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Initial Graphics Exchange Sepcification Volume 2: Application Protocols

Parks, C., Editor
U. S. DEPARTMENT OF COMMERCE
Technology Administration
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National Institute of Standards and Technology
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Foreword

Contents

This document brings together and updates the contents of application protocols (AP) developed by the Initial Graphics Exchange Specification (IGES) Organization and approved as American National Standards (ANS) by the IGES Product Data Exchange using STEP (PDES) Organization (IPO). The combining of material from three APs provided a mechanism wherein information supplied redundantly within the separate documents can be included once. Examples include the AP definitions and the common object models found in the Application Implementation Models (AIM, Section 3). All of the material has been updated to be compatible with, and referenced to, IGES Version 6.0.

"IGES Volume 2 - With approval of the AVM, RRC, and Chairman's Committees, it was recommended that the IPO initiate a Volume 2 of the IGES Specification for technically complete and approved APs. Both volumes will be updated with the document control procedures currently in place" (Plenary report to the IGES/STEP Meeting on July 27, 1990 by Bill Conroy, IPO Chairman).

The Drafting AP has been included through the gathering of its elements from other documents. One of the important elements of the Drafting AP, the drafting object models, had been approved as a supporting collection of objects within the Layered Electrical Products (LEP) AP. Internet-related entities have been introduced in IGES 6.0. A "Figure Viewer" application (see Section 2.1.5) for technical illustrations which would benefit Web-serving of vector graphic IGES files has been specifically defined to utilize these entities. For example, raster images can be displayed in an IGES presentation, and displayed geometry can be linked to a URL.

The 3D Piping AP content in this document is technically unchanged from the prior version (1.3), however minor edits have been introduced, together with a conversion to the AIM syntax formerly defined in the LEP's AIM.

The LEP AP content in this document is amended from the prior version (ANS US Pro/IPO-111-1997) to include the Bus Width entity introduced in IGES 6.0, together with numerous editorial corrections.

Contributors

Among the contributors (listed in IGES Volume 1) are members of the Drafting, Electrical Applications, and the NIDDESC/Piping committees, together with assistance from the Implementors Committee, who are especially recognized for their direct contributions to the material in this Volume.

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1 General

Industry requires comprehensive and reliable data exchange mechanisms to effectively integrate CAD (computer-aided design) technology. IGES is designed to support a broad range of applications and information, and it is recognized that few implementations will support all of the specification. Additionally, different CAD systems and uses of these systems for different product domains requires a uniform use of IGES entities to obtain consistently high levels of transfer fidelity. An application protocol defines a logical schema of specific product domain objects and the IGES entities to be used to represent those objects.

This document retains only essential portions of the source material. The objective of this document is to support the implementors of translators and the users of IGES translators for specific application constructs. In support of the redefined objective for this document, the “Application Reference Model” (ARM) and its mapping to the AIM are effectively combined into the object models found in Section 3 of this document. Within this document, the AIM has been renamed “Application Implementation Model.” The “Application Activity Model” (AAM) and the “Abstract Test Suite” found in the source material have not been included. Readers interested in the ARM, AAM, and Abstract Test Suites information are directed to the prior version of the separate APs.

1.1 Maintenance of the APs

The APs in this document shall be modified as part of the process of the incorporation of all Edit Change Orders (ECO) which are approved as applicable to a version of IGES. Each of the ECOs shall be evaluated to determine the impact, if any, on the APs herein. The revising of this document shall occur each time a revision to IGES Volume 1 occurs.

1.2 Prior AP Versions

Each of the source APs has followed a different development and approval cycle as indicated below.

1.2.1 Drafting AP.

Drafting Application Protocol, draft version 0.7, 14 July 1992, G. Morea, editor, General Dynamics Electric Boat Division, provided the AP description, the drawing and technical illustration taxonomy, and definitions. This version had included an AIM developed by Dr. Philip Kennicott, Sandia in the EXPRESS language which was used as resource material for the Drawing object models published in the LEP AP.

Drafting subsets were initially developed and published as “Guide to IGES Entities for Technical Illustrations,” M. Durnin and J. Wellington, 28 April 1989, and subsequently published as NISTIR 4379. This material is published in MIL-D-28000 “Representation for Communication of Product Data; IGES Application Subsets and Application Protocols” as Class 1 Technical Illustration Subset, and Class 2 Engineering Drawing Subset (revised as MIL-PRF-28000A, 10 February 1992, and MIL-PRF-28000B, 30 September 1999).

A Figure Viewer application is specified in Section 2.1.5 of this document. The Figure Viewer concept—a free-to-distribute limited-capability IGES viewer—was approved in 1995 by the IGES Implementors Committee and the IGES Project. The application was posted from 1996 through 1998 for review and comment as a Web document. This application includes the Class 1 entities as published in MIL-PRF-28000B together with extensions and application guidelines.

1.2.2 3D Piping AP.

Version 1.0, September 1990, Mark E. Palmer and Kent A. Reed editors, NIST, was published as NISTIR 4420. This document established a precedence for application protocols in both the IGES and STEP standards efforts. This version references IGES 5.0.

Version 1.1, March 1992, Mark E. Palmer and Kent A. Reed editors, NIST, was published as NISTIR 4797. This Version references IGES 5.1.

Version 1.2, September 1993, Burton F. Gischner editor, General Dynamics Electric Boat Division, was approved as an ANSI standard and published as ANS US PRO/IPO-110-1994. This version references IGES 5.2.

Version 1.3, 14 February 1997, Robert W. Schuler editor, M. Rosenblatt & Son, Inc. This version references IGES 5.3.

1.2.3 Electrical Products AP.
Version 2.3 of Guide to the IGES Electrical Entities, 14 May 1990, Larry O'Connell editor, Sandia, subtitled "Pre-cursor to an Application Protocol," provided reference models for later documents. This version references IGES 4.0.

Version 1.0 of Hybrid Microcircuit Application Protocol, January 1993, Curtis H. Parks et al, was published as NIST TN 1295, provided the baseline for the follow-on LEP AP, and in particular documented the AIM syntax for IGES object structure diagrams developed by International TechneGroup, Inc., Milford, Ohio. This version references IGES 5.1.

Version 1, Layered Electrical Products Application Protocol, February 1997, Curtis H. Parks editor, NIST, was approved as ANS US PRO/IPO-111-1997. This version references IGES 5.3.

1.3 Fundamental Concepts

The successful use of IGES for CAD information exchanges requires organizations to have comprehensive technical information management plans and documented procedures for creating, delivering, and maintaining technical information in digital form. This documentation must include the modeling conventions by which product information is created and the protocol for precisely transferring that information via the IGES format.

A protocol is a set of conventions or rules that govern the operation of functional units to achieve communication. IGES application protocols provide a formal procedure for specifying neutral, IGES-based, application specific formats. This procedure involves identifying the information requirements of an application area and documenting them in a collection of application-specific object models. Each object model is then used to select the IGES constructs for representing the required information.

The concept of application protocols incorporates many of the lessons learned from the use of IGES. The application protocols can be said to allow the exchange of information, while the use of IGES alone allows only the exchange of data.

An IGES AP defines the information content of a specific application area, specifies the mapping of the application information into IGES constructs, and describes the restrictions and conventions required in implementing these constructs.

The exchange of information using an IGES AP requires that the participating organizations agree to the objects to be exchanged and that they employ corresponding information configuration control procedures. This provides the framework for the reliable use of a specific IGES AP.

1.3.1 Development and Use of Application Information Models. The first phase of developing an AP is to define the context, scope, and functional requirements of the application(s). With these specified, the information requirements of the domain can be described by the use of an information model.

This information model documents the information objects and constraints of the subject application. This information model also provides the baseline from which the IGES Application Implementation Model (AIM) is developed. The AIM shows how the information is to be expressed by a subset of IGES entities.

Often, the representation of an information structure will require the use of multiple IGES entities.

The IGES entities selected for use in the AP have been selected to provide functional equivalence to the information objects and to minimize the size of AP files. The options for the use of the entities must be restricted so that only one method is available for carrying each element of information. The set of IGES entities and the necessary restrictions on the Global, Directory Entry, and Parameter Data Section field values are developed by using the object models and IGES.

The remainder of this document is organized as follows:

The subsections of Sections 2 contain the descriptive information and definitions for the Drafting, 3D Piping, and Layered Electrical Product (LEP), respectively.

Section 3 contains the model syntax and the common AIM for the APs. Subsection 3.1 contains the Drafting objects. Subsection 3.2 contains the 3D Piping objects. Subsection 3.3 contains the LEP objects.

Example IGES files from the source APs may be downloaded from the “Examples and Figures” page at http://www.nist.gov/iges.

1.4 Order of Precedence

Some of the material in this Volume may repeat information in IGES Volume 1. In the event of conflict, the information given in Volume 1 shall take precedence.

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2 Application Protocols

This section contains the description of three application protocols; Drafting, 3D Piping, and Layered Electrical Products.

2.1 Drafting Application Protocol

This protocol defines two of the most important classes of engineering drawing transfer. The first is the transfer of a drawing composed of views of a three dimensional model, i.e., a true model/view/draw drawing. The model is transferred along with the drawing. The second is the transfer of a flat two-dimensional drawing, where there is no explicit model. In this case, both geometry, and annotation are part of the drawing sheet. An additional two classes are also defined, for the completeness of the document, one for geometry only and one for generative drawings.

Engineering domains, such as 3D Piping and Electrical, specify and utilize various IGES entities in their product models. Each of the domains may include the product model in a drawing structure as a documentation or drawing file. This AP does not restrict model-defining entities used in these drawings. There are, however, two subsets defined for specific drawing usages. These are the Class 1- Technical Illustration Subset (Section 2.1.5), and the Class 2 - Engineering Drawing Subset (Section 2.1.6).

2.1.1 Taxonomy of Drawings Functionality. With the electronic production and exchange of drawings, there are several parameters that govern the functionality level at which the drawing is produced on a CAD system; there are several more that govern how the drawing is placed in the exchange file. Each parameter may be thought of as a switch that can be set in a number of different positions. Following this analogy further, each combination of switch positions represents a different option for drawing production and exchange. This protocol provides the overall taxonomy for drawing production and exchange. A set of parameter values is then defined that governs exchanges compliant with the protocol.

The following are the parameters that organize drawing production and exchange:

Table 1. Drawing Parameters

Category		Parameters
1.	Model Representation	Single Repetitive
2.	Drawing Organization	Model Only (none)
3.	Shape Geometry	2D Wireframe 3D Wireframe Surface BREP CSG Sketch
4.	Administrative Data	Sketched Named Parseable Generative

Table 1. Drawing Parameters

Category		Parameters
5.*	Annotation and Symbology Representation	Sketched Named Parsable Generative
6.*	Annotation and Symbology Associativity	Visual Only Representational Feature
7.	Model Data Organization	Group Definition/Instance Partition Connectivity
8.	Presentation	Single Multiple Multiple-Segmented
* (5 and 6 have subcategories Symbols, Notes, Dimensions)		

2.1.1.1 Taxonomy Definitions.

1. Model Representation: How the shaped definition of the product relates to the way it is shown in various views on the drawing.

   Single: There is only one model, and views show different orientations of the model. The same entity represents the same feature in multiple views.

   Repetitive: Multiple views of the product are not different orientations of the same model. Thus, different entities represent the same feature in multiple views.

2. Drawing Organization: How the shape definition and annotation of the product are combined on the drawing sheet.

   Model Only: There is no annotation present with the model. This is a representation of just the shape definition of a product, i.e., only its geometry and structure.

   Draw-Model: Both annotation and shape definition are present on the drawing; this means that a model accompanies the drawing.

   Draw Only: Annotation only is present on the drawing. This means that no shape definition is represented. Because of this, model views will not appear in conformant Draw Only files.

3. Shape Geometry: How the shape definition of the product is represented. Transformation rules define how this geometry is ultimately shown on the drawing. Unless noted, the drawing is “to scale.” Various combination of switches are permissible (i.e., 3D wireframe and 3D surfaces may be used together).

   2D Wire Frame: All of the shape definition is composed of wire frame entities which lie in the same plane. This class also includes schematic or symbolic representations of a product.

   3D Wire Frame: All of the shape definition is composed of wire frame entities which define edge boundaries of a product.

Surface: The shape definition is composed of 3D surface entities which define face boundaries of a product.

BREP: The shape definition is composed of boundary representation entities which define solid boundaries of a product (see IGES Volume 1 Section 3.4).

CSG: The shape definition is composed of constructive solid geometry entities which define solid boundaries of a product (see IGES Volume 1 Section 3.3).

Sketch: The shape definition is represented by wireframe entities which convey its general configuration without regard to true scale or size. Such representation either can be 2D or 3D. It mayserve for illustration purposes.

4. Administrative Data: The category of annotation allowing for the successful tracking, storage, cataloging and exchanging of drawings. Such information may or may not be viewable on the drawing hardcopy.

   Sketched: The information is present in the exchange file, but only as basic entities. Therefore, the information has no intelligence whatsoever.

   Named: The information is present in the exchange file, with more advanced construction entities. The information can be processed by type, but individual intelligence is still missing.

   Parsable: The information is present in the exchange file with both advanced construction entities and individual attribute intelligence. This makes it possible to selectively process such information.

   Generative: The information necessary to produce the desired information is present in the exchange file, but it is not explicitly defined. Therefore, the desired information must be obtained by processing other data contained in the file or in associated files.

5. Annotation and Symbology Representation: There are several ways of mapping annotation from a native system to an exchange file. These are at different levels of intelligence. How the information resides in the exchange file determines the level of intelligence that can be passed to a receiving system. The sub type definitions are the same as for Administrative Data.

6. Annotation and Symbology Associativity: Associativity between annotation and a model is possible on several levels. The degree of association may be deduced from both the exchange file and the drawing hardcopies in various combinations.

   Visual Only: There is no connection between the annotation and the model, other than that which can be deduced from the drawing hardcopy.

   Representational: There is a connection between an annotation entity and a model entity in the exchange file. The model entity represents a portion of the geometry, but not an identifiable feature of the product.

   Feature: There is a connection between a piece of annotation and an identifiable feature of the product. The feature will be identified in the conformant exchange file.

      Subcategories for (5) and (6)

         Symbol: A collection of graphic and text entities conveying a specific meaning when placed on a drawing hardcopy.

            Note: This subcategory includes text strings which are displayed on a drawing hardcopy.

         Dimension: Annotation that provides measurement or directed information about the product depicted on the drawing. The dimension shall be visible on the drawing hardcopy.

7. Data Organization: Several methods may be used in the exchange file to organize data for a variety of reasons, including presentation and drawing production.

   Group: Entities are given an attribute identifying them as belonging to a particular set. The set may or may not be named.

   Definition/Instance: Entities collected in a subfigure definition which is instanced in one or more places by transformation.

   Connectivity: A means of providing connections between model entities by more than just visual inspection.

8. Presentation: The ability of the same entity, displayed in different views, to take on different appearances in several views.

   Single: The entity appears the same way in each view in which it is displayed.

   Multiple: The entity may take on a different appearance in each of the views in which it is displayed. The appearance is constant over the entity's length in each view.

   Multiple- Segmented: Not only can the entity take on a different appearance in each of the views in which it is displayed, but the appearance may change over the length of the entity in each displayed view.

2.1.1.2 Parameter Definition. The parameter-controlled concept of this protocol has the potential of allowing numerous combinations of settings; however, all permutations of settings are not likely to be useful. Three combinations appear to be useful in meeting identified common business needs:

A. Model Only - This exchange mode includes only the lGES geometry entities which define the shape of the product; there are no IGES annotation entities, nor is annotation represented by lGES geometry entities. In the strict interpretation, this exchange does not represent a “drawing” and therefore does not belong in this protocol; however, this mode might be used in combination with one of the other modes to avoid the need for the recipient to edit the graphics part, so in that way, it is “drawing related” and its inclusion is justifiable.

B. Explicit - This exchange mode is intended for systems with two-dimensional databases. It depicts a traditional drawing, and it includes both IGES geometry and annotation entities. It is called “explicit” because the lGES geometry entities do not define a single model; instead, they define multiple representations of portions of the model, one for each view. If the model lends itself to the process (i.e., is essentially two-dimensional), there is an optional compatibility for distinguishing one of the multiple copies of the model as authoritative. This means that that copy of the model is the authoritative one in case similar features in copies of the model differ. This practice avoids problems of redundant and possibly conflicting information in the file.

C. Model/View/Draw - This exchange mode also depicts a traditional drawing, and likewise it includes both IGES geometry and annotation entities. It is called “model/view/draw” because the IGES geometry entities depict a single geometric model of the product; the lGES view and drawing entities are then used to show this model in various orientations to create a drawing. lGES annotation entities are located either in views or on the drawing. This mode typically is used by 3D wireframe or surface modelers.

D. Generative- This mode is noted here for the completeness of the document. This exchange mode enables the receiving system to generate a traditional drawing, and it includes IGES geometry and properties which describe the product sufficiently to enable generation of appropriate annotation. It is called “generative” because the annotation entities which comprise a drawing must be generated by the receiving

system based on implementor-defined properties (the IGES Specification does not define enough properties to do this currently).

2.1.2 Parameter settings.

Settings for “model only” exchange

Table 2. Parameter Settings for Model

1.	Model Representation	Single
2.	Drawing Organization	Model Only (none)
3.	Shape Geometry	2D or 3D Wireframe
4.	Administrative Data	none
5a.	A & S Rep. Symbols	none
5b.	A & S Rep. Notes	none
5c.	A & S Rep. Data Tables	none
5d.	A & S Rep. Dimensions	none
6a.	A & S Assoc. Symbols	none
6b.	A & S Assoc. Notes	none
6c.	A & S Assoc. Data Tables	none
6d.	A & S Assoc. Dimensions	none
7.	Model Data Organization	Group
8.	Presentation	Single

Settings for “explicit” exchange

Table 3. Parameter Settings for Explicit

1.	Model Representation	Repetitive
2.	Drawing Organization	Draw - Model*
3.	Shape Geometry	2D - 3D Wireframe**
4.	Administrative Data	Sketched, Named
5a.	A & S Rep. Symbols	Sketched, Named
5b.	A & S Rep. Notes	Sketched, Named
5c.	A & S Rep. Data Tables	Sketched, Named
5d.	A & S Rep. Dimensions	none
6a.	A & S Assoc. Symbols	none
6b.	A & S Assoc. Notes	none

Table 3. Parameter Settings for Explicit

6c.	A & S Assoc. Data Tables	none
6d.	A & S Assoc. Dimensions	none
7.	Model Data Organization	Group
8.	Presentation	Single

*In an explicit exchange, one drawing and one view are present to provide locating space for the geometry entities that make up the models.

**Entities may not necessarily be planar, but any 3D entities are used for convenience, not to depict a complete product model (e.g., an isometric view of a V6 engine might have 6 arcs tilted at some angle rather than 6 ellipses for the cylinders). This often happens on drafting-oriented CAD systems which have assist features to create isometric views.

Settings for “model/view/draw” exchange

Table 4. Parameter Settings for Model/View/Draw

1.	Model Representation	Single
2.	Drawing Organization	Draw - Model
3.	Shape Geometry	3D Wireframe, Sketch
4.	Administrative Data	Named
5a.	A & S Rep. Symbols	Named
5b.	A & S Rep. Notes	Named
5c.	A & S Rep. Data Tables	Sketched
5d.	A & S Rep. Dimensions	Named
6a.	A & S Assoc. Symbols	none
6b.	A & S Assoc. Notes	none
6c.	A & S Assoc. Data Tables	none
6d.	A & S Assoc. Dimensions	none
7.	Model Data Organization	Group, Definition/Instance
8.	Presentation	Multiple

Settings for “generative” exchange

Table 5. Parameter Settings for Generative

1.	Model Representation	Single

Table 5. Parameter Settings for Generative

2.	Drawing Organization	Draw - Model
3.	Shape Geometry	2D - 3D Wireframe, Surface, BREP, CSG
4.	Administrative Data	Parsable
5a.	A & S Rep. Symbols	Generative
5b.	A & S Rep. Notes	Parsable
5c.	A & S Rep. Data Tables	Parsable
5d.	A & S Rep. Dimensions	Generative
6a.	A & S Assoc. Symbols	Feature
6b.	A & S Assoc. Notes	Feature
6c.	A & S Assoc. Data Tables	Feature
6d.	A & S Assoc. Dimensions	Feature
7.	Model Data Organization	Group, Definition/Instance
8.	Presentation	Multiple-Segmented

2.1.3 Drawings Information Requirements. *Drawings* is a general purpose title which encompasses a wide variety of drafting applications. It includes, for example, drawings used extensively in the manufacturing and defense sectors, drawings prepared by the AEC (architecture, engineering, and construction) and building services sectors, and survey and utilities drawings used by government and land authorities.

A drawing is defined as the set of one or more drawing sheets that describe a product. In common engineering terms, a drawing may comprise several drawing sheets. For instance, a drawing of an automobile part assembly may be the set of drawing sheets that describe the individual components that make up the assembly. In AEC project building terms, a drawing may comprise the set of drawing sheets that are the plans and elevations of a building, or a single sheet may be specific to a particular discipline, such as plumbing.

This application protocol establishes parameter definitions and settings which support drawings which reference accompanying wire frame product geometry, either 2D or 3D (refer to Section 1.1.2). The product geometry shall include the entire wire frame model, even if portions are not visible in any of the views defined by the sender. Within the context of this AP, the purpose of the product geometry shall be to enable the receiver to generate new views of the model. Accordingly, no provisions will be made for items represented by solids or surfaces, unless a wire frame derivation is first performed on the sending system.

For scale drawings, the precision of the model shall be equal to, or more precise than, the dimensional precision shown on the accompanying drawings. Administrative requirements to enable the successful transfer of drawings are contained in this AP.

Annotation is not required to be associative, and it may be related either to the model or to the drawing. If related to the drawing, it shall be recognizable as a part of the drawing sheet's contents. Empty drawings are prohibited. Mixed units between the drawing and model are also prohibited. Multiple explicit drawing sheets shall be allowed in a single file. Each drawing sheet and its component views, data tables, and annotation shall be recognizable as a unit.

2.1 Drafting AP

This AP accommodates the two drawing types which are the most common of the current hard copy drawings used in industry. The first drawing type is a scaled drawing where graphic entities are proportional to the real object's physical attributes. The second drawing type is a not-to-scale (NTS) drawing where graphic entities are not depicted proportional to the real object's physical attributes. The identification of scaled or not-to-scale drawings shall be specified in user-established conventions.

Key Concepts The concepts presented here underly the creation of a drawing on a CAD system. They are presented here for information only.

Model/View/Draw (MVD)

The goal of a drawing is to convey information about a physical product. Traditionally, developing a drawing meant placing representations, such as scaled views, pictorial renderings (unscaled sketches and diagrams), or conceptual models (schematics) onto paper.

The development of CAD systems allowed engineers and designers for the first time to develop an idea from concept directly into an electronic model, from which a drawing could be made. As an electronic entity, the CAD model can take several forms (e.g., wire-frame, surface or solid) and can be either 2D or 3D.

Once the model is developed on the CAD system, it may be manipulated to show various sides, dimensions and details through the use of views. Depending on the user's needs, views may display different scales and orientations, and may show all or part of the model. True model-view-draw entities are not individually duplicated in different views; rather, the same MVD model entity is merely displayed differently in each view. Therefore, a change made in one view will manifest itself in all the other views of the same entity.

Multiple views and annotations necessary to define the product are collected on a 2D electronic drawing sheet to produce a drawing. The product geometry, or shape definition, is contained in the views of the entity, while annotation is usually contained in the drawing.

Coordinate System

Coordinate systems enable one to define the position of geometry within the model, (definition space), define the orientation of the model to a particular view (view space) and to define the placement of views and annotation on a drawing (draw space).

Among the many types of coordinate systems used are rectangular Cartesian, polar, and spherical. Cartesian is the only system supported by this protocol. All coordinate systems are comprised of units, and axes. The point where two or more axes come together is called an origin. A transformation matrix rotates a coordinate system with respect to global space. Some coordinate systems such as drawing space, are two-dimensional, in which one dimension is assumed to be zero within a 3D system.

Geometric Model

When a product is modeled in the CAD system, a collection of geometric entities is assembled. These are called geometric elements.

Geometric elements can be either 2D or 3D. 2D elements usually serve the functional needs of schematic or pictorial representation. These elements also determine what form the model takes: wireframe, surface, solid

or sketch form. A *sketch* is a not-to-scale pictorial representation.

Although most text is contained in the drawing as annotation, some text can be contained in the views as geometry. This is a special case, however, and it is discussed later (Section 2.1.3.4.2).

Drawings and Drawing Sheets

A drawing is a collection of views with annotation which describes a product, and may be made up of a set of one or more sheets. It is identified by a Name and a Revision, and its structure is governed by the properties of Standard and Type.

There are two types of standards which govern the drawing: Global Standards, such as ANSI Y-14; and organization-specific standards which are dictated by the individual company producing a drawing. The drawing type is specified by the organization producing the drawing. These types would include such examples as arrangement, diagram or selected record drawings. The specific guidelines for a drawing type are specified by the user-group and would suit their particular needs for a drawing. A drawing's dimensional relationship with the model that it represents is governed by the property of precision.

A drawing is a collection of model views and annotation on one or more drawing sheets, which are further identified by a sheet number and a revision. Each drawing sheet has properties of size and units. Drawing units refer to the physical size of the drawing sheet element but are not related to the size of the model which is represented.

Views

Drawing production requires different orientations of the model to be represented on the drawing sheet. These orientations are represented by views. The process used to show only a portion of the model is known as clipping. A collection of views is placed on the drawing sheet(s) and annotation is added to complete the drawing.

Text

Text is placed on the electronic drawing and in the exchange file in a series of strings, not individual characters. The capability to edit, or change, the string is desirable.

