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# Sectional Requirements for Specific Printed Circuit Board Assembly Equipment

## Introduction

Factory Information Systems (FIS) form the nervous system of an enterprise, analysing data and delivering information to the machines and people who need to make information-based decisions. These systems provide a bi-directional flow of information between the factory floor and the rest of the enterprise. The National Electronics Manufacturing Initiative's (NEMI) Plug & Play Factory project addressed some  critical problems involving factory information information system deployment on the electronics manufacturing factory floor. The Plug & Play Factory project focused on the development of standards necessary to achieve interoperability – or, plug-and-play capability – on the factory floor . Activities were comprised of three areas:

– Definition of standards for a software framework that will allow interoperability among software and equipment produced by different vendors.

– Development of process-specific, machine communication interface standards for surface mount equipment. These standards will leverage the Generic Equipment Model (GEM) specification developed for semiconductor equipment and web-based standards for data transmission.

Establishment of a test-bed manufacturing line to prove the concepts developed by the project.

## 1  Scope

IPC-2546 describes the event message content specific to assembly equipment. This standard **shall** be used together with the IPC-2541 standard entitled "Generic Requirements for Electronics Manufacturing Shop Floor Equipment Communication (CAMX)", which defines the set of messages and key attributes of the generic equipment class used in electronics manufacturing.

The types of processes covered by IPC-2546 include material movement systems like conveyors and buffers, manual placement, automated screen printing, automated adhesive dispensing, automated surface mount placement, automated plated through hole placement, forced convection and infrared reflow ovens, and wave soldering.

### 1.1  Interpretation

**"Shall**", the emphatic form of the verb, is used throughout this standard whenever a requirement intended to express a provision that is mandatory. Deviation from a **shall** requirement is not permitted, and compliance with the XML syntax and semantics **shall** be followed without ambiguity, or the insertion of superfluous information.

The words "should" and "may" are used whenever it is necessary to express non-mandatory provisions.

"Will" is used to express a declaration of purpose.

To assist the reader, the word **shall** is presented in bold characters.

## 2    Applicable documents

The following documents contain provisions, which, through reference in this text, constitute provisions of this standard. All documents are subject to revision. Parties who make agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the documents indicated below.

IPC-T-50    Terms and Definitions for Interconnecting and Packaging Electronic Circuits

IPC 2500    Generic Computer Aided Manufacturing (CAMX) Framework definitions

IPC 2511    Generic Computer Aided Manufacturing (GenCAM) descriptions for Printed Circuit Boards and Printed Board Assemblies

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

IPC 2547    Sectional Requirements for Specific Printed Circuit Board Inspection and Test Equipment

## 3    General Requirements

The requirements of IPC-2541 are a mandatory part of this standard.  That document describes the generic requirements for the CAMX format.

### 3.1  Date and Time Notation

All 2540 standards **shall** use the World Wide Web consortium (W3C) date time standard.  This standard **shall** use the Complete Date plus Hours, Minutes, Seconds, and a decimal fraction of a second and Time Zone Designator. Two decimal places will be used in order to represent time down to a hundredth of a second. For additional information on date and time, see web page:

http://www.w3.org/TR/1998/NOTE-datetime-19980827

### 3.2  CAMX Compliance

The IPC-2501 document defines a message packet structure. The IPC-2541 document defines a set of Equipment, Recipe, Item, and Operator events and related message formats. All screen printers, adhesive dispensers, surface mount placement machines, through hole placement machines, forced convection and infrared reflow ovens, final assembly and packaging equipment that comply with the IPC-2546 standards **shall** also comply with the event messages contained in the IPC-2541 standard as well as those events that are described in this document.  All event messages **shall** be formatted in compliance with the IPC-2501 message packet structure.

## 4    Generic Assembly Equipment Events and Message Formats

### 4.1  Dictionary of Common Terms

**AirSupply**
The source of the air supplied to operate the machine elements. One of possibly many sources of energy used to run the machine.

**Controller**
The device that directs the operation of a part of the machine. Some examples are motion or vision or sequence controllers.

### Environmental Control Unit (ECU)
A subsystem that monitors and controls the overall temperature and humidity of the machine.

### Inspection
The technique used to analyse the quality of the process.

### ItemRecognition/Vision System
A subsystem that captures images of the items being processed. The ItemRecognition/Vision System is typically used for alignment, locating features, and inspection.

### MaterialSupplyArea
The area in the machine were material is supplied to the machine. This could be a feeder area, tray area, glue area, adhesive area etc.

### Network
Any software or hardware related to a network connect.

### OperatingSystem
This is the software environment used by the controllers.

### PowerSupply
The source of the voltage and current to operate the machine elements. One of possibly many sources of energy used to run the machine.

### Process
The sequence of events required to locate and align the product and perform a specific machine operation.

### Safety
The protection mechanism to keep a human from harm or injury.

### Scanner
This is used to scan: items, components, feeders, material. Some examples of are specific id tags are: i.e. barcode, 2D barcode, linear barcode, touch memory cell, RF tag.

### Software
Any software that is used on the machine.

### Tooling
The mechanism used to support the product during the machine operation.

### Transport
The mechanism required to implement the following:

–    To load the product into the machine before a process begins.

–    To secure the product in the machine during the machines operation.

–    To unload the product after the machine operation is complete.

–    Protocol (messages or signals) between this machine and the upstream and downstream machines.

**VacuumGenerator**
A system used to generate the vacuum in the machine.

**Verification**
This is a system that validates a process. It can be a camera, electrical probe etc.

## 4.2 Model of Equipment

Under Consideration*

## 4.3 Dictionary of Attributes

| Attribute Name | Attribute Type | Description |
|---|---|---|
| command | string | A Specific action associated with a recipe step |
| designator | string | Identifies a unique location on the board. |
| description | string | Human readable description of the error |
| errorType | string | Describes the type of error message. |
| fromParameterValue | string | Value of parameter before change |
| imageId | string | The IPC-2510 Image. This is typically a single circuit in the panel array |
| imageShape | string | Shape of the image. Some types are Disc, Rectangle, Swiss Cross, Donut, Diamond, etc. |
| imageType | enumerated string | LOCAL \| GLOBAL |
| increment | double | Resolution of a parameter |
| informationType | string | Describes the type of information message. |
| laneList | string list | Identifies the lane(s) executing a recipe |
| maximum | double | Maximum value of a parameter |
| messageInitiator | string | A description of how this message was initiated. It could be an OPERATOR, HOST, AUTOMATIC. |
| minimum | double | Minimum value of a parameter |
| NameId | string | The name of a parameter |
| nominal | double | Expected value of a parameter |
| parameterId | string | Identifiesa parameter. Something like LaneOneBoardSpeedSetting or ZoneOneTemperatureSetting |
| recipeId | string | Identifies the Recipe |
| revision | string | Identifies the revision |
| recipeStep | string | Recipe step associated with the element |
| recognitionReference | string | Reference name used by the recognition system and/or the recipe. |
| scannedLot | string | Scanned Identification of the unit of component delivery, like a tape or bulk |
| scannerId | string | Identifies Scanner r |

| Attribute Name | Attribute Type | Description |
|---|---|---|
| score | string | Identifies confidence level |
| subsystemId | string | Identification of a Subsystem like "Network Interface Card" |
| subsystemType | string | Type of subsystem, this might be ItemRecognition \| ComponentRecognition \| Transport \| Nozzlechanger \| Head \| Headgroup \| Cutting \| ComponentsApplyArea \| Controller \| Network \| Software \| Scanner \| Applicator \| Cleaner \| Inspection \| MotionControl \| OperatingSystem \| PowerSupply \| AirSupply \| PrintMedium \| PrintStencil \| Tooling \| Transport \| Verification \| Communications \| Safety \| ECU |
| toParameterValue | string | Value of parameter after change |
| units | string | Units of a parameter |
| value | double | Value of a parameter |
| vendorErrorCode | string | Vendor specific Error Code |
| warningType | string | This describes the type of warning. |
| zoneList | string list | Identifies the zone(s) executing a recipe |

## 4.4    Dictionary of Nested Elements

The following tables define the attributes of nested elements that are appropriate for assembly functions.  These elements are necessary for tracking product and process quality.  The right-most column indicates the expected number of occurrences (cardinality) of each attribute or element.  0-1 indicates an optional field.  1-1 indicates a single mandatory field.  0-n indicates any number, including zero.  1-n indicates at least one.

