



ASSOCIATION CONNECTING
ELECTRONICS INDUSTRIES®

IPC-2546

Sectional Requirements for Shop-Floor Equipment Communication Messages (CAMX) for Printed Circuit Board Assembly

Amendment 2: Dispensing Equipment Section Reflow Equipment Section Final Assembly and Packaging Section

IPC-2546

January 2005

A standard developed by IPC

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IPC-2546

CAMX

– ASSEMBLY

Sectional Requirements for Shop-Floor Equipment Communication Messages (CAMX) for Printed Circuit Board Assembly

Amendment 2:

Dispensing Equipment Section

Reflow Equipment Section

Final Assembly and Packaging Section

A standard developed by the Assembly XML Schema Formatting Task Group (2-13b) of the Shop Floor Communications Subcommittee (2-13) of IPC.

Users of this publication are encouraged to participate in the development of future revisions.

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Acknowledgment

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Sectional Requirements for Specific Printed Circuit Board Assembly Equipment

Amendment 2: Dispensing Equipment Section Reflow Equipment Section Final Assembly and Packaging Section

2 APPLICABLE DOCUMENTS

IPC-2501 Definition for Web-Based Exchange of XML Data (Message Broker)

IPC-2541 Generic Requirements for Electronics Manufacturing Shop-Floor Equipment Communication Messages (CAMX)

IPC-2547 Sectional Requirements for Shop-Floor Equipment Communication Messages (CAMX) for Printed Circuit Board Test, Inspection and Rework

3.1 Date and Time Notation

Part 2: Datatypes

<http://www.w3.org/TR/xmlschema-2/>

dateTime

<http://www.w3.org/TR/xmlschema-2/#dateTime>

Format: yyyy-MM-ddThh:mm:ss.sss±zz:zz

duration

<http://www.w3.org/TR/xmlschema-2/#duration>

Format: PnYnMnDTnHnMnS

4 GENERIC ASSEMBLY EQUIPMENT EVENTS AND MESSAGE FORMATS

4.1 Dictionary of Common Terms

Add the following terms to section 4.1:

Dual Lane

A transport system with two independent lanes used to transport product through the equipment.

Transport Direction

The direction the items travel through the machine. A machine is usually set up for a right-to-left or left-to-right direction.

4.4 Dictionary of Nested Elements

Add the following elements to Section 4.4:

4.4.7 Element: EnvironmentalControlUnit

Description: This element can be used to generically describe an environmental control unit. It can be used for heaters, coolers, humidifiers etc.

Attribute / Element Name	Attribute / Element Type	Description	Occurrence
name	string	Unique name of the controller	1-1
units	string(enumerated)	KELVIN CELSIUS FAHRENHEIT RELATIVE_HUMIDITY	1-1
setPoint	double	Setpoint value of the controller	1-1
actualValue	double	Actual value of the controller	0-1
zoneType	string(enumerated)	CONVECTIONHEAT CONDUCTIONHEAT INFARED RADIATIONHEAT COOLING HUMIDIFIER	0-1
blowerSpeedRPM	nonNegativeInteger	Actual Revolutions per minute (RPM)	0-1
blowerSpeedRate	string(enumerated)	LOW MEDLOW MED MEDHIGH HIGH	0-1

```
<EnvironmentalControlUnit
  name="Preheat Lower"
  units="CELSIUS"
  setPoint="30.000000"
  actualValue="30.000000"
  zoneType="CONDUCTIONHEAT"/>
```

4.4.8 Element: ItemData

Description: This element can be used to generically describe the attributes of an item. This data includes the width and length of the item, the units these elements are being represented in, and the number of parts per item.

Attribute / Element Name	Attribute / Element Type	Description	Occurrence
itemMultiplier	nonNegativeInteger	Item Multiplier count of how many parts per item.	0-1
units	String (enumerated)	METER INCH	0-1
itemLength	double	Length of the item being processed	0-1
itemWidth	double	Width of the item being processed	0-1

```
<ItemData
  itemMultiplier="1"
  units="METER"
  itemLength="0.150"
  itemWidth="0.080"/>
```

4.5 Extensions to IPC-2541 Mandatory Messages

4.5.1 Extensions to <IPC-2541 EquipmentInformation>

4.5.1.7 InformationId: PauseButtonPushed

Description: Information event to indicate that the user is attempting to pause the currently running process program

4.5.1.8 InformationId: ResumeButtonPushed

Description: Information event to indicate that the user is attempting to resume the currently running process program.

4.5.4 Extensions to <IPC-2541 EquipmentAlarms>

4.5.4.1 InformationId: SafetyCoverUnlocked

Description: Information event to indicate that the user unlocked any of the safety covers on the equipment. This is a complement to 5.1.6.1 SafetyCoverOpen already in IPC-2546.

4.5.5 Generic Equipment Extensions to <IPC-2541 EquipmentError>

4.5.5.1 ItemTransportError

Description: This event will be sent whenever there is a problem controlling the transport mechanism. This includes motor problems, timeouts (when items are detected), etc.

```
<EquipmentError
  dateTime="2003-01-23T15:39:23.00+00:00"
  laneList="1"
  zoneList="1"
  errorId="ItemTransportError"
  errorInstanceId="12345">
</EquipmentError>
```

4.5.6 Generic Equipment Extensions to <IPC-2541 EquipmentRecipeSelected>

4.5.6.1 ItemData

Description: This event will be sent whenever a recipe is selected on a piece of equipment.

Attribute / Element Name	Attribute / Element Type	Description	Occurrence
ItemData	See 4.4.8	Information about the item	1-1

```
<Extensions>
  <ItemData
    itemMultiplier="1"
    units="METER"
    itemLength="0.150"
    itemWidth="0.080"/>
</Extensions>
```

4.5.7 Generic Equipment Extensions to <IPC-2541 EquipmentRecipeModified>

4.5.7.1 ItemData

Description: This event will be sent whenever a recipe is modified on a piece of equipment.

Attribute / Element Name	Attribute / Element Type	Description	Occurrence
ItemData	See 4.4.8	Information about the item	1-1

```
<Extensions>
  <ItemData
    itemMultiplier="1"
    units="METER"
    itemLength="0.150"
    itemWidth="0.080"/>
</Extensions>
```

5 SPECIFIC ASSEMBLY EQUIPMENT EVENTS AND MESSAGE FORMATS

5.1 Specific Screen Printing Equipment Events and Message Formats (Print)

5.2 Specific Adhesive Dispensing Equipment Events and Message Formats (Dispense)

5.2.1 Dictionary of Dispensing Terms

The following is a list of definitions used in dispensing machines including optical methods to verify dispense amounts.

Device Heater

A device, mounted in the conveyor path, that is used to heat a syringe, needle or item, to a specific temperature prior to, during or after the dispense cycle.

Head

The movable assembly that carries the Z-axis components side to side (X) and front to back (Y).

Needle

A hollow tube, usually made of metal or plastic, that is attached to a material supply syringe. The inside diameter of the needle determines the flow rate of the material.

Needle Calibrator

An accessory device that is used to maintain consistent needle distance from the substrate. The calibration utility is used when the needle is changed and/or when Z-axis components are removed and then reinstalled.

Pump

A motor driven device that is used to dispense material at a programmed rate and duration.

Syringe

A hollow plastic cylinder that contains material. Air pressure is used to drive a plunger, which forces material out of the syringe and through a needle.

VerificationLocation

The location where the verification sensor will measure and verify the dispensed material size. This location could be directly on the item itself or a designated area on the dispensing equipment used for all products.

VerificationSensor

The sensor or subsystem used to measure the amount of dispensed material. This is typically the fiducial recognition camera but it may be other devices such as laser-based systems, line scanners and so on.

Weight Scale

A device which is used to measure the weight of a programmed dispense sample. The weight of the sample is compared to a known benchmark. The dispensing parameters are then adjusted accordingly to maintain a constant volume.

Z-Head

The assembly to which the dispense unit or pump and other associated components are attached. The Z-axis controls the height of the dispense unit or pump.

ZSense

A term that describes the act of measuring the height of the substrate, relative to the needle on a dispensing unit or syringe.

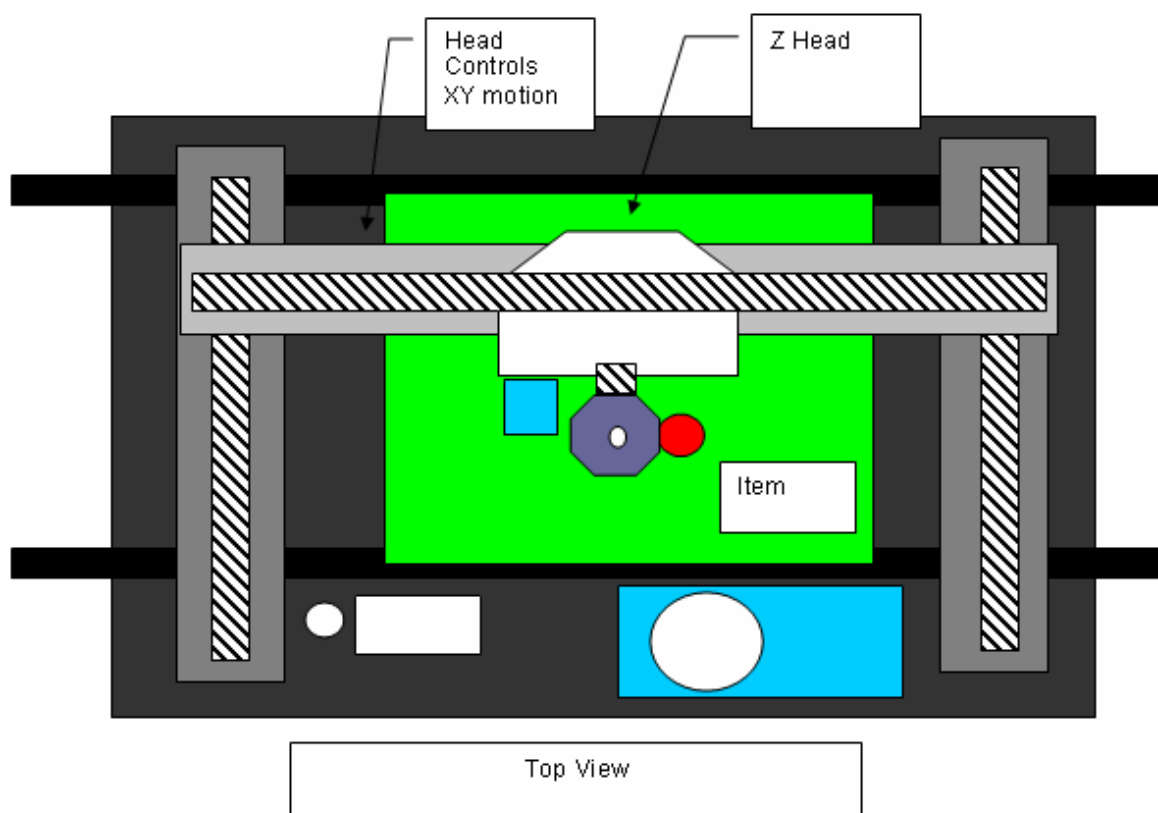
5.2.2 Abstract Model of Dispenser Subsystem