2.1.4 Application Requirements. These requirements define specific constructions and constraints that will be placed, or excluded from, the exchange file. The requirements are broken down by taxonomy categories. Note that the requirements may be different for each of the four defined exchange classes. Where this is the case, it is specifically noted. These requirements are further defined in the reference model, and the actual IGES entities used are introduced in the AIM (Section 3). Each of the sections is divided into content requirements and restrictions.

2.1.4.1 Model Representation.

Content Requirements

- Model geometry shall be composed of wireframe entities, identified as such in the exchange file. For a model only exchange, there will be a single model, either 2D or 3D.
- For an explicit exchange, the model will be repetitive. If necessary, a combination of 2D and 3D entities may be used.
- For a model/view/draw exchange, there shall be a three-dimensional single model.

Restrictions

- Annotation entities shall not be used for product geometry.

2.1.4.2 Drawing Organization.

Content Requirements

- For a model only exchange, one drawing and one view shall be provided to enable visualization of the model.
- For explicit exchange, one or more drawings shall be provided. One drawing per file. One view or at least one piece of annotation shall be placed on each drawing.
- For a model/view/draw exchange, one or more drawings shall be provided. At least one view on one of the drawings shall be provided.
- View scaling and clipping extends shall be provided for views.
- One drawing shall equal one IGES file.

Restrictions

- View scale shall be greater than zero.
- View orientations shall be in Cartesian coordinates.
- Empty drawings shall not be present in the exchange file.
- Empty views, i.e., views that show no model entities, shall not be present in the exchange file. Blanked views are permissible.
- Perspective views are not supported.
- Unlimited size drawings shall not be present in the exchange file.
- Drawings shall specify their size and units. The origin shall be at the lower left hand corner.
- Views shall be uniquely identified, named and instanced.
- The clipping volume shall be in model space coordinates such that when it is transferred to view coordinates, its sides are parallel to X=0, Y=0, Z=0 planes, and cross sections parallel to XY - plane have finite area.

2.1.4.3 Shape Geometry.

Content Requirements

- For model only exchange, the shape geometry shall be either 2D wireframe or 3D wireframe.
- For explicit exchange, the shape geometry shall be either 2D wireframe or 3D wireframe.
- For model/view/draw exchange, the shape geometry shall be 3D wireframe.
- For 2D wireframe, allowed geometry shall consist of points, lines and curves, all lying in the same plane of a Cartesian Coordinate Space.
- For 3D wireframe, allowed geometry shall consist of points, lines and curves in a Cartesian Coordinate Space.

Restrictions

- All curves shall have non-zero length, and they shall be continuous.
- The “best entity” shall be used to describe geometry. For example, one shall use a circular arc not an ellipse to represent a circle.

2.1.4.4 Administrative Data.

Content Requirements

- Sufficient information shall be present in the exchange file to identify:

  the product

  the file generation site

  the responsible organization

  the date of the file

Restrictions

- The data shall be placed in text strings. None of the required data shall be present on the drawing as stroked information.
- The data shall be labeled as annotation.

2.1.4.5 Annotation and Symbology Representation.

Content Requirements

- For explicit exchange, annotation shall be sketched or named. Thus a receiving system shall be capable of reading named annotation.
- For model/view/draw exchange, annotation shall be named.
- For named annotation, the following types of annotation shall be supported: dimensions, notes, symbols and crosshatching.

Restrictions

- Annotation shall be planar.
- With the exception of crosshatching, geometry and annotation shall not be combined to form annotation entities.
- For named annotation, the appropriate CAD entities shall be used.

2.1.4.6 Annotation and Symbology Associativity.

Content Requirements

- Annotation is not required to be associative for this initial release of the protocol.

Restrictions

- Associativity relations may be present in the exchange file provided that the annotation can be correctly processed without them.

2.1.4.7 Model Data Organization.

Content Requirements

- The ability to form groups shall be supported.
- The ability to form subfigure instances/definitions shall be supported.
- The ability to support connectivity is not required by this protocol. Note that specific applications outside this protocol's scope may require it.
- Layer usage conventions are agreed to by sending/receiving organizations.

Restrictions

- Subfigure definitions containing both annotation and geometry shall not be used.
- Recursive groups of subfigures shall not be used. They must be directed acyclic graphs.
- Groups or subfigures shall not be empty. For establishing a placeholder, a point may be used.
- Groups shall not be present in subfigure definitions.
- Non-uniform scaling shall not be used in subfigures.

2.1.4.8 Presentation.

Content Requirements

- For explicit or model/view/draw exchange, entity appearance may be controlled at any level.
- The following characteristics of curve appearance shall be supported: color, line font, line width and blanking.
- The following characteristics of text appearance shall be supported: color, font, size, slant angle, rotation and mirroring.
- For model/view/draw exchange, different appearance in different views shall be supported.

Restrictions

- For model only exchange, entity appearance shall be controlled at the entity level.

2.1.5 Figure Viewer Application. The figure viewer application IGES entities support the exchange of figures and illustrations normally found in a technical publication and in figures or illustrations delivered to viewers over the Internet. In this application, the emphasis is on the visual clarity of figures and illustrations designed for human interpretation.

2.1.5.1 File construction. Files produced specifically for the figure viewer application shall be IGES ASCII form as specified in IGES Volume 1, and optionally may be compressed as specified by the Internet Engineering Task Force (IETF).

2.1.5.1.1 Start section. The following information shall be placed in the start section of the file:

a. Statement of conformance to this application, the applicable revision level of this specification, and the release date of the latest amendment to this specification (or date of the latest revision if no amendment has been issued).

b. Illustration number or identifier.

2.1.5.1.2 Global section. Fields in the global section shall be restricted to certain ranges. Defaulted values shall be interpreted as “unspecified” except as noted in table 6 for global parameters 1, 2, 12, 15, and 24.

Table 6. Global Section Field Ranges

Field	Value	Required	Defaults/Notes
1	,	N	Default to “,”
2	;	N	Default to “;”
3-6		Y	
7-11		N	
12		N	Default to field 3
13	1.0	Y	
14	1, 2, 4-11	Y	
15		N	Default to 1
16-17		Y	
18		Y	The year shall be specifed as YYYY
19		Y	
20		N	
21		N	
22		N	
23	11 or greater	Y	
24	0-7	N	Default to zero
25		N	If date is provided, the year shall be YYYY

Table 6. Global Section Field Ranges

Field	Value	Required	Defaults/Notes
26		Y	25HFIGURE VIEWER APPLICATION

2.1.5.1.3 Directory Entry (DE) section. See notes for table 7 for restrictions placed on the parameters in the DE section.

2.1.5.1.4 Parameter Data (PD) section. See notes for table 7 for restrictions placed on the parameters in the PD section.

2.1.5.2 Information requirements and data functionality. Two dimensional (2D) geometry and annotation entity form the majority of data items although some non-geometric information is required as well. Information requirements for this application shall include (but are not limited to):

a. Two dimensional geometry in the form of lines, circular arcs, conic arcs, and spline curves.
b. Non-geometric attributes of line weight and line font.
c. Annotation entity.
d. Data relationships, including the concept of subfigures.

2.1.5.3 Data accuracy requirements. All data transformations shall maintain an accuracy of at least 0.001 units on all parametric and coordinate values and all measurable dimensions. The generating system shall document the accuracy of the file in global section field 19.

2.1.5.4 Mapping of information content to IGES subset entities. Illustration geometry shall be mapped into two dimensional IGES geometry entities and annotation entities. The composite curve, subfigure definition, and subfigure instance entities shall be used to organize the illustration information to preserve any required data relationships. Line weight and line style information shall be represented by the appropriate global and DE parameters. Several entity structures in this subset have been included to keep the file size to acceptable levels. For instance, the use of subfigures greatly reduces file size where illustration details are repeated. Similarly, the general note entity is a compact method of representing annotation entity as compared with the stroking of each character using line and arc geometry. However, there are instances where a system lacks the sophistication of subfigure entity constructs or it is desired to stroke the text for a special appearance not otherwise attainable. Lines, splines, linear curves, arcs, and conic arcs shall not have a zero arc length (zero length curves).

2.1.5.5 User conventions and data organization. A minimum complexity drawing/view entity combination, along with its drawing size property, shall be used to assure an illustration will be created on all receiving systems. The drawing shall be constructed in the positive quadrant. The origin point shall be located at the lower left corner of the illustration.

2.1.5.6 IGES entity subset specification. Table 7 lists the entities of this subset.

Table 7. Figure Viewer Entities and Usage Rules

Entity	Form	Entity Name	DE Notes	PD Notes
0		Null		
100		Circular Arc	3	17

Table 7. Figure Viewer Entities and Usage Rules

Entity	Form	Entity Name	DE Notes	PD Notes
102		Composite Curve	1	4
104	1	Conic Arc	3	17, 20
106	11	2D Linear Path	1	15
106	63	Simple Closed Planar Curve	1	21
110	0	Line	1	2
112		Parametric Spline Curve	1	2, 5
124	0	Transformation Matrix	6	7
126		Rational B-spline Curve	1	8
132*		Connect Point		20
212		General Note	10	11, 18
230		Sectioned Area	1	17
232**		Multimedia		
308		Subfigure Definition	6	4
320*		Network Subfigure Definition		
404	0	Drawing	9	19
406	15	Name Property		16
406	16	Drawing Size Property		
406	17	Drawing Units Property		
406	18	Intercharacter Spacing Property	12	
406**	38	URL Anchor Property		
408		Subfigure Instance	3	2
410		View	6	13
412		Rectangular Array Subfigure Instance	3	2, 14
414		Circular Array Subfigure Instance	3	2, 14
420*		Network Subfigure Instance	3	2

When the form column in table 7 is blank for an entity which has multiple form numbers, all forms of that entity are included in the subset.

* Systems which do not support connectivity shall handle these entities as follows:

Connect Point Entity (Type 132) those entities which are pointed to by the PD #4 and which are within this subset shall be displayed.

Network Subfigure Definition Entity (Type 320) shall be converted to the Subfigure Definition

Entity (Type 308) for display or presentation uses.

Network Subfigure Instance Entity (Type 420) shall be converted to the Subfigure Instance Entity (Type 408) for display or presentation uses.

** For IGES Version 6 files, shall be supported by Internet-capable systems and viewers.

Notes for table 7:

1. DE field 4, line font pattern, shall be 1, 2, 3, 4, or 5
   DE field 5, level, shall be 0.
   DE field 6, view pointer, shall be 0.
   DE field 7, transformation matrix pointer, shall be 0.
   DE field 8, label display pointer, shall be 0.
2. PD values for Z coordinates shall be 0.0.
3. DE field 4, line font pattern, shall be 1, 2, 3, 4, or 5.
   DE field 5, level, shall be 0.
   DE field 6, view pointer, shall be 0.
   DE field 8, label display pointer, shall be 0.
4. PD values shall point only to other entity types within this subset.
5. PD #3, NDIM, shall be 2 (planar).
6. DE field 7, transformation matrix, shall be 0.
7. Translation and rotation are restricted to XY plane. PD #R13, #R23, #R31, #R32 and #T3 shall be 0.0, and #R33 shall be 1.0 or -1.0.
8. PD #3, PROP1, shall be 1 (planar), ZK shall be 0.0, XNORM and YNORM shall be 0.0, ZNORM shall be 1.0 or -1.0. Rarional B-Splines are to be considered functionally and mathematically equivalent to NURBS (Non-Uniform Rational B-Spline) curves.
9. PD #1,number of view pointers, shall be 1.
   PD #5,number of annotation entities, shall be 0.
   PD #6,number of associativity pointers, shall be 0.
   PD #7,number of property pointers, shall be 1, 2 or 3.
   PD #8-#10,a DE pointer to a property (406, form 16) is required, a DE pointer to a property (406, form 15) is optional, a DE pointer to a property (406, form 17) is optional.
10. DE field 5, level, shall be 0.
    DE field 6, view pointer, shall be 0.
    DE field 7, transformation matrix pointer, shall be 0.
    DE field 8, label display pointer, shall be 0.
11. PD #5, font code, shall be 1, 1001, 1002, 1003 or 3001, the Latin-1 character set. If a pointer to a property entity (406, form 18) is used to control intercharacter spacing, then any IGES font value may be used.
12. DE field 5, level, shall be 0.
13. PD #2, scale, shall be 1.0.
    PD #3-#8 shall be 0.
14. PD values shall not point to entity type 412, entity type 414, or an entity 308 which points to a 412 or 414, and shall only point to other entity types within this subset.
15. N (the number of points, PD #2) shall be 3 or more.
16. The name property entity shall take precedence over a name in DE field 18, entity label, for any entity which has a name property.

17. PD value for Z coordinates shall be 0.0.

18. PD value $ZS_{(n)}$ shall be 0.0, where n=1...N.

19. Drawing origin shall be the lower left-hand corner, no negative coordinates are allowed once all appropriate offsets and rotations are applied.

20. conic coefficient B (PD #2) shall be zero (0.0). An associated matrix shall be used to rotate/translate the conic to its position in space.

21. PD #2, number of n-tuples, shall be greater than 2.

22. The geometry pointed to in PD "PTR" shall be displayed, or if defaulted, a plus-symbol displayed and centered on coordinates given.

2.1.5.7 Figure Viewer Application File Processing. The Figure Viewer shall display the graphical content of IGES files conforming to this specification such that the visual appearance depicts the functional intent and is equivalent to requirements specified in IGES Volume 1

Each of the limits and restrictions specified herein constrain the more general specifications found in IGES. The Figure Viewer is required to process the data as restricted by this specification, and may optionally process any data defined by IGES.

The processing of IGES entities shall not produce an exception list, and shall not cause a hault to processing and the display of displayable entities in the file. The required and optional entities and forms are specified in IGES. The functional intent for each entity and its forms is specified in Table 7.

Initial File Processing

The input file shall be checked for characters in the file name extension or the beginning of the file indicating uu-encoding or compression may have been applied to the file. If the file is not clear-text IGES, provisions shall be included to pass the file to an appropriate utility. If an appropriate utility cannot be located, a message shall be presented asking the user to select a handling option.

The file shall be checked for the existance of any of the three characters in character location 73 of the first line of the file as permitted by IGES. If characters other than "S" or "B" or "C" is found, a message shall be

presented asking the user to select a handling option. The Figure Viewer may optionally check the beginning of the file for an empty line or other faulty condition and correct the input as appropriate.

IGES includes specification for three file formats. The character in character location 73 of the first line shall be checked for the character "S" indicating the file is ASCII, and the first line is part of the Start Section (see below).

If the character in location 73 of the first line is "B" the user shall be alerted that the file is IGES Binary format and asked to select a handling option. No further processing of IGES Binary files is required.

If the character in location 73 of the first line is "C" the Figure Viewer may optionally include processing for the IGES-specified compressed form. (Note that the IGES Compressed form is also clear-text ASCII. Further, the IGES Compressed file may have also been compressed or encoded as indicated in the first paragraph of this section.)

The contents of the file shall be processed as follows.

Start Section

No special requirements are added by this Specification. (See IGES Volume 1 for requirements for this file section). Optionally, the Figure viewer may display (in a separate window) the first 72 character locations of each file line containing the character "S" in line location 73.

Global section

Fields in the global section shall be processed for value ranges as specified in Table 6.

Directory Entry and Parameter Data sections

The entities listed in Table 7 shall be processed and displayed. Entities which are not listed in Table 7 shall be ignored.

Terminate section

Any file content following the IGES Terminate section, if any, shall be ignored.

2.1 Drafting AP

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2.2 Three-Dimensional (3D) Piping Application Protocol

Introduction This AP is for exchanging 3D arrangement data of piping system models which includes definition data types of geometry (shape and location), connectivity, and material characteristics. The scope of this AP includes only piping system data and not drawings, internal details of equipment, or interference check results. The AP does support the information required for performing interference analysis and simple one dimensional flow network analysis. The specified piping model is sufficiently detailed to support the fabrication and final assembly of a piping system.

Background The representations discussed in this document were initially developed under the U.S. Navy's SEAWOLF program for exchanging data from the detail design phase to pipe fabrication and assembly. This material has been reviewed and enhanced by NIDDESC and representatives of the process plant industry to develop a specification which meets the requirements of a broad user community of 3D piping applications. The provisions in this version of the AP which allow for the exchange of simple one dimensional flow network analysis are the result of work completed under the U.S. Navy's CAD2 initiative.

Although the AP allows for the use of reference files for the definition of piping parts, this version of the AP does not provide full catalog functionality. A parallel project has been initiated to develop the catalog functionality. When this catalog work is complete, it will be submitted to the Architecture, Engineering, and Construction (AEC) Committee of the IGES/PDES Organization as a proposed extension for this AP.

2.2.1 Application Information Requirements.

Piping Application Piping systems are used to convey and process fluids and gases in a variety of industries, including: chemical and petrochemical processing, power generation, ship and aircraft construction, and food processing. Generally, a piping system is comprised of a network of pipe, pipe fittings, and processing equipment such as pressure vessels and pumps. Large piping systems are generally attached to some supporting structure through the use of piping supports and hangers. Insulation, heat tracing, and vibration or sound damping assemblies are often attached to piping systems.

Many software packages are now available to assist the design and manipulation of 3D models of piping systems. The model contains information about each element of the system as well as that of the system as a whole. It may also contain information about groups of elements within a piping system. The 3D model generally serves as a source of input for numerous activities related to the design, fabrication, and assembly of piping systems.

Scope The scope of this application protocol is the exchange of 3D piping models. For this application protocol, a 3D piping model consists only of piping system data. Specifically excluded are other types of systems that are similarly modeled, i.e., structural steel and concrete, HVAC (heating, ventilating and air-conditioning), and electrical cable tray and conduit systems. The specified piping model is sufficiently detailed to support the fabrication and final assembly of a piping system.

This AP is defined with a core of required data which supports a corresponding set of required piping-related activities. These activities are shown on Figure 1 and are defined in detail in the following section. The AP provides the structure for the addition of sender/receiver defined attributes that could support additional activities such as design, analysis, manufacturing, or logistics.

The sender/receiver would extend the functionality of the core data by passing additional attributes attached to some piping entities. In the description of the parameter data for IGES entities in Section 4.2, the parameter for the number of attributes has been set as "N," and ellipses added after the last required attribute to indicate which entities may include additional sender/receiver defined attributes. These attributes shall be from the Process Plant Attribute List (Alt=4).

2.2 3D Piping AP

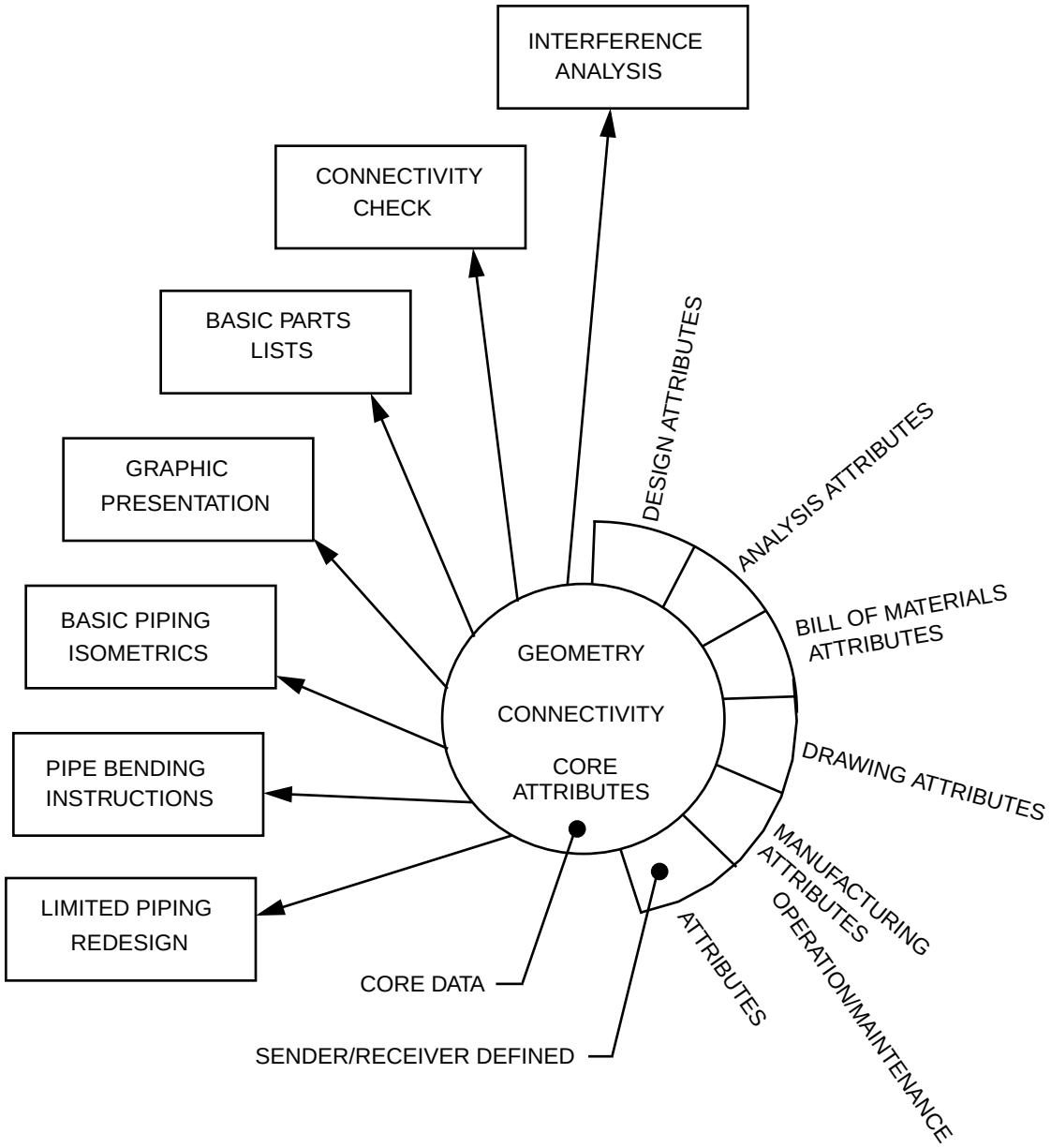


Figure 1: Scope of the 3D Piping IGES Application Protocol
The AP provides the structure for the addition of sender/receiver defined attributes that could support additional activities such as design, analysis, manufacturing, or logistics.

Physical objects that are represented in 3D piping models, and that are defined to reside within the core region of this protocol, are:

1) Pipe - Piping, tubing, or hose, either variable or fixed length.

Note:It is recognized that the pipe path of tubing and hose is not static. However, within this AP, the pipe path of tubing and hose is defined at a nominal static location.

2) Piping Components

A) Commodities -Standard fittings purchasable off the shelf (e.g., elbows, reducers, tees, valves).

B) Specialties -Specialized fittings used for process control (e.g., control valves, relief valves, gauges) or other special functions (e.g., filters, expansion joints, steam traps.)

3) Fasteners -Bolts, gaskets, welds, clamps, etc. that may be needed to join piping components or pipe to other piping components, pipes, or piping equipment nozzles.

4) Piping Supports -Items used to anchor or restrain piping systems.

Note:The scope of this application protocol does not extend to the full detailing of piping support systems. Excluded in particular are full details of structural steel members that may comprise piping support assemblies.

5) Pipe Damping -Items attached to piping systems to protect them from damage due to vibration or shock.

6) Piping Equipment-Pressure vessels, rotating equipment, furnaces, etc. to which piping systems are normally connected via nozzles.

Note:The scope of this application protocol does not extend to the full detailing of equipment items from either a process function or mechanical design point of view.

This AP also supports the grouping of physical objects into structures such as pipe runs, pipelines, piping assemblies, and piping systems. A pipe run is a single path through a portion of a piping system having common attribute values and having one start and one end point. A pipeline is a portion of a piping system composed of one or more pipe runs. A piping assembly is a collection of piping parts and/or other piping assemblies for the purpose of construction (e.g., shop spool pieces and packaged systems). A piping system is a collection of one or many pipe runs, zero, one, or many pipelines, and zero, one, or many pieces of piping equipment that performs a specific function.

2.2.2 Application Core Requirements. This AP (or an application supporting this AP) shall include descriptions of all pipes, components, equipment, piping supports, and pipe damping with sufficient detail to support the following applications on a receiving system:

1. Interference analysis (e.g., 3D solid): A check for spatial conflicts or overlaps between the elements of the 3D piping model. Objects which may be considered in the analysis include:

- pipe
- piping components
- piping equipment
- access envelopes
- insulation envelopes
- other envelopes from another source (e.g., non-piping equipment, structural members, ship hull)

Required data:

- piping system network topology
- piping part location and orientation
- pipe path and nominal pipe outside diameter
- piping component envelope
- piping equipment envelope
- piping support envelope
- installed access envelope
- pipe damping segment
- pipe run attributes, including:
- insulation thickness
- extent of insulation

- piping system identifier
- pipeline identifier
- pipe run identifier
- piping part identifier
- piping support identifier
- pipe damping identifier
- piping joint identifier
- piping part stock number (i.e., commodity code)

Where,

1) Piping system network topology is the data structure within a 3D model which defines how the elements of the model are connected and positioned relative to one another.

2) Connectivity checks: A check on the validity of the piping system network. The following network characteristics can be verified:

- positional consistency
- alignment checking
- end type compatibility

Where,

1) Positional consistency checks verify that there are no gaps or overlaps between the elements of the 3D model which should be "connected."

2) Alignment checking ensures that elements of the model are oriented properly with respect to those to which they are connected.

3) End type compatibility checking ensures that the attachments between connected elements of the model are physically possible (e.g., flanges must be attached only to other flanges of the same nominal diameter and having the same bolt hole pattern).