### 4.4.1    Element: BadBoardMark

**Description:** Information about a specific bad board mark.

| Attribute Name | Attribute Type | Description | Occurrence |
|---|---|---|---|
| imageId | string | The IPC-2510 Image. Typically a single circuit in the panel array | 1-1 |
| designator | string | Identifies a unique location on the board. | 0-1 |
| imageType | enumerated string | LOCAL \| GLOBAL | 0-1 |

```
<BadBoardMark>
      imageId="2"
      designator="B1"
      imageType="LOCAL"
</BadBoardMark>
```

### 4.4.2  Element: Fiducial

**Description:** Information about a specific fiducial.

| Attribute Name | Attribute Type | Description | Occurrence |
|---|---|---|---|
| designator | string | Identifies a unique location on the board. | 1-1 |
| imageId | string | The IPC-2510 Image.<br>Typically a single circuit in the panel array | 0-1 |
| imageType | Enumerated string | LOCAL \| GLOBAL | 0-1 |
| imageShape | string | Shape of the image. Some types are Disc, Rectangle, Swiss Cross, Donut, Diamond, etc. | 0-1 |
| recognitionReference | String | Reference name used by the recognition system and/or the recipe. | 0-1 |
| score | string | Identifies confidence level | 0-1 |

```
<Fiducial>
      designator="F1"
      imageId="2"
      imageType="GLOBAL"
      imageShape="Rectangle"
      recognitionReference="123.gf"
      score=90
</Fiducial>
```

### 4.4.3  Element: MachineError

**Description:** Information about an error in the machine.  This element **shall** have the element Subsystem imbedded as a part of the Machine Error message

| Attribute Name | Attribute Type | Description | Occurrence |
|---|---|---|---|
| *Subsystem* | See 4.4.6 | Information about a specific subsystem | 1-1 |
| vendorErrorCode | string | Vendor specific Error Code | 0-1 |
| description | string | Human readable description of the error | 0-1 |

```
<MachineError>
      <Subsystem>
            subsystemType="Network"
            subsystemId="Ethernet Adapter:1"
      </Subsystem>
      vendorErrorCode="NW1002139123"
      description="Network not reachable"
</MachineError>
```

### 4.4.4 Element: Parameter

**Description:** A record of the name, value and units for an equipment parameter. Optional constraints can also be applied to the parameter.

| Attribute Name | Attribute Type | Description | Occurrence |
|---|---|---|---|
| nameId | string | The name of a Parameter | 1-1 |
| value | double | Value of a parameter | 1-1 |
| units | string | Units of parameter | 1-1 |
| nominal | double | Expected value of a parameter | 0-1 |
| minimum | double | Minimum value of a parameter | 0-1 |
| maximum | double | Maximum value of a parameter | 0-1 |
| increment | double | Resolution of a parameter | 0-1 |

```
<Parameter>
        nameId = "PrintSpeed"
        value = "100.0"
        units = "mm/s"
        nominal = "100.0"
        minimum = "0.0"
        maximum = "200.0"
        increment = "1.0"
</Parameter>
```

### 4.4.5 Element: Recipe

**Description:** The Recipe element uniquely identifies the recipe, program or algorithm set that is being applied at the station.

| Attribute Name | Attribute Type | Description | Occurrence |
|---|---|---|---|
| recipeId | string | Identifies the name of the recipe | 1-1 |
| revision | string | Identifies the revision of the recipe | 0-1 |
| zoneList | string list | Identifies the zone(s) executing this recipe | 0-1 |
| laneList | string list | Identifies the lane(s) executing this recipe | 0-1 |
| recipeStep | string | Identifies the step of the executing recipe | 0-1 |
| command | string | Command in the recipe such as line number or process step. | 0-1 |

```
<Recipe>
        recipeId="VCR-2912"
        revision="4"
        zoneRange="1,2"
        laneRange="1,2"
</Recipe>
```

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### 4.4.6  Element: Subsystem

**Description:** Information about a specific Subsystem.

| Attribute Name | Attribute Type | Description | Occurrence |
|---|---|---|---|
| subsystemType | string | Unique area found on the machine | 1-1 |
| subsystemId | string | Unique location on the machine | 1-1 |
| revision | string | Identifies the revision of the subsystem | 0-1 |

```
<Subsystem>
      subsystemType="Scanner"
      subsystemId="Zone 1: Lane 1:top"
</Subsystem>
```

### 4.5  Extensions to IPC-2541 Mandatory Messages

The following tables define the event message attributes or elements that are appropriate for assembly functions.  These events are necessary for tracking product and process quality.  The right-most column indicates the expected number of occurrences (cardinality) of each attribute or element.  0-1 indicates an optional field.  1-1 indicates a single mandatory field.  0-n indicates any number, including zero.  1-n indicates at least one.

IPC-2541 <EquipmentError> Message

IPC-2541 <EquipmentWarning> Message

IPC-2541 <EquipmentInformation> Message

### 4.5.1  informationId: BadBoardMarkReport

**Definition:** This is an indication that one or more Bad Board Marks were found on the item. For every found Bad Board Mark the equipment must send one Fiducial element.

| Attribute/Element Name | Attribute / Element Type | Description | Occurrence |
|---|---|---|---|
| nameId | string | Name of bad board mark report | 1-1 |
| BadBoardMarkReport | See 4.4.1 | Information about a specific bad board mark | 1-n |
| Subsystem | See 4.4.6 | Information about a specific Subsystem | 0-1 |
| Recipe | See 4.4.5 | Identifies the recipe, program or algorithm | 0-1 |

```
<BadBoardMarkReport>
```

```
        nameId = "BadBoardMarkReport1"
            <BadBoardMark>
                imageId="2"
                designator="B1"
                imageType="LOCAL"
            </BadBoardMark>
            <Subsystem>
                subsystemType="Scanner"
                subsystemId="Zone 1: Lane 1:top"
            </Subsystem>
            <Recipe>
                recipeId="VCR-2912"
                revision="4"
                zoneRange="1,2"
                laneRange="1,2"
            </Recipe>
    </BadBoardDataReport
```

### 4.5.2   informationId: StartSession

Under Consideration

### 4.5.3   informationId: EndSession

Under Consideration

### 4.5.4   informationId: SessionManagement

Under Consideration

### 4.5.5   informationId: ManagementData

Under Consideration

### 4.5.6   informationId: ProcessDataReport

**Description:** A report containing process data in order to permit SPC (Statistical Process Control) analysis

| Attribute / Element Name | Attribute / Element Type | Description | Occurrence |
|---|---|---|---|
| nameId | string | Name ofprocess data report | 1-1 |
| parameter | See 4.4.4 | process data  report parameter(s) | 1-n |

```
    <ProcessDataReport>
         nameId = "ProcessDataReport1"
        <Parameter>
                nameId = "XError"
                value = "0.05"
                units = "mm"
                minimum = "-0.0"
                maximum = "0.1"
                increment = "0.01"
        </Parameter>
```

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```
<Parameter>
            nameId = "YError"
            value = "0.02"
            units = "mm"
            minimum = "-0.0"
            maximum = "0.1"
            increment = "0.01"
        </Parameter>
    </ProcessDataReport>
```

### 4.5.7   IPC-2541 <EquipmentParameterModified> Message

**Definition:** This is an extension to the IPC-2541 message

| Attribute Name | Attribute Type | Description | Occurrence |
|---|---|---|---|
| ParameterId | string | Identifies a parameter. Something like LaneOneBoardSpeedSetting or ZoneOneTemperatureSetting | 1-1 |
| FromParameterValue | string | Value of parameter before change | 0-1 |
| ToParameterValue | string | Value of parameter after change | 0-1 |

### 4.5.8   IPC-2541 <WaitingforOperatorAction> Message

Under Consideration

### 4.5.9   New Events

#### 4.5.9.1   Event: EquipmentPoweringUP

**Description:** This event is sent when the machine is in the process of powering up. This is not mandatory but is helpful when the machine has knowledge that is in the process of powering up. It should occur before the Equipment is initialised.

| Attribute Name | Attribute Type | Description | Occurrence |
|---|---|---|---|
| dateTime | dateTime | Date and time of the event | 1-1 |
| revision | string | Software or Firmware revision code | 0-1 |