Figure 6 Abstract model of dispenser equipment (top view)

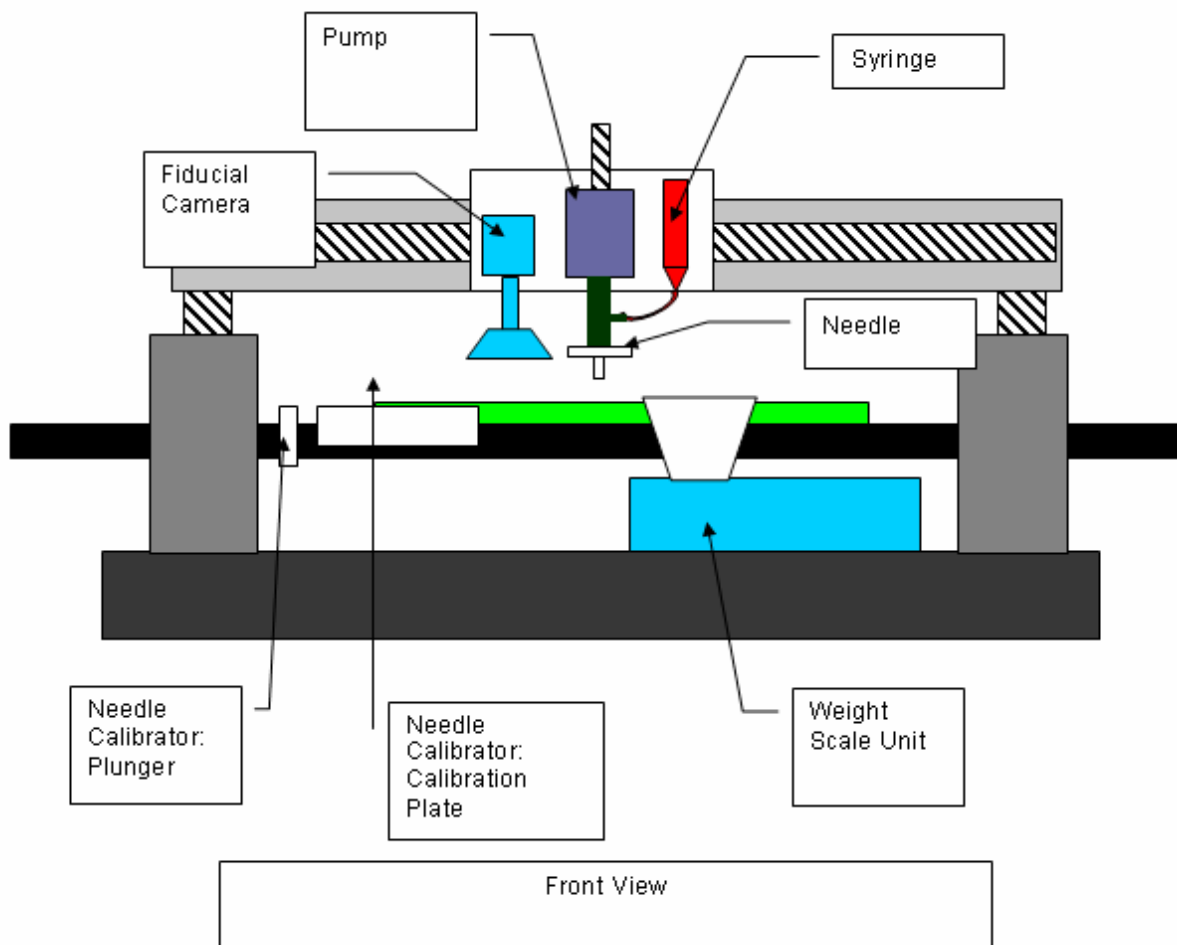
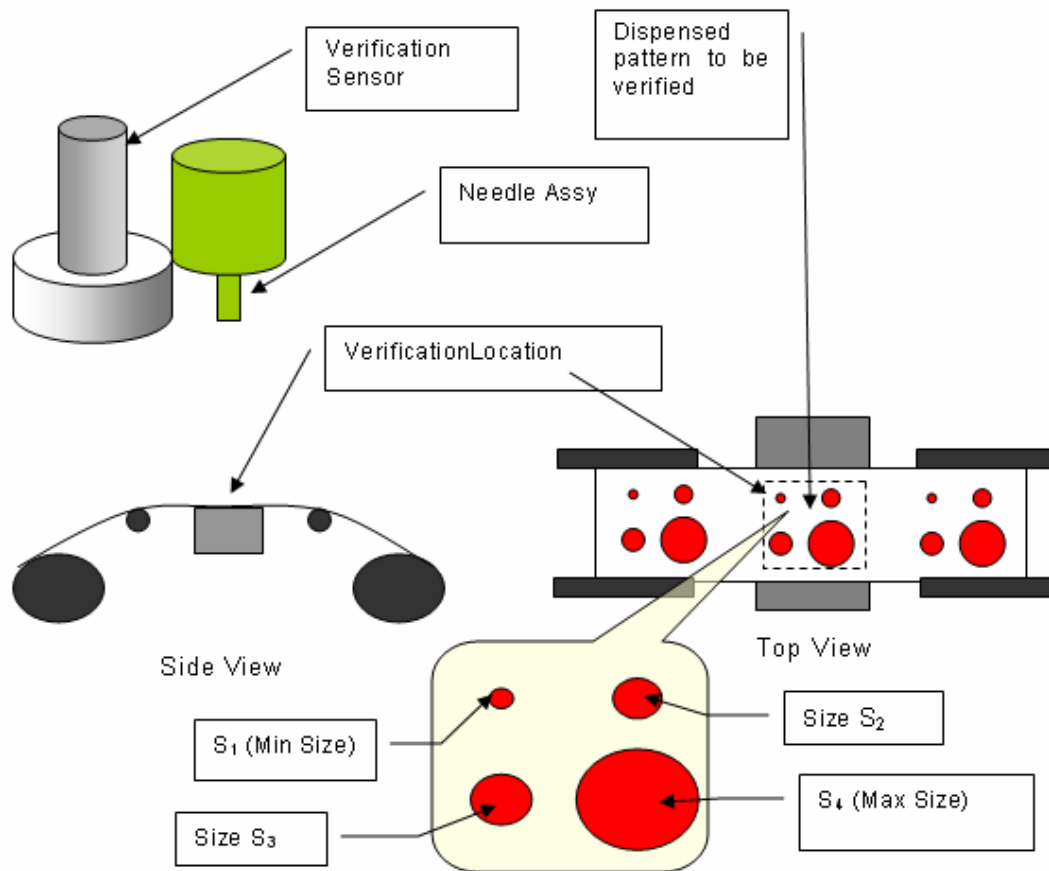


Figure 7 Abstract model of dispenser equipment (front view)

5.2.3 Abstract Model of Dispenser Verification Subsystem



For multiple featured patterns, the verification system will send the machine into an error state (down) when one or more of the following conditions occur:

1. $\text{Min Size} < \text{PercentToleranceComponent} \times \text{Max Size}$
2. $\text{ActualValue (sum of } S_1 \text{ to } S_4) < \text{DesiredValue} \times \text{PercentToleranceTotal}$ after $\text{VerificationMaxRetry}$ has been attempted.
3. $\text{ActualValue (sum of } S_1 \text{ to } S_4) > \text{DesiredValue} \times (1 + \text{PercentToleranceTotal})$ after $\text{VerificationMaxRetry}$ has been attempted.
4. The pattern from the verification sensor does not match the pattern described in the $\text{VerificationPattern}$ element.

Figure 8 Abstract model of dispenser verification subsystem

5.2.4 Subsystem Types

The subsystem element should be used for the subsystem type field. These are “logical” subsystems for dispensing equipment.

Subsystem Type	Attribute Type	Examples / Description
EnvironmentalControl	string	The environmental (heat) control subsystem.
Head	string	The x, y motion subsystem.
Scale	string	The scale subsystem used to measure material.
Transport	string	The item transport subsystem.
Vision	string	The vision system subsystem.

5.2.5 Dictionary of Attributes: Dispensing Verification/Optical Method

The following elements are associated with the optical method used to control or verify the dispensed material amount.

Attribute Name	Attribute Type	Description
verificationLocation	string (enumerated)	ITEM FIXED
verificationPositionXY	double	The x,y location on the item or from the machine's reference defining the location of the verification location.
verificationStartCount	nonNegativeInteger	The point at which the verification sensor measures the dispensed material's size after consecutive dispensing patterns. Example, if set to 3, the first 2 patterns will not be measured, and the first measured material will be on the third pattern.
verificationPattern	string	Describes the dispensed pattern of the particular needle used.
percentToleranceComponent	double	Percent allowance of the individual components of a multiple feature dispensed pattern.

5.2.6 Extensions to <IPC-2541 EquipmentInformation>

5.2.6.1 DeviceVerification (weigh or optical system)

Description: There are several ways the amount of material being dispensed can be measured and verified. For all of them the machine takes measurements while running to check the accuracy of the dispense unit. If the amount of material dispensed is not equal to the expected amount plus or minus a tolerance a correction can be applied to adjust for the inaccuracy. This event contains all of the information used for the verification process.