Required Data:

- piping system network topology
- piping part location and orientation
- pipe attributes, including:
- pipe path
- nominal pipe size
- schedule/wall thickness
- pressure rating
- piping port attributes, including:
- nominal pipe size
- end preparation type
- schedule/wall thickness
- pressure rating
- location and orientation
- piping system identifier
- pipeline identifier
- pipe run identifier
- piping part identifier
- piping support identifier
- pipe damping identifier
- piping joint identifier
- piping part stock number

Where,

1) Piping ports represent attachment points on pipe, piping components, and piping equipment.

2) Piping port location defines the position of an attachment point in space. The orientation defines the

orientation of the flow centerline of the attachment point.

3) Basic parts lists: Produce a listing of the elements comprising the 3D piping model.

Required data:

- piping part stock number
- pipe run attributes, including:
- pipe specification
- pipe run identifier
- pipe path
- pipe attributes, including:
- nominal pipe size
- schedule/wall thickness
- pressure rating
- piping ports attributes, including:
- nominal pipe size
- end preparation type
- schedule/wall thickness
- pressure rating
- fastener quantity
- bolt attributes, including:
- bolt type, length, and diameter
- piping system identifier
- pipeline identifier
- piping assembly identifier
- piping part identifier
- piping support identifier
- pipe damping identifier

4) Graphic presentation: Produce shaded and wireframe images of the 3D piping model on a display screen or hardcopy device using viewing and clipping information added on the receiving system. Although this AP does not provide the capability to exchange drawings, the piping model provided through this AP supports the development of drawings on the receiving system.

It should be noted that the specific parameters selected for graphic presentation must be provided by the user on the receiving system, as the piping model transferred is designed to contain the information needed to produce a drawing, but not the specific attributes a user may wish to assign to a given drawing.

Required data:

- piping part location and orientation
- pipe path and nominal pipe outside diameter
- piping component envelope
- piping equipment envelope
- piping support envelope
- installed access envelope
- pipe damping segment
- pipe run attributes, including:
- insulation thickness
- extent of insulation

5) Basic piping isometrics: Generation of isometric drawings from the 3D model.

Required data:

- piping system network topology

- piping part location and orientation
- pipe path
- pipe attributes, including:
- nominal pipe outside diameter
- pressure rating
- piping component envelope
- piping equipment envelope
- piping support envelope
- installed access envelope
- pipe damping segment
- pipe run part material name
- pipe run attributes, including:
- insulation thickness
- extent of insulation
- pipe run identifier
- piping port attributes, including:
- nominal pipe size
- end preparation type
- pressure rating
- location and orientation
- piping part stock number
- fastener quantity
- bolt attributes, including:
- bolt type, length, and diameter
- piping system identifier
- pipeline identifier
- piping assembly identifier
- piping part identifier
- piping support identifier
- pipe damping identifier

6) Generation of pipe bending instructions: Produce instructions for bending pipe on a pipe bending machine using bending machine tables and bending rules on the receiving system.

Required data:

- pipe path (from which the pipe bend radii can be generated)
- nominal pipe size
- pipe wall thickness
- pipe material name

7) Limited piping redesign: Provide the following limited redesign capabilities:

(a) Modification of the space arrangement by

- rotation and/or translation of pipes, piping components, piping equipment, piping supports, and/or pipe damping
- modification of the pipe path.

(b) Modification of the composition of piping assemblies.

2.2 3D Piping AP

Required data:

- piping system network topology
- piping part location and orientation
- pipe path and nominal pipe outside diameter
- piping component envelope
- piping equipment envelope
- piping support envelope
- installed access envelope
- pipe damping segment
- piping system identifier
- piping assembly identifier
- pipeline identifier
- pipe run identifier
- piping part identifier
- piping support identifier
- pipe damping identifier
- piping joint identifier
- piping part stock number

8) Simple one dimensional flow network analysis: Produce boundary value problem for determining network flow rates and pressure differentials.

Required data:

- boundary values
- transfer functions for pumps
- tank curves
- operating point
- piping system network topology
- friction factors (for components and passive equipments)

Other applications could be supported by this AP with additional data requirements. The current proposed extensions are listed below.

E1. Piping Design: In addition to the functionality specified in “limited piping redesign” of the core AP, piping design includes the following functionality:

- transfer and use of a piping specification
- transfer and use of a component reference catalog
- post-translation placements of transferred components

E2. Extended Piping Isometrics: In addition to the functionality specified in the “basic piping isometrics” of the core AP, extended piping isometrics includes the additional attributes necessary to support isometrics for fabrication and construction. This includes data such as:

- clean/testing requirements
- construction status
- design & operating conditions (pressure and temperature)
- flow direction
- heat tracing media and temperature
- locations on the pipe line of field welds
- locations on the pipe line of isometric sheet breaks
- painting requirements
- project area
- shop/field material status (shop = fabricate in a shop, field = assembly at a site)
- spool numbers

- title block information

E3. Piping analysis: The extraction of geometry and attribute data for input to stress analysis.

E4. Weight Management: The extraction of weight and center of gravity data.

E5. Bill of Material (BOM) Generation: The production of lists of items in the piping model, with sufficient descriptive information to purchase each item. BOM data should include:

- The stock number, size, short description, and quantity of each item in a pipe run or pipeline. The short description should include schedule/wall thickness, pressure rating, materials of construction, and references to details or standards as required to identify the items.
- Cut pipe summary, which accurately accounts for insertion depth at socket weld and threaded connections.
- Identification of items supplied by the shop, supplied by other sources, or provided in the field.

E6. Drawing Creation: Drawings are derived from a 3D model by assembling or composing one or more views of the model together with annotation, dimensioning, and graphics produced by hidden-line removal. Drawings may contain “intelligence” in the sense that if a change is made in the model, a corresponding change occurs in drawings that reference that affected volume of the model. Data structures that support the “intelligence” feature include: associative coordinate labels, associative annotation (i.e., text), and associative dimensioning.

E7. Manufacturing Applications: Additional attributes are provided to support manufacturing of piping equipment and special piping components.

E8. Logistics Applications: Additional attributes are provided to support the Operations and Maintenance portion of the life cycle. This includes data such as:

- customer's item identifier (that ties to other databases)
- valve percent open
- last inspection date
- leakage rate
- last maintenance date

2.3 Layered Electrical Products Application Protocol

This application protocol (AP)[7] for layered electrical product (LEP) assemblies and parts to be incorporated onto such assemblies specifies the structure of Initial Graphics Exchange Specification (IGES)[4] data for the representation of the product definition and for the exchange of these definitions from one LEP defining application to another. Since the LEP application protocol makes use of a specific interpretation of entities in the IGES file, both the sending and receiving processors must conform to this AP with regard to the information they process. It will not suffice to simply use IGES entities listed in a subset in the AP or in IGES or other documents. Proper packaging of connectivity information, for example, is crucial to success of some subsequent operations.

The LEP is defined in this AP for a combination of documents (called presentation) and for the underlying CAD/ECAD data (called representation). The CAD/ECAD data consists of the screen display data and the CAD/ECAD product model itself. The drawing presentation/documentation of an LEP is found in the Drafting AP. For example, the product may be defined through a drawing, such as a Specification Control Drawing, produced manually or on a CAD system. CAD systems may be utilized in such a way as to produce a "paper document" intended primarily for human interpretation. Information such as the electrical schematic and waveforms are frequently treated as human-readable drawing data. Some applications include the CAD or ECAD display information such as the color with which a particular system-layer is displayed. Some applications are developed such that lists may be extracted (e.g., net lists, test probe locations, and drill lists) from the ECAD or CAE model of the product.

2.3.1 Background . The layered electrical product is a complex assembly made up of both graphic and non-graphic information, interrelated through parent/child relations and associations.

LEPs are defined to be modules or subcircuits that are incorporated into larger electronic assemblies, in a hierarchy of devices for use in operational systems. The LEP may be either a monolithic device, such as an integrated circuit, or an assembly such as a hybrid microcircuit or printed circuit, or more than one assembly connected by means of a cable. Typically, an LEP is connected to the larger assembly with external leads or pins. An LEP assembly incorporates an insulating substrate onto which a mix of integrated circuits and other electronic components (such as thick- and thin-film devices) are interconnected.

A neutral data format serves several purposes: It permits the interchange of data between computer-aided design (CAD) and computer-aided manufacturing (CAM) systems. It allows the archiving of the LEP design in a format that can be used in the future, even if the original CAD or CAM systems or their software are no longer in use.

There are a number of motivations for developing a specified representation for LEPs. The most compelling motive is to reduce the errors created by different interpretations of a format as used for a particular product. A specified representation for LEPs can also minimize cost and maximize efficiency in the design and maintenance of translators. These uniform applications can provide means for coping with the increasing complexity of LEPs. In current practice, there is often the need for manual intervention—which sometimes introduces errors—in order to transfer the data between the CAD workstations and to the CAM stations that produce the LEP.

2.3.1.1 Electrical Assembly Complexity. Assemblies have become increasingly complex. One measure of this increased complexity is the ratio of the area of active elements (usually silicon chips) to the unoccupied area of the substrate of a hybrid microcircuit (see [2]). In a single-chip package of a monolithic integrated circuit, the ratio is about 1:20; in today's typical hybrid, the ratio is from 1:10 to 1:6. Present engineering efforts have the goal of raising this ratio to 1:1, i.e., 50% of the substrate would be covered by silicon chips. These high-density hybrids are often referred to as multichip modules, or MCMs. To cope with this expanding complexity, hybrid manufacturing will increasingly depend on CAD and CAM techniques. For practical implementation of combined CAD and CAM techniques, it is important to have a single electronic representation of the CAD data available for interfacing with CAM environments. The representations described in this AP apply to MCM and conventional hybrid technology plus integrated

circuits and printed boards and related products. The technologies of integrated circuits, printed wiring assemblies, flex cables and flex circuits have seen comparable density increases.

Many assembly manufacturers still use extensive paper documentation, such as prints and drawings, to document their product during manufacturing. Often, these drawings are produced on CAD stations that contain information that is not represented on the drawing and yet may be useful during the design process. As automated manufacturing methods become more available, such “paper” documentation will impede manufacturing. Further, as the complexity of electrical products increases, it will become much more necessary to convey this information to manufacturing machines in computer-comprehensible form.

2.3.1.2 Consistent Information for Concurrent Engineering. Another benefit from a unified representation of the data describing a product is the ability to achieve concurrent engineering, which in the case of an LEP permits various automated and human resources to be applied to the design simultaneously. Since these resources share common data regarding the design, it is possible for various groups of engineers to refine the mechanical, electrical, thermal, and testability characteristics of the LEP in a much shorter time than would be required otherwise. In addition, concurrent engineering permits different application specialists to work in parallel with the designer. Thus, for example, those that are responsible for the manufacturing, assembly, quality, and reliability of an LEP design are able to provide suggestions concerning the design from its inception.

This method of business is in sharp contrast to the traditional methods where each department contributed sequentially to the design process of an LEP. Concurrent engineering methods promote a combined effort where all information builds on an existing model and changes can be easily accommodated through the separate functional areas. Since changes in the design are incorporated early in the design cycle, the costs of such changes is decreased. The result of effective concurrent engineering is a product at lower cost and with a shorter design cycle than can be realized with traditional methods. Increased product quality results from accurate data transfer, as opposed to manual regeneration of CAD data on succeeding systems.

There are several existing neutral file specifications to describe electrical and electronic functions. These include specifications developed by the Institute for Interconnecting and Packaging Electronic Circuits (IPC), the Electronic Design Interchange Format (EDIF), the Initial Graphics Exchange Specification (IGES), and the VHSIC Hardware Description Language (VHDL). These neutral file specifications may support many of the data elements needed to represent an LEP design. Adding these formats is encouraged, and may be accomplished by adding the appropriate models to Section 5 of this AP. During such additions, the remaining sections should be refined by agreement between the organizations that are responsible for the formats. Conflicting information requirements (e.g., Sections 3 and 4 of this document) among different formats are not considered appropriate to the goals of product data consistency.

2.3.2 Application Protocol Contents. Section 2.3.2.3 of the AP provides a list of documents which are used in the construction of this protocol. Definitions of terms used in the AP are listed in alphabetical order in Section 2.3.3.

2.3.2.1 Terms and Definitions. In addition to the definitions listed in Section 2.3.3, there are many terms associated with electrical product technologies as discussed below.

Products to which this AP apply are also distinguished by many “technology” terms. In particular, some of the terms which are associated with integrated circuits include custom, application specific integrated circuit (ASIC), gate array, digital, analog, mixed, and monolithic microwave integrated circuit (MMIC). Some of the terms which are associated with hybrid microcircuits include multi-chip module (MCM), single-chip module (SCM), microstrip assembly, thin film circuit, thick film circuit, green tape design, and surface mount technology. Some of the terms which are associated with printed circuit assembly (PCA) include printed circuit board (PCB), printed wiring board (PWB) or assembly (PWA), Flexible Circuits, Flexible Cables, and microstrip board.

The characteristics which distinguish the above domain of product types are their physical product model defined by features on one or more strata. Some features of various strata may be associated with a signal or signal bundle and/or various electrical properties.

The AP-applicable product types may also include features common to mechanical product types. Such features may include base plates, milled pockets, routed edges, threads or threaded inserts, mounting brackets, and heat sinks.

The AP information is applicable to the various ways that parts and components are defined. One way is the (external) package, usually as defined in Joint Electron Device Engineering Council (JEDEC) specifications, or the “footprint” for such a package. Another way may be the depiction of wire bonds electrically connecting a silicon chip to the leads of the package. Yet another way is the depiction of the part assembled as a component on another LEP such as an MCM or a PCA.

2.3.2.2 Scope. Layered Electrical Products include Flexible (Flex) Cables, Flex Circuits, Printed Circuit Assemblies, (includes Printed Wiring Boards), Hybrid Microcircuit Assemblies, Multi-Chip Modules, and Integrated Circuit die. The unifying element common to all these LEP technologies is the series of photomasks used in their manufacture. Practitioners[4] of each technology use some jargon different from all or most of the others, but the concepts are remarkably similar.

The scope of this Application Protocol includes:

- a reduced set of two-dimensional geometry sufficient to describe physical features of Layered Electrical Products, deposited components, and incorporated parts;
- connectivity of Traces, Conductive Areas, wirebonds, and Vias built into the LEP plus Pins, Pads, and Sockets of components incorporated into the LEP;
- patterns of photoplots and masks used in fabricating the LEP substrate;
- data plus context to support automated and semi-automated fabrication (such as numerically controlled drilling, panel layout, and automatic part insertion), testing of some kinds (such as bare board and in-circuit), technical illustrations (including process pictures and maintenance manuals), and Engineering Drawings (including schematics, netlists, bills of material, assembly drawings and layouts). Notice that this AP is not sufficient for these activities (for instance, a drafting AP may be needed to control dimensions and other annotation) but this AP controls the provision of much of the technical information needed by the activities.

The scope of this Application Protocol does not include:

- circuit simulation;
- behavior analysis;
- finite element analysis;
- drafting of engineering drawings;
- production of full color illustrations;
- control of process operations;
- selection of component parts;
- control of automated testing;
- vendor qualification; nor
- dispensing of consumable properties.

The AP may cover some of the activities within its scope in less detail than users might like. If so, such users are invited to send constructive suggestions to the editor of this AP.

2.3.2.3 Application and Core Requirements. This AP applies to electrical designs which were originated in a computer program (herein called “ECAD” system) designed to capture electrical-specific

4. The Application Reference Model in Reference [2], a resource for this document, was developed largely by people working in the domain of Hybrid Microcircuits. Some of the people involved had worked on the Cal Poly model years earlier. That model was developed by a team of people experienced with Printed Boards and Integrated Circuits.

information. (Technically, this term often refers to Electrical Computer Aided Engineering (CAE) systems as well as to Electrical Computer Aided Design (CAD) systems.) Some electrical designs, drawings, or descriptions may be originated on non-ECAD systems sometimes called MCAD systems, and resulting files do not convey the electrical-specific attributes and properties. The following subsections provide guidelines for determining the content of those applications which depend on the electrical data (most importantly connectivity data) defined within ECAD systems.

This AP requires that non-ECAD systems either display the graphics associated with the Network Subfigure Instances and Connect Point IGES entities, or convert them to their internal version of IGES Subfigure Instance and Point entities. Non-ECAD systems are not required to write out IGES files with Network Subfigure Instances and Connect Point entities

Application Information Requirements

The core requirements were determined by examining a portion of the product life cycle. These life cycle tasks were:

- Physical Design Layout
- Manufacturing
- Visualization (for assembly, troubleshooting, etc.)
- Testing
- Logistic Support Documentation

A single LEP design file may be used as the source for several different kinds of processes.

Parts are often involved in a lead preparation step such as lead bending and tinning prior to their being assembled on an LEP. Transfer of part models which specify these intermediate life cycle steps are considered within the domain of this AP.

During these life cycle stages there are data added such as pin swapping and netlist back annotation. These data are added within the CAD or CAE system; the IGES output file following such CAE operations is differentiated by a different file name. Different fabrication facilities have different capabilities and different pre-defined processes. Thus it may be premature for the IGES file to contain detailed information governing the fabrication processes prior to the selection of a facility and receipt of a commitment at that facility. As concurrent engineering becomes a reality, this will be less of a concern because the fabrication planner will participate in the definition captured and then transferred using IGES.

This AP is not applicable to the electrical product life cycle phases preceding the capture of the structural design by way of a schematic drawing or netlist representation unless the behavior is presented as a graphic such as a waveform. Where product behavioral definition exists in a data format other than IGES, provisions will be defined for the association of behavior at a logical pin (or “port”) with a schematic or physical pin defined within the IGES file. Such association is frequently achieved in CAE systems by matching on the assembly component’s reference designator and pin number occurring in each data definition.

The information for all life cycle phases may originate in a computer aided design (CAD) system. Some information may only be computer-processed within a Computer Aided Engineering (CAE) system. Or, part of the information for any category may be created by manual—non-CAD/CAE— means. LEP information from any source must be constrained semantically for use within the AP, and further, the requirements for the IGES form defined herein are (syntactically) constrained by the constructs in the application interpretation model.

All functionality categories which have been originated in a CAD system are capable of being transmitted to another, or to an intermediate CAD or CAE system. In this event, much of the information may be “exchanged” without distinction. When electrical-specific information has been added by a CAE system, such information may not be comprehensible by a CAD system. The CAD system receiving a CAE-created file is required to ignore (i.e., to not process) the connectivity and electrical property entities, but to process and display the physical product model.

All information originated from a CAE system shall be processed by another CAE system; whether through

direct conversion into the CAE native data, or through display to the CAE operator in such a way that the information may be accommodated by manual entry means.

For example, a design exchanged between CAD systems may adopt a level of information content that is greater than the Drawing. The receiving CAD system would benefit by “knowing” the properties and rules defined in the source system in addition to the depiction of the product as a graphic drawing.

LEP Entity Usage for Core Applications

Section 5 identifies objects, which in turn define which entities are required to support a specific application. For example, production test requires Network Subfigure Instances (representing components) and Connect Points (representing pins), in order to identify each testable point uniquely.

Entities may not always map directly between various applications. Section 6.6 contains guidelines for specific applications. For example, within the photolithography application, some programs will accept complex geometry, text strings, tapered lines, and subfigure constructions. Other programs can understand no more than simple fixed width lines (no arcs), and a few predefined geometries called flashes.

There are two different ways of looking at this problem. One approach would have the LEP AP detail which entities may be found in conformant files, implying a method to process those entities into something the application would accept. The second approach would detail which entities will probably be accepted by the application. The LEP AP follows the first approach, and assumes there is a tool available to perform required tasks of simplifying and remapping entities from the LEP AP conformant file.

2.3.2.4 Normative References. This AP is specifically applicable to IGES Version 6.0. The versions of IGES listed below include electrical product capability; any one of them may be cited in an exchange. Earlier versions of IGES may contain electrical product-defining objects compliant with this AP.

In the event of conflicting LEP requirements, IGES shall take precedence over this document. This document shall take precedence over other IGES application protocols.

IGES versions 1.0, 3.0, 4.0, and 5.2 have been registered as an American National Standard (ANS) Y14.26M by the American National Standards Institute. Additionally, IGES version 4.0 is registered by NIST as a Federal Information Processing Standard; FIPS PUB 177. IGES electrical-related entities and the versions in which each was first published are identified in Section 5 of this document.

1. IPC-T-50E, “Terms and Definitions for Interconnecting and Packaging Electronic Circuits,” February, 1991, Institute for Interconnecting and Packaging Electronic Circuits, Lincolnwood, IL 60646.
2. MIL-H-38534, “Hybrid Microcircuits, General Specification for,” 31 March 1989.
3. The Initial Graphics Exchange Specification (IGES) Version 6.0; available from the U.S. Product Data Association, Suite 204, 5300 International Blvd., N. Charleston, SC 29418; (803) 760-3327.

2.3.2.5 Informative References. 4.Information on obtaining The Initial Graphics Exchange Specification (IGES) Versions 3.0 (1986), 4.0 (1988), 5.0 (1990), 5.1 (1991), 5.2 (1993), and 5.3 (1996) may be obtained from the U.S. Product Data Association, Suite 204, 5300 International Blvd., N. Charleston, SC 29418; (803) 760-3327.

5. O’Connell, L., “Guide to the IGES Electrical Entities,” EACP-2.3, unpublished, June 24, 1989, Available from IPO Office, National Institute of Standards and Technology, Bldg. 220, Room A-127, Gaithersburg, MD 20899
6. Harrison, R.J. and Palmer, M. E., “Guidelines for the Specification and Validation of IGES Application Protocols” NISTIR 88-3646, January 1989. Available from the National Technical Information Service (NTIS), Springfield, VA 22161, October 1990, (110 pages).
7. “Integration Definition for Information Modeling (IDEF1X),” FIPS PUB 184, National Institute of Standards and Technology, Computer Systems Laboratory, Gaithersburg, MD 20899, December 21, 1993.
8. “Integration Definition for Function Modeling (IDEF0),” FIPS PUB 183, National Institute of Standards and Technology, Computer Systems Laboratory, Gaithersburg, MD 20899, December 21, 1993.

9. Parks, C., “Tutorial: Reading and Reviewing the Common Schema for Electrical Design and Analysis,” Proceedings of the 24th Design Automation Conference; IEEE & ACM, June 30, 1987, paper 27.2.

10. Loomis, M., “Data Modeling - The IDEF1X Technique,” Proceedings of the IEEE 1986 Phoenix Conference on Computers and Communications, Phoenix, AZ, page 146-149.

11. Tsichritzis, D.; Klug, A.; *The ANSI/X3/SPARC DBMS Framework Report of the Study Group on Database Management Systems*, X3 project 226, 1977, AFIPS Press, 210 Summit Avenue, Montvale, NJ 07645

12. ISO/IEC 10641-1993(E) *Information Technology - Computer Graphics and Image Processing - Conformance Testing of Implementations of Graphics Standards*. First Edition, 31 pp., CH-1211 Genève 20, Switzerland.

13. Parks, R., “CADCAM-035; An IGES Electrical Test,” Sandia National Laboratories, Albuquerque, NM 87185, SAN87-0489.UC-13, March 1987.

2.3.3 LEP Constructs. The layered electrical product is a complex assembly made up of both graphic and non-graphic information, interrelated through parent/child relations and associations. This Section provides the additional detail about IGES entities and structures for given use applications. The range of applications is indicated in figure 2. This information supplements and enhances the object descriptions in Section 3.4.

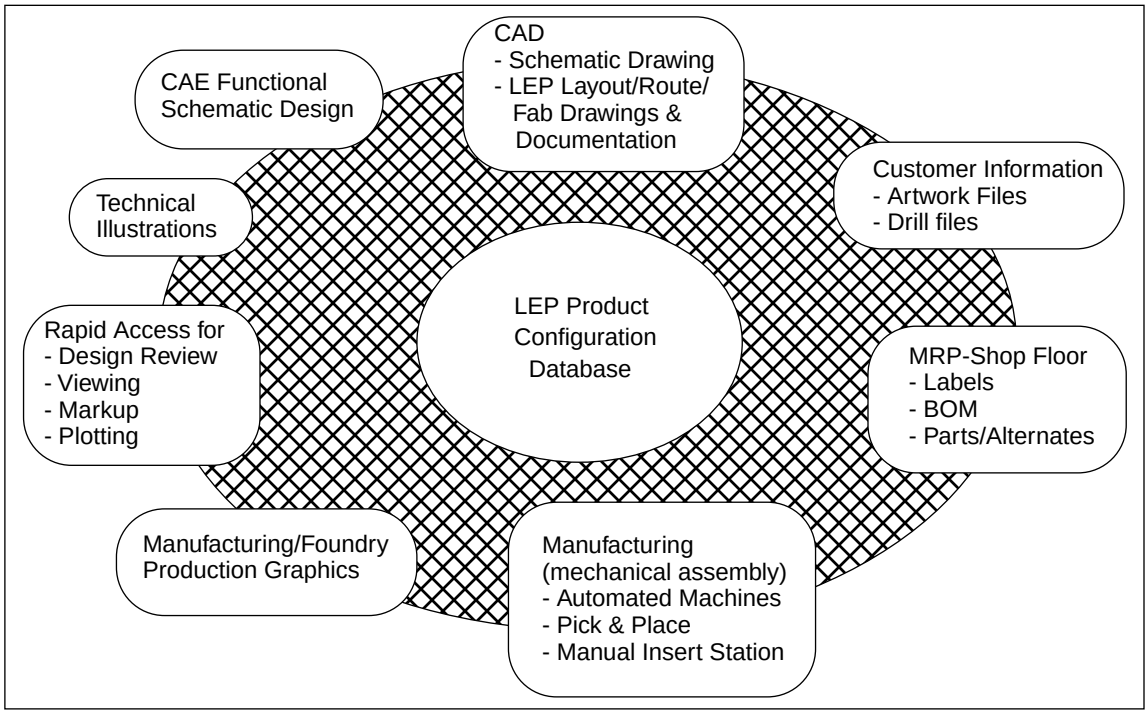


Figure 2. LEP Information Interface Requirements

2.3.3.1 LEP Constructs Supporting Signal Conductivity.

j**oins:** Joins are herein defined as the physical product’s patterns which provide circuit connectivity. Traces and pads use simple geometry entities such as lines and arcs. They interconnect electronic Components and carry Signals. Physically, they have a specific width. Portions of the resulting join may be deposited on more than one layer. Joins usually pass between the different layers by means of *vias* and through-pins.

jumpers: Jumpers are a physical interconnect which may be implemented as a component or a trace. The jumper and the other joins it connects shall bear a single signal name.

planes: Planes, such as ground and power planes, outline the appropriate (filled) areas.

vias: Vias are holes made through two or more layers on the LEP. They are plated so they can carry the Signal. The holes are made by different means such as drilling, milling or cutting. This variability makes it hard to select specific entities which relate to some aspects of v*ias.* However one makes the hole, the functions of the via are still the same. Vias may be through, blind, or buried. Vias are often used as Test Points.

padstacks (through and SMT): Padstacks provide the electrical interface between the LEP PWB and the Component. Padstacks may be either through-hole or surface mount. Each Padstack shall have a LEP defined property to identify which type it is.

