagger_tolerance:  tolerance_range;  
END_ENTITY;
```

1.19.1 overlap_width

the width of the overlap between courses.

1.19.2 overlap_direction

the direction of the overlap.

1.19.3 stagger_distance

the distance between overlaps on consecutive layers.

1.19.4 stagger_repeat

the number of layers before a stagger repeats.

1.19.5 stagger_tolerance

the range allowed for the distance between the last tape of one course and the first tape of the next course.