Attribute / Element Name	Attribute / Element Type	Description	Occurrence
units	string (enumerated)	OUNCE KILOGRAM METER METER^2 METER^3 INCH INCH^2 INCH^3	1-1
decade	double	Multiplier used to convert values into the unit type. Unit multiplier in powers of 10. Default is 0.	1-1
desiredValue	double	Target value for each verification	1-1
actualValue	double	Actual measured value	1-1
percentToleranceTotal	double	Acceptable total tolerance	1-1
scaleFactor	double	Multiplier used to adjust dispensed material to get to the desired value.	1-1
attemptNumber	nonNegativeInteger	Attempt number: 1, 2 or 3	1-1

maxAttempts	nonNegativeInteger	The maximum number of attempts that are allowed before a verification error occurs.	0-1
verificationLocation	string (enumerated)	ITEM FIXED	0-1
verificationPositionXY	double	The x,y coordinates on the item or from the machine's reference defining the location of the verification location.	0-1
verificationStartCount	nonNegativeInteger	The point at which the verification sensor measures the dispensed material's size after consecutive dispensing patterns. Example, if set to 3, the first 2 patterns will not be measured, and the first measured material will be on the third pattern.	0-1
dispenseVerificationRecipeId	string	Name of the recipe used to define the verification parameters	0-1
percentToleranceComponent	double	Acceptable tolerance for the individual features in the dispensed pattern.	0-1
verificationPattern	string	Type of pattern used. Items like SINGLE DOT, TWO DOT, FOUR DOT.	0-1

```

<EquipmentInformation
  dateTime="2003-01-23T15:39:23.00+00:00"
  laneList="1"
  zoneList="1"
  informationId="DispenseVerification">
  <Extensions>
    <DispenseVerification
      units="KILOGRAM"
      decade="-6"
      desiredValue="880.000000"
      actualValue="861.299988"
      percentToleranceTotal="10.000000"
      scaleFactor="1.000000"
      attemptNum="1"
      maxAttempts="3"
      dispenseVerificationRecipeId="C:\Verification880mg"
      percentToleranceComponent="25.000000"
      verificationPattern="TWO DOT"
    />
  </Extensions>
</EquipmentInformation>

```

5.2.6.2 DispenserDataUpdate

Description: This event will be sent on a periodic basis from the equipment to notify the host of the current temperature values for all of the temperature controllers in the system. The host can use this data to track the temperatures of the devices at the time a given board was traveling through the equipment.

Note: This message will be sent on a user-settable time interval.

Attribute / Element Name	Attribute / Element Type	Description	Occurrence
updateRate	nonNegativeInteger	Frequency this message is sent. Time is in seconds.	0-1
EnvironmentalControlUnit	See 4.4.7	A specific instance of an ECU and it associated data.	1-n

```

<EquipmentInformation
  dateTime="2003-01-23T15:39:23.00+00:00"
  laneList=""
  zoneList=""
  informationId="DispenserDataUpdate">
    <Extensions>
      <DispenserDataUpdate
        updateRate="60">
          <EnvironmentalControlUnit
            name="Preheat Lower"
            units="CELSIUS"
            actualValue="30.000000"
            setPoint="30.000000"/>
          <EnvironmentalControlUnit
            name="Dispense"
            units="CELSIUS"
            actualValue="30.000000"
            setPoint="30.000000"/>
          <EnvironmentalControlUnit
            name="Postheat Lower"
            units="CELSIUS"
            actualValue="30.000000"
            setPoint="30.000000"/>
        </DispenserDataUpdate>
      </Extensions>
    </EquipmentInformation>

```

5.2.6.3 DispenserConfiguration

Description: This event will be sent at startup to tell the host the options that a given piece of equipment has installed. It is assumed that not every piece of equipment has the same options. The host can then use this data to determine how or what to display. For instance, if the machine has multiple lanes the host could show additional material movement tracking information for every lane in the system. Or if the machine only had a single lane the host could hide the lane data for all but the one lane.

Attribute / Element Name	Attribute / Element Type	Description	Occurrence
laneCount	nonNegativeInteger	Number of lanes in the machine	1-1
zoneCount	nonNegativeInteger	Number of zones/lane in the machine	1-1
conveyorDirection	string (enumerated)	LEFTTORIGHT RIGHTTOLEFT LEFTTOLEFT RIGHTTORIGHT	1-1
dispenseVerification	string (enumerated)	NONE WEIGH OPTICAL	1-1
EnvironmentalControl Unit	See 4.4.7	A specific instance of an ECU and it associated data.	1-n

```

<EquipmentInformation
  dateTime="2003-01-23T15:39:23.00+00:00"
  laneList=""
  zoneList=""
  informationId=" DispenserConfiguration">
    <Extensions>
      <DispenserConfiguration
        laneCount="1"
        zoneCount="3"
        conveyorDirection="LEFTTORIGHT"
        dispenseVerification="WEIGH">
          <EnvironmentalControlUnit

```

```

        name="Preheat Lower"
        units="CELSIUS"
        actualValue="30.000000"
        setPoint="30.000000"/>
    <EnvironmentalControlUnit
        name="Dispense"
        units="CELSIUS"
        actualValue="30.000000"
        setPoint="30.000000"/>
    <EnvironmentalControlUnit
        name="Postheat"
        units="CELSIUS"
        actualValue="30.000000"
        setPoint="30.000000"/>
    <EnvironmentalControlUnit
        name="Dispense Zhead 1"
        units="CELSIUS"
        actualValue="30.000000"
        setPoint="30.000000"/>
    <EnvironmentalControlUnit
        name="Dispense Zhead 2"
        units="CELSIUS"
        actualValue="30.000000"
        setPoint="30.000000"/>
    </DispenserConfiguration>
</Extensions>
</EquipmentInformation>

```

5.2.7 Dispenser Specific IPC-2541 EquipmentError

5.2.7.1 HeadError

Description: This event will be sent whenever there is an error with a given head. The error can be with the X, Y or Z motion.

```

<EquipmentError
    dateTime="2003-01-23T15:39:23.00+00:00"
    laneList="1"
    zoneList="1"
    errorId="HeadError"
    errorInstanceId="12345">
    <Extensions>
        <MachineError
            vendorErrorCode="44231"
            description="CoordinateSystemStatus">
            <Subsystem
                subsystemType="Head"
                subsystemId="Head 1: Needle 1"
            />
        </MachineError>
    </Extensions>
</EquipmentError>

```

5.2.7.2 DispenseVerificationError

Description: This event will be sent whenever there is an error with the dispense verification system.

```

<EquipmentError
    dateTime="2003-01-23T15:39:23.00+00:00"
    laneList="1"

```

```

zoneList="1"
errorId="DispenseVerificationError"
errorInstanceId="12345">
<Extensions>
  <MachineError
    vendorErrorCode="23421"
    description="FailedToConverge">
    <Subsystem
      subsystemType="Scale"
      subsystemId="Head 1: Needle 1"
    />
  </MachineError>
</Extensions>
</EquipmentError>

```

5.2.7.3 ZSenseError

Description: This event will be sent whenever there is a problem with the Zsense device. Zsense's are used to determine the actual height of a board in the machine. A Zsense can be a probe or a laser.

```

<EquipmentError
  dateTime="2003-01-23T15:39:23.00+00:00"
  laneList="1"
  zoneList="1"
  errorId="ZSenseError"
  errorInstanceId="12345">
  <Extensions>
    <MachineError
      vendorErrorCode="21266"
      description="OutOfRange">
      <Subsystem
        subsystemType="Head"
        subsystemId="Head 1"/>
    </MachineError>
  </Extensions>
</EquipmentError>

```

5.2.7.4 PumpError

Description: This event will be sent whenever there is a problem with a pump, e.g. torque limit error on the pump.

```

<EquipmentError
  dateTime="2003-01-23T15:39:23.00+00:00"
  laneList="1"
  zoneList="1"
  errorId="PumpError"
  errorInstanceId="12345">
  <Extensions>
    <MachineError
      vendorErrorCode="57231"
      description="TorqueLimit">
      <Subsystem
        subsystemType="Head"
        subsystemId="Head 1: Needle 1"/>
    </MachineError>
  </Extensions>
</EquipmentError>

```

5.2.7.5 EnvironmentalControlUnitError

Description: This event will be sent whenever there is a problem with an environmental control unit, e.g. an out of range error.

```
<EquipmentError
  dateTime="2003-01-23T15:39:23.00+00:00"
  laneList="1"
  zoneList="1"
  errorId="EnvironmentalControlUnitError"
  errorInstanceId="12345">
  <Extensions>
    <MachineError
      vendorErrorCode="44255"
      description="OutOfRange">
      <Subsystem
        subsystemType="EnvironmentalControl"
        subsystemId="Controller 1: DispenseChuck"/>
      </Subsystem>
    </MachineError>
  </Extensions>
</EquipmentError>
```

5.3 Specific Manual Placement Equipment Events and Message Formats (Manual)

Under consideration

5.4 Specific Reflow Equipment Events and Message Formats (Reflow)

5.4.1 Dictionary of Reflow Terms

The objective of this model is to define a common naming convention for the subsystem categories used in reflow machines.

Actual

In terms of process control variables, the value of the present, real time reading of a parameter read through some type of sensing device. This value is often compared to the setpoint value.

Additional Cooling

Term used to describe an optional cooling module or zone within the machine. Independent data may or may not be collected from this module.

Automatic Width Adjust

A mechanism used to automatically control the width of a rail transport or center board support through the integrated control system.

Belt Transport

A term used to describe mesh belt type systems used to convey the product through the machine. Typically, the item travels directly on top of the transport. Belt transports are fixed width transports.

Center Board Support

A support mechanism used in conjunction with the transport to prevent item warpage and/or sagging while conveying the product through the oven. Used in conjunction with a rail or some equivalent form of edge holding transport system to support an otherwise unsupported portion of

the item. A system could potentially have more than one Center Board Support per rail transport and/or lane.

Center Board Support Up Position

Center Board Support is at its width setting and fully extended in an upward position as to properly support the item while conveying it through the system.

Center Board Support Down Position

Center Board Support is at its width setting, but in a downward position so as to provide clearance for the item to convey through the system without support.

Center Board Support Park Position

Center Board Support is at a predefined “home” position where it allows the unsupported conveyance of items without impeding on lead clearance.

Center Board Support Width

The distance of the support mechanism from some reference position, usually a fixed rail, defines the width parameter

Combination Transport

A term used to describe a transport system that uses a rail transport with a belt transport in the same lane.

Cooling Zone

Used in reference to the final section of the reflow process, it refers to the portion of the oven that gradually cools the processed item and solidifies the solder joints. Temperature in these zones may or may not be controlled.

Dual Lane Transport

A transport system with two independent rail lanes/tracks. See Rail Transport.

Dual Lane, Single Belt Transport

A transport system with two independent rail lanes/tracks with a single mesh belt transport, spanning both lanes, traveling below the rails.

Flux Extraction

A subsystem of a reflow oven used to capture, collect, or otherwise eliminate flux volatiles released into the chamber atmosphere during the reflow process.

Heated Zone

A zone that provides a unique set of control or display parameters for purposes of heating the item. Heated zones can utilize infrared radiation, convection, conduction, or any combination thereof. Usually used in reference to the first three stages within the reflow process (ramp, soak, spike/reflow). Temperature in these zones is usually controlled to a specific temperature.

Inert Gas

In terms of the reflow process, the inert gas, most commonly nitrogen (N₂), displaces oxygen within the reflow chamber, allowing better soldering properties and results. Often referred to in terms of an allowable concentration of oxygen in parts per million (PPM). In the absence of an inert gas, the environment is simply referred to as an “air” environment.