2.3.3.2 LEP Constructs Supporting a Physical Representation. A physical LEP shall contain at least one simple closed planar geometry entity depicting the LEP outline. This LEP *CLOSED CURVE* may be a *KEEPIN/KEEPOUT*, tool path, or any other functional type of closed geometry entity.

Several applications require a PDQ LEP representation. Computer controlled equipment may then extract needed data without manual intervention. For example, Component insertion equipment can put a Component at the X, Y coordinates specified by the Network Subfigure Instance Entity (Type 420) locating the Component.

Operations which modify the physical representation of the LEP, such as scaling or rotation, will have adverse affects on some application systems. Constructs which are beyond the scope of an automated operation (such as dimensions and view/draw) could stall or disable the processing system.

2.3.3.3 LEP Constructs Supporting a Logical Representation. A logical LEP element (e.g., a gate or a driver) shall be represented by a Network Subfigure Definition Entity (Type 320). The Definition may or may not reference a *CLOSED CURVE* depicting a schematic symbol. In either case, the Network Subfigure Definition Entity (Type 320) shall list the ports corresponding to physical connect points. The corresponding Connect Points (Type 132) referenced by the Network Subfigure Instance Entity (Type 420) may participate in logical flow associativities. Physical locations are not needed. If present, they locate symbols and port representations in the “drawing space” of the schematic.

2.3.4 LEP Constructs Supporting Intelligent Representation. The *intelligent representation* of a LEP includes uniquely identified data objects and attributes of the product model. These data enable the extraction of information by queries in support of activities subsequent to the design and layout of the LEP. Rather than refer to the files and product representations as *intelligent*, we shall herein call them “Product Data by Queries” or **PDQ** representations. For example, when we can extract a component’s reference designator (e.g., “R1”), and the number of a pin providing a particular function, automation support may be provided for shop processes, such as component insertion, testers, pick/place, inspection, and others.

IGES allows many different ways to add semantics to a file. Among these ways are using properties, associativities, groupings, and even attributes. One way uses the level on which an entity is found. Another uses the color of the entity. These may seem like clever schemes which make it easy for users or vendors to support the semantic convention. However, it actually leads to confusion, frustration, and reduced semantic information exchange when the convention is not both well documented and universally supported. This Section provides the additional detail about IGES entities and structures for given use applications. This information supplements and enhances the object descriptions in Section 3.3.

The Application Protocol for a PDQ LEP will focus on the use of IGES Property Entities (Type 406) to add more semantic information to the LEP.

This section specifies what entities may appear in conformant files in a PDQ LEP representation. This section also specifies what entities are required in a PDQ LEP. Some of the required entities are Property Entities (type 406). It is not difficult for a pre-processor to include these Properties when writing an IGES file. This approach does assume though, that the data for the Properties do exist in the native database of the sending system. For example, the component_height property is required for several applications. However, if the value is not contained in the part data within the originating CAD system, the component_height property cannot be generated in a conformant way. This may lead to rejection of an IGES file for non-conformance when the fault was not with the IGES preprocessor.

2.3 LEP AP

Please remember that all rules and requirements which apply to all IGES entities used still apply to those conformant to the LEP AP. For example, a zero length text string is non-conformant and the maximum pre-defined Color Number is eight.

DE Fields are NOT expected to convey meaning. DE fields shall not convey any semantic information beyond their specific use. DE fields 1,2,10,11,14,15, and 20 are artifacts of the physical format of the IGES file, and shall not provide semantic information.

The following section describes entities which appear in a PDQ LEP representation

2.3.4.1 LEP Usage of Geometry. Geometry entities may represent many distinct kinds of LEP objects and features. Examples include a LEP outline, a surface mount Pad, and a strangely shaped power plane. In each case, the geometric shape depicts the object or feature graphically. In some cases, the same IGES entity types may have been used for each object. Thus, no semantic information is provided by most Geometry (type 1xx) entities.

Geometry entities may also represent non-electrical objects and features such as tooling holes, *FIDUCIALS*, LEP outline(s), and heat sinks. Electrical parts such as Vias, Components, edge connectors, paste resistors, SMT Pads, testpoints, Padstacks, Traces, jumpers, and signal planes are represented in like manner.

Most of the geometry (but not all) will be on the X-Y plane, with Z being 0.0. Even the geometry representing signals on top, inner, and bottom layers will have Z = 0.0. The Z depth of each layer is determined by the substrate thickness and the sequence of layer assembly.

The bulk of the LEP Application needs for geometry do not require exotic Geometry entities. So, a reduced set of Geometry entities permitted in an LEP AP conformant file has been defined. This reduced set, the "LEP Geometry Entities," is defined below.

There are two uses of geometry in the LEP AP. One use is to define enclosed areas, the other is to define a non-closed linear path as defined in Section 3.4.3 and as detailed below.

Enclosed areas may be defined with a single circle, a multi-segment line, or a combination of geometries which are grouped together. A single Geometry Entity shall represent or associate the constituent Geometry Entities that enclose the given area. The Circular Arc Entity (Type 100) and Copious Data Enclosed Planar Curve Entity (Type 106, Form 63) are examples of single entity enclosed areas. Multi-entity paths which form an enclosed area and are subordinate to an occurrence of a Composite Curve Entity (Type 102) typify a multi-entity enclosed area.

Levels may imply grouping, but shall not imply function. The Level Function Property Entity (Type 406, Form 3) shall assign function.

The following "LEP Geometry Entities" (as restricted in this section) may appear in LEP AP conformant files:

Circular Arc Entity	(Type 100)
Copious Data Entity	(Type 106, Forms 11 and 63)
Line Entity	(Type 110)
Point Entity	(Type 116)
Flash Entity	(Type 125)
Connect Point Entity	(Type 132)
Composite Curve Entity	(Type 102)
Plane Entity	(Type 108)
Transformation Matrix Entity	(Type 124)

(The determinant of the Transformation Matrix shall be +/- 1.0)

(no other scaling shall appear in conformant files.))

Filled areas shall use the Sectioned Area Entity (Type 230). Only the (full circle) Circular Arc Entity (Type 100), Composite Curve Entity (Type 102), Flash Entity (Type 125) and Simple Closed Planar Curve Entity

(Type 106, Form 63) shall represent areas which are shown filled.

The Flash Entity (Type 125) shall not reference a Transformation Matrix.

2.3.4.2 LEP Usage of Annotation. The following annotation entities may appear in conformant files:

General Note Entity	(Type 212, Form 0) (Type 212, Forms 1,6,7,8) as required for technical illustrations (see 5.3.1.3 and 6.6.3.5).
Sectioned Area (fill area)	(Type 230, Form 0) fill patterns 0,19 only

The Sectioned Area Entity (Type 230) shall depict filled areas such as irregularly shaped signal planes, ground planes, or power planes. Only the (full) Circular Arc Entity (Type 100), Composite Curve Entity (Type 102), and Simple Closed Planar Curve Entity (Type 106, Form 63) shall be filled by the Sectioned Area Entity. Only the unfilled Fill Pattern (0) and the solid filled Fill Pattern (19) of the Sectioned Area Entity (Type 230) shall appear in conformant files.

Multimedia Entity	(Type 232) as required for non-CAD presentation annotation

Color Definition Entity (Type 314) is not required for preprocessors by this AP, but support is required by IGES for post- processors. Please refer to the discussion in section 2.3.5.

No other annotation entities shall appear in conformant files.

2.3.4.3 LEP Usage of Structure (Excluding Properties). The following seven structure entities may appear in conformant files:

Subfigure Definition Entity	(Type 308)
Subfigure Instance Entity	(Type 408)
Network Subfigure Definition Entity	(Type 320)
Network Subfigure Instance Entity	(Type 420)
Text Display Template Entity	(Type 312)
Attribute Table Definition Entity (ALT=2)	(Type 322)
External Reference Entity	(Type 416)

2.3.4.4 LEP Usage of Existing Specific Property Entities. One of the easiest and most widely supported methods for adding more semantic information to an entity or group of entities is the Property Entity (Type 406). A property is a well defined mechanism in IGES. One entity may have several Properties. One Property may apply to many entities. An entity may exist with no Properties, and a Property may be in a file but not referenced by any entity. The second group of additional pointers (see IGES section 2.2.4.4.2) provide the mechanism for referencing Properties.

The conformant LEP representation will use Properties in adding both graphic and non-graphic information in the file. Properties are of Type 406. The conformant LEP representation will use existing Properties whenever possible. The Generic Data Properties detailed in this AP shall be used in most other cases.

Definition Level Property Entity (Type 406, Form 1) allows an entity (or entities) to exist on more than one level. The DE Level field of the target entity (or entities) contains a pointer to the Definition Levels Property. The Definition Levels Property shall list all the levels on which the target entities exist. For example, the DE field of a Drilled Hole Property may contain a pointer to the Definition Levels Property which lists all the levels penetrated by the drilled hole.

Region Restriction Property Entity (Type 406, Form 2) shall identify keepin/keepout areas for Traces, Components and Vias.

Line Widening Property Entity (Type 406, Form 5) shall specify line geometry thickness (e.g. to depict Trace width).

Drilled Hole Property Entity (Type 406, Form 6) shall describe a drilled hole size, plating, and affected

levels.

Part Number Property Entity (Type 406, Form 9) shall assign up to four different unique identifiers for referencing a Component. The property provides for a generic part number, a military standard part number, a vendor part number, and an internal part number. Components (such as those represented by a Network Subfigure Instance) are the primary users of this Property.

Tabular Data Property Entity (Type 406, Form 11) shall be used when a file requires annotation for simulation or analysis (SPICE, FEM, etc.).

Name Property Entity (Type 406, Form 15). The name Property may exist in the file, but shall not convey LEP semantic information. Specifically, it may name a level, but it shall NOT imply a level function.

Level to LEP Layer Map Property (Type 406, Form 24) shall define a correspondence among four items: 1) An exchange file level number, 2) A native level identifier, 3) A physical LEP layer number, and 4) A pre-defined functional level identification.

2.3.4.5 LEP Usage of the (Augmented) Generic Data Property Entity. Several new Properties are introduced in order to simplify and extend the capability of IGES for the exchange of LEP semantic information. These Properties all share a common form number. Thus, they must use pattern matching to determine the name, and therefore the function, of the Property. While this method increases processing time, it does allow a file to be complete and self contained. See Section 3.3.2.30 for definitions of these new Generic Properties.

2.3.4.6 LEP Usage of Simulation/Analysis Annotation Entities. Several entities provide attributes appropriate for circuit simulation, analysis, and other (e.g., finite element) modeling when it is desired to so annotate the LEP representation. While these annotations are not usually found in a general product definition file, these entities are useful during design and development life cycle phases. See Section 3.3.1.3 for the IGES file structure using these entities.

2.3.4.7 Entities Which Shall NOT be Used in a PDQ LEP Representation. The following entities are those which have similar functionality to recommended entities. They shall not be used in LEP AP conformant files.

Reference designator Property Entity (Type 406, Form 7)
Reference designator is assigned in Network Subfigure Instance (type 420)

Pin Number Property Entity (Type 406, Form 8)
Pin number is assigned in Connect Point Entity (Type 132)

2.3.5 LEP Entity Usage for Core Applications. Some physical representations are common to many different application areas. This section will discuss these core applications. This Section provides the additional detail about IGES entities and structures for given use applications. This information supplements and enhances the object descriptions in Section 3.3.

The LEP core applications include engineering and design tasks such as schematic entry, netlist generation, auto-placement, auto-route, and Component engineering.

This LEP application **does** require a PDQ data repository.

All constructs specified in 2.3.5 apply when an LEP product is fully contained in a single file. When the LEP is described with a hierarchy of designs—each design in a separate file—the PWB component of the assembly shall contain those features required for the PWB only as described in 2.3.9. When the hierarchy of designs is used, features such as padstacks, traces, drilled holes, and fiducials are found in the PWB file, and the LEP assembly file includes the identification of the PWB design required. NOTE: The use of “PWB” is intended to include the substrate for a MCM or other LEP product-types.

2.3.5.1 LEP Entity Usage for Padstack Representation. A Padstack shall be represented by an ordinary Subfigure Definition Entity (Type 308) as specified in 3.3.2.18.

The Padstack shall contain, at a minimum, one simple Closed Curve which represents a conductive area. That conductive area joins two signal carriers into one. This conductive area shall exist on at least one Level

in the IGES file. That level shall be set in the Level field of the geometry entity. [The desired setting may require the use of a Hierarchy Property Entity (Type 406, Form 10).] More than one layer may share the same conductive area by application of the Definition Levels Property Entity (Type 406, Form 1).

Different geometric shapes which perform different functions (such as isolating a through-pin from a signal plane) may appear in the Padstack.

Physical Padstack Definition

Entities required:

A Subfigure Definition Entity (Type 308) shall define each Physical Padstack. Each such definition shall have an *LEP SEMANTIC PROPERTY* named component_default_padstack.

A *CLOSED CURVE* shall enclose the area of each Land in the Physical Padstack. See Geometry below for more details.

A Sectioned Area Entity (Type 230) shall fill the *CLOSED CURVE* which depicts a *LAND*. Only the Fill Patterns specified by code 0 (blank fill) and code 19 (solid fill) of the Sectioned Area Entity (Type 230) shall appear in conformant files.

Geometry -

At least one *CLOSED CURVE* shall define the outline of the area which represents the conductive Land in a Padstack. One of four LEP Geometry Entities shall depict each Land. Those four are: the (full) Circular Arc Entity (Type 100), the Composite Curve Entity (Type 102), the Flash Entity (Type 125), or the Simple Closed Planar Curve Entity (Type 106, Form 63).

Annotation -

The *CLOSED CURVES*(s) enclosing the conductive area of the Land(s) in the Physical Padstack shall (each) reference a Sectioned Area Entity (Type 230). That Sectioned Area shall reference an *LEP SEMANTIC PROPERTY* named component_pkg_type (=pad). No other Annotation Entities shall appear as part of a Physical Padstack representation.

Structure -

The Subfigure Definition Entity (Type 308) shall depict the Physical Padstack. The Transformation Matrix field of the Subfigure Definition shall be zero. The Subfigure Definition shall reference each *CLOSED CURVE* described above as annotation. Each Closed Curve shall reference a Sectioned Area Entity (Type 230) with a Fill Pattern of 0 or 19.

Associativities -

Conformance to the LEP AP does not require any Associativities in the definition of the Physical Padstack.

Properties -

The Subfigure Definition Entity (Type 308) defining the Padstack shall reference the following two properties:

LEP SEMANTIC PROPERTY named physical_padstack_definition

LEP SEMANTIC PROPERTY named component_pkg_type (=pad).

Drilled Holes Included in a Padstack.

Entities required:

A Point Entity (Type 116) shall locate the Hole. Each such Point Entity shall reference a Drilled Hole (Type 406, Form 6) Property.

Geometry -

A Point Entity shall provide the x, y location of the Hole(s) within the Padstack definition space.

Annotation -

Conformance to the LEP AP does not require any Annotation Entities in the representation of the Padstack.

Structure -

The Padstack Subfigure (type 308) shall reference one Point Entity (Type 116) for each hole. The Transformation Matrix field of the Point Entity (type 116) shall be 0.0. The Point Entity (Type 116) shall reference the Drilled Hole Property (Type 406, Form 6).

If the Point Entity (Type 116) references another Subfigure Definition Entity (Type 308) for display purposes, that definition shall exist in the same physical IGES file as the Point. More than one Padstack may use the same display definition.

Associativities -

Conformance to the LEP AP does not require any Associativities in the representation of the Point.

Properties -

The Point Entity (Type 132) locating the Padstack Hole shall reference the following Property:

The Drilled Hole (Type 406, Form 6) Property.

The Drilled Hole Property shall specify the Drill diameter size, the Finish diameter size, and the Plating indication flag of a plated Component Pin or Via hole. The DE Level field of the Drilled Hole Property Entity (Type 406, Form 6) shall be zero for a through-hole which passes through the entire LEP. The DE Level field of the Drilled Hole Property Entity (Type 406, Form 6) shall reference a Definition Levels Property Entity (Type 406, Form 1) for a Hole which does NOT go all the way through the PWB. That Definition Levels Property shall indicate which levels are penetrated.

The Point Entity (Type 132) locating the Padstack Hole shall specify one of the following two Properties:

The test_point *LEP SEMANTIC PROPERTY* named not_allowable_test_point or

the test_point *LEP SEMANTIC PROPERTY* named allowable_test_point.

If neither is referenced, the not_allowable_test_point semantic shall apply.

2.3.5.2 Display Appearance of Holes in a Padstack.

Entities required:

A Point Entity (Type 116) locating the Padstack Hole may reference a Subfigure Definition Entity (type 308) to display the presence of the *HOLE*. If the Point does not reference a Subfigure Definition in the file, the receiving system may display the default system icon for Point graphics instead.

Geometry -

A Subfigure Definition Entity (Type 308) may depict the presence of the *HOLE* as illustrated in Figure 3. One *CLOSED CURVE* may define the outline of the area which represents the *HOLE* in a *PADSTACK*.

Annotation -

Conformance to the LEP AP does not require any Annotation Entities in the representation of the *HOLE*.

Structure -

The Point Entity (Type 116) may reference one Subfigure Definition (Type 308). The Transformation Matrix

field of the Point Entity (Type 116) shall be zero.

Table 8. IGES Data Fragments Showing Padstack Structures

Entity Type	Form	DE Status	Parameter Data
308	0	010201	308,0,11Hpad_060_038,3,3,5,7,0,1,9;
100	0	010001	100,0.0,0.0,0.0,0.09,0.0,0.09,0.0;
230	0	010101	230,03,19,0.0,0.0,0.0,0.005;
116	0	010001	116,0.0,0.0,0.0,0,1,11;
406	27	020301	406,2,3,8HPadstack,3,17Hthru_hole_regular;
406	6	020301	406,5,0.046,0.038,1;
408	0	000001	408,1,0.2,0.2,0.0,1.0;

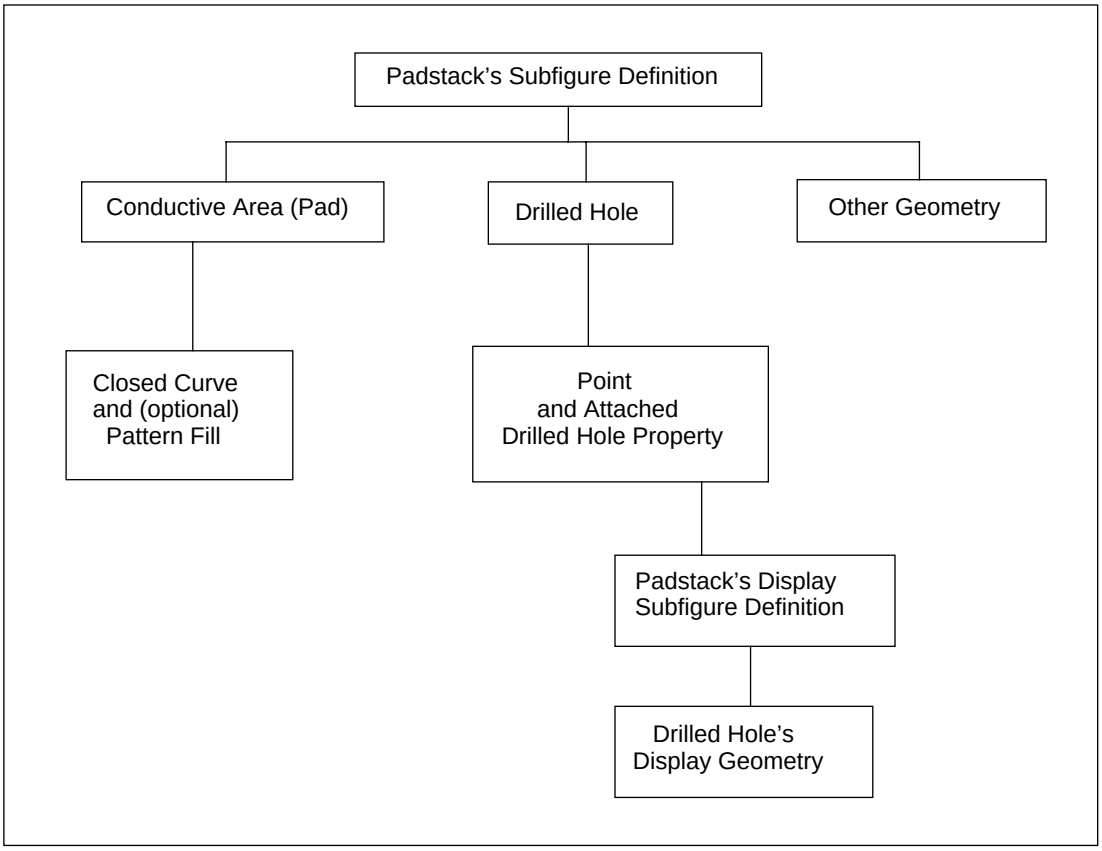


Figure 3. General Structure of Objects Found in a Padstack

Associativities -

Conformance to the LEP AP does not require any Associativities in the representation of the Point Entity (Type 116).

Properties -

The Subfigure Definition Entity (Type 308) depicting the Padstack Hole shall reference the following Property:

LEP SEMANTIC PROPERTY named physical_outline.

2.3.6 LEP Entity Usage for Physical Component Representation. There are two parts to the representation of Physical Components in an IGES file. The first part is the definition. The second part is the instance. Multiple occurrences of similar Physical Components may share a single Definition. Connect Points in each Instance need to correspond exactly to their counterparts in the Definition. Circuit nodes, or Signals are represented by Flow Associativity Entities (Type 402, Form 18).

2.3.6.1 Physical Component Definition. The Physical Component itself is simple to represent. It requires a Network Subfigure Instance Entity (Type 420). Although its definition may be shared with other Instances, a Network Subfigure Definition Entity (Type 320) is also needed. One Connect Point Entity (Type 132) for each *PIN* or Pad is also needed. The Connect Points of the Instance may each reference a Flow Associativity Entity (Type 402, Form 18). The Flow Associativity shall group all the pertinent objects subjected to the same electrical signal (*NET*).

Entities required:

A Network Subfigure Definition Entity (Type 320) shall define each Physical Component in the AP conformant files. Each Network Subfigure Definition (Type 320) shall reference as many LEP Geometry Entities as needed to depict the Component. Each Network Subfigure Definition Entity (Type 320) may reference many of the properties listed below. Conformance to the LEP AP does not require any Text Display Template Entities (Type 312) in the representation of the Physical Component. At least one Connect Point Entity (Type 320) shall provide a means of connecting signals to Pin 1 of the Component.

Geometry -

One Closed Curve shall define the outline of the Physical Component in the X, Y plane of the LEP. Each Closed Curve shall have one LEP Property attached to it which defines its function. Examples of LEP functions include: placement_outline, thermal_outline, physical_outline, and footprint.

Any LEP Geometry Entity may appear as part of the Component Geometry. All LEP Geometry shall lie entirely in the Z = 0.0 plane.

Annotation -

Conformance to the LEP AP does not require any Annotation Entities in the representation of the Physical Component Definition.

Structure -

The Network Subfigure Definition Entity (Type 320) shall reference one or more LEP Geometry Entities. Each Geometry Entity may reference some properties. The Network Subfigure Definition Entity (Type 320) shall reference at least one property. The Network Subfigure Definition Entity (Type 320) Type Flag shall indicate (TF = 2) because the type is physical. The Network Subfigure Definition Entity (Type 320) shall reference one (for pin 1) or more Connect Point (Type 132) entities. The Transformation Matrix field of the Network Subfigure Definition Entity (Type 320) shall be zero.

Associativities -

Conformance to the LEP AP does not require any Associativities in the representation of the Component Definition.

Properties -

Mandatory Properties:

The Network Subfigure Definition Entity (Type 320) defining the Physical Component shall reference the LEP Semantic Property Entity (see Section 3.3.2.31).

2.3.6.2 Physical Component Instance.
Entities required:

The Network Subfigure Instance Entity (Type 420) locates the Component occurrence and provides a way to connect to its ports. A Connect Point Entity (Type 132) models each port (Pin or Pad). The Reference Designator shall be provided in the PRD parameter of the Network Subfigure Instance Entity (Type 420). The Part Number(s) shall be provided in the Part Number Property Entity (Type 406, Form 9). Other properties provide such information as whether the Component is attached to the top or the bottom of the LEP and how many 90 degree rotations (with the rotation axis perpendicular to the surface of the LEP) are required for insertion processes.