```
<EquipmentPoweringUP>
      dateTime="2000-02-02T11:13:12.00-05:00"
      revision="Rev 3.2.0"
</EquipmentPoweringUP>
```

## 5   Specific Assembly Equipment Events and Message Formats.

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

Under Consideration

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

Under Consideration

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

Under Consideration

### 5.4   Specific Reflow Equipment Events and Message Formats (Reflow)

Under Consideration

### 5.5   Specific Pick and Place Equipment Events and Message Formats (Place)

This section pertains to automated surface mount pick and place equipment, including turret style chipshooters and fine pitch placement equipment.

### 5.5.1   Dictionary of Common Terms

**Component Supply**
A device to supply the equipment with components, which have to be placed. This is a term, which should cover all existing technologies like feeders or matrix tray changer.

**Component Supply Area**
A unique area of component supplies (i.e. left right front back) found on the machine

**Feeder**
Component Supply, which feeds the head with components out of tapes or bulk cases.

**FeederId**
This is a unique serial number associated with a feeder.

**Feeder Table**
A changeable group of slots that has the capacity to hold feeders. These are usually filled off-line and changed in mass when needed.

**Feeder Type**
A type of feeder.

**Feeder Track**
Unique location of the feeder in a component supply area

**Feeder Division**
Unique location within a feeder.

**Head**
Unit which is picking and placing the components. Each head can contain several nozzle segments, which hold a nozzle to pick and place the component.

**Head Group**
A Head Group is holding one or more heads, which are moved together in the machine.

**MaterialCuttingArea**
The area that cuts the excess material used for holding components. This area usually cuts the excess tape that on a pick and place machine.

**Nozzle**
Changeable part on the head to pick up all the different shapes of components.

**Nozzle Changer**
This is a holding bin for Nozzle Changer Sections. This is a physical location on the machine.

**Nozzle Changer Section**
A holding section for a group of nozzles to be used at a latter time.

**Nozzle Changer Division**
This is a location within the Nozzle Changer Section.

**Nozzle Segment**
Fixed Location of a changeable nozzle on a head.

**Tray Server**
A tray server is holding trays to supply the machine with components delivered in trays.

**Tray Tower**
A Tray server can hold one or more towers, which is a stack of trays.

**Tray**
Unit of delivery for components to a tray server

**Tray Location**
Location of a tray in a tray tower.

**Tray Section**
One tray can contain several sections with different types of components

**Tray Division**
A Tray Section is divided into several Tray Divisions. Each Division holds one component during delivery

### 5.5.2 Model of Equipment

The objective of the model of the pick and place machine (see figure 1) is to define a common terminology to name the subsystems in all machines. This might be useful to have a consistent naming for all vendors, although each vendor might have different definitions for the same kind of subsystem.
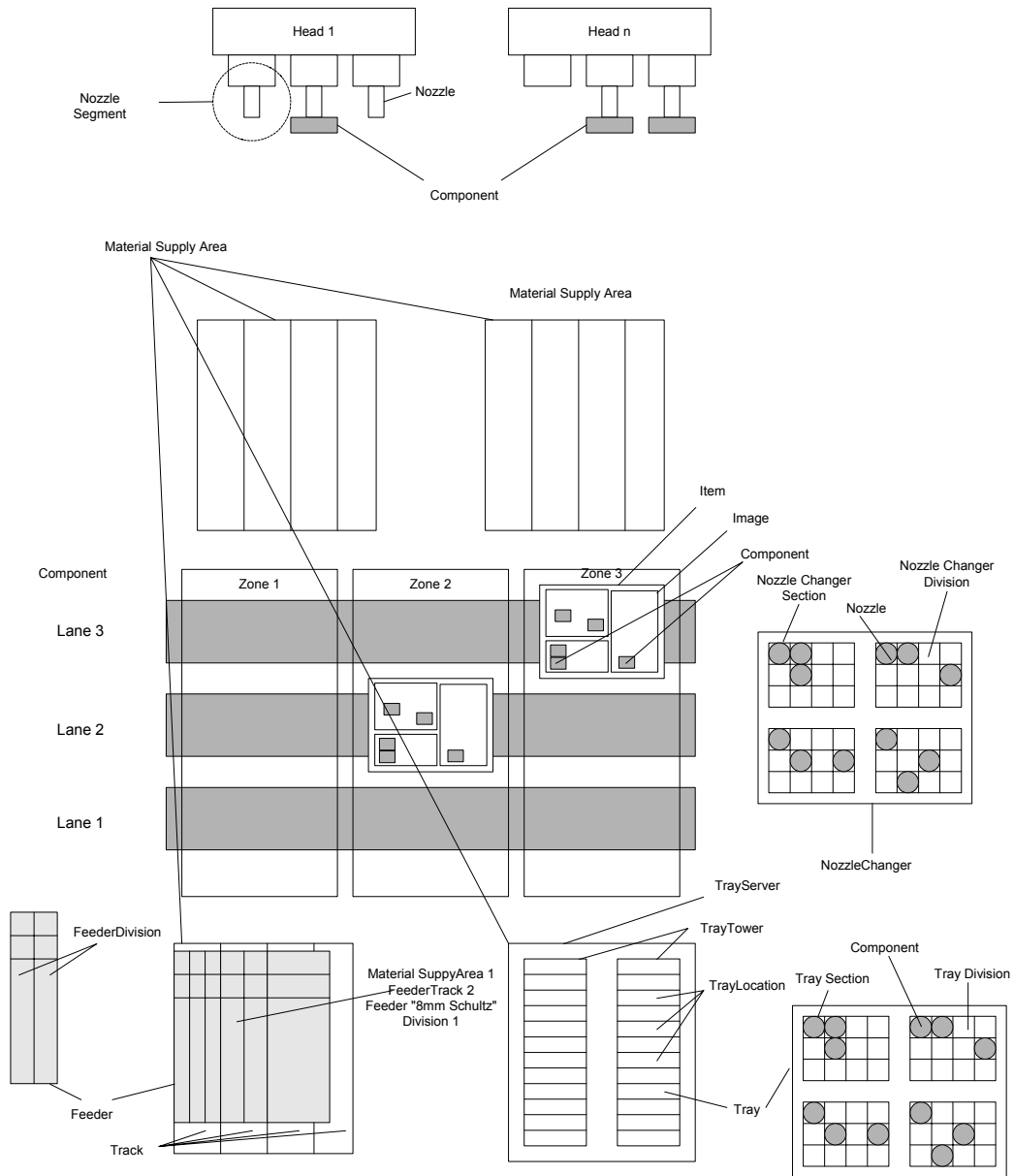
**Figure 1  Abstract model of the equipment**

### 5.5.3   Dictionary of Attributes

| Attribute Name | Attribute Type | Description |
|---|---|---|
| componentId | string | Unique component identifier |
| materialSupplyArea | string | Unique area of material (i.e. component) supplies found on the machine |
| decrementMisPickCount | 1...n | Most pick & place equipment detect an empty MaterialHandler by counting pickup warnings on one specific MaterialHandler. When sending a MaterialHandlerOutOfComponents message this attribute can be used to decrement the count of Pickup Errors charged to the Material Handler by the appropriate number. The 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 OutOfComponent error then a 3 would be entered in this attribute. |
| estimatedTimeTillEndOfComponents | timeDuration | Estimated time till end of components in seconds. |
| feederType | string | A specific type of a feeder |
| feederDivision | string | Unique location within a feeder |
| headId | string | Head name |
| itemInstanceId | string | Unique identification |
| materialHandlerType | string (enumeration) | A type of material handler: FEEDER \| TRAYSERVER |
| materialHandlerTableId | string | Unique identification of a specific materialHandler table |
| nozzleChanger | string | Nozzle changer location |
| nozzleChangerSection | string | Nozzle changer section in a nozzle changer |
| nozzleChangerDivision | string | Nozzle changer division located in a nozzle changer |
| nozzleSegmentId | string | Fixed location of a changeable nozzle on a head |
| nozzleType | string | Type of Nozzle |
| numberOfComponentsLeft | positiveInterger | Number of components left for consumption. |
| package | string (enumeration) | See GenCAM (IPC-2511) package enumerations |
| partId | string | Unique part identification such as a serial number. |
| rejectLocation | string | The location where a component is rejected |
| trackId | 1..n | Unique location on the machine. Sometimes referred to as slot. |
| trayServerType | string | A type of tray server |
| trayServerTower | 1..n | Tray server tower number |
| trayServerLocation | 1..n | Tray server location number |
| traySection | string | Tray section |
| trayDivision | string | Tray division |

### 5.5.4   Dictionary of Elements

#### 5.5.4.1   Element: Component

**Description:** Information about a specific component package.

| Attribute Name | Attribute Type | Description | Occurrence |
|---|---|---|---|
| componentId | string | Unique component identifier | 1-1 |
| designator | string | Identifies a unique location on the board. | 0-1 |
| imageId | string | The IPC-2510 Image.<br>This is typically a single circuit in the panel array | 0-1 |
| recognitionReference | string | Reference name used by the recognition system and/or the recipe. | 0-1 |
| partId | string | Part identification such as a serial number. | 0-1 |
| package | string<br><br>(enumeration) | See GenCAM (IPC-2511) package enumerations | 0-1 |

```
<Component>
    componentId="SOIC-16"
    designator="S100"
    imageId="2"
    recognitionReference="S100.gf"
    partId="AZ266533E5Z"
    package="SOIC 16"
</Component>
```

#### 5.5.4.2   Element: ComponentValidation

**Description:** Information about a specific batch/lot of components. This would be used at the instance of validation of a batch/lot.

| Attribute Name | Attribute Type | Description | Occurrence |
|---|---|---|---|
| componentId | string | Unique component identifier | 1-1 |
| partId | string | Part identification such as a serial number. | 0-1 |
| package | string<br><br>(enumeration) | See GenCAM (IPC-2511) package enumerations | 0-1 |

```
<ComponentValidation>
    componentId="SOIC-16"
    partId="4001-300-G0402-Sally-7220-6543321"
    package="SOIC 16"
</ComponentValidation>
```

### 5.5.4.3   Element: Nozzle

**Description:** Information about a specific nozzle located on a head.

| Attribute Name | Attribute Type | Description | Occurrence |
|---|---|---|---|
| nozzleType | string | Type of Nozzle | 1-1 |
| headId | string | Head name | 1-1 |
| nozzleSegmentId | string | Fixed location of a changeable nozzle on a head | 1-1 |
| partId | string | The location where a component is rejected | 0-1 |

```
<Nozzle>
      nozzleType="912"
      headId="1"
      nozzleSegmentId="2"
      partId="123456"
</Nozzle>
```

### 5.5.4.4   Element: NozzleChangerLocation

**Description:** Information about a specific location in the nozzlechanger.

| Attribute Name | Attribute Type | Description | Occurrence |
|---|---|---|---|
| nozzleType | string | Type of Nozzle | 1-1 |
| nozzleChanger | string | Nozzle changer location | 1-1 |
| nozzleChangerDivision | string | Nozzle changer division located in a nozzle changer | 1-1 |
| nozzleChangerSection | string | Nozzle changer section in a nozzle changer | 0-1 |
| partId | string | Unique part identification such as a serial number. | 0-1 |

```
<NozzleChangerLocation>
      nozzleType="912"
      nozzleChanger="1"
      nozzleChangerDivision="4"
      nozzleChangerSection="2"
</NozzleChangerLocation>
```

### 5.5.4.5 Element: MaterialHandler

**Description:** Information about a specific material handler (i.e. materialHandler, tray server). Usually a component is presented to the machine using either a feeder or a tray server. The attributes associated with a feeder would be used if the component is located on a feeder component supply area and the attributes associated with a tray would be used if the component is located on a tray server.

| Attribute Name | Attribute Type | Description | Occurrence |
|---|---|---|---|
| materialSupplyArea | string | Unique area of material (i.e. component) supplies found on the machine | 1-1 |
| trackId | 1..n | Unique location on the machine. Sometimes referred to as slot. | 1-1 |
| materialHandlerType | string (enumeration) | A type of material handler: FEEDER \| TRAYSERVER | 1-1 |
| feederType | string | A specific type of a feeder | 1-1 |
| feederDivision | string | Unique location within a feeder | 1-1 |
| trayServerType | string | A type of tray server | 1-1* |
| trayServerTower | 1..n | Tray server tower number | 1-1* |
| trayServerLocation | 1..n | Tray server location number | 1-1* |
| traySection | string | Tray section | 1-1* |
| trayDivision | string | Tray division | 0-1 |
| partId | string | Unique part identification such as a serial number. | 0-1 |
| materialHandlerTableId | string | Unique identification of a specific materialHandler table | 0-1 |

\* Mandatory only if materialHandlerType is TRAYSERVER