Pin Chain Transport

See Rail Transport

Rail Transport

A conveying system that provides two rails along the length of the machine, each supporting one edge of an item. This is accomplished through the use of a support system traveling within the rail. The most common type of support is a pin chain that travels within a groove in the rail; therefore, this type of system is often referred to as a "pin chain" transport. Several independent rail transports can be configured within a single oven. Two sets of rail transports within the same system are known as "Dual Lane" transports. Three sets of rails within the same system are known as "Triple Lane" transports. Each track or "lane" can be dependently or independently controlled in terms of width and speed. The physical distance between the two rails defines the transport width. Each "lane" can potentially support multiple center board supports if needed.

Reflow

A term used to describe the melting of previously placed solder. For example, it applies to the fusing of electroplated tin-lead coatings on printed circuit boards through infrared, conductive, or convection type heating.

Setpoint

The process control value for which the specified controller is attempting to maintain. This value is often compared to the actual value.

SMEMA

In terms of reflow oven terminology, refers to the electrical interface/communication system used to convey critical item transport data to and from upstream/downstream transport systems. Refer to SMEMA standard for further explanation.

Transport Direction

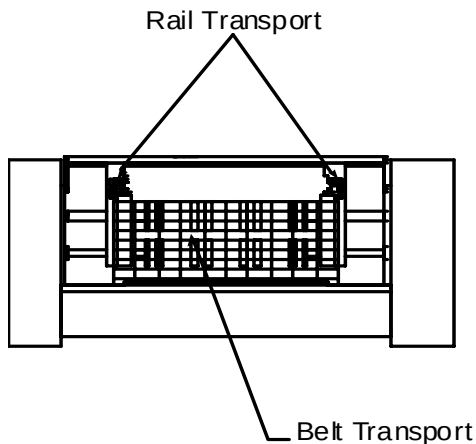
The direction of product travel through the oven. Usually a right-to-left or left-to-right direction.

Triple Lane Transport

A transport system with three independent rail lanes/tracks. See Rail Transport.

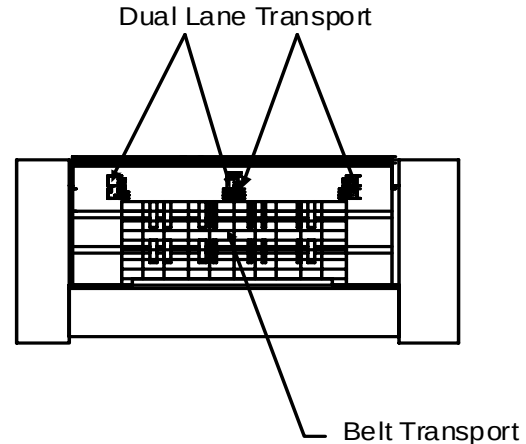
5.4.2 Abstract Model of Reflow Subsystems**5.4.2.1 Examples of Transport Types**

As described in previous sections, transport systems within reflow ovens can become fairly complex. In terms of identifying the common terminology used throughout this standard, please refer to the diagrams shown in Figures 9 through 11. These figures show a representative sample, from an end view, of a rail, belt, dual lane, and center board support transport systems.



Rail + Belt

Figure 9 Combination Transport



Dual Lane + (Single) Belt

Figure 10 Dual Lane, Single Belt Transport

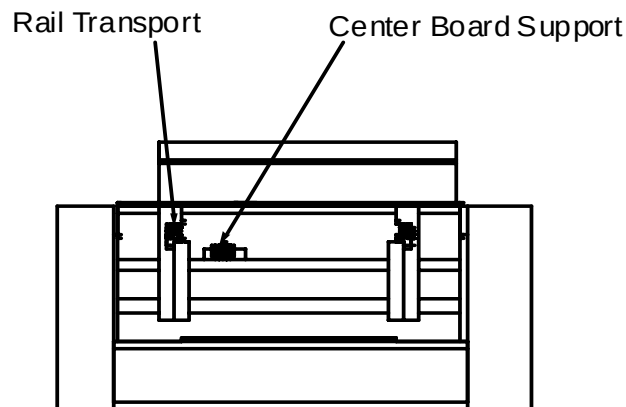


Figure 11 Center Board Support

5.4.2.2 Examples of Zone descriptions

A “zone” within a reflow oven can take on many different meanings. Simply stated, it can be described as a physical section within the chamber, which maintains its own unique control and/or display parameters. It could be referred to as heated, cooling, spike, reflow, ramp, soak, or other specific indicator (i.e., top 10, bottom 5, etc.) based on the construction and independent control/display capabilities within the design of the oven. The overall number of zones may vary per manufacturer and/or oven type. Examples of some common zone descriptions are shown in Figures 12 and 13.

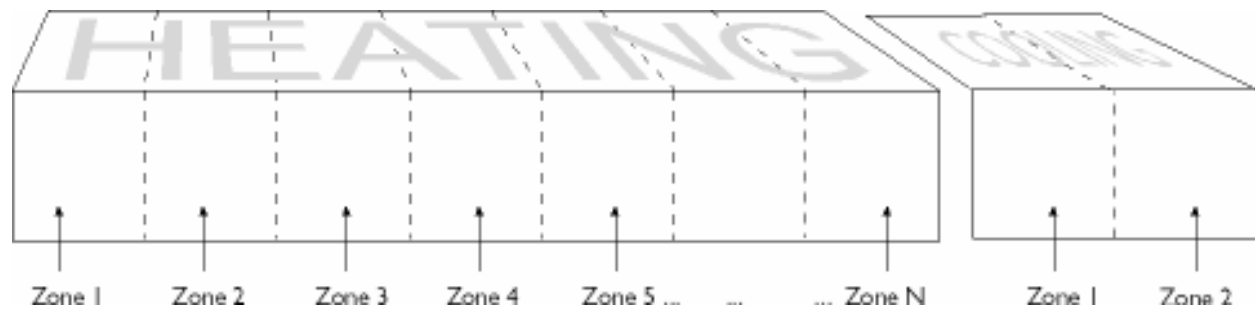


Figure 12 Example of Zone Description

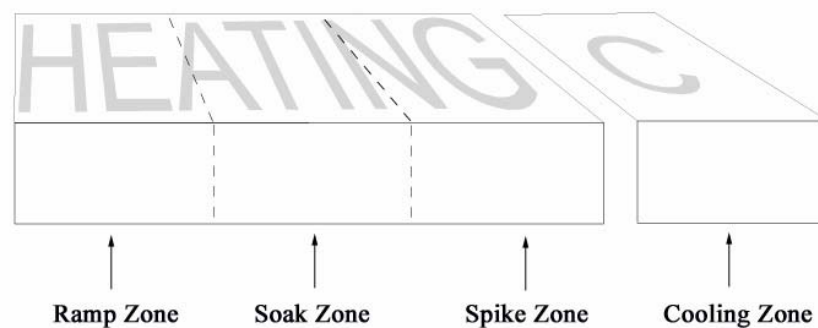


Figure 13 Example of Zone Description

5.4.3 Reflow-Specific Nested Elements

5.4.3.1 Element: InertGasController

Description: This element is used to describe an inert gas controller (specifically air or nitrogen).

Attribute / Element Name	Attribute / Element Type	Description	Occurrence
name	string	Unique name of the controller (i.e., zone 10 PPM, cooling PPM, etc.)	0-1
type	string (enumerated)	AIR NITROGEN	0-1
setPointPPM	nonNegativeInteger	Setpoint PPM (parts per million)	0-1
actualPPM	nonNegativeInteger	Actual PPM (parts per million) value	0-1
flowUnits	string (enumerated)	FEET^3/SECOND METER^3/SECOND (zone specific)	0-1
decade	double	Multiplier used to convert values into the unit type. Unit multiplier in powers of 10. Default is 0.	0-1
flow	double	Total Consumption in specified Inert Gas flow units (zone specific)	0-1

```
<InertGasController
  name="Zone10 PPM"
  type="NITROGEN"
  setPoint="550"
  actualPPM="555"
  flowUnits="FEET^3/SECOND"
  decade="-3.556302501"
  flow="540"/>
```

5.4.3.2 Element: TransportData

Description: This element is used to describe the characteristics of the item transport device

Attribute / Element Name	Attribute / Element Type	Description	Occurrence
name	string	Unique name of the transport (i.e. transport 1, transport 2 w/Center Board Support, Rail 1, Rail 1 w/dual Center Board Support, etc...)	1-1
laneId	string	Line lane identifier	1-1
units	string (enumerated)	METER INCH	1-1
decade	double	Multiplier used to convert values into the unit type. Unit multiplier in powers of 10. Default is 0.	1-1
speed	nonNegativeInteger	Actual Transport Speed in units/second	1-1
width	nonNegativeInteger	Transport Width in units	0-1
centerBoardSupport1Position	string (enumerated)	UP DOWN PARK	0-1
centerBoardSupport1Width	double	Position of center board support (in transport units)	0-1
centerBoardSupport2Position	string (enumerated)	UP DOWN PARK	0-1
centerBoardSupport2Width	double	Position of center board support (in transport units)	0-1

```
<TransportData
  name="Rail 1"
  units="METER"
  speed="44"
  width="10"
  decade="-2"
  centerBoardSupport1Position="UP"
  centerBoardSupport1Width="5"
  centerBoardSupport2Position="UP"
  centerBoardSupport2Width="5"/>
```

5.4.4 Extensions to <IPC-2541 EquipmentError> Messages

5.4.4.1 SystemGasLowPressure

Description: This event will be sent whenever the air/nitrogen pressure in the system is below an acceptable value.

```
<EquipmentError
  dateTime="2003-01-23T15:39:23.00+00:00"
  laneList="1"
  zoneList="1"
  errorId="SystemGasLowPressure"
```

```

    errorInstanceId="12345">
</EquipmentError>

```

5.4.5 Extensions to <IPC-2541 EquipmentInformation>

5.4.5.1 ReflowDataUpdate

Description: This event will be sent on a periodic basis from the equipment to notify the host of the current values of items in the machine that change as the machine runs. For instance the current temperatures of all of the temperature controllers in the system. The host can use this data to track the temperatures of the devices at the time a given board was traveling through the equipment.

Note: This message will be sent on a user settable time interval.