Geometry -

A Connect Point Entity (Type 132) having an *LEP SEMANTIC PROPERTY* named pad_tech_type shall represent each Component Pin or each Component Pad in LEP AP conformant files. That property shall specify whether the Pad or Pin is of type surface mount (SMT) or through-hole. One of the Connect Points shall also reference an *LEP SEMANTIC PROPERTY*) named pin1.

One Connect Point Entity (Type 132) shall appear in the Network Subfigure Instance Entity (Type 420) for each Pin in the referenced Network Subfigure Definition, whether the Pin is actually used or not.

Annotation -

Conformance to the LEP AP does not require any Annotation Entities in the representation of the Physical Component Instance.

Structure -

The Network Subfigure Instance Entity (Type 420) shall reference one and only one Network Subfigure Definition Entity (Type 320). The Instance shall also specify the location of the Component with respect to the origin of the LEP.

The Network Subfigure Instance Entity (Type 420) shall reference one or more Connect Point Entities (Type 132).

Associativities -

The Connect Points of the Instance may each reference a Flow Associativity Entity (Type 402, Form 18). The Flow Associativity groups all the pertinent objects subjected to the same electrical signal.

Properties -

Mandatory Properties:

The Network Subfigure Instance Entity (Type 420) modeling the Component shall reference the following three properties:

Part Number Property Entity (Type 406, Form 9)

LEP SEMANTIC PROPERTY named component_instance_side

LEP SEMANTIC PROPERTY named component_instance_rotation.

Each Connect Point Entity (Type 132) modeling a Component Pad or Pin shall reference the LEP Semantic Property Entity (see Section 3.3.2.32).

2.3.6.3 Physical Connect Point.
Entities required:

Connect Point Entities (Type 132) shall locate the place where a connection may occur between the Component and the LEP. One Connect Point Entity (Type 132) shall appear in the Network Subfigure Definition for each Pin in the corresponding Physical Component.

Geometry -

See Entities required above and Structure below. Any LEP Geometry Entity may appear as part of the Physical Connect Point geometry. All LEP Geometry shall lie entirely in the Z = 0.0 plane.

Annotation -

Conformance to the LEP AP does not require any Annotation Entities in the representation of the Physical Connect Point.

Structure -

The Connect Point Entity (Type 132) may reference one or more LEP Geometry Entities.

Each Geometry Entity may reference some properties. The CID parameter of the Connect Point shall provide the Pin Number. The Transformation Matrix field of the Connect Point shall be 0.0.

Associativities -

Each Connect Point Entity may reference a Flow Associativity Entity (Type 402, Form 18). The Flow Associativity groups all the pertinent objects subjected to the same electrical signal.

Properties -

Each Connect Point Entity modeling a Physical Connect Point may reference the following Properties:

Definition Levels (Type 406, Form 1) Property.

LEP Semantic Property Entity (see Section 3.3.2.32).

2.3.6.4 Physical Via.

Entities required:

The Connect Point Entity (Type 132) models the Via. The Singular Subfigure Instance Entity (Type 408) may depict the shape of the Via. The Connect Point Entity shall reference at most one Singular Subfigure Instance Entity in LEP AP conformant files.

Geometry -

The Connect Point Entity (Type 132) locates the Via within the LEP. A Singular Subfigure Instance Entity (Type 408) having a *LEP SEMANTIC PROPERTY* named stand-alone_via shall tag each Via. Each such Subfigure Instance may reference any LEP Geometry Entity.

Annotation -

Conformance to the LEP AP does not require any Annotation Entities in the depiction of the Via.

Structure -

The Connect Point Entity (Type 132) modeling a Via shall not reference an owning entity.

The Connect Point Entity (Type 132) modeling a Via may reference one Singular Subfigure Instance Entity (Type 408) to graphically depict the presence of a Via at the indicated location.

If the Connect Point Entity (Type 132) does not reference a Subfigure Definition in the LEP AP conformant file, the receiving system may display its default icon for Via graphics.

Associativities -

The Connect Point Entity (Type 132) modeling a Via shall reference the proper Flow Associativity Entity (Type 402, Form 18) to connect the Via to the signal join.

Properties -

Mandatory Properties:

The Connect Point Entity (Type 132) modeling a Via shall reference the LEP Semantic Property Entity (see Section 3.3.2.32).

The PWB Drilled Hole Property shall specify the Drill diameter size, the finish diameter size, and the Function Code (5) of a plated Via *HOLE*. The DE Level field of the Drilled Hole Property shall be zero for a through-hole which passes through the entire LEP. The DE Level field of the PWB Drilled Hole Property shall reference a Definition Levels Property Entity (Type 406, Form 1) for a *HOLE* which does **not** go all the way through the PWB. In such a case, that Definition Levels Property (Type 406, Form 1) shall specify which levels are penetrated.

Optional Property:

Each Connect Point Entity (Type 132) modeling a Via may reference a Definition Levels Property Entity (Type 406, Form 1).

Note: The preferred method of displaying text pointed to from the 320,420,132, and 408 entities is by using the text display template. However, a preprocessor may display text using the General Note Entity (Type 212) instead. The only concern with using this method is that it is possible to get the PDQ intelligence and the General Note Entity (Type 212) text out of agreement.

2.3.7 LEP Entity Usage for Physical Mechanical Part Representation.

Entities required:

The Singular Subfigure Instance and Subfigure Definition Entities shall model the Mechanical Part in LEP AP conformant files. The Singular Subfigure Instance Entity (Type 408) shall locate and depict the Mechanical Part. It shall reference one Subfigure Definition (which may also be referenced by other Instances.) The Subfigure Definition Entity (Type 308) shall reference one LEP Closed Curve depicting the X, Y outline of the Mechanical Part. The LEP Closed Curve may reference one or more other LEP Geometry Entities. Various properties shall add the needed semantics.

Geometry -

A Closed Curve having a *LEP SEMANTIC PROPERTY* "physical_outline" Property shall depict each Mechanical Part.

Annotation -

Conformance to the LEP AP does not require any Annotation Entities in the representation of the Mechanical Part.

Structure -

See the discussion under Required Entities above.

Associativities -

Conformance to the LEP AP does not require any Associativities in the representation of the Mechanical Part.

Properties -

Mandatory Properties:

The Subfigure Definition Entity (Type 308) depicting the Mechanical Part shall reference the LEP Semantic Property Entity (see Section 3.3.2.32).

The Singular Subfigure Instance Entity (Type 408) locating the Mechanical Part shall reference the following three properties:

Part Number Property Entity (Type 406, Form 9),

LEP SEMANTIC PROPERTY named component_instance_side, and

LEP SEMANTIC PROPERTY named component_instance_rotation.

Optional Properties:

The Subfigure Definition Entity (Type 308) depicting the Mechanical Part may reference any or all of the

following eight properties:

The *LEP SEMANTIC PROPERTY* named component_std_name.

The *LEP SEMANTIC PROPERTY* named component_version.

The *LEP SEMANTIC PROPERTY* named component_pkg_type.

The *LEP SEMANTIC PROPERTY* named component_tech_type.

The *LEP SEMANTIC PROPERTY* named component_layout_surface.

The *LEP SEMANTIC PROPERTY* named component_height.

The *LEP SEMANTIC PROPERTY* named component_max_size.

The *LEP SEMANTIC PROPERTY* named component_outline_overhang.

In addition, the Subfigure Definition depicting the Mechanical Part may reference the following two LEP properties:

Region Restriction Property Entity (Type 406, Form 2), and

Drilled Hole Property Entity (Type 406, Form 6).

The Singular Subfigure Instance Entity (Type 408) locating the Mechanical Part may reference any of the following three *LEP SEMANTIC PROPERTIES*:

component_preplace,

therm_cond, and

therm_r

2.3.8 LEP Entity Usage for Physical PWB Representation. The PWB from which a PCA is assembled may be an integral part of the assembly file/drawing or may be a separate file/drawing that is called out (in the drawing hierarchy) by the assembly drawing. This Section is applicable to the latter case, and the traces, vias, drilled holes and other features are applicable to the PWB. All components, Traces, Vias, (see Section 5.3.2.) and other entities are subordinate to the LEP PWB.

2.3.8.1 PWB Definition.
Entities required:

A Network Subfigure Definition Entity (Type 320) shall depict the Physical PWB. Each Network Subfigure Definition shall reference as many LEP Geometry Entities as needed to depict the PWB. Each Network Subfigure Definition may reference many of the properties listed below. Conformance to the LEP AP does not require any Text Display Template Entities (Type 312) in the representation of the PWB. At least one Connect Point Entity (Type 132) shall provide a means of locating and connecting signals to “pin1” of the PWB.

Geometry -

Any LEP Geometry Entity may appear in conformant files. All geometry shall lie entirely in the Z = 0.0 plane. There shall be one Closed Curve defining the LEP outline. The Closed Curve shall reference the “lep_physical_outline” property. LEP properties shall assign functionality to any additional curves. Any of the LEP Geometry Entities may represent deposited Traces.

Annotation -

The LEP Physical PWB Definition (Type 320) may reference a General Note Entity (Type 212, Form 0).

Structure -

Network Subfigure Definition Entity (Type 320) shall depict the LEP itself. Additional Network Subfigure Definitions and Instances may represent electrical Components, and Vias. Subfigure Definitions and Singular Subfigure Instances may represent Padstacks and mechanical parts.

Associativities -

Conformance to the LEP AP does not require any Associativities in the representation of the Definition.

Properties -

Mandatory Properties:

The Closed Curve depicting the LEP Outline shall reference the LEP Semantic Property Entity (see Section 3.3.2.32).

Each collector of Geometry representing conductive Joins in the form of Traces shall reference the following property.

Line Widening Property Entity (Type 406, Form 5)

Level Function Property Entities (Type 406, Form 1) shall ascribe functionality (such as silk-screen layer) to various IGES levels.

Optional Properties:

The Network Subfigure Definition Entity (Type 320) modeling the LEP Physical PWB as a Component may reference the properties as specified for Generic Part Definition (3.3.2.4).

2.3.8.2 LEP Physical PWB Instance.

Entities required:

The Network Subfigure Instance Entity (Type 420) shall locate the Physical PWB Instance occurrence and shall provide a way to connect to its ports. A Connect Point Entity (Type 132) shall model each port (e.g., Pin or Pad on an edge connector).

Geometry -

A Connect Point Entity (Type 132) having a *LEP SEMANTIC PROPERTY* named pad_tech_type shall represent each Component Pin or each Component Pad on the Physical PWB. That property shall specify whether the Pad or Pin is of type edge_finger_pad, connector_socket, or connector_pin.

One Connect Point shall appear in the Network Subfigure Instance for each Pad, Pin or Socket in the referenced Network Subfigure Definition, even if the Pad, Pin or Socket is not used.

Annotation -

Conformance to the LEP AP does not require any Annotation Entities in the representation of the Physical PWB Instance. Stand-alone annotation may denote information on the LEP such as part_number, silk-screen, reference designator, or Pin number.

Structure -

The Network Subfigure Instance Entity (Type 420) shall reference one and only one Network Subfigure Definition Entity (Type 320). The Instance shall also specify the location of the Physical LEP with respect to the origin of Model Space.

The Network Subfigure Instance shall reference one or more Connect Point Entities (Type 132).

Associativities -

The LEP Physical PWB Definition (Type 320) shall reference one Flow Associativity Entity (Type 402, Form 18) for each Join on the PWB. The Flow Associativity shall reference each Trace, filled area, Via, and Component Pin that is a member of the Join carrying the corresponding signal.

Properties -

Mandatory Properties:

The Network Subfigure Instance Entity (Type 420) representing the LEP Physical PWB Instance shall reference the following two properties:

Part Number Property Entity (Type 406, Form 9).

LEP SEMANTIC PROPERTY named top_level_assembly_instance.

Optional Properties:

The Network Subfigure Instance Entity (Type 420) may reference any of the following six *LEP SEMANTIC PROPERTIES*:

abs_voltage_max
tolerance
therm_cond
therm_jc
therm_r
junction_max_t

Note: The PDQ LEP representation in the IGES file shall have a Model space scale (Global index 13) of 1.0. A Transformation Matrix (needed for rotation) shall have no translation component.

2.3.8.3 LEP Constructs Supporting Signal Conductivity.

Traces Traces use simple geometry objects such as *LINES* and *ARCS*. They interconnect electronic components and carry signals. Physically, they have a specific width and may pass between the different product layers by means of vias and through-pins.

Jumpers A physical interconnect which may be implemented as a component or a trace, but which shall have only one signal name.

Planes Planes, such as ground and power planes, outline the appropriate (filled) area.

Vias Vias are holes or voids through the insulating material(s) between two or more layers on the LEP. They are plated so they can carry the signal. The holes are made by different means such as drilling, milling or cutting. This variability makes it hard to select specific entities which relate to some aspects of vias. However one makes the hole or void, the functions of the via are still the same. Vias may be through, blind, or buried. Vias are often used as test points.

Pad stacks (through and SMT) Pad stacks provide the electrical interface between the LEP substrate and the component. Pad stacks may be either through_hole or surface mount.

2.3.8.4 LEP Constructs Supporting Components.

Network Subfigure Definition The Network Subfigure Definition (Type 320) defines certain aspects of an electrical component. It has specific points where connections between it and a signal carrier can be made. These points are component terminals of the LEP. The Connect Point Entity (Type 132) shall model the component terminal. The component terminals may be pins, pads, wire bonds, or any other means of connecting a component to a signal. In addition to Connect Points (Type 132), the Network Subfigure Definition (Type 320) may contain geometry defining functionality, such as thermal outline, footprint outline, and placement outline.

The Network Subfigure Definition (Type 320) may also contain properties, things like technology type (through-hole or surface mount), board side placement rules, value, tolerance, version number, and any special instructions. A Network Subfigure Instance (Type 420) shall place the electrical component defined by the Network Subfigure Definition (Type 320). The LEP AP requires each instance to have a corresponding definition within the same file. More than one Network Subfigure Instance (Type 420) in the file may reference the same Network Subfigure Definition (Type 320). Each Network Subfigure Instance (Type 420) is unique. It is placed at a specific location, and it has a unique reference designator. The instance uses the geometry and the properties defined in the definition. The Network Subfigure Instance (Type 420) shall have one Connect Point (Type 132) for each pad/pin. Each has a counterpart in the Network Subfigure Definition (Type 320). The counterpart Connect Points (Type 132) must correspond because different signals connect to the same generic definition *PIN* at each instance. For example, both R1 and R2 may reference the Network Subfigure Definition (Type 320) having the name (axial.100). Distinct Connect Points (Type 132) in the instances are needed to connect R1 pin 1 to sig_1 while R2 pin 1 connects to ground.

Connect Point A Connect Point Entity (Type 132) plays two roles depending on whether it is referenced by a Network Subfigure Instance Entity (Type 320) or not. A Connect Point Entity (Type 132) not referenced by a Network Subfigure Instance Entity (Type 320) shall define a specific and unique point of connection between two or more signal carriers. A Connect Point Entity (Type 132) referenced by a Network Subfigure Definition Entity (Type 320) provides a template for a Connect Point in Network Subfigure Instance Entities (Type 320) and does not participate in connectivity representations. The Connect Point Entity (Type 132) provides a physical location, a function flag, and an identifier. It shall reference an ordinary Subfigure Definition Entity (Type 308) which contains information such as pad size and shape, drill hole (if applicable), and display geometry. The most common examples of Connect Points are vias, test points, component pins, or SMT dedicated through-pins. The function flag (PD FF) shall distinguish between Connect Point Entity (Type 132) occurrences in logical representations and those in physical representations.

2.3.8.5 LEP Constructs Supporting Connectivity. Connectivity is represented by appropriate use of the Network Subfigure Definition (Type 320); the Network Subfigure Instance (Type 420); the Connect Point (Type 132); and the Flow Associativity (Type 402, Form 18). The Flow Associativity (Type 402, Form 18) may include connecting geometry.

The Flow Associativity shall provide the signal name and pointers to all features associated with that signal. Such features include pins, pads, stand-alone vias, traces and planes. There shall be one Flow Associativity (Type 402, Form 18) for each signal in the file. Note that it is possible to include both the logical and physical product data in one file using the Flow “Type” flag or entity level assignments to discriminate between the two product representations. Though permitted by IGES, having both logical connectivity and physical connectivity in the same file is not conformant to the LEP AP.

“Backpointers” pointing from each of the features back to the Flow Associativity are not required for LEP AP conformance.

2.3.8.6 LEP Constructs Supporting a Physical Representation. A physical LEP shall be represented by simple closed planar *GEOMETRY* depicting its outer perimeter. An LEP may have more than one defined outline. There may be keepin/keepout outlines for component placement, traces, and vias, or tool path outlines, and other objects.

All entities on the LEP shall be subordinate to it. This includes: all components such as Network Subfigure Instances (Type 420) and as Network Subfigure Definitions (Type 320), traces (*JOIN*), flow associativities (*NET*), padstacks (*PADSTACK DEFINITION* and *PADSTACK INSTANCE*), vias (*VIA*), tooling holes, fiducials, through holes, mounting holes, mounting hardware, and other objects. Thus, there shall be a top level Network Subfigure Instance (Type 420) of the LEP which calls the top level Network Subfigure Definition (Type 320) of the LEP. If the top level instance is not present, nothing will be displayed.

What then is not subordinate to the LEP? Dimensions are not. Any assembly information, views/draws, scales, grids, and certain kinds of details and cross-sections are not subordinate to the LEP representation.

Several applications require a PDQ LEP representation. This refers to one in which Product Data may be Queried. Computer controlled equipment can then extract needed data without manual intervention. For example, component insertion equipment can put a component at the X, Y location specified by the component's Network Subfigure Instance. Operations which modify the physical representation of the LEP, such as scaling or rotation, will have adverse affects on some application systems. Constructs which are beyond the scope of an automated operation, such as dimensions and view/draw could stall or disable some processing systems.

2.3.8.7 LEP Physical Flow Associativity (Signal/Netlist). Each Flow Associativity Entity (Type 402, Form 18) shall model a distinct Signal in a Netlist. Each Signal is insulated from all others. The Netlist is a report of all the signals in a particular (sub)assembly of a product. Each LEP Connect Point Entity (Type 132) represents a port of a symbol in a schematic or a Pin/Pad of a physical Component. Thus, at least two types of Netlist exist for each LEP. IGES permits both logical and physical Flow Associativities to exist in the same file. The presence of both a logical and a physical netlist in the same file shall not be conformant to this AP. This discussion is limited to the physical realm.

Entities required:

Flow Associativity Entity (Type 402, Form 18), Connect Point Entity (Type 132), and LEP Join Geometry (below).

Geometry -

In the Physical realm, each Connect Point Entity (Type 132) shall represent a Component Pin or a Component Pad or a stand-alone Via. The Join geometry, representing the electrical connections between and among Connect Points, shall be selected from the following LEP Geometry Objects: Line Entity (Type 110), Circular Arc Entity (Type 100), Composite Curve Entity (Type 102), and Simple Closed Planar Curve Entity (Type 106, Form 63). Each Closed Curve shall reference one *LEP SEMANTIC PROPERTY* which defines its function. Each Line, Arc, or open Composite Curve shall reference two LEP properties: Line Widening Property Entity (Type 406, Form 5) and one *LEP SEMANTIC PROPERTY* named conductive_trace_function. All geometry shall lie entirely in the Z = 0.0 plane.

Annotation -

Conformance to the LEP AP does not require any Annotation Entities in the representation of the Physical Signal.

The Flow Associativity Entity (Type 402, Form 18) shall collect the Connect Point Entities (Type 132) for each Signal. Network Subfigure Instance Entities (Type 420) shall reference each Connect Point Entity (Type 132) corresponding to a Pin or Pad of the Component represented in the Physical Netlist. LEP Geometry Entities or Flash Entities may depict the location of each Connect Point in the Netlist.

Associativities -

The Flow Associativity Entity (Type 402, Form 18) shall model each Signal in the Netlist.

Properties -

Mandatory Properties:

Each Closed Curve Join shall reference one *LEP SEMANTIC PROPERTY* which defines its function. The applicable LEP functions for Join geometry include: planar_shape_function {signal, power, ground, ..}. Each Line, Arc, or open Composite Curve Join shall reference two LEP properties: Line Widening Property Entity (Type 406, Form 5) and one *LEP SEMANTIC PROPERTY* named conductive_trace_function {signal, power, ground, ..}.

Optional Properties:

The *LEP SEMANTIC PROPERTY* named pad_tech_type attached to the Connect Point may state whether the Pin is of SMT or through-hole design. The “pin1” *LEP SEMANTIC PROPERTY* shall appear on those Connect Points bearing that designation.

2.3.8.8 LEP Physical LEP Signal Carriers (Traces/Shapes). The Physical LEP Signal Carriers shall constitute the Join defined in IGES 3.6.3.2. Taken together, the Joins provide the connectivity that the Logical Netlist requires. Lines having specified width depict conductive Traces of similar width and a specified nominal thickness. Some Joins are irregularly shaped areas of conductive material of a specified nominal thickness.

Entities required:

Connect Point Entities (Type 132) shall also be used in join representations. The join geometry, depicting the electrical connections between and among Connect Points, shall be selected from: Line Entity (Type 110), Arc Entity (Type 100), full Circular Arc Entity (Type 100), Composite Curve Entity (Type 102), Flash Entity (Type 125), and Simple Closed Planar Curve Entity (Type 106, Form 63).

Geometry -

LEP Join Geometry is defined above under Entities required. Any LEP Join Geometry Entities may appear in conformant files. All geometry shall lie entirely in the Z = 0.0 plane. Flash Entity (Type 125) shall not

reference a Transformation Matrix.

Annotation -

The Closed Curve(s) enclosing the conductive areas of LEP Joins shall (each) reference a Sectioned Area Entity (Type 230). That Sectioned Area shall reference a *LEP SEMANTIC PROPERTY* named planar_shape_function {signal, power, ground, ...}. No other Annotation Entities shall appear as part of a Physical Signal/netlist representation.

Structure -

LEP Physical PWB Signal Carriers shall reference no structure entities other than the Flow Associativity.

Associativities -

LEP Physical PWB Signal Carriers shall reference one Flow Associativity Entity (Type 402, Form 18) for each Join.

Properties -

Mandatory Properties:

Each Closed Curve Join shall reference one *LEP SEMANTIC PROPERTY*) named planar_shape_function which defines its function. Applicable LEP functions for Join geometry include: signal, power, and ground.

Each Line, Arc, or open Composite Curve Join shall reference two LEP properties:

Line Widening (type 406 form 5) and

LEP SEMANTIC PROPERTY named conductive_trace_function.

The *LEP SEMANTIC PROPERTY* named pad_tech_type attached to the Connect Point shall state whether the Pin is of SMT or thru-hole design. If it is a thru_hole design, a further choice among three design intentions shall be made. The three valid alternatives are: thru_hole_anti, thru_hole_regular, and thru_hole_thermal.

The “pin1” *LEP SEMANTIC PROPERTY* shall appear on those Connect Points bearing that designation.

2.3.9.9 LEP Physical PWB Features: Fiducials. A Fiducial provides a reference location for accurate positioning of other LEP features.

Entities required:

The *FIDUCIAL* shall be depicted by any LEP Geometry *CLOSED CURVE* .

Geometry -

Any LEP Geometry Entity may appear in conformant files. All geometry shall lie entirely in the Z = 0.0 plane. The Flash Entity (Type 125) shall not reference a Transformation Matrix.

Annotation -

Conformance to the LEP AP does not require any Annotation Entities in the representation of the *FIDUCIAL*.

Structure -

Conformance to the LEP AP does not require any Structure Entities in the representation of the *FIDUCIAL*.

Associativities -

Conformance to the LEP AP does not require any Associativity Entities in the representation of the *FIDUCIAL*.

Properties -

Mandatory Properties:

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The following properties shall be referenced by each Closed Curve representing a *FIDUCIAL*:

The *LEP SEMANTIC PROPERTY* named fiducial having a first value from among (component/cluster/ board/panel) and a second value from among (top/bottom)

2.3.9 LEP Entity Usage for Specific Applications. This section discusses tests of conformant files and their construction. For example, Netlist reports require Flow Associativities. This Section provides the additional detail about IGES entities and structures for given use applications. This information supplements and enhances the object descriptions in Section 3.3.

2.3.9.1 LEP Entity Usage for Design/Engineering Applications.

Netlist Reports The netlist is a comprehensive report of the interconnection of the Component terminals (Pins or Pads) sharing the same signal. Notice this includes both the logical and physical forms. The logical form relates each signal in the database with all of the unique part_pins which are part of that signal. The physical form adds the X, Y location of each part_pin, and the connection geometry (Traces). This is the only instance in the LEP AP where the presence of both the logical flow and the physical flow Type flags of the Flow Associativity (Type 402, Form 18) in the same IGES file are appropriate and conformant. Such files also require use of counts of associated Flow Associativities and NF SPTR pointers.

This application does require a PDQ representation.

Entities required:

The Flow Associativity shall model each Signal. The LEP Geometry Entities depict the shape of the Join entities in the Physical Netlist. The LEP Geometry Entities may each reference one Line Widening Property Entity (Type 406, Form 5) to convey Trace width.

Geometry -

Logical:

The logical form of the netlist shall use no geometry. Any geometry present shall be ignored.

Physical:

Any LEP Geometry Entity may appear in conformant files. All geometry shall lie entirely in the Z = 0.0 plane. If present, the Flash Entity (Type 125) shall not reference a Transformation Matrix. The geometry entities usually depict the Traces. Via depictions may employ geometry. A Connect Point Entity (Type 132) shall model each Via.

Both:

Component through connections shall appear as Connect Points in Physical netlists. However, the physical characteristics of the Connect Point shall not appear in the logical form of the netlist.

Annotation -

The Flow Associativity Entity (Type 402, Form 18) parameter NAME1 shall provide the Signal name. The Connect Point Entity (Type 132) parameter CID shall provide the Pin name. The Network Subfigure Instance Entity (Type 420) parameter PRD shall provide the Reference Designator of the Component having the participating *PIN*.