```
<MaterialHandler>
      materialSupplyArea="Front"
      trackId=4
      materialHandlerType="FEEDER"
      feederType="8mm Tape"
      feederDivision="2"
</MaterialHandler>
```

### 5.5.5 Extensions to IPC-2541 Mandatory Messages

IPC-2541 <EquipmentError> Message

### 5.5.5.1

### 5.5.5.2 ErrorId: EquipmentOutOfComponent

**Definition:** The machine cannot continue processing because there are no materialHandlers available with this component.

| Element Name | Element Type | Description | Occurrence |
|---|---|---|---|
| Component | See 5.5.4.1 | Information about a specific component package | 1-1 |

```
<EquipmentOutOfComponent>
      <component>
            componentId="SOIC-8"
            package="SOIC 8"
      </component>
</EquipmentOutOfComponent>
```

### 5.5.5.3  ErrorId: EquipmentErrorSubsystem

**Definition:** The machine detects an error in one of its subsystems and therefore can not continue processing.

| Element Name | Element Type | Description | Occurrence |
|---|---|---|---|
| Subsystem | See 4.4.6 | Information about a specific subsystem | 1-1 |
| MachineError | See 4.4.3 | Information about an error in the machine | 0-1 |

```
<EquipmentErrorSubsystem>
      <subsystem>
            subsystemType="Scanner"
            subsystemId="Lane 1: input area"
      </subsystem>
      <machineError>
            vendorErrorCode="St2947-ab12"
            description=="Scanneris malfunctioning"
      </machineError>
</EquipmentErrorSubsystem>
```

### 5.5.6  IPC-2541 <EquipmentWarning> Messages

### 5.5.6.1  WarningId: ItemRecognitionFailure

**Definition:** A recognition failure pertaining to an item.

**warningTypes:**

MissingFiducial | BadMeasurement

MissingFiducial: Fiducial is not recognized on location defined in recipe |

BadMeasurement: Quality of the fiducial measurement is not good enough

| Attribute / Element Name | Attribute / Element Type | Description | Occurrence |
|---|---|---|---|
| warningType | string | Describes the type of warning. | 1-1 |
| itemInstanceId | string | Unique identification | 1-1 |
| Fiducial | See 4.4.2 | Information about a specific fiducial | 1-1 |
| Subsystem | See 4.4.6 | Information about a specific Subsystem | 0-1 |
| Recipe | See 4.4.5 | Identifies the recipe, program or algorithm | 0-1 |

```
<ItemRecognitionFailure>
            warningType="MissingFiducial"
            itemInstanceId="668VCR255"
            <Fiducial>
                    designator="F1"
                    imageId="4"
                    imageShape="Rectangle"
                    recognitionReference="123.gf"
            </Fiducial>
            <Subsystem>
                    subsystemType="Medium Resolution Camera"
                    subsystemId="Downward looking: Head1"
                    revision="3.4"
            </Subsystem>
            <Recipe>
                    name="VCR-2912"
                    revision="4"
                    zoneRange="1,2"
                    laneRange="1,2"
            </Recipe>

        </ItemRecognitionFailure>
```

### 5.5.6.2  WarningId:  ItemDidNotTransferSuccessfully

**Definition:** This is an indication that the item was transferred into or within the equipment and never made it successfully to its destination.

**warningTypes:**

TimeOut | Jam

TimeOut: The item did not arrive at location in expected period of time

Jam: Item was not able to transfer. It is still detected at the starting location.

| Attribute / Element Name | Attribute / Element Type | Description | Occurrence |
|---|---|---|---|
| warningType | string | Describes the type of warning. | 1-1 |
| Recipe | See 4.4.5 | Identifies the recipe, program or algorithm | 0-1 |
| itemInstanceId | string | Unique identification | 0-1 |

```
        <ItemDidNotTransferSuccessfully>
            warningType="TimeOut"
            itemInstanceId="0002"
            <Recipe>
                    recipeId="VCR-2912"
                    revision="4"
            </Recipe>
        </ItemDidNotTransferSuccessfully>
```

### 5.5.6.3 WarningId: MaterialHandlerLow

**Definition:** The materialHandler is almost out of components.

**warningTypes:**

MeasuredMaterialHandlerLow | EstimatedMaterialHandlerLow

MeasuredMaterialHandlerLow: The equipment knows exactly how many components are in the component supply

EstimatedMaterialHandlerLow: The equipment is estimating how many components are in the component supply

| Attribute / Element Name | Attribute / Element Type | Description | Occurrence |
|---|---|---|---|
| warningType | string | Describes the type of warning. | 1-1 |
| MaterialHandler | See 5.5.4.5 | Information about a specific material handler (i.e. materialHandler, tray server). | 1-1 |
| estimatedTimeTillEndOfComponents | timeDuration | Estimated time till end of components in seconds. | 0-1 |
| numberOfComponentsLeft | positiveInterger | Number of components left for consumption. | 0-1 |
| Component | See 5.5.4.1 | Information about a specific component package. | 0-1 |

```
<MaterialHandlerLow>
      warningId="EstimatedMaterialHandlerLow"
      estimatedTimeTillEndOfComponents=123
      numberOfComponentsLeft=55
      <MaterialHandler>
            materialSupplyArea="Front"
            trackId=3
            materialHandlerType="FEEDER"
            feederType="8mm Tape"
            feederDivision="2"
      </MaterialHandler>
</MaterialHandlerLow>
```

### 5.5.6.4 WarningId: MaterialHandlerInstalled

**Definition:** The materialHandler is placed on the machine.

| Attribute / Element Name | Attribute / Element Type | Description | Occurrence |
|---|---|---|---|
| MaterialHandler | See 5.5.4.5 | Information about a specific material handler (i.e. materialHandler, tray server). | 1-1 |
| messageInitiator | string | A description of how this message was initiated. It could be an OPERATOR, HOST, AUTOMATIC. | 0-1 |
| Component | See 5.5.4.1 | Information about a specific component package. | 0-1 |

```
<MaterialHandlerInstalled>
      messageInitiator="Operator: David JJ B"
      <MaterialHandler>
            materialSupplyArea="Front"
            trackId=3
            materialHandlerType="FEEDER"
            feederType="8mm Tape"
            feederDivision="2"
      </MaterialHandler>
</MaterialHandlerInstalled>
```

### 5.5.6.5  WarningId:  MaterialHandlerUninstalled

**Definition:** The materialHandler has been removed from the machine.

| Attribute / Element Name | Attribute / Element Type | Description | Occurrence |
|---|---|---|---|
| MaterialHandler | See 5.5.4.5 | Information about a specific material handler (i.e. materialHandler, tray server). | 1-1 |
| messageInitiator | string | A description of how this message was initiated. It could be an OPERATOR, HOST, AUTOMATIC. | 0-1 |
| Component | See 5.5.4.1 | Information about a specific component package. | 0-1 |

```
<MaterialHandlerUninstalled>
      messageInitiator="Operator: David JJ B"
      <MaterialHandler>
            materialSupplyArea="Front"
            trackId=3
            materialHandlerType="FEEDER"
            feederType="8mm Tape"
            feederDivision="2"
      </MaterialHandler>
</MaterialHandlerUninstalled>
```

### 5.5.6.6  WarningId:  MaterialHandlerDivisionDown

**Definition:** The division of a materialHandler is not available. The reason is not determined yet. It could be followed by a MaterialHandlerOutOfComponent or MaterialHandlerTrouble. This could be preceded by MaterialHandlerUninstalled.

| Attribute / Element Name | Attribute / Element Type | Description | Occurrence |
|---|---|---|---|
| MaterialHandler | See 5.5.4.5 | Information about a specific material handler (i.e. materialHandler, tray server). | 1-1 |
| messageInitiator | string | A description of how this message was initiated. It could be an OPERATOR, HOST, AUTOMATIC. | 0-1 |
| Component | See 5.5.4.1 | Information about a specific component package. | 0-1 |

```
<MaterialHandlerDivisionDown>
     <MaterialHandler>
          materialSupplyArea="Front"
          trackId=3
          materialHandlerType="FEEDER"
          feederType="8mm Tape"
          feederDivision="2"
     </MaterialHandler>
</MaterialHandlerDivisionDown>
```

### 5.5.6.7   WarningId: MaterialHandlerTrouble

**Definition:** This event occurs when the equipment has tried to pick a component out of a materialHandler and it has been determined that the materialHandler is not out of components. One possible reason might be jam of the tape.

| Attribute / Element Name | Attribute / Element Type | Description | Occurrence |
|---|---|---|---|
| MaterialHandler | See 5.5.4.5 | Information about a specific material handler (i.e. materialHandler, tray server). | 1-1 |
| messageInitiator | string | A description of how this message was initiated. It could be an OPERATOR, HOST, AUTOMATIC. | 0-1 |
| Component | See 5.5.4.1 | Information about a specific component package. | 0-1 |

```
<MaterialHandlerTrouble>
     <MaterialHandler>
          materialSupplyArea="Front"
          trackId=3
          materialHandlerType="FEEDER"
          feederType="8mm Tape"
          feederDivision="2"
     </MaterialHandler>
</MaterialHandlerTrouble>
```

### 5.5.6.8   WarningId: MaterialHandlerOutOfComponent

**Definition:** The materialHandler is determined to be out of components.

| Attribute / Element Name | Attribute / Element Type | Description | Occurrence |
|---|---|---|---|
| MaterialHandler | See 5.5.4.5 | Information about a specific material handler (i.e. materialHandler, tray server). | 1-1 |
| Component | See 5.5.4.1 | Information about a specific component package. | 1-1 |
| DecrementMispickCount | 1...n | Most pick & place equipment detect an empty MaterialHandler by counting pickup warnings on one specific MaterialHandler. When sending a MaterialHandlerOutOfComponents message this attribute can be used to decrement the count of Pickup Errors charged to the Material Handler by the appropriate number. The will allow the | 0-1 |

_____

| | | 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 OutOfComponent error then a 3 would be entered in this attribute. | |
|---|---|---|---|