Attribute / Element Name	Attribute / Element Type	Description	Occurrence
updateRate	nonNegativeInteger	Frequency this message is sent. Time is in seconds.	0-1
itemsInMachine	nonNegativeInteger	Total Number of items	1-1
inertGasOn	boolean	true, false (not used with air)	0-1
fluxExtraction	boolean	true (if Enabled), false	0-1
EnvironmentalControlUnit	See 4.4.7	A specific instance of an ECU and it associated data.	1-n
TransportData	See 5.4.3.2	A specific instance of transport data	1-n
InertGasController	See 5.4.3.1	A specific instance of an inert gas controller and data	0-n

```

<EquipmentInformation
  dateTime="2003-01-23T15:39:23.00+00:00"
  laneList=""
  zoneList=""
  informationId="ReflowDataUpdate">
  <Extensions>
    <ReflowDataUpdate
      updateRate="60"
      itemsInMachine="4"
      inertGasOn="true"
      fluxExtraction="true">
      <EnvironmentalControlUnit
        name="Zone1 Upper"
        units="CELSIUS"
        actualValue="30.000000"
        setPoint="30.000000"
        zoneType="CONVECTION"
        blowerSpeedRate="MEDHIGH"/>
      <EnvironmentalControlUnit
        name="Zone1 Lower"
        units="CELSIUS"
        actualValue="30.000000"
        setPoint="30.000000"
        zoneType="CONVECTION"
        blowerSpeedRate="MEDHIGH"/>
      <EnvironmentalControlUnit
        name="Zone2 Upper"
        units="CELSIUS"

```

```

        actualValue="30.000000"
        setPoint="30.000000"
        zoneType="CONVECTION"
        blowerSpeedRate="MEDHIGH"/>
    <EnvironmentalControlUnit
        name="Zone2 Lower"
        units="CELSIUS"
        actualValue="30.000000"
        setPoint="30.000000"
        zoneType="CONVECTION"
        blowerSpeedRate="MEDHIGH"/>
    <EnvironmentalControlUnit
        name="Zone3 Upper"
        units="CELSIUS"
        actualValue="30.000000"
        setPoint="30.000000"
        zoneType="CONVECTION"
        blowerSpeedRate="MEDHIGH"/>
    .
    .
    .
    <EnvironmentalControlUnit
        name="Zone N"
        units="CELSIUS"
        actualValue="30.000000"
        setPoint="30.000000"
        zoneType="CONVECTION"
        blowerSpeedRate="MEDHIGH"/>
    <InertGasController
        name="Zone10 PPM"
        type="NITROGEN"
        setPoint="550"
        actualPPM="555"
        flowUnits="FEET^3/SECOND"
        decade="-3.556302501"
        flow="540"/>
    <TransportData
        name="Rail 1"
        units="METER"
        speed="44"
        width="10"
        decade="-2"
        centerBoardSupport1Position="UP"
        centerBoardSupport1Width="5"
        centerBoardSupport2Position="UP"
        centerBoardSupport2Width="5"/>
    </ReflowDataUpdate>
    </Extensions>
</EquipmentInformation>

```

5.4.5.2 ReflowConfiguration

Description: This event will be sent at startup to tell the host the options that a given piece of equipment has installed. It is assumed that not every piece of equipment has the same options. The host can then use this data to determine how or what to display. For instance if the machine has multiple lanes the host could show additional material movement tracking information for every lane in the system. Or if the machine only had a single lane the host could hide the lane data for all but the one lane.

Attribute / Element Name	Attribute / Element Type	Description	Occurrence
laneCount	nonNegativeInteger	Number of lanes in the machine	1-1
zoneCount	nonNegativeInteger	Number of zones per lane in the machine	1-1
transportDirection	string (enumerated)	LEFTTORIGHT RIGHTTOLEFT LEFTTOLEFT RIGHTTORIGHT	1-1
highTemp	boolean	true (if Installed), false	1-1
gasType	string (enumerated)	NITROGEN AIR	1-1
additionalCooling	boolean	true (if Installed), false	1-1
fluxExtraction	boolean	true (if Installed), false	1-1
transportType	string (enumerated)	BELT RAIL COMBINATION DUALLANE DUALLANESINGLEBELT TRIPLELANE	1-1
autoWidthAdjust	boolean	true (if Installed), false	1-1
smema	boolean	true (if Installed and enabled), false	1-1
centerBoardSupport	boolean	true (if Installed and enabled), false	1-1

```

<EquipmentInformation
  dateTime="2003-01-23T15:39:23.00+00:00"
  laneList=""
  zoneList=""
  informationId="ReflowConfiguration">
  <Extensions>
    <ReflowConfiguration
      laneCount="1"
      zoneCount="8"
      transportDirection="LEFTTORIGHT"
      highTemp="true"
      gasType="NITROGEN"
      additionalCooling="true"
      fluxExtraction="true"
      transportType="BELT"
      autoWidthAdjust="true"
      smema="true"
      centerBoardSupport="false"/>
    </Extensions>
  </EquipmentInformation>

```

5.9 Final Assembly and Packaging

This section pertains to final assembly and packaging equipment. This primarily includes assembly, marking and automated packaging as well as material movements modules, routers and similar equipment.

5.9.1 Instructions

All elements and extensions presented in Section 5.9 are defined in separate XML namespace. URI is webstds.ipc.org/2546/fa/*.xsd.

NOTE: There exist different definitions for some elements with same name but different content located in other namespaces. See 5.9.5.12 *Parameter* as example.

5.9.2 Dictionary of Common Terms

Assembly Operation (or assembly primitive)

A single action changing one state of the targeted object (product, product's part, tool, etc.)
Examples: Translation, Rotation

Assembly Processes

A series of actions or operations associated with the assembly of parts. Examples: Inserting, screw insertion, tray feeding, vibratory feeding

Assembly Task

A set of assembly processes for the performing of similar assembly functions.
Examples: Composing (or joining), Grasping, Fixturing, Releasing

Container

A unit housing one or more products or components. A container can also house one or more containers.
Examples: Pallet, Carton/Box, Tray.

Container Position

A specific location on or in a container.

Depaneling (also Routing, Separating or Singulating) process

The process of separating product or component PWBs from each other or from a PWB frame that consists of one or several PWBs.

End Effector

An End Effector consists of an End Effector Base and End Effector Tool(s). End Effector is used for processing or handling an item.
Examples: Gripper, Soldering Head, Screwdriver.

End Effector Base

A base unit of End Effector. Both base and End Effector can be changeable or fixed.

End Effector Group

An End Effector Group holds one or more End Effectors that are moved together in the equipment.

Example: Revolver Tool.

End Effector Tool

A part of an End Effector that interacts with an item like a component or a product. It can be a changeable part of an End Effector.

Examples: Finger, Suction Head, Soldering Iron, Screw Insertion Tool, Sensor

End Effector Tool Storage

A holding bin for End Effector Tools. This is a physical location on the equipment.

End Effector Tool Storage Location

A location within the End Effector Tool Storage that can hold End Effector Tool(s) not currently in operation.

End Effector Segment

A fixed location of an (changeable) End Effector Base that can have one (changeable) End Effector Tool.

End Effector Storage

A holding bin for End Effectors. This is a physical location on the equipment.

End Effector Storage Location

A location within the End Effector Storage that can hold End Effector(s) not currently in operation.

Feeder

A material handler, that feeds the end effector with components out of tapes or bulk cases. Examples: Tape, bowl or tray feeder, label printer.

Feeder Division

A unique location within a feeder.

Feeder Track

A unique location of the feeder in a component supply area

FeederId

A unique identification number associated with a feeder.

Final Assembly

Actions applied to the product after the PWB is finalized. Beginning with the depaneling of the PWB, assembly of subcomponents and the product itself, ending with the finalized product.

Gripper

A specific type of an End Effector.

Identifier Tag

A medium where identification information about a container can be stored.

Examples: Bar Code, RF tag

Material Handler

A device to supply the equipment with material (e.g. components) that have to be placed. This is a term that should cover all existing technologies like feeders, printers or matrix tray changer.

Material Supply Area

A unique area of material supplies found on the equipment.

Examples: Right, Left, Front, Back.

PCB

Printed Circuit Board. In this document this term is replaced with PWB.

PWB

Printed Wiring Board. This acronym will be used when referring to a Printed Circuit Board.

Packaging

Places the finalized product into an intermediate or a retail package. This includes typically the product, accessories and manuals.

Pallet

A specific type of container whose primary use is for transporting products. It can also contain components. It is recommended that the term *pallet* be used for containers that contain product(s) and transfer them within the production flow rather than in and out of the process.

Process Step

Process steps are sub-processes of equipment work cycle. e.g. Transportation, screwdriving, welding, milling.

Tray

A specific type of container that is used for storing and/or delivering components or products. It is recommended that the term *tray* be used for containers that transfer components in and out of the process rather than within the production flow.

Tray Feeder

A tray feeder is a specific type of feeder that holds trays and supplies them to the equipment

Tray Location

The location of a tray in a tray feeder.

Tray Section

The area of a tray containing one type of item (component, product). A tray may contain one or more tray sections. The sections may be of different sizes and shapes.

5.9.3 Model of Equipment

A model of typical final assembly cell is shown in Figure 14. The model consists of two pieces of equipment: an assembly cell and a container transporter. The assembly area for the assembly cell is in location: Lane2, Zone2.