Structure -

The Flow Associativity Entity (Type 402, Form 18) groups the Connect Point Entities (Type 132) for each Signal. Network Subfigure Instance Entities (Type 420) shall reference each Connect Point Entity (Type 132) corresponding to a *PIN* or Pad of the Component represented in the Physical Netlist and may do the same in the Logical Netlist. LEP Geometry Entities or Flash Entities may depict the location of each Connect Point in either Netlist.

Associativities -

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The Flow Associativity Entity (Type 402, Form 18) shall model each Signal in either form of Netlist. IGES requires the TF (type of flow flag) to be set to 1 or 2 for each occurrence of the Flow Associativity when both logical (1) and physical (2) flows are present in one file. Corresponding signals shall reference each other using the Flow Associativity parameters NF and SPTR1 through SPTRNF in such cases.

Properties -

The *LEP SEMANTIC PROPERTY* named pad_tech_type attached to the Connect Point may state whether the Pin is of SMT or through-hole design. The “pin1” *LEP SEMANTIC PROPERTY* may appear on some of the appropriate Connect Points.

Component Placement Reports. Component placement refers to the assignment of Components to specific X, Y locations on the LEP. At times, particular Components must occupy well cooled spots or must adjoin other Components. The LEP component_preplace Property shall identify such concerns. Component placement is also known as Component layout or LEP layout.

This Component placement application does require a PDQ representation.

Entities required:

Network Subfigure Definition Entity (Type 320) and Instance Entity (Type 420) shall represent the electrical parts. Subfigure Definition Entity (Type 308) and Singular Subfigure Instance Entity (Type 408) represent the mechanical parts.

The Network (or Singular) Subfigure Instance Entity (Type 420 or Type 408) shall locate the LEP Component. The LEP *CLOSED CURVE* depicts the shape of the LEP Component Outline. The LEP Closed Curve shall reference one *LEP SEMANTIC PROPERTY* named physical_outline.

Geometry -

A LEP Closed Curve having a physical_outline Property shall model each LEP Component Outline. Any LEP Geometry may be part of the LEP Closed Curve subject to the usual IGES constraints.

Associativities -

Conformance to the LEP AP does not require any associativities in the representation of the LEP Component Outline.

Annotation -

Conformance to the LEP AP does not require any Annotation Entities in the representation of the LEP Component.

Structure -

The LEP Closed Curve may reference one or more *LEP SEMANTIC PROPERTIES* named component_preplace, or component_instance_side in LEP AP conformant files.

Properties -

Mandatory Properties:

The Network (or Singular) Subfigure Instance Entity (Types 420 or 408) shall reference the following four LEP properties:

The *LEP SEMANTIC PROPERTY* named component_std_name.

The *LEP SEMANTIC PROPERTY* named component_version.

The *LEP SEMANTIC PROPERTY* named physical_outline.

The *LEP SEMANTIC PROPERTY* named component_tech_type.

Optional Properties:

The Network (or Singular) Subfigure Instance Entities (Types 420 or 408) may reference the following two

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LEP properties:

The *LEP SEMANTIC PROPERTY* named component_preplace, and
component_instance_side

Bill of Materials Reports. The Bill of Materials (BOM) report lists the Components which make up the LEP. The BOM lists part numbers, quantity used, and a brief description of the parts. Some BOMs also list reference designators. The report may include other semantic information as well. This BOM application does require a PDQ representation.

Entities required:

Network Subfigure Definition Entity (Type 320) and Instance Entity (Type 420) shall represent the electrical Components. Subfigure Definition Entity (Type 308) and Singular Subfigure Instance Entity (Type 408) represent the mechanical Components.

The Part Number Property Entity (Type 406, Form 9) attached to the Singular (or the Network) Subfigure Instance Entities (Type 408 or 420) provides the part number to the BOM report. The quantity used is calculated by the software. If needed, the PRD parameter of the Network Subfigure Instance Entity (Type 420) shall provide the Reference Designator data.

Geometry -

Any LEP Geometry Entities may be referenced by the Subfigure Definitions in the depiction of LEP Components.

Annotation -

Conformance to the LEP AP does not require any Annotation Entities in the representation of the LEP Component.

Structure -

The Network Subfigure Instance Entity (Type 420) shall reference one Network Subfigure Definition Entity (Type 320) and one or more BOM Properties for each electrical Component. Each Singular Subfigure Instance Entity (Type 408) shall reference one Subfigure Definition Entity (Type 308) and one or more BOM Properties for each mechanical Component.

Associativities -

Conformance to the LEP AP does not require any associativities in the representation of the BOM.

Properties -

Mandatory Properties:

The Part Number Property Entity (Type 406, Form 9) shall provide part numbers for each Component. This property identifies 4 different part number families; the generic, military, vendor, and internal part numbers. The property shall provide at least one of these four part numbers for each Component.

Each Component instance represented by a Network Subfigure Instance Entity (Type 420) or a Singular Subfigure Instance Entity (Type 408) shall reference the following LEP property:

The Part Number Property Entity (Type 406, Form 9).

Optional Properties:

Each Component instance represented by a Network Subfigure Instance Entity (Type 420) or a Singular Subfigure Instance Entity (Type 408) may reference any of the following nine LEP properties:

The *LEP SEMANTIC PROPERTY* named:

component_std_name
component_version
component_pkg_type

component_tech_type
component_layout_surface
component_insertion_origin
component_height
component_max_size
component_outline_overhang

2.3.9.2 LEP Entity Usage for Manufacturing Applications. Usage rules are laid down for providing usable information to support Photo-lithography tools, LEP Testers, Numerically Controlled Component processing and Panelization of PWB details. Concepts for support of Wire Wrap are included and Labelmaker application may be added later.

Photo-lithography Tools. Photo-lithography in this application refers to the creation of the master artwork used to manufacture the physical bare PWB or other LEP. This includes the Traces, planes, and Vias. It also includes annotation such as reference designators, Pin numbers, Component outlines, part numbers, tooling holes, Fiducials, and labels.

This photolithography application does NOT require a PDQ representation.

Entities required:

Any LEP Geometry Entity may depict part of the Traces, Vias, and annotation graphics needed for this application. The General Note Entity (Type 212, Form 0) may provide the text strings needed for other annotation.

Geometry -

Any LEP Geometry Entity may appear in conformant files. All geometry shall lie entirely in the Z = 0.0 plane. If present, the Flash Entity (Type 125) shall not reference a Transformation Matrix. Receiving systems may balk at geometry more complex than a Line Entity (Type 110), Circular Arc Entity (Type 100), Copious Data Entity (Type 106), Composite Curve Entity (Type 102), or Flash Entity (Type 125).

Single entities shall depict each Fiducial and each tooling mark. The (full) Circular Arc Entity (Type 100) or the Flash Entity (Type 125) may serve some of these needs. The others may require a Composite Curve Entity (Type 102) or the Copious Data Entity (Type 106, Form 63). The Composite Curve shall gather the constituent entities when multi-entity representations are needed. That Composite Curve shall reference any properties providing semantics such as the *LEP SEMANTIC PROPERTY* named “fiducial.”

Annotation -

Closed Curves may annotate the LEP by stylized depictions of Component outlines. The General Note Entity (Type 212, Form 0) may present Reference Designator and Pin text plus LEP identifiers.

Structure -

The simpler the structure, the better. Copious Data Entity (Type 106) may depict objects representable by polygons and Composite Curve Entity (Type 102) Entities may group Lines and Circular Arcs or enclose irregular planar areas.

Associativities -

Conformance to the LEP AP does not require any associativities in the representation of the photo-tools.

Properties -

The Composite Curve Entity (Type 102), Circular Arc Entity (Type 100), Copious Data Entity (Type 106), Flash Entity (Type 125), or the Line Entity (Type 110) shall reference the following LEP properties:

The Line Widening (Type 406, From 5) Property shall specify nominal Trace width. Thus, it shall not widen or narrow as the underlying geometry gets scaled.

The *LEP SEMANTIC PROPERTY* named “fiducial” shall tag referenced objects.

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Test Aids. This application involves provision of information to support automated testing of an LEP. The tester needs probe locations tied to signal names. The tester also needs locations of Components which might interfere with probe insertion or removal. The object descriptions needed include those of the Traces, planes, padstacks and Vias. The object descriptions shall also includes annotation such as Reference Designators, Pin numbers, Component outlines, Part Numbers, tooling holes, Fiducials, and labels.

This application does require a PDQ representation.

Entities required:

The Flow Associativity Entity (Type 402, Form 18), the Connect Point Entity (Type 132), and the Network Subfigure Instance Entity (Type 420) shall provide the "PDQ intelligence" (connectivity information) needed for this application. Network Subfigure Definition Entity (Type 320) and Instance Entities (Type 420) shall represent the electrical Components. If needed, the PRD parameter of the Network Subfigure InstanceEntity (Type 420) shall provide the Reference Designator string.

Any LEP Geometry Entity may depict part of the Traces, Vias, and annotation graphics needed for this application. The General Note Entity (Type 212, Form 0) shall provide the text strings needed for other annotation.

Geometry -

A LEP Closed Curve having a physical_outline Property shall model each LEP Component Outline. Any LEP Geometry may be part of the LEP Closed Curve. All geometry shall lie entirely in the Z = 0.0 plane.

Single entities shall depict each Via, each connect point, each Fiducial and each tooling mark. The (full) Circular Arc Entity (Type 100) or the Flash Entity (Type 125) may serve some of these needs. The others may require a Composite Curve Entity (Type 102) or the Copious Data Entity (Type 106, Form 63). The Composite Curve shall group the constituent entities when multi-entity icons are needed. That Composite Curve shall reference any properties providing semantics such as the *LEP SEMANTIC PROPERTY* named "fiducial".

The Sectioned Area Entity (Type 230) shall depict filled areas such as irregularly shaped signal planes, ground planes or power planes. Only the (full) Circular Arc Entity (Type 100), Composite Curve Entity (Type 102), and Simple Closed Planar Curve Entity (Type 106, Form 63) shall be filled by the Sectioned Area Entity. Only the unfilled Fill Pattern (0) and the solid filled Fill Pattern (19) of the Sectioned Area Entity (Type 230) shall appear in conformant files.

Annotation -

Network Subfigure Instance Entities (Type 420) shall provide information on Component location, Pin location, Signal Name, Reference Designator, Part number, and Pin text.

The Flow Associativity Entity (Type 402, Form 18) parameter NAME1 shall provide the Signal name. The Connect Point Entity (Type 132) parameter CID shall provide the Pin Name. The Network Subfigure Instance Entity (Type 420) parameter PRD shall provide the Reference Designator of the Component having the participating Pin.

Structure -

The Network Subfigure Instance Entity (Type 420) shall reference one Network Subfigure Definition Entity (Type 320) and one or more Test Properties for each electrical Component. The Network Subfigure Instance shall also reference one Connect Point Entity (Type 132) for each corresponding Connect Point in the referenced Network Subfigure Definition Entity (Type 320). Each Connect Point Entity (Type 132) shall provide its Pin Name in parameter PRD. Some instanced Connect Points Entities (Type 132) may model Vias rather than Component Pins. (Vias have no owner. In other words, the PSFI parameter of the Type 132 has no valid pointer.) Each owned and instanced Connect Point Entity (Type 132) shall provide a Pin name. The combination of the Reference Designator and the Pin name shall be unique within the IGES file in which it appears. Each instanced Connect Point Entity (Type 132) shall indicate (by reference or default) a *LEP SEMANTIC PROPERTY* stating whether test probing is allowable or not. Each Flow Associativity

Entity (Type 402, Form 18) shall provide a Signal Name (in NAME1). Each Flow Associativity shall reference all the Connect Points carrying the Signal Name provided in NAME1.

Associativities -

The Flow Associativity Entity (Type 402, Form 18) shall model each Signal.

Properties -

Mandatory Properties:

Each Connect Point Entity (Type 132) shall reference one of the following two LEP properties:

The *LEP SEMANTIC PROPERTY* name:

allowable_test_point

or (the default) not_allowable_test_point

The Network Subfigure Instance shall reference the following LEP property:

The *LEP SEMANTIC PROPERTY* named: component_instance_side.

Optional Properties:

The Connect Point Entity (Type 132) may reference the following LEP property:

The *LEP SEMANTIC PROPERTY* name: pin1.

The Closed Curve may reference the following LEP property:

The *LEP SEMANTIC PROPERTY* name: fiducial.

2.3.9.3 LEP Entity Usage for Numerically Controlled (NC) Production Files. Component Pick and Place, Component Insertion, and Component Verification and a concept for Wire Wrap are discussed below. The LEP AP files described below may be converted to MIL-PRF-28000 Class IV files as needed.

Component Insertion. This Component Insertion application does require a PDQ representation.

Component Insertion refers to the process of inserting through-hole Components of one or more distinct types into the PWB. All Components within each type are the same as far as the inserter is concerned. For example, one type may be a 10K 1/4w 5% resistor and another type may be a 22K 1/4w 10% resistor. Each type shall be distinctly identified. The most common method to do this is with a Part Number Property Entity (Type 406, Form 9), using the internal Part Number Property Entity (Type 406, Form 9) value.

Automated insertion is concerned with two distinct rotations. The first rotation occurs during physical layout when placing the part from the LEP design library. For example, an axial Component is usually mounted with its axis parallel to the plane of the LEP. With the axis perpendicular to the plane of the LEP, the Component has been rotated 90 degrees (or 270 degrees.) (The amount of rotation (90 or 270) matters little if the Component is non-polarized. For a diode or a polarized capacitor, though, it is important.) These rotations shall be provided to the insertion machinery by means of the *LEP SEMANTIC PROPERTY* named component_placement_angle. The Transformation Matrix Entity (Type 124) shall not be applicable in such cases because there is no fixed frame of reference.

The other kind of rotation is beyond the scope of this AP. It tracks the motions of the head of the inserter and of the Component in the feeder.

Entities required:

The Network Subfigure Instance Entity (Type 420) shall model the Component inserted. It shall reference a Network Subfigure Definition containing a *CLOSED CURVE* which depicts the shape of the Component outline after insertion. It may also reference a Transformation Matrix Entity (Type 124) to model the rotation of the Component into position in model space. The Transformation Matrix shall not apply translations of the Component in the plane of the LEP. The X and Y coordinates within the Network Subfigure Instance Entity (Type 408) shall determine the lateral position of the Component on the LEP. The Network Subfigure

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Instance Entity (Type 420) shall reference a *LEP SEMANTIC PROPERTY*) named component_instance_side to state whether the Component is mounted on the top or the bottom of the LEP. Else, the default position shall be the top of the PWB. The Subfigure Instance shall also reference a *LEP SEMANTIC PROPERTY* named component_instance_rotation if needed. The Network Subfigure Instance Entity (Type 420) shall reference other properties to provide semantic information to the inserter.

Geometry -

One *CLOSED CURVE* shall define the outline of the Physical Component in the X, Y plane of the LEP. Only the (full) Circular Arc Entity (Type 100), the Composite Curve Entity (Type 102), and the Simple Closed Planar Curve Entity (Type 106, Form 63) shall appear as entities which define Component outlines. Each such *CLOSED CURVE* shall reference one LEP Property which defines its function. For this application, the LEP function needed is the physical_outline.

Any LEP Geometry Entity may appear as part of the Component Geometry. All LEP Geometry shall lie entirely in the Z = 0.0 plane.

Annotation -

Conformance to the LEP AP does not require any Annotation Entities in the representation of the Physical Component.

Structure -

The Network Subfigure Instance Type (Type 420) shall reference one Network Subfigure Definition Entity (Type 320) and one or more Component Insertion Properties for each electrical Component to be inserted. The Network Subfigure Definition (together with its Transformation Matrix) controls the orientation and position of insertion.

Associativities -

Conformance to the LEP AP does not require any associativities in the representation of the Physical Component to be inserted.

Properties -

Mandatory Properties:

The Network Subfigure Definition Entity (Type 320) shall reference the following LEP properties:

The *LEP SEMANTIC PROPERTY* named:

component_insertable
component_insertion_origin

The Network Subfigure Instance Entity (Type 420) shall reference the following LEP properties:

The *LEP SEMANTIC PROPERTY* named:

component_insertion_force
component_insertion_height

The Connect Point Entity (Type 132) shall provide (by reference or default) one of the following two LEP properties:

The *LEP SEMANTIC PROPERTY* name:

allowable_test_point
or (the default) not_allowable_test_point

Optional Properties:

The Network Subfigure Definition Entity (type 320) may reference the following LEP property:

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The *LEP SEMANTIC PROPERTY* named:

component_max_size

The Network Subfigure Instance Entity (Type 420) may reference any of the following 13 LEP properties:

The *LEP SEMANTIC PROPERTY* named:

component_instance_side
component_instance_rotation
component_outline_overhang
component_placement_lead_diameter
component_placement_yn
component_placement_zspan
component_placement_body
component_placement_center
component_placement_angle
component_placement_form_code
component_placement_form_code_description
component_insertion_force
component_insertion_height

Component Pick and Place. This application does require a PDQ representation.

Component Pick and Place refers to the process of pasting SMT (surface mount technology) components of one or more distinct types onto the LEP. All Components within each type are the same as far as the Pick and Place system is concerned. For example, one Component type may be a memory chip and another Component type may be a multiplexer chip. Each Component type shall be distinctly identified with a Part Number Property Entity (Type 406, Form 9), using the internal Part Number Property value.

Automated Pick and Place is concerned with two distinct rotations. The first rotation occurs during physical layout when placing the part from the LEP design library. For example, an MCM chip Component is usually mounted with Pin 1 in the upper left hand corner. With Pin 1 in the upper right hand corner, the Component has been rotated 270 degrees. These rotations are communicated to the placement machinery by means of the *LEP SEMANTIC PROPERTY* named component_placement_angle. The Transformation Matrix Entity (Type 124) is not applicable in such cases because there is no fixed frame of reference.

The other kind of rotation is beyond the scope of this AP. It tracks the motions of the head of the Pick and Place system and of the Component in the Pick mechanism.

Entities required:

The Network Subfigure Instance Entity (Type 420) shall model the Component placed. It shall reference a Network Subfigure Definition containing a *CLOSED CURVE* which depicts the shape of the Component outline after placement. It may also reference a Transformation Matrix Entity (Type 124) to model the rotation of the Component into position in model space. The Transformation Matrix shall not apply translations of the Component in the plane of the LEP. The X and Y coordinates within the Network Subfigure Instance Entity (Type 420) shall determine the lateral position of the Component on the LEP. The Subfigure Instance shall reference a *LEP SEMANTIC PROPERTY* named component_instance_side to state whether the Component is mounted on the top or the bottom of the LEP. If it does not, the default position shall be on top of the LEP. The Subfigure Instance shall also reference a *LEP SEMANTIC PROPERTY* named component_instance_rotation if needed. The Subfigure Instance shall reference other properties to provide semantic information to the Pick and Place system.

Geometry -

One Closed Curve shall depict the outline of the Physical Component in the X, Y plane of the LEP. Only the (full) Circular Arc Entity (Type 100), the Composite Curve Entity (Type 102), and the Simple Closed Planar Curve Entity (Type 106, Form 63) shall appear as entities which define Component outlines. Each Closed Curve shall have one LEP Property attached to it which defines its function. For this application, the LEP

function needed is the physical_outline.

Any LEP Geometry Entity may appear as part of the Component geometry. All LEP Geometry shall lie entirely in the Z = 0.0 plane.

Annotation -

Conformance to the LEP AP does not require any Annotation Entities in the representation of the Physical Component.

Structure -

The Network Subfigure Instance Entity (Type 420) shall reference one Network Subfigure Definition Entity (Type 320) and one or more Component Insertion Properties for each electrical Component to be placed. The Network Subfigure Definition (together with its optional Transformation Matrix) controls the orientation and position of adhesion.

Associativities -

Conformance to the LEP AP does not require any associativities in the representation of the Physical Component to be placed.

Properties -

Mandatory Properties:

The Network Subfigure Definition Entity (Type 320) shall reference the following two LEP properties:

The *LEP SEMANTIC PROPERTY* named:

component_layout_surface (top/bottom)
component_insertable (yes/no)

The Network Subfigure Instance Entity (Type 420) shall reference the following LEP properties:

Part Number Property Entity (Type 406, Form 9).

The *LEP SEMANTIC PROPERTY* named (note: if the first property has a negative value for ‘n’, the remaining four shall be omitted):

component_placement_yn
component_placement_force
component_placement_height
component_placement_angle
component_placement_depth_stop

Optional Properties:

The Network Subfigure Definition Entity (Type 320) may reference any of the following ten LEP properties:

The *LEP SEMANTIC PROPERTY*) named:

component_std_name
component_version
component_pkg_type
component_tech_type
component_layout_surface
component_insertion_origin
component_insertable
component_height
component_max_size
component_outline_overhang

The Network Subfigure Instance Entity (Type 420) may reference any of the following twelve LEP

properties:

LEP SEMANTIC PROPERTY named:

component_placement_body
component_placement_pickpoint_id
component_placement_preplace
component_placement_bonding
component_placement_bonding_material_specifications
component_placement_bonding_process_specifications
component_placement_center
component_placement_feeder
component_placement_force
component_placement_form
component_placement_form code
component_placement_form code_description

Component Verification. This application verifies the correct Components, properly oriented, are correctly positioned on the LEP. It needs Component outline (a Closed Curve), Part number, X, Y position, and "pin1" LEP SEMANTIC PROPERTY for each Component occurrence. This application does NOT require a PDQ representation.

Entities required:

The Network Subfigure Instance Entity (Type 420) shall model the LEP Component. The *CLOSED CURVE* depicts the shape of the LEP Component. The Network Subfigure Instance Entity (Type 420) shall reference one or more LEP Component Properties in LEP AP conformant files.

Geometry -

A Closed Curve having a placement_outline Property shall model each LEP Component in LEP AP conformant files.

Annotation -

Conformance to the LEP AP does not require any Annotation Entities in the representation of the LEP Component representation.

Structure -

The Network Subfigure Instance Entity (Type 420) shall reference one Network Subfigure Definition Entity (Type 320). The Network Subfigure Definition Entity (Type 320) shall reference a *CLOSED CURVE*. The Definition shall reference one or more LEP Component Properties in LEP AP conformant files.

Associativities -

Conformance to the LEP AP does not require any associativities in the representation of the LEP Component.

Properties -

Mandatory Properties:

The Network Subfigure Instance Entity (Type 420) shall reference both the following LEP properties:

Part Number Property Entity (Type 406, Form 9).

The *LEP SEMANTIC PROPERTY* named placement_outline.

The proper Connect Point Entity (Type 132) of each Component shall reference the *LEP SEMANTIC PROPERTY* named pin1.

2.3.9.4 LEP Entity Usage for Wire Wrap. A simplified model of a 2 layer board will suffice for most wire wrap situations; for more complex designs you will see a multilayer PWB (with or without some

mounted components) with compliant pins friction-fit into the through hole barrels of the board. Wire wrap will usually extend off the board typically to connectors with wire wrap pins (in most cases, it is illegal or inadvisable to solder the solid wire used for wire wrap). Occasionaly, the motherboard will include some flex-tape arrangement also (this is infrequent, but a possibility).

For the wire wrap board, the PWB, Section 2.3.8 is applicable; however the traces and associated Line Widening Property Entity (Type 406, Form 5) shall be omitted. The completed wire wrap representation will contain components whose pins are located only where a wire wrap pin exists. There are various CAE techniques employed to guide the layout of components on the PWB such as grids and wire wrap board graphics.

For the components, Section 2.3.9.4 is applicable; a padstack may be used, however the usual PWB lands may be omitted.

The netlist is merged such that the component pins are associated with a signal, thus Section 2.3.9.1 on Net List Reports is applicable. Routing is routinely done for many wire wrap situations (especially for 3-D harness situations, where the final assembly has connections in multiple planes and a “twist” has to be thrown in), but seldom is any of the routing described in any CAD data. The wire wrap product definition may be released or archived at this point.

The wire wrap product is completed by extraction (from the CAE system or from an IGES LEP file) of the netlist with the X, Y locations recorded for each “terminal” in the netlist. The extracted list is “post-processed”; sorted into a wire wrap-sequence order as determined to be optimum for the wire wrap machine used, and the wire lengths (usually precut to the machine requirements) selected. The completed wire wrapped board is continuity-tested (see Section 2.3.10.2 Test Aids), and the components are inserted (for automated insertion Section 2.3.9.2 Component Insertion applies) in the identified locations.

Note that there is little control on the “path” taken by the wires; thus the wire wrap method of assembly is usually limited to low production runs, such as prototypes and special purpose test equipment. Some computer backplanes have utilized wire wrap construction because of the relatively low distributed capacitance between wires and the relative ease of making field modifications to the connections.

2.3.9.5 LEP Entity Usage for Panelization. Panelization involves laying out two or more LEP assembly outlines on the surface of a substrate panel for processing efficiency considerations. Fiducials and test coupons are usually added to the layout design to enable better Quality Control. The information needed is the LEP outline (Singular Subfigure Definition Entity (Type 308) referencing a *CLOSED CURVE* having a *LEP SEMANTIC PROPERTY* named lep_physical_outline Property, and those *CLOSED CURVES* which reference fiducial/board and fiducial/panel Properties).

This application does NOT require a PDQ representation.

Entities required:

One Closed Curve shall define the outline of the PWB. Two or three other *CLOSED CURVES* depicting Fiducials are also needed. A Group Associativity Entity (Type 402, Form 7) without backpointers shall reference each entity that is to appear in a given panel.

Geometry -

Fiducials may be represented by single entities, such as the Flash Entity (Type 125), or multiple entities such as circles depicted by many short lines. Multi-entity Fiducials shall be subordinate to a Composite Curve Entity (Type 102). The single entity or Composite Curve Entity (Type 102) shall reference a Fiducial Property.