```
<MaterialHandlerOutOfComponents>
      decrementMisPickCount=3
      <MaterialHandler>
            materialSupplyArea="Front"
            trackId=3
            materialHandlerType="FEEDER"
            feederType="8mm Tape"
            feederDivision="2"
      </MaterialHandler>
      <Component>
            componentId="SOIC-16"
            partId="AZ266533E5Z"
      </Component>
</MaterialHandlerOutOfComponents>
```

### 5.5.7  IPC-2541 <EquipmentInformation> Messages

#### 5.5.7.1  InformationId: ComponentMissPick

**Definition:** This is an indication that the component was not properly picked up from a feeding device.

**informationTypes:**

MissingOnNozzle | MissAlignedComponent

MissingOnNozzle: Component is completely missing from the nozzle

MissAlignedComponent: Recognition system not able to correct alignment. This could be because of the following reasons: misaligned (X,Y, Theta), (please add anymore that could come up.)

| Attribute / Element Name | Attribute / Element Type | Description | Occurrence |
|---|---|---|---|
| informationType | string | Describes the type of information message. | 1-1 |
| Nozzle | See 5.5.4.3 | Information about a specific nozzle located on a head | 1-1 |
| MaterialHandler | See 5.5.4.5 | Information about a specific material handler (i.e. materialHandler, tray server). | 1-1 |
| Component | See 5.5.4.1 | Information about a specific component package. | 1-1 |
| Recipe | See 4.4.5 | Identifies the recipe, program or algorithm | 0-1 |

```
<ComponentMissPick>
      informationType="MissingOnNozzle"
      <Nozzle>
            nozzleType="912"
            headId="1"
            nozzleSegmentId="2"
      </Nozzle>
      <MaterialHandler>
            materialSupplyArea="Front"
            trackId=3
            materialHandlerType="FEEDER"
            feederType="8mm Tape"
            feederDivision="2"
      </MaterialHandler>
      <Component>
            componentId="SOIC-16"
            partId="AZ266533E5Z"
      </Component>
</ComponentMissPick>
```

#### 5.5.7.2  InformationId: ComponentNotPlaced

**Definition:** This is an indication that the component was lost between pick and place. This could occur when a component is picked up correctly, the recognition system detects it correctly however the component is not placed on the board.

_____

**informationTypes:**

LostDuringMovement

LostDuringMovement: Component is getting lost from the nozzle after component recognition

| Attribute / Element Name | Attribute / Element Type | Description | Occurrence |
|---|---|---|---|
| informationType | string | Describes the type of information message. | 1-1 |
| Nozzle | See 5.5.4.3 | Information about a specific nozzle located on a head | 1-1 |
| MaterialHandler | See 5.5.4.5 | Information about a specific material handler (i.e. materialHandler, tray server). | 1-1 |
| Component | See 5.5.4.1 | Information about a specific component package. | 1-1 |
| Recipe | See 4.4.5 | Identifies the recipe, program or algorithm | 0-1 |

```
<ComponentNotPlaced>
      informationType="LostDuringMovement"
      <Nozzle>
            nozzleType="912"
            headId="1"
            nozzleSegmentId="2"
      </Nozzle>
      <MaterialHandler>
            materialSupplyArea="Front"
            trackId=3
            materialHandlerType="FEEDER"
            feederType="8mm Tape"
            feederDivision="2"
      </MaterialHandler>
      <Component>
            componentId="SOIC-16"
            partId="AZ266533E5Z"
      </Component>
</ComponentNotPlaced>
```

### 5.5.7.3 InformationId: MaterialHandlerChanged

**Definition:** This is an indication that new material has been placed on the machine. i.e. MaterialHandler refilled.

| Attribute / Element Name | Attribute / Element Type | Description | Occurrence |
|---|---|---|---|
| MaterialHandler | See 5.5.4.5 | Information about a specific material handler (i.e. materialHandler, tray server). | 1-1 |
| Component | See 5.5.4.1 | Information about a specific component package | 1-1 |
| ComponentValidation | See 5.5.4.2 | Information about a specific batch/lot of components | 0-1 |
| messageInitiator | string | A description of how this message was initiated. It could be an OPERATOR, HOST, AUTOMATIC. | 0-1 |

```
<MaterialHandlerChanged>
        messageInitiator="Operator: David JJ B"
        <MaterialHandler>
                materialSupplyArea="Front"
                trackId=3
                materialHandlerType="FEEDER"
                feederType="8mm Tape"
                feederDivision="2"
        </MaterialHandler>
        <Component>
                componentId="SOIC-16"
                partId="AZ266533E5Z"
        </Component>
        <ComponentValidation>
                componentId="SOIC-16"
                partId="73829-2329g-ADSJ-9999"
                package="SOIC 16"
        </ComponentValidation>
</MaterialHandlerChanged>
```

### 5.5.7.4 InformationId: ComponentNotRecognized

**Definition:** A component was not recognized therefore was not placed on an item.

**informationTypes:**

MissingLead | LeadOutOfTolerance | Coplanarity | BadSize

MissingLead: One of the component leads is missing

LeadOutOfTolerance: Size does not meet tolerance

Coplanarity: Coplanarity check failed

BadSize: Size of the component is incorrect

| Attribute / Element Name | Attribute / Element Type | Description | Occurrence |
|---|---|---|---|
| InformationType | string | Describes the type of information message. | 1-1 |

| | | | |
|---|---|---|---|
| Nozzle | See 5.5.4.3 | Information about a specific nozzle located on a head | 1-1 |
| Component | See 5.5.4.1 | Information about a specific component package | 1-1 |
| MaterialHandler | See 5.5.4.5 | Information about a specific material handler (i.e. materialHandler, tray server). | 1-1 |
| Recipe | See 4.4.5 | Identifies the recipe, program or algorithm | 0-1 |

```
<ComponentNotRegognized>
    informationType="LeadOutOfTolerance"
    <Nozzle>
        nozzleType="912"
        headId="1"
        nozzleSegmentId="2"
    </Nozzle>
    <MaterialHandler>
        materialSupplyArea="Front"
        trackId=3
        materialHandlerType="FEEDER"
        feederType="8mm Tape"
        feederDivision="2"
    </MaterialHandler>
    <Component>
        componentId="SOIC-16"
        partId="AZ266533E5Z"
    </Component>
</ComponentNotRegognized>
```

### 5.5.7.5  InformationId:  MaterialHandlerTableInstalled

**Definition:** A materialHandler table is added to a component supply area.

| Attribute / Element Name | Attribute / Element Type | Description | Occurrence |
|---|---|---|---|
| materialHandlerTableId | string | Unique identification of a specific materialHandler table | 1-1 |
| messageInitiator | string | A description of how this message was initiated. It could be an OPERATOR, HOST, AUTOMATIC. | 0-1 |
| Component | See 5.5.4.1 | Information about a specific component package | 0-1 |

```
<MaterialHandlerTableInstalled>
    materialHandlerTableId="Left"
    messageInitiator="Operator: David JJ B"
</MaterialHandlerTableInstalled>
```

### 5.5.7.6   InformationId: MaterialHandlerTableUnInstalled

**Definition:** A materialHandler table is removed from a component supply area.

| Attribute / Element Name | Attribute / Element Type | Description | Occurrence |
|---|---|---|---|
| materialHandlerTableId | string | Unique identification of a specific materialHandler table | 1-1 |
| Component | See 5.5.4.1 | Information about a specific component package | 0-1 |
| messageInitiator | string | A description of how this message was initiated. It could be an OPERATOR, HOST, AUTOMATIC. | 0-1 |

```
<MaterialHandlerTableUnInstalled>
      materialHandlerTableId="Left"
      messageInitiator="Operator: David JJ B"
</MaterialHandlerTableUnInstalled>
```

### 5.5.7.7   InformationId: MaterialHandlerDivisionUp

**Definition:** The materialHandler is available.

| Attribute / Element Name | Attribute / Element Type | Description | Occurrence |
|---|---|---|---|
| MaterialHandler | See 5.5.4.5 | Information about a specific material handler (i.e. materialHandler, tray server). | 1-1 |
| Component | See 5.5.4.1 | Information about a specific component package | 0-1 |
| MessageInitiator | string | A description of how this message was initiated. It could be an OPERATOR, HOST, AUTOMATIC. | 0-1 |

```
<MaterialHandlerDivisionUp>
      messageInitiator="Operator: David JJ B"
      <MaterialHandler>
            materialSupplyArea="Front"
            trackId=3
            materialHandlerType="FEEDER"
            feederType="8mm Tape"
            feederDivision="2"
      </MaterialHandler>
      <Component>
            componentId="SOIC-16"
            partId="AZ266533E5Z"
      </Component>
</MaterialHandlerDivisionUp>
```

### 5.5.7.8   InformationId: MaterialHandlerRefilled

**Definition:** The materialHandler has been refilled with components.

| Attribute / Element Name | Attribute / Element Type | Description | Occurrence |
|---|---|---|---|
| | | | |

| | Type | | |
|---|---|---|---|
| MaterialHandler | See 5.5.4.5 | Information about a specific material handler (i.e. materialHandler, tray server). | 1-1 |
| Component | See 5.5.4.1 | Information about a specific component package | 1-1 |
| ComponentValidation | See 5.5.4.2 | Information about a specific batch/lot of components | 0-1 |
| MessageInitiator | string | A description of how this message was initiated. It could be an OPERATOR, HOST, AUTOMATIC. | 0-1 |