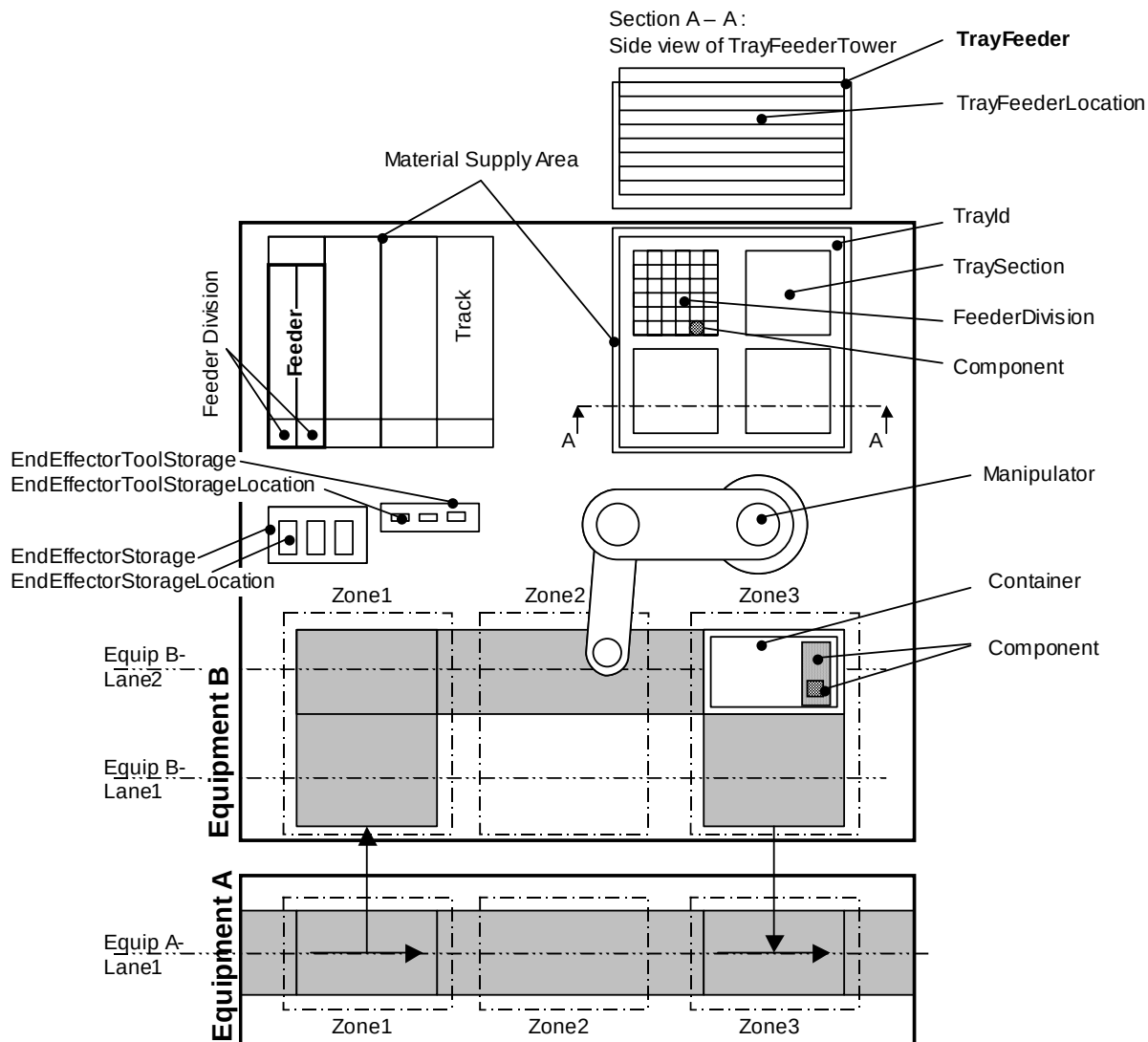


Figure 14 Abstract Model of Assembly Cell (=Equipment B) and Transporter module (=Equipment A)

Few models of changeable End Effectors are shown in Figure 15.

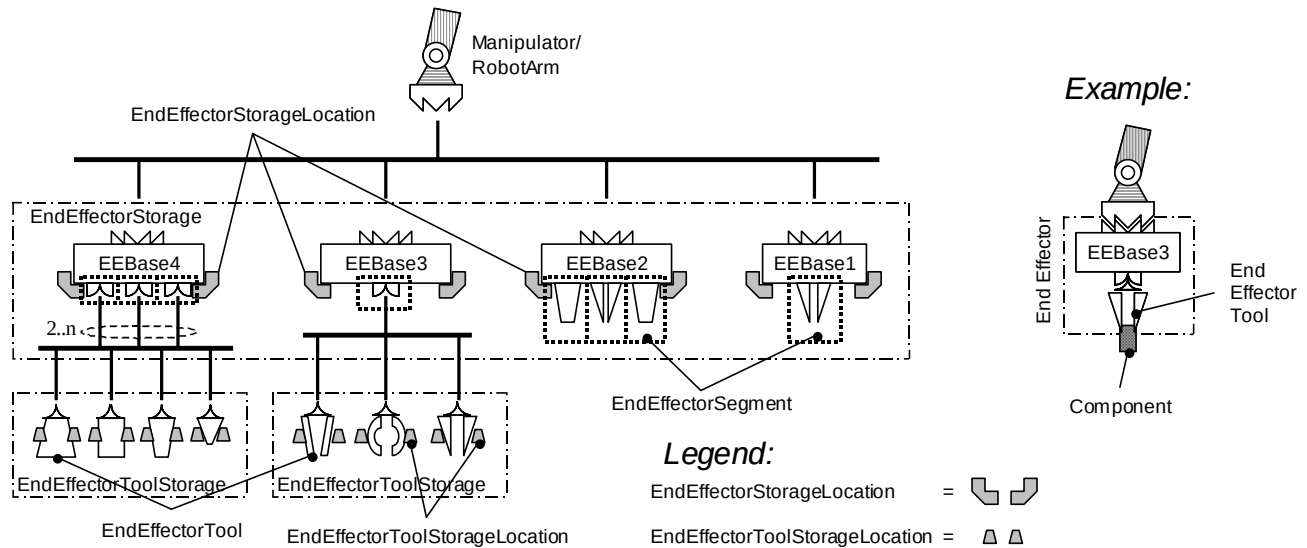


Figure 15 Abstract model of End Effectors

Example cases of changeable End Effector Bases and explanation of Figure 15:

- **EEBase1:** Simplest possible changeable end effector that has one End Effector Segment, which has one fixed End Effector Tool attached.
Example: a pneumatic gripper with fingers.
- **EEBase2:** End Effector that has several fixed End Effector Tools attached into the End Effector Base. End Effector Base has End Effector Segments that identifies, which End Effector Tool is attached into this segment.
Example: a revolver gripper that has two or more End Effector Segments with fixed fingers.
- **EEBase3:** End effector that has a single End Effector Segment for carrying changeable End Effector Tool.
Example: a multi finger servo gripper (entity has pair of fingers)
- **EEBase4:** End effector that has several locations for carrying changeable End Effector Tools. End Effector Base has two or more End Effector Segments that identifies the End Effector Tool placed into this specific segment.
Example: a revolver gripper that has two or more End Effector Segments with changeable End Effector Tools.

Figure 16 describes possible relationships between objects in abstract FA&P equipment model.

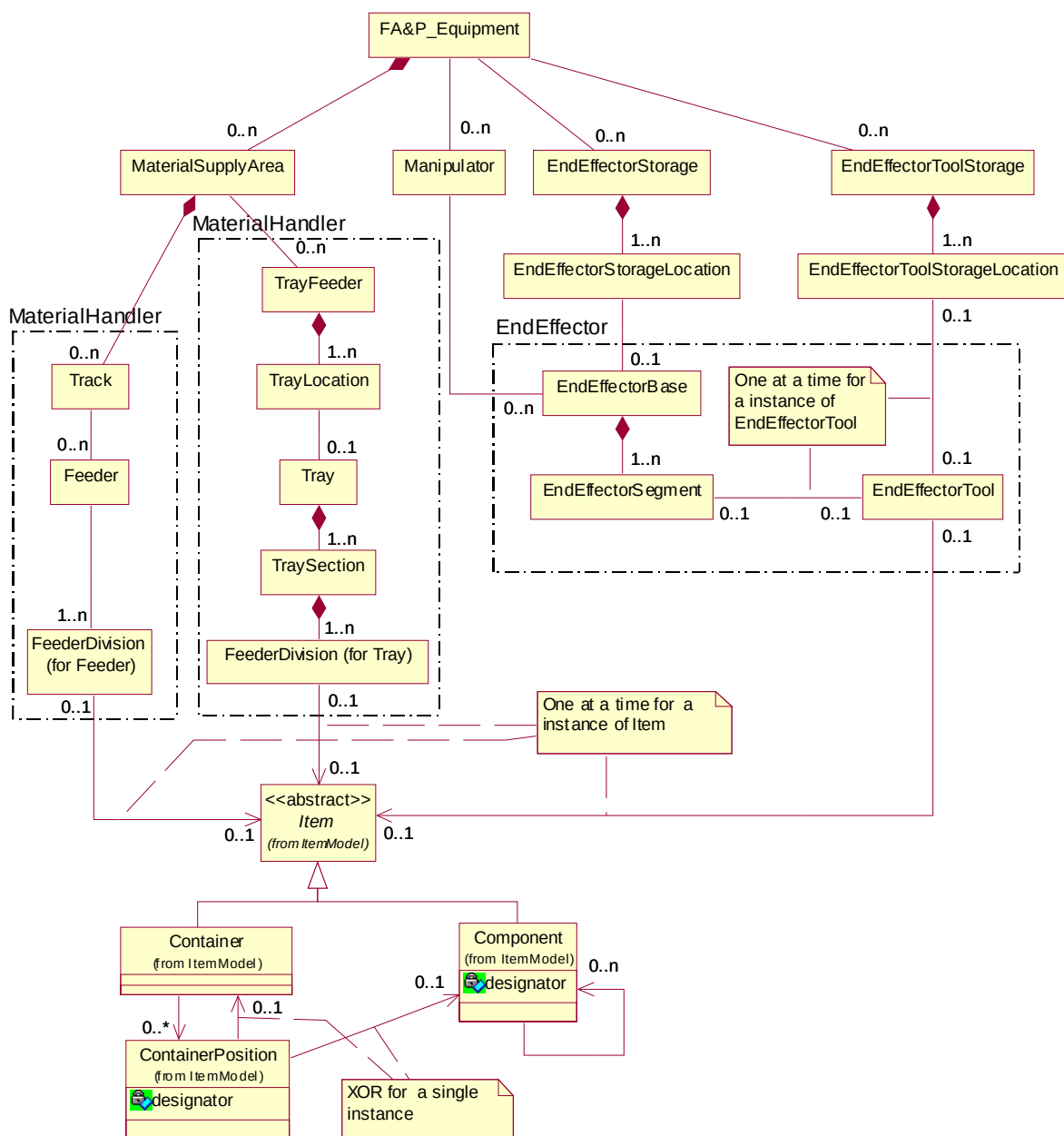


Figure 16 Abstract FA&P equipment and item model, object relationships

Explanations:

- End Effector Base belongs always to one End Effector Location, either to one in Manipulator or End Effector Storage. For a very short moment it can belong to both. This can happen when manipulator is gripping or releasing the End Effector Base from/to End Effector Storage.

- End Effector Tool belongs to either End Effector Segment or End Effector ToolStorage Location. For same reason as End Effector Base the End Effector Tool may for a short moment belong to both.
- Manipulator usually has only one End Effector Location, but e.g. in case of revolver head it can have two or more locations for End Effectors.