Annotation -

Conformance to the LEP AP does not require any Annotation Entities in the representation of the *CLOSED CURVE* depicting the PWB.

Structure -

One *CLOSED CURVE* shall define the outline of the PWB. Only the (full) Circular Arc Entity (Type 100), the Composite Curve Entity (Type 102), and the Simple Closed Planar Curve Entity (Type 106, Form 63) may appear as entities which define the PWB outline. That *CLOSED CURVE* shall reference the *LEP SEMANTIC PROPERTY* named top_level_assembly_instance. The other *CLOSED CURVES* needed shall reference the *LEP SEMANTIC PROPERTY* named "fiducial" and having the value "board" or the one having the value "panel" as described below.

Associativities -

A Group Associativity, without backpointers (Type 402, Form 7) shall reference each entity that is to appear in a given panel.

Notice that this associativity does not require backpointers from each entity back to the Group Associativity.

Properties -

Mandatory Properties:

The *CLOSED CURVE*(s) depicting fiducials outside the PWB outlines shall reference

The *LEP SEMANTIC PROPERTY* named fiducial/panel.

The other *CLOSED CURVES* depicting fiducials shall reference

The *LEP SEMANTIC PROPERTY* named fiducial/board.

A *LEP SEMANTIC PROPERTY* named "panel_offset" shall be attached to each associativity to mark it as a panel associativity. In addition, the panel_offset property has two real values, X and Y, that specify the offset for this pattern in relation to the panel origin.

2.3.9.6 LEP Entity Usage for Drafting/Documentation Applications . Documentation of the LEP is primarily a manual operation. However, there are ways to automate parts of the documentation preparation processes. The differences between the information needed for documentation versus that needed for automated and semi-automated processes are discussed below. Following that is usage information about Assembly Documentation. The Drafting AP (Sections 2.1 and 3.1) shall apply to other LEP uses such as fabrication documentation.

Major differences between the documentation and the PDQ model of a conformant LEP AP.

The PDQ model of a conformant LEP AP is at a specific orientation with a scale of 1.0. The documentation may be at any rotation(s) with any scale (e.g., to show fine detail). The picture may be cut into two or more sheets. One part of a scaled drawing then appears on one sheet, and the other part on the second sheet.

The PDQ model of a conformant LEP AP usually contains only a few annotation entities. The documentation contains many annotation entities, such as dimensioning and labeling.

The PDQ model of a conformant LEP AP exists in model space. The documentation often has many distinct views and may have a drawing space for each drawing entity.

Changes and additions to PDQ LEP AP.

Changes to the DE for Documentation files:

No hierarchy is needed,
Line font may have more variability than eight colors,
Line thickness may have more variability, and
Components need not be subordinate.

Entities (Type 1xx) or entity forms beyond the LEP AP may be needed.

Geometry entities have been added:

Unbounded Plane Entity (Type 108) (only as a clipping plane to a View Entity (Type 410) has been added for documentation). Additional forms of the Copious Data Entity (Type 106) include Forms

20 and 21, 31-38, and 40.

Dimensioning entities have been added:

All 200 series entities are permitted in documentation files.

Other entities have been added for documentation files:

Full color (including the Color Definition Entity (Type 314)); dimensions of various types; the View Entity (Type 410) and Drawing Entity (Type 404); plus various Properties- (e.g., for Units and Size).

The Flow Associativity Entity (Type 402, Form 18) is not needed for documentation files.

Type 420/320/132 entities:

Strictly speaking, these connectivity entities are not needed for documentation files. For some users though, the loss of PDQ information may outweigh the ease of implementation.

Documentation of the LEP includes:

Drafting/Dimensioning usually provides overall LEP dimensions, plus dimensions relating various LEP features such as tooling holes and mounting hardware.

Fabrication Documentation. This documentation includes: Fabrication instructions including layer order, substrate material and thickness, special processing notes, and registration Fiducials.

Assembly Documentation. Production Assembly information tells how to build a specific LEP product using detailed step by step instructions for a given manufacturing process.

One common method used in manufacturing is the “station/operation” approach. This method divides the task of populating a LEP into several discrete steps. Each step begins with a check of the work done in the previous step. Then the task(s) of the current step are performed and the partial assembly is passed onto the correct location for the next step. For example, step one might inspect the unpopulated LEP for damage or irregularities. If the LEP seems good in that regard, it is placed in a holder, and then five resistors having identical part numbers are inserted into the PWB. Step two begins with an inspection to ensure the five parts supposedly added in step 1 are in position, and that each has (or could have) the correct part number. The operator performing step 2 then inserts six capacitors and four more resistors. Step 3 begins by inspecting the four resistors. Then the six capacitors are checked for polarity as well as correct part number and location.

The elapsed time to perform the tasks at each station may be adjusted to minimize bottlenecks. Each station is furnished with a color coded picture, indicating which parts added at the previous station are to be inspected, and which parts are to be added at this station. Manual creation of these process pictures may take quite a bit of resources and time, or, it may be automated using a PDQ LEP database.

If this process sheet creation application will not be automated, then Drafting Application Protocol (see Section 2.1) may be invoked to assure conformance of any IGES drawing files created to provide color coded pictures at each station.

If this process sheet creation application will be automated, a PDQ LEP AP or data base may well be employed. Notice that the final IGES files that are generated by the automated process may need to be converted to Drafting (see Section 2.1) IGES files. Colors and fill patterns may be assigned during that conversion process.

One additional file is required by the automated process. It is a file that tells which parts are placed at which station.

LEP Technical Illustrations. The Drafting Figure Viewer Application Protocol (see 2.1.5) requirements shall apply for LEP Technical Publications. The LEP Technical Illustrations application shall add no entities, nor impose changes to the Figure Viewer Application Protocol entities.

2.3.10 LEP Entity Usage for CAD to CAD exchange. Modifying the LEP AP IGES file to improve

postprocessing success for a particular brand or version of receiving CAD system is outside the scope of this AP. Vendors products may exist in this area.

Layer Assignment. The assignment of particular LEP features, such as LEP Layers, to specific IGES Levels is outside the scope of this AP. In this AP, most semantic information is conveyed through the use of IGES Properties (Type 406).

Color Assignment The custom of using colors to convey semantic information is outside the scope of this AP. A palette of 8 colors has been adopted to provide acceptable visual variety.

Semantic Property Assignment. This AP requires the use of specific properties to communicate the intended use of some of the data encoded by means of the AIM. These properties are gathered into sections (see Figure 4) for particular Application Information Requirement areas and listed below. Each entry in the list is in the form of a string as it might appear in the Parameter Data of the Property Entity (Type 406). This serves to illustrate how name strings, (e.g., “3, 3Htop” for top) integers, (e.g., “1, 420” for 420) and real numbers (e.g., “2, 0.250” for 0.25) may appear in the IGES file sent to the processor(s). The LEP SEMANTIC PROPERTY is especially versatile in this regard.

Forms 1, 2, 3, 5, 6, 9, 10, 15, 24, 27, 36, and 37 of the IGES Property Entity (Type 406) may be found in conformant files. This AP specifies which entities are to reference particular Properties whenever that seems feasible. Some Properties may stand alone in the LEP AP conformant files. Many *LEP SEMANTIC PROPERTIES* are introduced in this AP to convey important semantic information and data for LEP applications.

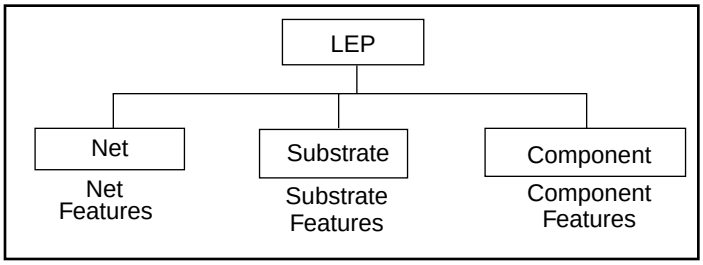


Figure 4. LEP Semantic Features

List of New Level Function Properties for LEP Applications. Processors should treat property text strings, both descriptions and values, as not case sensitive.
0=No value; 1=Integer; 2=Real; 3=Character string; 4=Pointer; 5=Not used; 6=Logical

Table 9. Level Function Properties (Type 406, Form 3)

Parameter Data (fragment)

`0,9Htrace_top`
`0,9Htrace_bot`
`0,7Htrace_2`
`0,7Htrace_n`
`0,14Hsilkscreen_top`
`0,14Hsilkscreen_bot`

2.3 LEP AP

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3 IGES Application Implementation Model

The Application Implementation Model (AIM) is an information model that describes the logical information structures of objects required for accomplishing a physical implementation in IGES. This AIM is prepared at a level of abstraction that is sufficient for selecting the necessary IGES[4] entities for an application protocol.

AIM Structure The AIM shows how information is to be expressed by a subset of IGES entities. Objects identify an abstraction of information. Connection lines indicate relationships to other objects and to IGES entities. The cardinality of the relationships is also indicated.

The IGES entities selected for use in the AP specification have been selected to best convey the information needed in subsequent processes subject to constraints defined in this section. The options for the use of the entities within this subset have been restricted so that only one method is available for carrying each element of information. The set of IGES entities and the necessary restrictions on the Global, Directory Entry, and Parameter Data Section field values are also specified.

IGES Structure and Syntax of the AIM Graphical model objects will be defined in this section to correspond closely to the constructs of the IGES file structure.

IGES File Structure The following is the brief review of the IGES file structure from a predecessor[5] to this document:

> "IGES provides format guidance for data transfer/archive. It defines several data structures or entities, whose pre-defined purpose may be geometry, annotation, or structure. The individual vendor can then map information contained in his proprietary database into this neutral format, then transfer that information to other vendor's applications, or archive the file for future use. IGES is fully three dimensional, and includes finite element, graphics, documentation/annotation, manufacturing and electrical entities.
>
> … The transfer mode will commonly be character (ASCII) … The logical record length is 80 characters (block to 800 on tape) and is formatted for human readability and interaction. The advantage of the ASCII format are at the sacrifice of file size. However, there are standard file compression algorithms which may be used to achieve great reductions in file size, but the compressed files must be decompressed prior to translation. Also see ANSI X3.27-1978 labeled variable block.
>
> The IGES data file structure consists of five sections. The start section, contains 72 columns of user comments which are not to be processed by the program other than listing to screen or printer. Next is the global section, a free format area specifying certain file attributes such as creation date, time, location, designer, units, display resolution, etc. The third section is the Directory Entry (DE) section containing fixed format attribute data (level, line font, transformation matrix, view, etc.) for each entity. The Parameter Data (PD) section follows and contains actual parameters for each of the entities in the DE section. Finally, the terminate section contains a single record containing the count of the records in each section. The entities come in two classes, those that are pre-defined and documented by the IGES committee (numbers 0001 to 5000), and those that are implementor definable (5001 to 9999). The constructs for a valid IGES file shall conform to those specified in the current version of the IGES Specification.

START Section The IGES file Start section structure shall be in accordance with IGES. The contents of the start section are not specified or constrained herein.

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4. This section depends on the IGES document cited in section 2 for definitions and explanations of the format structure and the entities cited.
5. see Appendix E of [6].

3 AIM

TERMINATE Section The IGES file Terminate section shall be in accordance with the IGES document identified in Global parameter number 23.

GLOBAL Section The IGES file Global section shall be in accordance with the IGES document identified in Global parameter number 23 described in Section 3.0.1 below.

DIRECTORY ENTRY and PARAMETER DATA Sections The IGES file Directory Entry and Parameter sections shall be in accordance with IGES Volume I. The values applicable to these section entries are dependent on the IGES entities and the objects (information structures) contained in the file. Those entities and objects shall be structured as defined in the remainder of this section.

Global Values and Entities List. The following are IGES constructs that aserve to fulfill the requirements of each AP. Other entities defined in the IGES Specification may be used for other purposes, however, these other entities should not be used for the purposes stated in the AIM. The IGES Volume I should be consulted for the details of the syntactical constructs needed to produce valid IGES files.

Globals: (these serve to identify general product-file attributes) The following values are specific to this document:

Global No.	Description
3	Product identification from sending system; for 3D Piping applications, values of “8HINSTNANCE” or 10HDEFINITION” shall be assigned.
4	File name (80 characters maximum)
5	Sending system identification (40 characters maximum)
6	Translator version (20 characters maximum)
12	Product identification for the receiving system
13	Model space scale; for 3D Piping applications, value shall be “1.0.”
14	Unit flag; for 3D Piping applications value shall be “1” (= Inches).
15	Units; for 3D Piping applications value shall be “2HIN” (= Inches).
21	Name of author (20 characters maximum)
22	Author’s organization (20 characters maximum)
23	IGES Version Code number; “12” shall be assigned.
25	Date and time the model was created or last modified*
26	Application protocol / subset identifier**

* IGES permits the year to be either 2 or 4 characters. Year values shall be written using 4 characters. Values read containing 2 character years shall be interpreted as preceded by “19.”

** For Drafting applications value shall be 21HIGES AP: DRAFTING 2.0
For 3D Piping applications value shall be 22HIGES AP: 3D PIPING 2.0
For LEP applications value shall be 16HIGES AP: LEP 2.0

IGES Entities Used in the AIM: The AIM defines objects needed by the designer of translators and other software. The information requirements for these objects are defined within the ARM. The ARM information elements, excepting those identified as “out of scope,” have been developed as detailed IGES-specific objects in the AIM.

All versions of IGES subsequent to version 3.0 are capable of transferring LEP information. To provide guidance needed to interpret files written to various versions, this section contains information on each applicable IGES entity and the initial version for the entity. Individual object definition models in the AIM contain usage restrictions (i.e., usage constraints) appropriate to the application. Please refer to the applicable IGES document for detailed information regarding these entities. Implementors are also

encouraged to write a Request for Change (RFC) where user-defined IGES entities have demonstrated a worthwhile capability. Implementors are encouraged to return results from implementation and exchange through the use of the constructs defined in an RFC.

Version	Type	Form	Description
V1.0	100	0	Circular Arc
V1.0	102	0	Composite Curve
V1.0	106	11	Copious Data - Planar Piecewise Linear Curve
V1.0	106	20, 21, 40	Copious Data*
V2.0	106	63	Copious Data - Simple Closed Planar Curve
V1.0	108	0, 1, -1	Plane
V1.0	110	0	Line
V1.0	116	0	Point
V1.0	124	0-1	Transformation Matrix
V2.0	125	0-4	Flash
V3.0	132	0	Connect Point
V4.0	150-162	All	Solids(CSG) Entities (Piping applications)
V5.0	182		Selected (CSG) Component (Piping applications)
V3.0	184	0, 1	Solid (CSG) Assembly (Piping application)
V1.0	212	0	General Note
V3.0	212	1,6,7&8	General Note*
V4.0	230	0	Sectioned Area (LEP: patterns 0 and 19 used as filled region)
	2xx	x	Other Annotation entities*
V1.0	308	0	Subfigure Definition
V3.0	312	0, 1	Text Display Template
V3.0	314		Color Definition*
V3.0	320	0	Network Subfigure Definition**
V4.0	322	All	Attribute Table Definition**
V1.0	402	1	Group Associativity with Back Pointers
V1.0	402	7	Group Associativity without Back Pointers
V3.0+	402	18	Flow Associativity**
V1.0	404	0	Drawing*
V1.0	406	1	Property - Definition Levels
V2.0	406	2	Propertu - Region Restriction**
V2.0	406	3	Property - Level Function
V2.0	406	5	Property - Line Widening**
V2.0	406	6	Property - Drilled Hole***
V2.0	406	9	Property - Part Number
V2.0	406	10	Property - Hierarchy
V3.0	406	11	Property - Tabular Data
V3.0	406	15	Property - Name
V4.0	406	16	Property - Drawing Size*
V4.0	406	17	Property - Drawing Units*
V5.0+	406	24	Property - Level to LEP Layer Map**
V5.1	406	27	Property - Generic Data

V5.3	406	32	Property - Drawing Sheet Approval*
V5.3	406	33	Property - Drawing Sheet ID*
V5.3	406	34	Property - Underscore
V5.3	406	35	Property - Overscore
V5.3	406	36	Property - Closure (product model geometry)
V6.0	406	37	Property - Bus Signal Width (LEP application)**
V6.0	406	38	Property - Universal Resource Locator (URL) Anchor
V1.0	408	0	Subfigure Instance
V1.0	410	All	View*
V3.0	416	2	External Reference (logical reference)
V5.0	416	3	External Reference (to subfigure copy)
V3.0	420	0	Network Subfigure Instance**
V4.0	422	All	Attribute Table Instance**

* Optional; used in Drafting application when appropriate.
** Optional; used in Piping and in LEP circuit analysis/simulation applications where appropriate.
*** LEP; may only be applicable to certain product types, in particular the Printed Wiring Board.

Basic Syntax Used in the AIM. A graphic notation has been adopted to describe the IGES data structures. The objective of these diagrams is the ease of developing unambiguous IGES translators and proofreading files. The notation is not intended for use as a conceptual modeling language. The brief descriptions which follow explain the use of principal elements of the notation; the Object Definition Block, the Object Instance Block, the Object Value Block, and the Cardinality code.

Object Definition Block. The Object Definition Block is used to depict an IGES entity type, form, directory entry values, parameter data values, and relationships to other IGES entities. There are several forms of the Object Definition Block depending upon how the object is being used within the model.

Each in-scope Object is depicted at least once using the Object Definition Block.

The graphic in Figure 5 is used to depict data and relationships to other objects for a particular “Abstract Object” (a high-level abstraction usually from the electronic design domain). The graphic shows the field name and required value(s)—if appropriate—for a particular field within the definition or instance of an object. An Object Value Block (see 3.0.3.3) may be referenced by either an Object Definition Block or an Object Instance block.

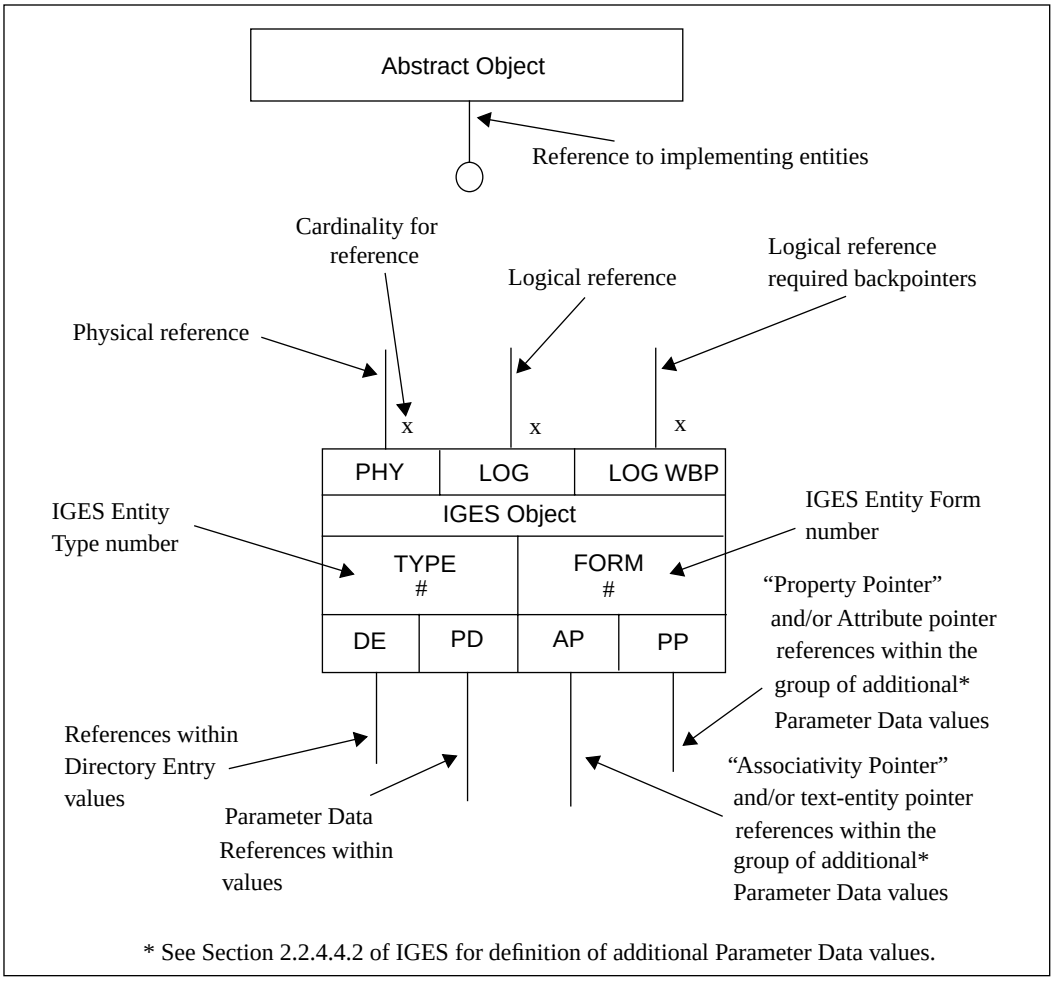


Figure 5. AIM Object and Referencing

Object Instance Block. The graphic in Figure 6a illustrates a particular reference to a previously defined object.

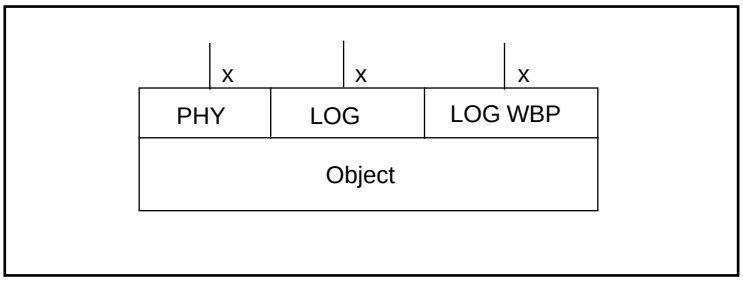


Figure 6a. Short Form of References to Previously Defined Object

The long form in Figure 6b is available if the particular instance needs to reference other IGES entities.

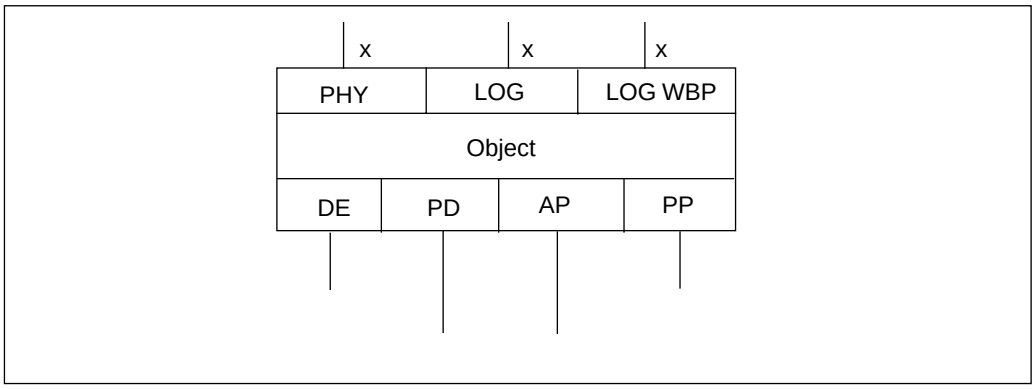


Figure 6b. Long Form of References to Previously Defined Object

Object Value Block. The graphic in Figure 7 illustrates the field name and required value(s), if appropriate, for a particular field within the definition or instance of an object. This Value Block shown corresponds to the IGES parameter data section.

The Value Definition Block is used to show a set of Object reference mechanisms. The mechanisms provide ways to show either Directory Entry (DE) values or Parameter Data (PD) values. These values may reference other IGES Entities via their DE identifying numbers.

A Value Block may be referenced by either an Object Definition Block or an Object Instance Block.

Value		
Index	Name	Value
1	name1	Value
2	name2	*
3	name3	⇒
4	name4	value |⇒
5	name5	N/A
...	name...	...

Field value as appropriate

Any acceptable value

Pointer to a predefined Instance Block

Value or pointer to a predefined Object Instance Block

Value will be ignored

Figure 7. Object Field Value Restrictions

Object Reference Mechanism. The Object Definition Block or the Object Instance Block each may reference subordinate /child objects. Each object block will distinguish a reference to a subordinate object by any of the following mechanisms:

1) a directory entry (DE) pointer
2) a parameter data (PD) pointer, or (when appropriate)
3) an associativity back pointer (AP) or
4) a property pointer (PP)

as shown in Figure 10.

The reference to the subordinate object may involve either of the two kinds of dependencies described in 2.2.4.3.9.2 of IGES Volume 1. The three dependency mechanisms indicated in Figure 8 are:

1) physically subordinate (Physical),
2) logically subordinate (Logical), or
3) logically subordinate with back pointer (LogW/BP).