```
<MaterialHandlerRefilled>
        messageInitiator="Operator: David JJ B"
        <MaterialHandler>
                materialSupplyArea="Front"
                trackId=3
                materialHandlerType="FEEDER"
                feederType="8mm Tape"
                feederDivision="2"
        </MaterialHandler>
        <Component>
                componentId="SOIC-16"
                partId="AZ266533E5Z"
        </Component>
        <ComponentValidation>
                componentId="SOIC-16"
                partId="73829-2329g-ADSJ-9999"
                package="SOIC 16"
        </ComponentValidation>
</MaterialHandlerRefilled>
```

### 5.5.7.9   InformationId: ComponentReject

**Definition:** The machine is rejecting a component. This might be caused by the recognition system. The component will not be placed.

| Attribute / Element Name | Attribute / Element Type | Description | Occurrence |
|---|---|---|---|
| Component | See 5.5.4.1 | Information about a specific component package | 1-1 |
| RejectLocation | string | The location where a component is rejected | 1-1 |

```
<ComponentReject>
        rejectLocation="Front-Left"
        <Component>
                componentId="SOIC-16"
                partId="AZ266533E5Z"
        </Component>
</ComponentReject>
```

### 5.5.7.10 InformationId: ItemWorkComplete

**Definition:** This should be a collection of information associated with the completion of the work done to this board. Information for this could be: ComponentsPlacedOnBoard,

_____

## 5.6    Plated Through Hole Placement

Under Consideration

## 5.7    Solder Reflowing

Under Consideration

## 5.8    Wave Soldering

Under Consideration

## 5.9    Final Assembly and Packaging

Under Consideration

# 6    The Specific PCB-Assembly Equipment XML-Message Format

This document section describes in detail the XML-equipment message format, using XML-Schemas (instead of XML-DTD). A schema is a model for describing the structure of information. In XML-context, a schema describes a model for a whole class of documents. The model describes the possible arrangement of tags and text in a valid XML-document (or message). A schema might also be viewed as an agreement on a common vocabulary for a particular application domain (like the Electronics Manufacturing) that involves exchanging documents or messages.

XML Schema documents are XML documents (unlike DTD documents). More about XML Schema can be found under www.w3c.com and www.xml.com.
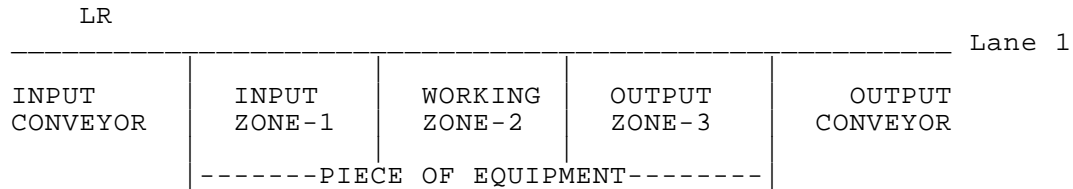
The purpose of the following XML-Schema file describing the specific PCB-assembly equipment standard XML-message format, is to define a set of XML elements and attributes and the rules for their correct combination.

## 7    Equipment Flow Event Scenarios – Single Lane Equipment

### Scenario 1, Version 1

#### Component Types SOIC

```
Scenario - Equipment Idle; single item enters system and is processed.
Equipment has single lane, single working zone.
Note: LR is a label reader.
The equipment  runs out of components and stops. The materialHandler is
refilled and work resumes.

    LR
_____ Lane 1

INPUT         │ INPUT     │ WORKING   │ OUTPUT    │   OUTPUT
CONVEYOR      │ ZONE-1    │ ZONE-2    │ ZONE-3    │   CONVEYOR
              │           │           │           │
              │-------PIECE OF EQUIPMENT--------│
```
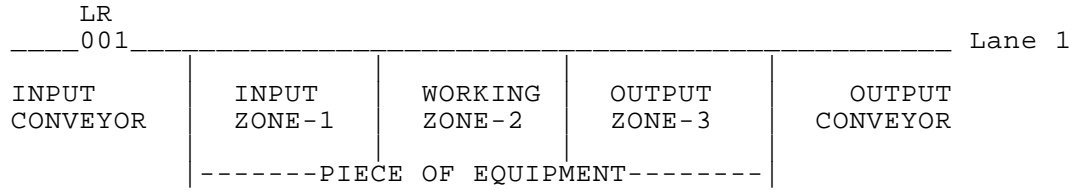
**Action:**    Steady   state   condition,   no   items   anywhere.   Equipment
previously issued message associated with EquipmentStarved event.

**====================================**
**Event:**       –
**State:**       Ready-Idle-Starved

```
     LR
_____001_____ Lane 1

INPUT          INPUT         WORKING        OUTPUT         OUTPUT
CONVEYOR       ZONE-1        ZONE-2         ZONE-3         CONVEYOR

               |-------PIECE OF EQUIPMENT--------|
```

**Action:**    Single item enters the system for processing.  Item becomes available on the Input Conveyor, equipment no longer starved.

```
=================================
```
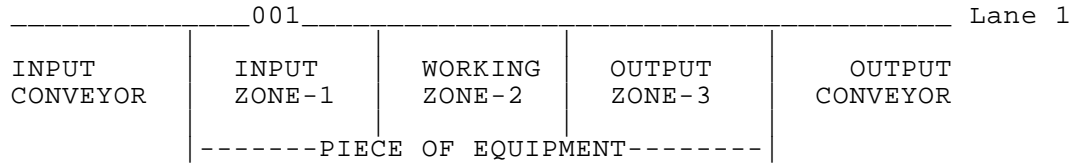**Event:**                        ItemLabelRead
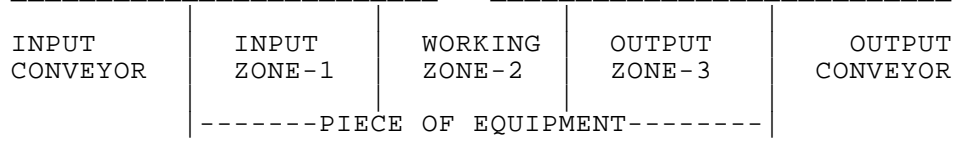**State:**                        Ready-Idle-Starved

**dateTime:**                     2000-02-02T10:35:00.00-05:00
**itemInstanceId:**               001
**laneRange:**                    1
**zoneRange:**                    1
**scannerId:**                    Scanner 1; top
```
===================================
```

**Event:**                        EquipmentUnStarved
**State:**                        Ready-Processing-Active

**DateTime:**                     2000-02-02T10:35:00.00-05:00

```
======================================
```
**Event:**                        EquipmentChangeState
**State:**                        Ready-Processing-Active

**dateTime:**                     2000-02-02T10:35:00.00-05:00
**previousState:**                Ready-Idle-Starved
**currentState:**                 Ready-Processing-Active
**eventId:**                      EquipmentUnStarved

```
LR
_____001_____ Lane 1

INPUT          INPUT          WORKING        OUTPUT         OUTPUT
CONVEYOR       ZONE-1         ZONE-2         ZONE-3         CONVEYOR

               |-------PIECE OF EQUIPMENT-------|
```

**Action:**    Transfer of item to Input Zone completes.

```
================================
```

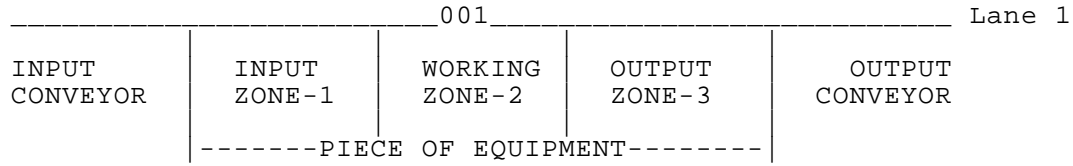| | |
|---|---|
| **Event:** | ItemTransferIn |
| **State:** | Ready-Processing-Active |
| **dateTime:** | 2000-02-02T10:36:00.00-05:00 |
| **itemInstanceId:** | 001 |
| **laneRange:** | 1 |

```
     LR
_____001_____ Lane 1

INPUT          |  INPUT     |  WORKING   |  OUTPUT   |  OUTPUT
CONVEYOR       |  ZONE-1    |  ZONE-2    |  ZONE-3   |  CONVEYOR
               |                                     |
               |-------PIECE OF EQUIPMENT-------|
```

**Action:**       Transfer of item to Working Zone completes.

```
==================================
```
| | |
|---|---|
| **Event:** | ItemTransferZone |
| **State:** | Ready-Processing-Active |
| **dateTime:** | 2000-02-02T10:37:00.00-05:00 |
| **itemInstanceId:** | 001 |
| **fromZoneId:** | 1 |
| **toZoneId:** | 2 |
| **laneRange:** | 1 |

```
LR
_____001_____ Lane 1

INPUT          INPUT       WORKING      OUTPUT        OUTPUT
CONVEYOR       ZONE-1      ZONE-2       ZONE-3        CONVEYOR

               |-------PIECE OF EQUIPMENT--------|
```

**Action**:    Processing of item begins.