5.9.4 Dictionary of Final Assembly and Packaging Specific Attributes and Parameters

5.9.4.1 Dictionary of Final Assembly and Packaging Attributes

Attribute Name	Attribute Type	Description
abortId	string	Abort identifier
actionType	string (enumerated)	Type of modify action: CREATE ATTACH DETACH
amount	integer	Amount of components filled into (>0) or taken away from (<0) the material handler. (* check: changeType)
application	string (enumerated)	The type of the element MEASURED EXPECTED ALARMLIMITS
caseSensitive	string (enumerated)	Reference: IPC-2547 YES NO (only applies to character string values)
cautionType	string (enumerated)	Describes the type of warning message. List varies.
changeType	string (enumerated)	ABSOLUTE DIFFERENTIAL (* check: amount)
comparator	string (enumerated)	Reference: IPC-2547 EQ NE GT LT GE LE GTLT GELE GTLE GELT LTGT LELE LTGE LEGT
containerPositionType	string	Identifies the type of container location. e.g.. This ContainerPosition can carry Component A.
dateTime	dateTime	Date and Time of the event
decrementMispickCount	positive integer	Most pick & place equipment detects an empty MaterialHandler by counting pickup warnings on one specific MaterialHandler. When sending a MaterialHandlerOutOfItems message this attribute can be used to decrement the count of Pickup Errors charged to the Material Handler by the appropriate number. This will allow the host system to correct the number of warnings for this materialHandler. For example if 3 MisPick warnings were sent to the host which turned out to be an OutOfItem error then a 3 would appear in this attribute.
designator	string	Identifies a unique location on the component, product or container.
diagonalX	double	Projection of diagonal dimension to X-axis
diagonalY	double	Projection of diagonal dimension to Y-axis
diagonalZ	double	Projection of diagonal dimension to Z-axis
endEffectorBaseId	string	Identifier for the base.
endEffectorSegmentId	string	Identifier for the location in End Effector Base
endEffectorToolId	string	Identifier for the End Effector tool.
endEffectorType	string	Type of End Effector
estimatedTimeTillEndOfComponents	duration	Estimated time till end of components in seconds. Link to data type definition: http://www.w3.org/TR/xmlschema-2/#duration Format: PnYnMnDTnHnMnS
feederDivision	string	Unique location within a feeder or a tray
feederId	string	Identifier of the feeder

feederType	string	A specific type of a feeder
format	string	Type of value (e.g. Binary, ascii, csv, xml).
idCategory	string	Unique category for the ID source (e.g. LOT, BATCH, PRODUCT_SERIAL_NUMBER, MES, {End user specific})
identifier	string	Unique identifier of the instance. Defined inside idCategory.
idType	string (enumerated)	UNIQUE NONUNIQUE BULK
initiator	string (enumerated)	A description of how this message was initiated. OPERATOR AUTOMATIC.
instanceId	string	Instance this parameter is connected to
itemType	string	Identifies the type of instance. e.g. This container can carry Product A or Component B.
laneId	NMTOKEN	Lane identifier
laneList	NMTOKENS	Identifies the lane(s) executing this recipe
materialHandlerTableId	string	Identifier for the specific materialHandler table which contains bank of feeders
materialSupplyArea	string	Unique area of material (i.e. component) supplies found on the equipment
numberOfComponents Left	nonnegative Integer	Number of components left for consumption.
pauseId	string	Pause identifier
position	NMTOKENS	Describe the positional location if the expression is for a multidimensional array of values
processStepId	string	Process step identifier
recipeName	string	Name of specific recipe
recipeStep	string	Identifies the step of the executing recipe
rejectLocation	string	The location where an item is rejected
rotationX	double	Rotation around X-axis
rotationY	double	Rotation around Y-axis
rotationZ	double	Rotation around Z-axis
routeIndex	NMTOKEN	Index of current route step in routeInformation list. See A.5 in implementation Guide.
routeInformation	NMTOKENS	Route of the container through the system
targetDesignator	string	Designator information of target location.
trackId	1..n	Unique location on the equipment. Sometimes referred to as slot.
trayFeederLocation	1..n	Tray feeder location number
trayFeederTower	1..n	Tray feeder tower number
trayId	string	Identifier of the tray
traySection	string	Tray section
vendorId	string	Identification of the vendor of the component lot.
zoneId	NMTOKEN	Area segment identifier
zoneList	NMTOKENS	Identifies the zone(s) executing this recipe

General enumerated attributes:

application	MEASURED	Element is representing measured or read data
	EXPECTED	Element is representing set value(s)
	ALARMLIMITS	Element is representing alarm limits
comparator	EQ NE GT ...	See IPC-2547
initiator	OPERATOR	Operator has initiated the message
	AUTOMATIC	Equipment or other automatic entity has triggered the message

5.9.4.2 Dictionary of Final Assembly and Packaging Recipe Parameters

Under Consideration.

5.9.4.3 Dictionary of Final Assembly and Packaging Process Data Parameters

This table defines examples of different *namelds* for Parameter. The table is not comprehensive and *namelds* specific to application shall be added case by case. But if the topic is listed, the *nameld* should be followed exactly as written.

Each process data parameter can have:

- Measured value(s) (single value or range (min-max))
- Expected value(s) (single value or range (min-max))
- Alarm limits (min-max)

Applicable value sets are application and parameter specific, e.g. in case of dustlevel the maximum limit is the only applicable alarm limit.

nameld	Unit	Assy Task / Process	Description	Equipment Type*
Manipulator				
AxisAcceleration	METER/SECOND^2	Pick & Place	Acceleration of an axis	E1, E3, E4, E5, E6
AxisJerk	METER/SECOND^3	Pick & Place	Jerk of an axis	E1, E3, E4, E5, E6
AxisPosition	METER	Pick & Place	Position of an axis	E1, E3, E4, E5, E6
AxisVelocity	METER/SECOND	Pick & Place	Velocity of an axis	E1, E3, E4, E5, E6
ManipulatorAcc	METER/SECOND^2	Pick & Place	Manipulator acceleration	E1, E3, E4, E5, E6
ManipulatorSpeed	METER/SECOND	Pick & Place	Manipulator movement speed	E1, E3, E4, E5, E6
GlueingUnit				
GlueAmount	KILOGRAM METER^3	Glueing	The amount of glue applied	E1, E3
GlueTemperature	KELVIN	Glueing	The temperature of glue applied	E1, E3
GlueAge	SECOND	Dispenser	Time for glue in the pump. Set max time; Alarm if time is getting short	E1, E3
InsideTemp	KELVIN	Dispenser	Temperature inside the cell	E1, E3
Weigher				
ObjectWeight	KILOGRAM	Weighting	The weight of object	E1, E2, E3, E5
VacuumUnit				
DustDistance	METER	Depaneling	The milling distance after dust container cleaning	E1, E4
DustLevel	METER	Depaneling	The level of dust in dust container	E1, E4
DustVacuum	PASCAL	Depaneling	The vacuum of dust removal.	E1, E4

Milling unit				
MillingFeedRate	METER/SECOND	Depaneling	The feederate of milling	E1, E4
MillingSpindleSpeed	REVOLUTION/SECOND	Depaneling	The spindle speed of milling	E1, E4
MillingBitDistance	METER	Depaneling	The total milling distance of current bit	E1, E4
Ionisator				
IonisatorOperation	-	Depaneling	Ionisator status on/off	E1, E4
Gripper				
GrippingForce	NEWTON	Pick & Place	The force used for mechanical gripping	E1, E3, E4
GrippingVacuum	PASCAL	Pick & Place	The vacuum used for gripping	E1, E3, E4
AssemblyForce	NEWTON	Pick & Place	Force applied in assembly direction	E1, E3, E4
ScrewInsertion				
ScrewdrivingTurns	-	Screwdriving	The number of turns screwdrived per screw	E1
ScrewdrivingSpeed	REVOLUTION/SECOND	Screwdriving	The rpm-speed of screwdriving	E1
ScrewdrivingTime	SECOND	Screwdriving	The time used for screwdriving per screw	E1
ScrewdrivingTorque	NEWTON*METER	Screwdriving	The torque of screwdriving	E1
ScrewHeight	METER	Screwdriving	The final height of screw head when screwdrived to its final position compared to some reference level.	E1
SolderingUnit				
SolderingTemperature	KELVIN	Soldering	Soldering heat	E1
SolderingTinFeedrate	METER/SECOND	Soldering	Tin feeding speed	E1
WeldingUnit				
WeldingEfficiency	PERCENT	Welding	Efficiency of the weld	E1
WeldingEnergy	JOULE	Welding	Consumed energy	E1
WeldingPower	WATT	Welding	Welding power	E1
WeldingPowerLoss	PERCENT	Welding	Power loss during welding	E1
HeatTransferUnit				
HeatTransferDiePad Temperature	KELVIN	Heat Transfer	Die temperature	E1
HeatTransferDwell Time	SECOND	Heat Transfer	Length of time die stays in contact with part being marked	E1
HeatTransferHeadUp Delay	SECOND	Heat Transfer	Length of time stamp allows for label to transfer onto part, with out pulling tape off part.	E1
HeatTransferStamp Pressure	PASCAL	Heat Transfer	Application pressure	E1, E4,
LaserUnit				
LaserBeamMovement Speed	METER/SECOND	Laser marking	The movement speed of laser beam	E1
LaserBulb/diode OperatingTime	SECOND	Laser marking	The bulb/diode operating time	E1
LaserCurrent	AMPERE	Laser marking	The current of laser	E1
LaserPower	WATT	Laser marking	The power of laser	E1
LaserPulseFrequency	HERZ	Laser marking	The pulse frequency of laser	E1

Conveyor				
ConveyorBeltSpeed	METER/SECOND	Transport	Belt speed	E1, E2, E3, E4, E5, E6
ConveyorPalletSpeed	METER/SECOND	Transport	Pallet speed	E1, E2, E3, E4, E5, E6

*EquipmentTypes:

- E1 = Assembly cell,
- E2 = Conveyor,
- E3 = Carton forming cell,
- E4 = Router / Depanelling cell,
- E5 = Storage / Buffering cell,
- E6 = Testhandler

5.9.4.4 Dictionary of Final Assembly and Packaging SubsystemTypes

Subsystem element is defined in IPC-2546 section 4.4.6. Types defined below should be used for subsystemType field. The table is not comprehensive and *subsystemTypes* specific to application shall be added case by case. But if the topic is listed, the *subsystemType* should be followed exactly as written. SubsystemType is used e.g. in 5.9.6.1.1 AlarmId or ErrorId or WarningId: EquipmentSubsystemCaution.

subsystemType	Attribute Type	Examples / Description
AirSupply	string	Air supply of the equipment
Conveyor	string	A transporting mechanism for a item.
EndEffector	string	End effector. e.g. Gripper
EscortMemory	string	A device for storing/transporting information with a pallet
Feeder	string	A material supply e.g. Tray, bowl or tape feeder, magazine
GlueingUnit (*)	string	Unit for glue supply/apply
Gripper (*)	string	A device for grasping items.
HeatTransferUnit (*)	string	A device for heat transfer operation e.g. for decoration
Ionisator	string	Ionisator device used to charge gas molecules to improve dust removal e.g. in depanelling applications
LaserUnit (*)	string	Radiator, optics, transport media
Manipulator	string	Manipulator / robot of assembly cell
MillingUnit (*)	string	Milling unit of depanelling cell
MotionControl	string	Unit providing motion control capabilities.
PowerSupply	string	Power supply of cell or subunit
Printer	string	Printer device; bubble jet printer, heat transfer printer, laser printer
Reader	string	Barcode or 2D code reader
SafetyDevice	string	Safety door, light curtain, emergency stop
ScrewInsertion (*)	string	Screw insertion / screw driving unit
SolderingUnit (*)	string	Device for soldering.
VacuumUnit	string	Unit for creating vacuum for vacuum gripping or dust removal
VisionUnit	string	Camera and control system for vision inspection / manipulator teaching/ machine vision etc.
Weigher	string	Weight measurement device
WeldingUnit (*)	string	Device for welding