```
===============================
```
| **Event:** | ItemWorkStart |
|---|---|
| **State:** | Ready-Processing-Executing |

| **dateTime:** | 2000-02-02T10:37:00.00-05:00 |
|---|---|
| **itemInstanceId:** | 001 |
| **laneRange:** | 1 |
| **zoneRange:** | 2 |

```
=====================================
```
| **Event:** | EquipmentChangeState |
|---|---|
| **State:** | Ready-Processing-Executing |

| **dateTime:** | 2000-02-02T10:37:00.00-05:00 |
|---|---|
| **previousState:** | Ready-Processing-Active |
| **currentState:** | Ready-Processing-Executing |
| **eventId:** | ItemWorkStart |

```
LR
_____001_____ Lane 1

INPUT         | INPUT    | WORKING  | OUTPUT   | OUTPUT
CONVEYOR      | ZONE-1   | ZONE-2   | ZONE-3   | CONVEYOR

              |-------PIECE OF EQUIPMENT--------|
```
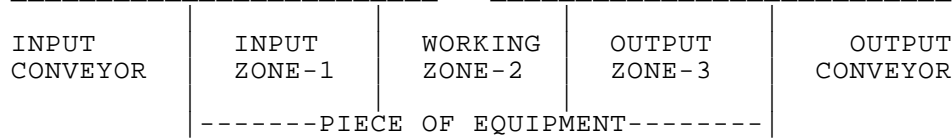
**Action:**      Equipment is running out of components.

**===================================**

| | |
|---|---|
| **Event:** | EquipmentInformation |
| **State:** | Ready-Processing-Executing |

| | |
|---|---|
| **dateTime:** | 2000-02-02T10:40:00.00-05:00 |
| **InformationId:** | ComponentMissPick |
| **laneRange:** | 1 |
| **zoneRange:** | 2 |

**2546 extension of a 2451 event:**

ComponentMissPick

| | |
|---|---|
| **informationType:** | MissingOnNozzle |
| **Nozzle:** | |
|      nozzleType | 912 |
|      headId | 1 |
|      nozzleSegmentId |      2 |
| **MaterialHandler:** | |
| | |
|      materialSupplyArea | "Front" |
|      trackId | 4 |
|      materialHandlerType | FEEDER |
|      feederType | "8mm Tape" |
|      feederDivision | "2" |
| **Component:** | |
|      componentId | "0402" |
|      designator | "R100" |
|      imageId | "2" |
|           recognitionReference | "100.gf" |
|      package | "0402" |

```
=================================
Event:                          EquipmentInformation
State:                          Ready-Processing-Executing
dateTime:                       2000-02-02T10:41:00.00-05:00
InformationId:                  ComponentMissPick
laneRange:                      1
zoneRange:                      2
```

**2546 extension of a 2451 event:**
```
                                ComponentMissPick
informationType:                MissingOnNozzle
Nozzle:
     nozzleType               912
     headId                   1
     nozzleSegmentId                  2
MaterialHandler:
          materialSupplyArea      "Front"
     trackId                  4
     materialHandlerType      FEEDER
     feederType               "8mm Tape"
     feederDivision           "2"
Component:
     componentId              "0402"
     designator               "R100"
     imageId                  "2"

     recognitionReference     "100.gf"
     package                  "0402"
```

```
=================================
Event:                       EquipmentInformation
State:                       Ready-Processing-Executing
dateTime:                    2000-02-02T10:42:00.00-05:00
InformationId:               ComponentMissPick
laneRange:                   1
zoneRange:                   2
```

**2546 extension of a 2451 event:**

```
                             ComponentMissPick
informationType:             MissingOnNozzle
Nozzle:
     nozzleType              912
     headId                  1
     nozzleSegmentId               2
MaterialHandler:

     materialSupplyArea      "Front"
     trackId                 4
     materialHandlerType     FEEDER
     feederType              "8mm Tape"
     feederDivision          "2"
Component:
     componentId             "0402"
     designator              "R100"
     imageId                 "2"

     recognitionReference    "100.gf"
     package                 "0402"
```

| **Event:** | EquipmentWarning |
|---|---|
| **State:** | Ready-Processing-Executing |
| **dateTime:** | 2000-02-02T10:42:00.00-05:00 |
| **warningId:** | MaterialHandlerOutOfComponent |
| **warningInstanceId:** | W4 |
| **laneRange:** | 1 |
| **zoneRange:** | 2 |

**2546 extension of a 2451 event:**

|  | MaterialHandlerOutOfComponent |
|---|---|

| **decrementMisPickCount:** | 3 |
|---|---|
| **MaterialHandler:** | |
|     materialSupplyArea | "Front" |
|   trackId | 4 |
|   materialHandlerType | FEEDER |
|   feederType | "8mm Tape" |
|   feederDivision | "2" |
| **Component:** | |
|   componentId | "0402" |

```
====================================
Event:                    ItemWorkPause
State:                    Ready-Processing-Executing
dateTime:                 2000-02-02T10:42:00.00-05:00
itemInstanceId:           001
laneRange:                1
zoneRange:                2
pauseId:                  Machine down


====================================
Event:                    EquipmentChangeState
DateTime:                 2000-02-02T10:42:00.00-10:00
PreviousState:            Ready-Processing-Executing
CurrentState:             Ready-Processing-Executing
EventId:                  ItemworkPause


====================================
Event:                    EquipmentError
State:                    Ready-Processing-Executing
dateTime:                 2000-02-02T10:42:00.00-05:00
errorId:                  EquipmentOutOfComponent
errorInstanceId:          E1
laneRange:                1
zoneRange:                2

2546 extension of a 2541 event:
                          EquipmentOutOfComponent
Component:
     componentId          "0402"


====================================
Event:                    EquipmentChangeState
DateTime:                 2000-02-02T10:42:00.00-05:00
PreviousState:            Ready-Processing-Executing
CurrentState:             Down
EventId:                  EquipmentError
```
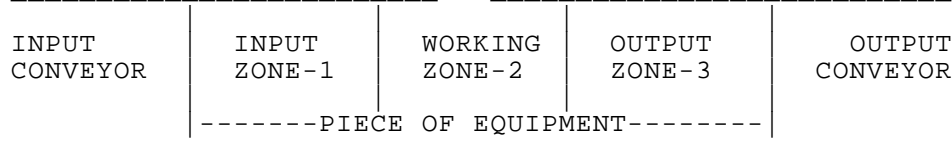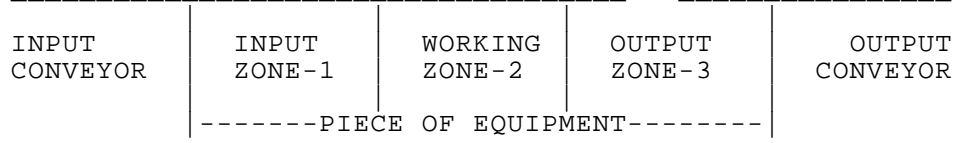
```
=================================
Event:                  EquipmentInformation
```
```
dateTime:               2000-02-02T11:04:00.00-05:00
informationId:          MaterialHandlerRefilled
laneRange:              1
zoneRange:              2
```

**2546 extension of a 2541 event:**
```
                        MaterialHandlerRefilled
```
```
MaterialHandler:
        materialSupplyArea    "Front"
    trackId                4
    materialHandlerType    FEEDER
    feederType             "8mm Tape"
    feederDivision         "2"
Component:
    componentId            "0402"
```

```
=================================
Event:                  EquipmentWarningCleared
```
```
dateTime:               2000-02-02T11:04:00.00-05:00
warningInstanceId:      W4
```

```
=================================
Event:                  EquipmentErrorCleared
```
```
dateTime:               2000-02-02T11:04:00.00-05:00
errorInstanceId:        E1
```

```
=================================
Event:                  EquipmentStartSelected
```
```
dateTime:               2000-02-02T11:04:00.00-05:00
messageInitiator:           Operator
```

```
=================================
Event:                  EquipmentChangeState
```
```
dateTime:               2000-02-02T11:04:00.00-05:00
previousState:          Down
currentState:           Ready-Processing-Active
eventId:                EquipmentStartSelected
```

```
=================================
Event:                  ItemWorkResume
```
```
dateTime:               2000-02-02T11:07:00.00-10:00
itemInstanceId:         001
laneRange:              1
zoneRange:              2
```

```
=================================
Event:                  EquipmentChangeState
```
```
dateTime:               2000-02-02T11:07:00.00-15:00
previousState:          Ready-Processing-Active
currentState:           Ready-Processing-Executing
eventId:                ItemWorkResume
```

```
      LR
_____001_____ Lane 1

INPUT           INPUT      │ WORKING    │ OUTPUT    │ OUTPUT
CONVEYOR        ZONE-1     │ ZONE-2     │ ZONE-3    │ CONVEYOR

                │-------PIECE OF EQUIPMENT--------│
```

**Action:**     Processing of item completes.

```
===================================
```
| **Event:** | ItemWorkComplete |
| **State:** | Ready-Processing-Active |
| **dateTime:** | 2000-02-02T11:07:00.00-05:00 |
| **itemInstanceId:** | 001 |
| **laneRange:** | 1 |
| **zoneRange:** | 2 |

```
=======================================
```
| **Event:** | EquipmentChangeState |
| **State:** | Ready-Processing-Active |
| **dateTime:** | 2000-02-02T11:07:00.00-05:00 |
| **previousState:** | Ready-Processing-Executing |
| **currentState:** | Ready-Processing-Active |
| **eventId:** | ItemWorkComplete |

```
LR
_____001_____ Lane 1

INPUT          INPUT        WORKING      OUTPUT        OUTPUT
CONVEYOR       ZONE-1       ZONE-2       ZONE-3        CONVEYOR

               |-------PIECE OF EQUIPMENT--------|
```

**Action:**     Transfer of item to Output Zone completes.

```
===================================
```
| | |
|---|---|
| **Event:** | ItemTransferZone |
| **State:** | Ready-Processing-Active |
| **dateTime:** | 2000-02-02T11:07:00.00-05:00 |
| **itemInstanceId:** | 001 |
| **fromZoneId:** | 2 |
| **toZoneId:** | 3 |
| **laneRange:** | 1 |

```
     LR
_____001___ Lane 1

INPUT          INPUT         WORKING        OUTPUT          OUTPUT
CONVEYOR       ZONE-1        ZONE-2         ZONE-3          CONVEYOR

               |-------PIECE OF EQUIPMENT-------|
```
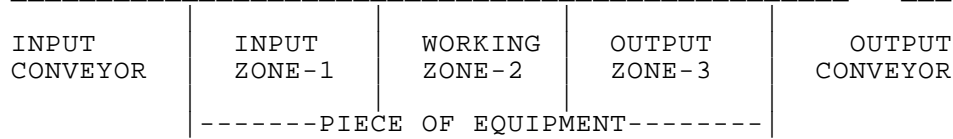
**Action:**    Transfer  of  item  to  Output  Conveyor  completes.  Equipment
becomes starved as no items are available.