(*) Specific types of End Effector

5.9.5 Dictionary of Nested Elements

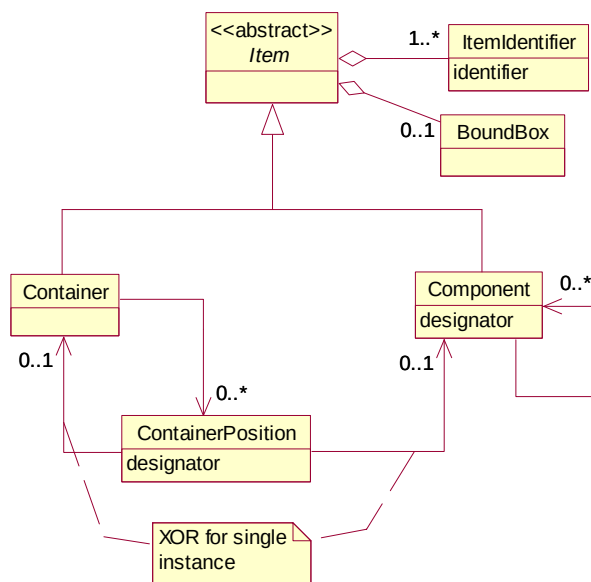


Figure 17 Element relations

Container and Component elements can be generally called Items. Item is an abstract element. It can never be instantiated. Direct known subclasses of Item are Container or Component. These are illustrated in details in Figure 17.

A Container has ContainerPosition(s) that can carry either another Container (a box inside of another box) or Component (see Figure 18). ContainerPosition can also be empty (e.g. after initialization).

Component can be carried by Container or it can be attached to the Component (assembly operations). In case of subassembly, relations can be presented as components belonging together.

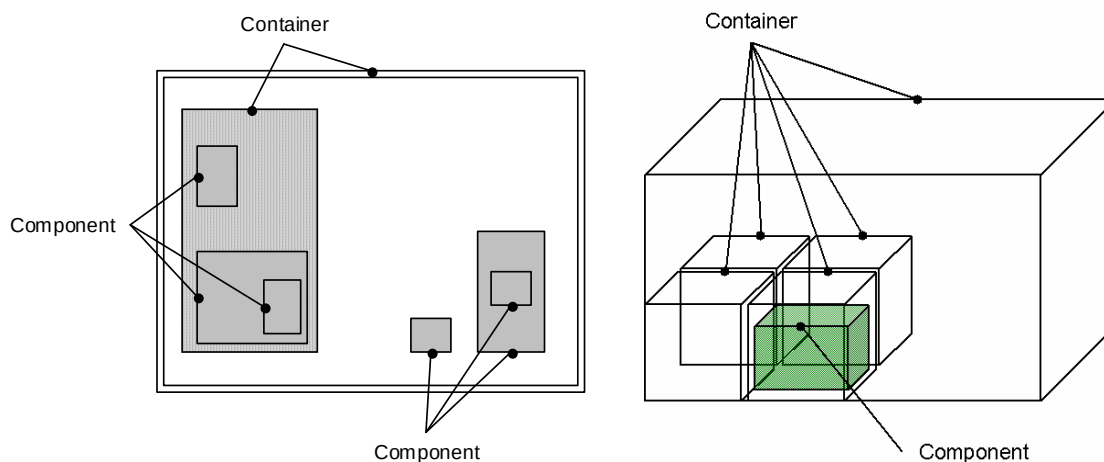


Figure 18 Element relations – example cases from real life

Element: Item <abstract>

Description: Item is an *abstract* element. It can never be instantiated. When Item is used the intention is to have one of the defined substitutionElements to appear in place of the Item element. Those substitutionElements must be inherited from Item. See illustration in Figure 19.

Known instances of Item are Container and Component.

Attribute / Element Name	Attribute / Element Type	Description	Occurrence
ItemIdentifier	See 5.9.5.2	Identifier of the instance	1-n
itemType	string	Identifies the type of instance. e.g. This container can carry Product A or Component B.	1-1
BoundingBox	See 5.9.5.3	Size of item	0-1

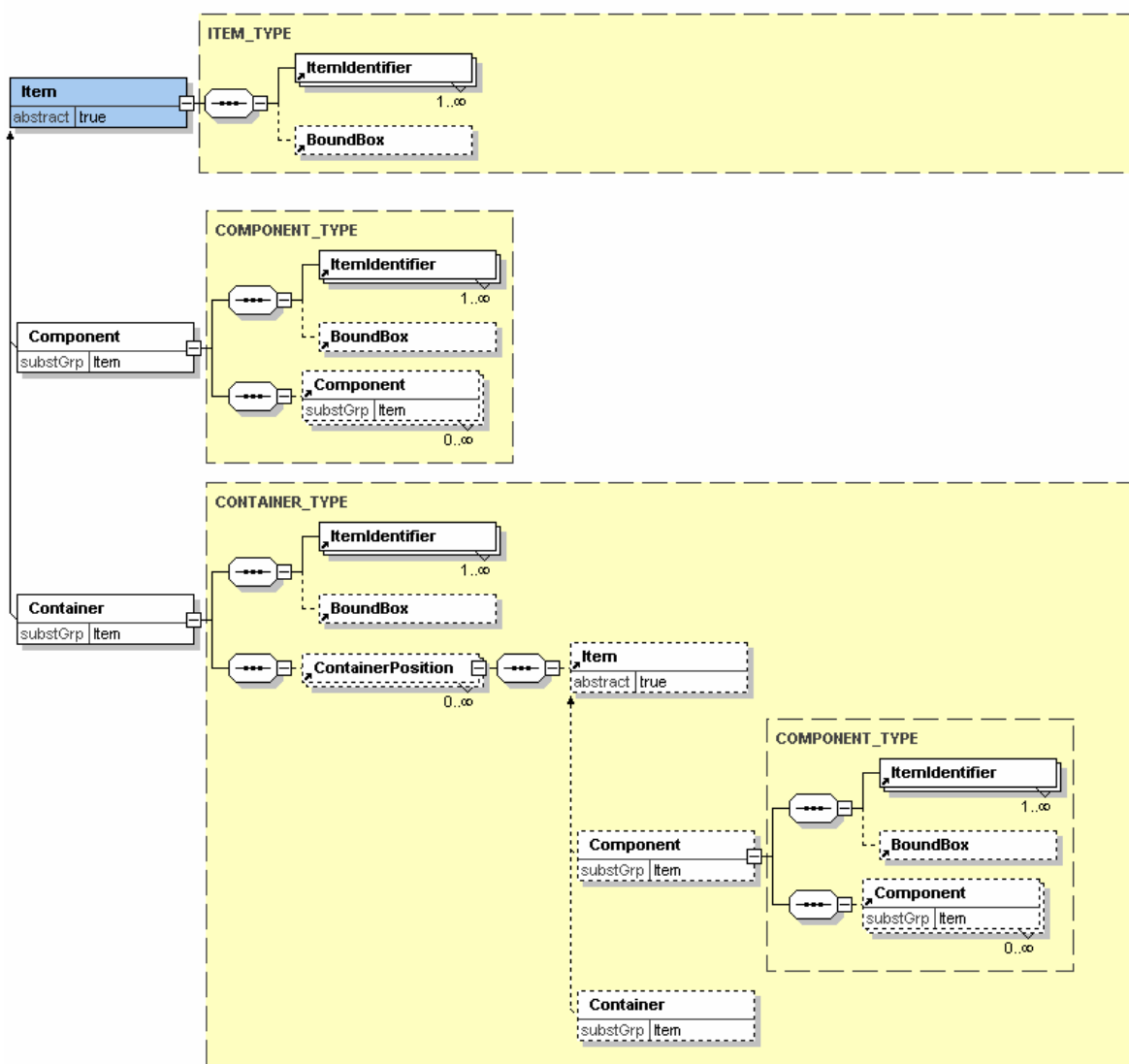


Figure 19 Substitution groups of Item

Element: ItemIdentifier

Description: Identifier for an item instance. (Check implementation guide for additional information: A.2.1 Use of ItemIdentifier)

idType:

UNIQUE | NONUNIQUE | BULK

UNIQUE: An item can be uniquely identified with keypair (idCategory and identifier).

NONUNIQUE: An item has a relevant identification, but it doesn't uniquely identify the item. (e.g.. an identifier that identifies a batch of items.) The keypair (idCategory and identifier) is used for identification.

BULK: Item does not have any identifier.

Attribute / Element Name	Attribute / Element Type	Description	Occurrence
idType	string (enumerated)	UNIQUE NONUNIQUE BULK	1-1
idCategory	string	Unique category for the ID source (e.g. LOT, BATCH, PRODUCT_SERIAL_NUMBER, MES, {End user specific}) If idType is BULK field shall be 'N/A' (Not Available).	1-1
identifier	string	Unique identifier of the instance within idCategory. If idType is BULK field shall be 'N/A' (Not Available).	1-1

```
<ItemIdentifier
  idType="UNIQUE"
  idCategory="PRODUCT_SERIAL_NUMBER"
  identifier="1234"/>
```

```
<ItemIdentifier
  idType="NONUNIQUE"
  idCategory="BATCH"
  identifier="Y2003_W12_1"/>
```

```
<ItemIdentifier
  idType="BULK"
  idCategory="N/A"
  identifier="N/A"/>
```

5.9.5.3 Element: BoundBox

Description: Axis aligned bound box defines the size of the item e.g. the minimum box into which the item can be fitted.

Attribute / Element Name	Attribute / Element Type	Description	Occurrence
diagonalX	double	Projection of diagonal dimension to X-axis	1-1
diagonalY	double	Projection of diagonal dimension to Y-axis	1-1
diagonalZ	double	Projection of diagonal dimension to Z-axis	1-1
units	string	Units of the parameter	1-1
decade	double	Unit multiplier in powers of 10. Default is 0.	0-1
rotationX	double	Rotation around X-axis	0-1
rotationY	double	Rotation around Y-axis	0-1
rotationZ	double	Rotation around Z-axis	0-1