```
====================================
```
| | |
|---|---|
| **Event:** | ItemTransferOut |
| **State:** | Ready-Processing-Active |
| **dateTime:** | 2000-02-02T11:07:00.00-05:00 |
| **itemInstanceId:** | 001 |
| **laneRange:** | 1 |

```
====================================
```
| | |
|---|---|
| **Event:** | EquipmentStarved |
| **State:** | Ready-Idle-Starved |
| **dateTime:** | 2000-02-02T11:07:00.00-05:00 |

```
====================================
```
| | |
|---|---|
| **Event:** | EquipmentChangeState |
| **State:** | Ready-Idle-Starved |
| **dateTime:** | 2000-02-02T11:07:00.00-05:00 |
| **previousState:** | Ready-Processing-Active |
| **currentState:** | Ready-Idle-Starved |
| **eventId:** | EquipmentStarved |

# 8    2546 XML Schema

Here is the complete listing of the XML schema for IPC-2546. The Uniform Resource Indicator (URL) for each IPC-2546 schema is listed first, followed by the XML schema for the IPC-2500 that it extends. A graphical representation of each IPC-2546 schema is then shown, followed by the actual schema definition for each of the 2546 events.

## 8.1 BadBoardMarkReport

| |
|---|
| **URL:** http://webstds.ipc.org/IPC-2546/ BadBoardMark.xsd |
| **Extends:** http://webstds.ipc.org /IPC2501/Envelope-(2000-11-13).xsd |

**Graphical Representation:**



**Schema:**

```
<?xml version = "1.0" encoding = "UTF-8"?>
<!--Generated by XML Authority. Conforms to w3c http://www.w3.org/2000/10/XMLSchema-->
<xsd:schema xmlns:xsd = "http://www.w3.org/2000/10/XMLSchema">
        <xsd:element name = "BadBoardMark">
                <xsd:complexType>
                        <xsd:sequence>
                                <xsd:element ref = "BadBoardMarkElement"/>
                                <xsd:element ref = "Subsystem"/>
                                <xsd:element ref = "Recipe" minOccurs = "0"/>
                                <xsd:element ref = "Extensions" minOccurs = "0"/>
                        </xsd:sequence>
                </xsd:complexType>
        </xsd:element>
        <xsd:element name = "BadBoardMarkElement">
                <xsd:complexType>
                        <xsd:attribute name = "imageId" use = "required" type = "xsd:integer"/>
                        <xsd:attribute name = "designator" type = "xsd:string"/>
                        <xsd:attribute name = "imageType" type = "xsd:string"/>
                </xsd:complexType>
        </xsd:element>
        <xsd:element name = "Subsystem">
                <xsd:complexType>
                        <xsd:attribute name = "subsystemType" use = "required" type = "xsd:string"/>
                        <xsd:attribute name = "subsystemId" use = "required" type = "xsd:string"/>
                        <xsd:attribute name = "revision" type = "xsd:string"/>
                </xsd:complexType>
        </xsd:element>
        <xsd:element name = "Recipe">
                <xsd:complexType>
                        <xsd:attribute name = "recipeId" use = "required" type = "xsd:string"/>
                        <xsd:attribute name = "revision" type = "xsd:string"/>
                        <xsd:attribute name = "zoneRange" type = "xsd:string"/>
                        <xsd:attribute name = "laneRange" type = "xsd:string"/>
                        <xsd:attribute name = "recipeStep" type = "xsd:integer"/>
                        <xsd:attribute name = "command" type = "xsd:string"/>
                </xsd:complexType>
        </xsd:element>
        <xsd:element name = "Extensions"/>
</xsd:schema>
```

## 8.2 ProcessDataReport

**URL:** http://webstds.ipc.org /IPC2546/ProcessDataReport.xsd

**Extends:** http://webstds.ipc.org /IPC2501/Envelope-(2000-11-13).xsd

**Graphical Representation:**



**Schema:**

```
<?xml version = "1.0" encoding = "UTF-8"?>
<!--Generated by XML Authority. Conforms to w3c http://www.w3.org/2000/10/XMLSchema-->
<xsd:schema xmlns:xsd = "http://www.w3.org/2000/10/XMLSchema">
        <xsd:element name = "SPCReport">
                <xsd:complexType>
                        <xsd:sequence>
                                <xsd:element ref = "Parameter" minOccurs = "1"/>
                                <xsd:element ref = "Extensions" minOccurs = "0"/>
                        </xsd:sequence>
                        <xsd:attribute name = "nameId" use = "required" type = "xsd:string"/>
                </xsd:complexType>
        </xsd:element>
        <xsd:element name = "Parameter">
                <xsd:complexType>
                        <xsd:attribute name = "nameId" use = "required" type = "xsd:string"/>
                        <xsd:attribute name = "value"  use = "required" type = "xsd:string"/>
                        <xsd:attribute name = "units"  use = "required" type = "xsd:string"/>
                        <xsd:attribute name = "Nominal" type = "xsd:string"/>
                        <xsd:attribute name = "Minimum" type = "xsd:string"/>
                        <xsd:attribute name = "Maximum" type = "xsd:string"/>
                        <xsd:attribute name = "Increment" type = "xsd:string"/>
                </xsd:complexType>
        </xsd:element>
        <xsd:element name = "Extensions"/>
</xsd:schema>
```

### 8.3   EquipmentParameterModifiedExtension

**URL:** http://webstds.ipc.org/IPC2546/EquipmentParameterModifiedExtension.xsd

**Extends:** http://webstds.ipc.org /IPC2501/Envelope-(2000-11-13).xsd

**Graphical Representation:**



**Schema:**

<?xml version = "1.0" encoding = "UTF-8"?>

**Draft Document for Consensus Vote Only**

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## 8.4   EquipmentOutOfComponent

**EquipmentErrorSubsystem**

## 8.6 ItemRecognitionFailure

## 8.7   ItemDidNotTransferSuccessfully

**Draft Document for Consensus Vote Only** May 2001

_____

238

## 8.8   MaterialHandlerLow

## 8.9 MaterialHandlerInstalled

_____

385

## 8.10 MaterialHandlerUnInstalled

## 8.11 MaterialHandlerDivisionDown

522

## 8.12  MaterialHandlerTrouble

624

633

## 8.13  MaterialHandlerOutOfComponent

**Draft Document for Consensus Vote Only**

## 8.14  ComponentMisPick

## 8.15 ComponentNotPlaced

## 8.16  MaterialHandlerChanged

**Draft Document for Consensus Vote Only**

## 8.17  ComponentLotChanged

## 8.18  ComponentNotRecognized

## 8.19 TrayRefilled

## 8.20 MaterialHandlerTableInstalled

## 8.21  MaterialHandlerTableUnInstalled

## 8.22  MaterialHandlerDivisionUp

## 8.23 MaterialHandlerRefilled

## 8.24 ComponentReject

# Appendix A – IPC Web-based Standards (IPC25XX)

The web-based standards (IPC 25XX) are designed to foster application integration and electronic commerce through data and information interchange standards based on XML. It assumes that application programs (including equipment interfaces) are distinct entities, and application integration takes place using a loosely coupled, message-passing approach. There is no need for a common object model, programming language, network protocol, persistent storage mechanism or operating system for two applications to exchange XML messages formatted using the web-based standards. The two applications simply need to be able to format, transmit, receive and consume a standardized XML message.

The web-based standards series have been identified for each of the value-added activities occurring throughout the product life cycle of an electronics product. The web-based standards are:

IPC-2500 – Framework Standard

IPC-2510 – Product Data Representation

IPC-2520 – Product Data Quality

IPC-2530 – Surface Mount Equipment Standard Recipe File Format

IPC-2540 – Shop Floor Equipment Communications

IPC-2550 – Manufacturing Execution Systems Communications

IPC-2560 – Enterprise Resource Planning Systems Communications

IPC-2570 – Supply Chain Communications

Table A-1 shows the correlation of the different standards in each of the series. Although not every standard has been started, the figure represents a coordinated opportunity to maintain consistency throughout the standard development cycle.

**Table A-1  CAD/CAM Standardization**

Messages are the basis of the web-based standards. Messages are the means to integrate applications at the business-process level by defining a loosely coupled, request-based communication process. Since many business processes involve one party performing a service at the request of another party, the mapping of messages to requests is natural. An XML-based messaging system with open, extensible formats captures the essential elements of an electronics business communication message while allowing flexible implementations.

It is anticipated that in the vast majority of interchanges, the exchange of XML documents and messages between trading partners or applications will occur. Implementation using the CAMX Framework Standards will use a simple hyper-text transfer protocol (HTTP) transport, but business can also use other transports including file transfer protocol (FTP) and message queuing technologies.

Until applications have native support for XML, these types of CAMX Framework interchanges will require layered software that transforms native data types into XML.

The IPC 2541 and its sectional standards should provide value in both serialized and non-serialized production environments. In serialized production environments, detailed information from the production process can be gathered from each piece of IPC 2541 compliant equipment. In non-serialized production environments, it should still be possible to gauge overall production efficiency such as number of units produced in a given amount of time, or overall line and equipment status, by analyzing the IPC 2541 messages generated by each piece of IPC 2541 compliant equipment. If a bar code reader is present then a unique item identifier may be the bar code label that is read. If no bar code reader is present then the unique item identifier may be generated by the piece of equipment.