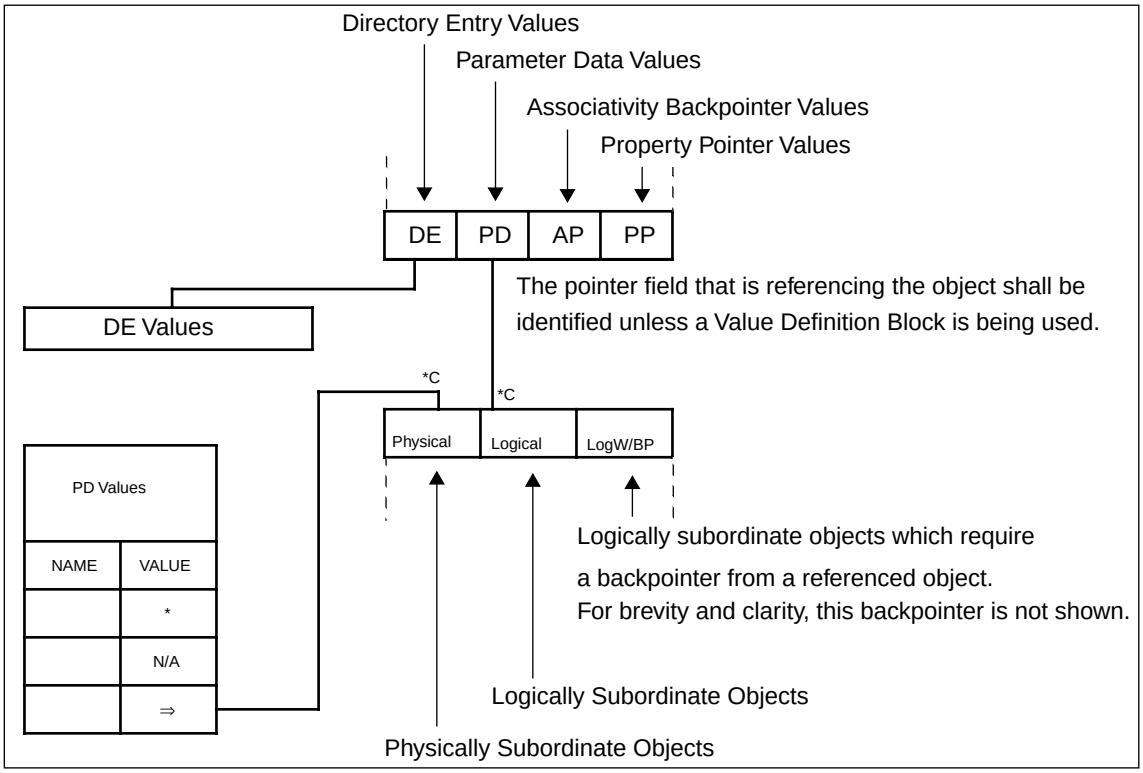


Figure 8. Reference Mechanism

The back pointers for the third mechanism are never explicitly shown in the figures that follow.

The representations of cardinality indicators are shown in Figure 9

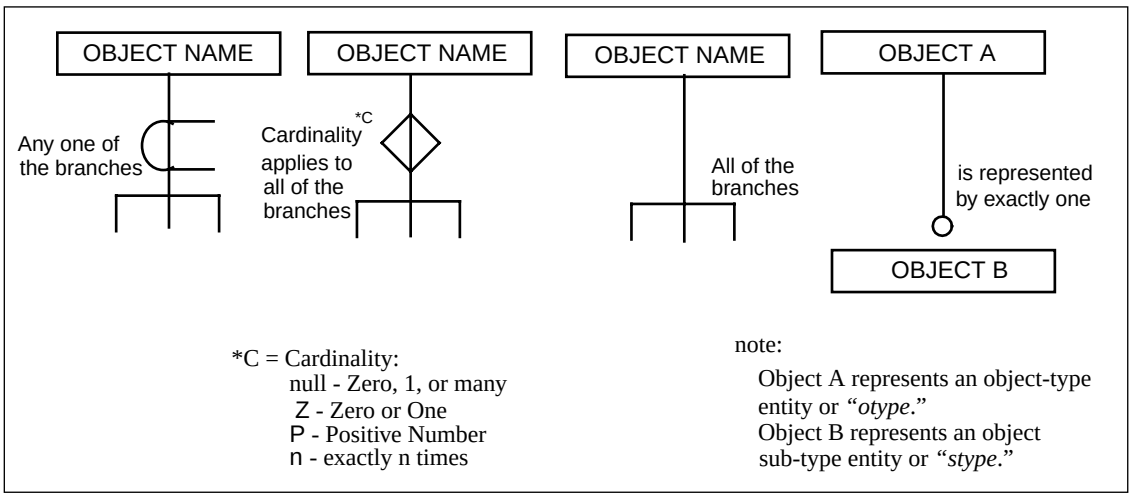


Figure 9. Representation Mechanism

3.1 Drafting Application

The scope includes product presentation and visualization graphic and graphics annotation information contained in computer-aided design (CAD) systems. These systems are in widespread use and translation between dissimilar systems is a high priority in the user community. IGES serves as the implementation for this information because many CAD suppliers are familiar with the specification and support it in their software packages.
The scope is also inclusive of IGES viewers and other display applications such as publishing, computer visualization, and Internet-accessed graphics.

3.1.1 Presentation Graphics.

Description:

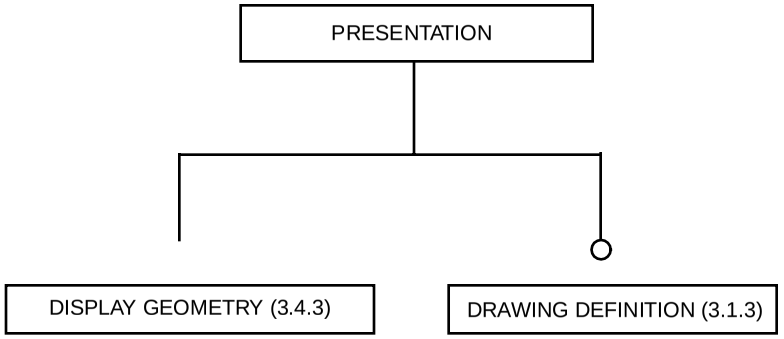
The presentation consists of both a displayable geometry and drawing-defining entities.

Requirements/Restrictions:

Translation Usage Notes:

General:

Output:
Input:



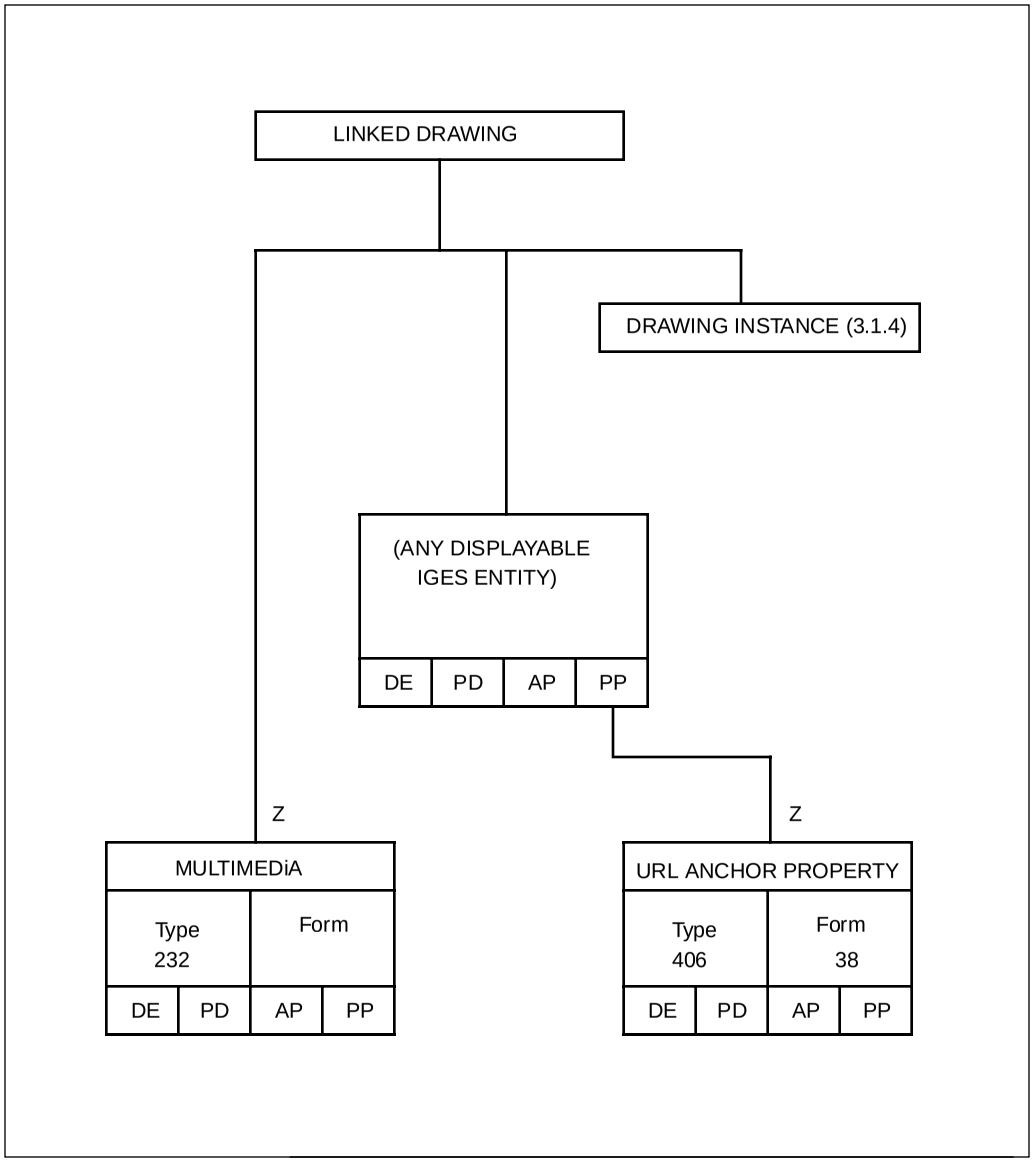
3.1.2 Linked Drawing Object Models.

The Linked Drawing objects provide the method for including drawings, technical illustrations, annotation, or other information which is in associated files and/or media. The Multimedia Entity (Type 232) is used to present a linked file within a defined area of a drawing. The URL Anchor Property Entity (Type 406, Form 38) associates a link to any graphical entity which provides ahypertext link for those systems which support such links.

Requirements/Restrictions:

1. The URL Anchor Property Entity (Type 406, Form 38) shall be used to associate navigable links with displayable IGES entities.

Translation Usage Notes:
General:
Output:
Input:



3.1.3 Drawing Definition.

Description:

The *DRAWING DEFINITION* object is a Subfigure Definition which represents an engineering drawing of a product, such as a 3D Piping application, an *LEP*, a *PANEL*, or some portion of the *LEP*.

Requirements/Restrictions:

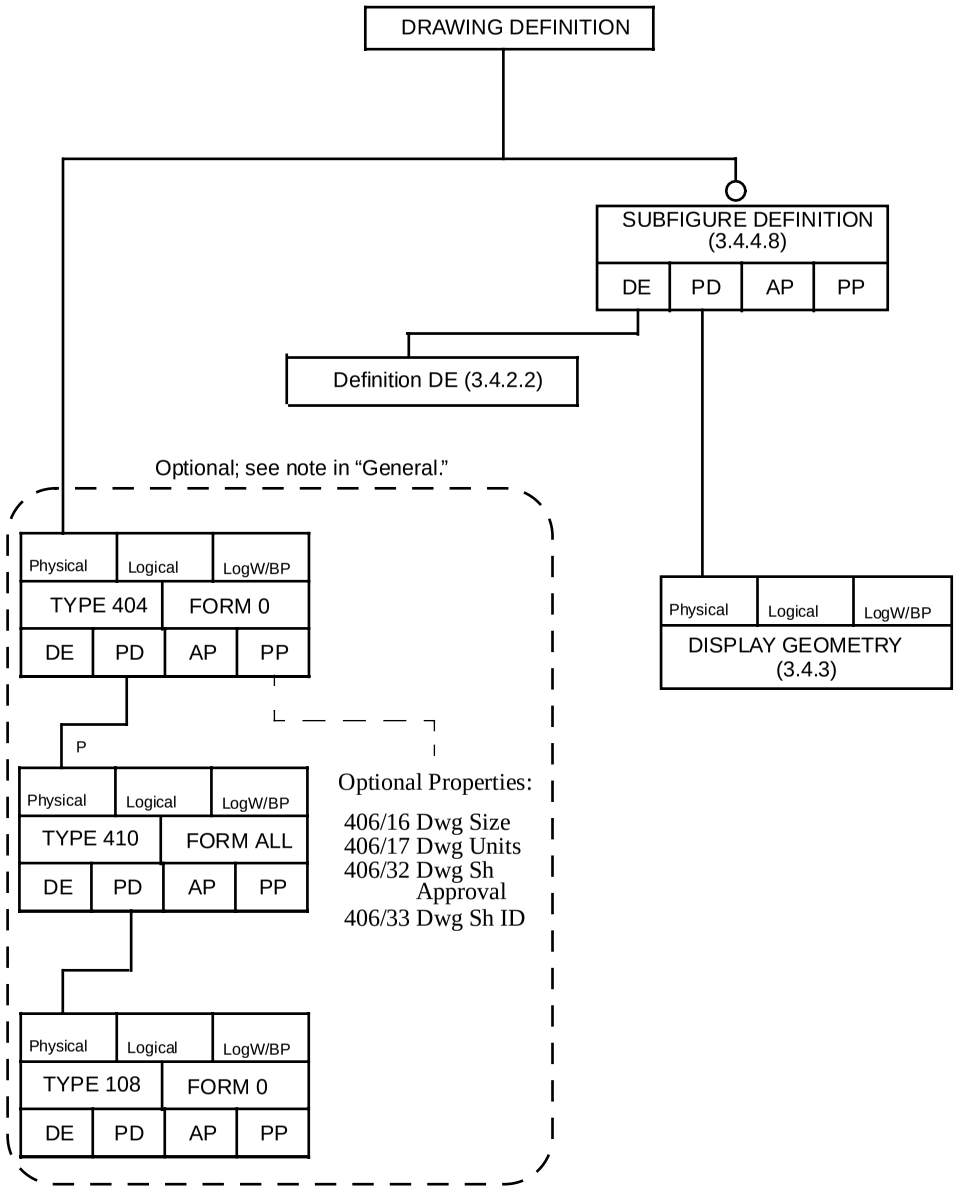
1. The NAME field in the *SUBFIGURE DEFINITION* shall be unique within the scope of the IGES File.

Translation Usage Notes:

General:
The Drawing Entity (Type 404), View Entity (Type 410), Plane Entity (Type 108) and properties as appropriate optionally appears in*TECHNICAL ILLUSTRATION*. See Section 3.6.5 of IGES for association of these entities.

Output:

Input:



3.1.4 Drawing Instance.

Description:

The *DRAWING INSTANCE* object is an instantiation of a *DRAWING DEFINITION*.

Requirements/Restrictions:

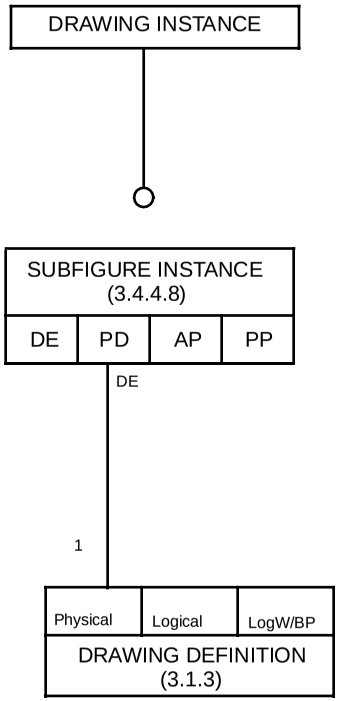
1. The *GENERIC DATA PROPERTY* which is referenced from the *SUBFIGURE INSTANCE* object shall specify
   top_level_assembly_instance.

Translation Usage Notes:

General:

Output:

Input:



3.2 Piping Objects

The objects in this section define the structure for exchanging 3D piping representations.

3.2.1 Piping System.

Description:
These objects serve to depict shapes of physical objects in the piping system and its related mechanical products.

Requirements/Restrictions:

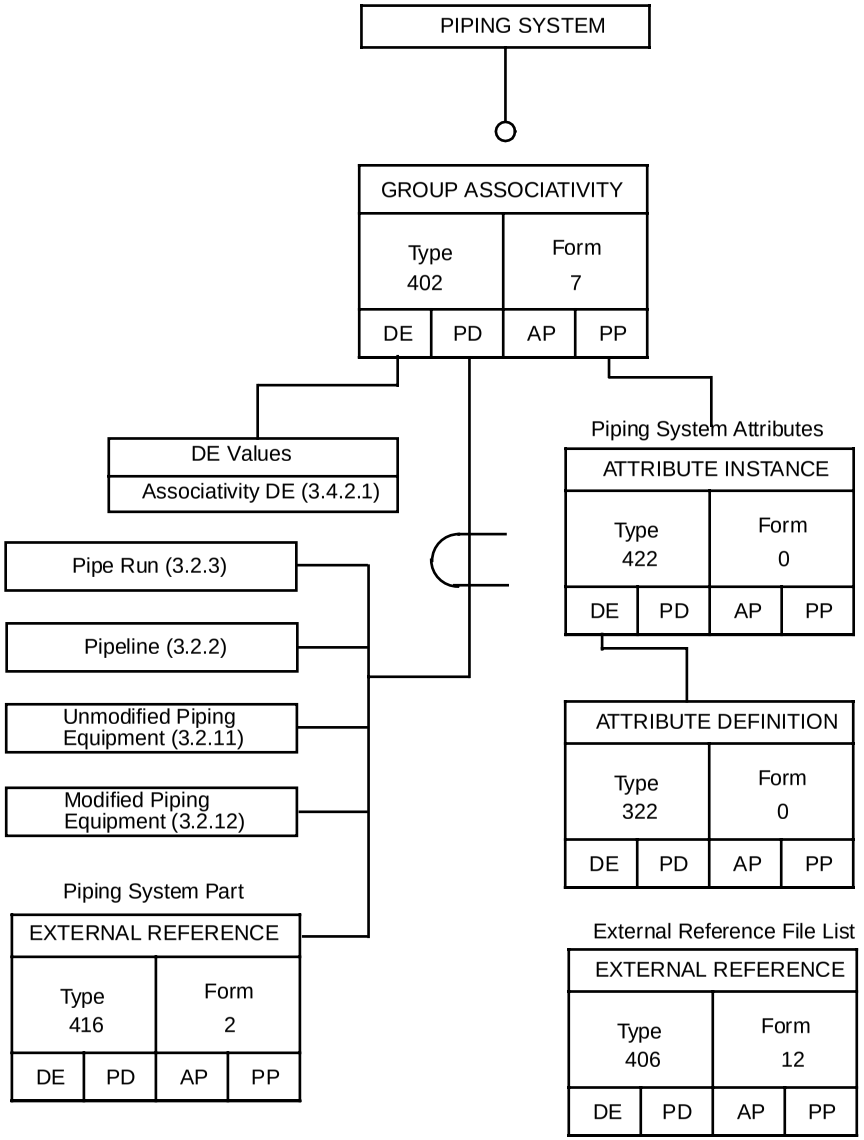
1. A Piping System shall have at least one Pipe Run.
2. A Pipe Run shall belong to at most one Pipe System.
3. A Pipeline shall belong to at most one Pipe System.
4. Piping System Part is one of
   pipe_run_identifier
   pipeline_identifier
   piping_equipment_identifier
5. Piping System Attributes are:
   piping_object_type
   piping_system_identifier
6. Piping System File List shall contain a list of all files which are referenced in Type 416, Form 2 Entities elsewhere in the file.

Translation Usage Notes:

General:

Output:

Input:



3.2.2 Pipeline.

Description:

The Pipeline object is one or more connected Pipe Run objects.

Requirements/Restrictions:

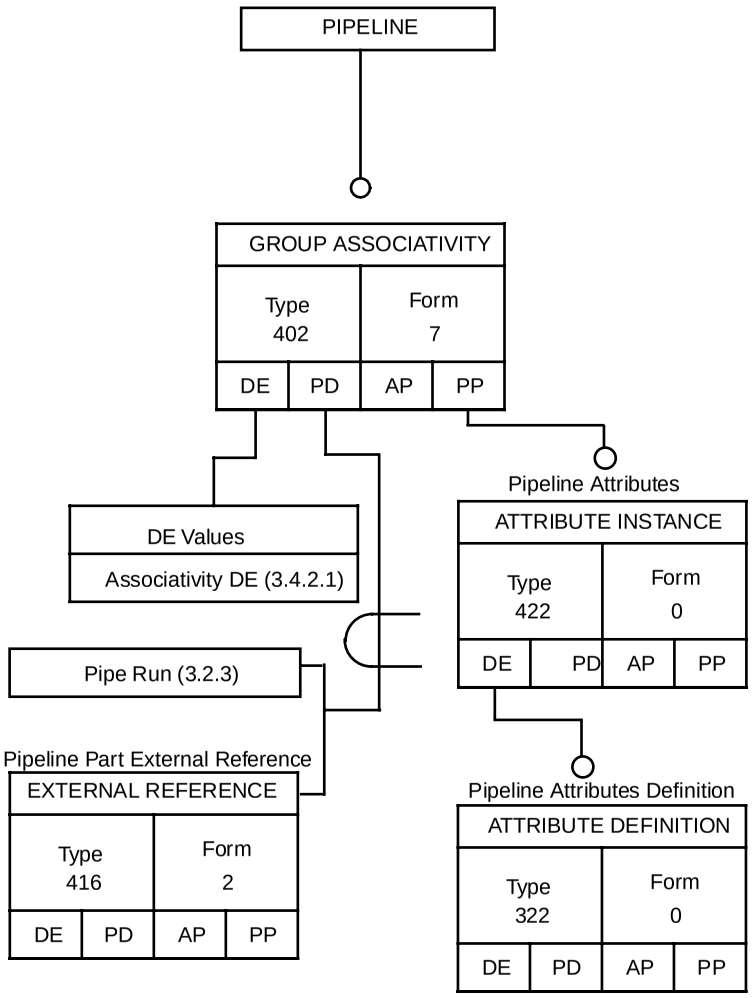
1. A Pipe Run belongs to at most one Pipeline.
2. Pipeline Part reference is
   pipe_run_identifier
3. Pipeline Attributes are
   pipeline_identifier
   Piping_object_type.

Translation Usage Notes:

General:

Output:

Input:



3.2.3 Pipe Run.

Description:

The Pipe Run object consists of related Pipes, Unmodified Piping Components or Modified Piping Components.

Requirements/Restrictions:

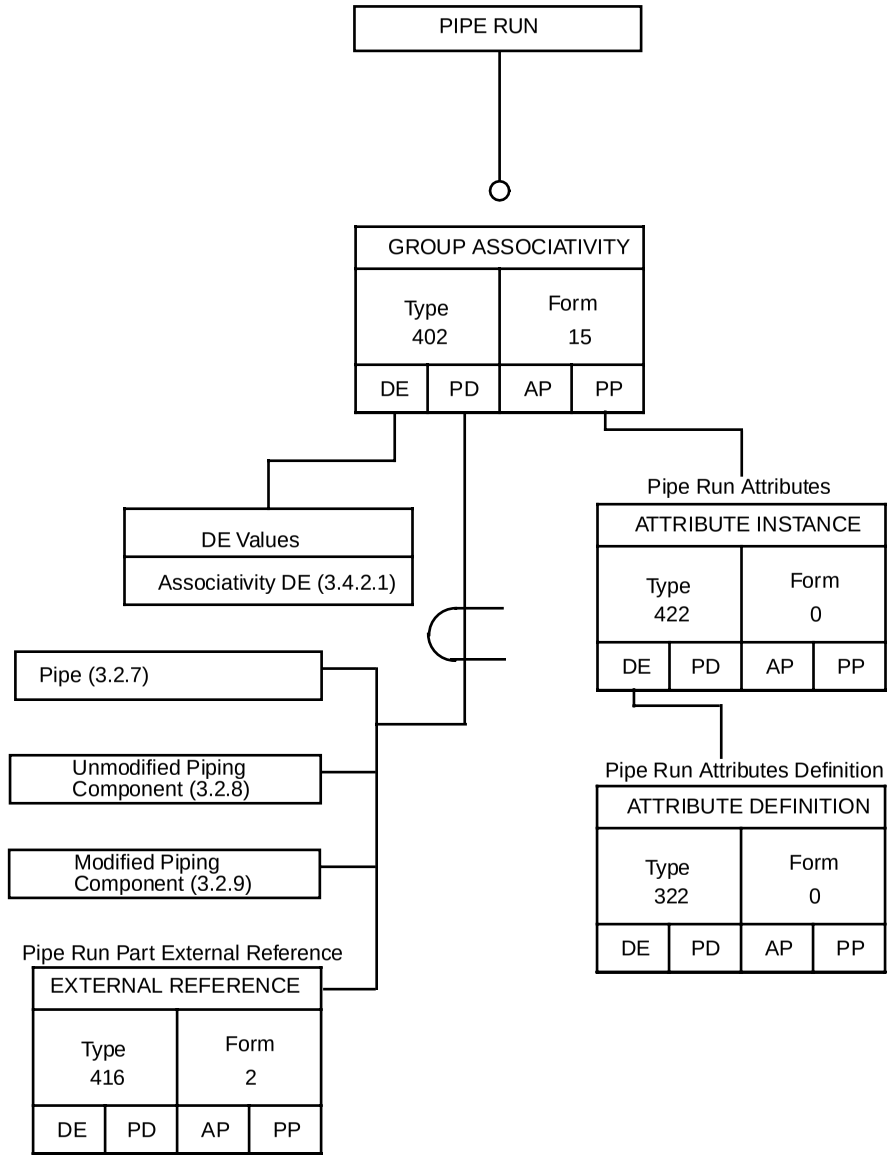
1. A Pipe Line Part belongs to at most one Pipe Run.
2. A Pipe Run is represented by a string of connected pipes and components originating and terminating at a component with more than two ports, at a change in pipe run attributes, or at a boundary point in the Piping System.
3. Pipe Run Part reference is
   pipe_identifier
   piping_component_identifier
4. Pipe Run attributes are
   piping_object_type
   pipe_run_identifier
   pipe_specification
   pipeline_identifier

Translation Usage Notes:

General:

Output:

Input:



3.2.4 Piping Assembly.

Description:

The Piping Assembly is a collection of (sub) piping assemblies, pipe, components, equipment, and related mechanical parts.

Requirements/Restrictions:

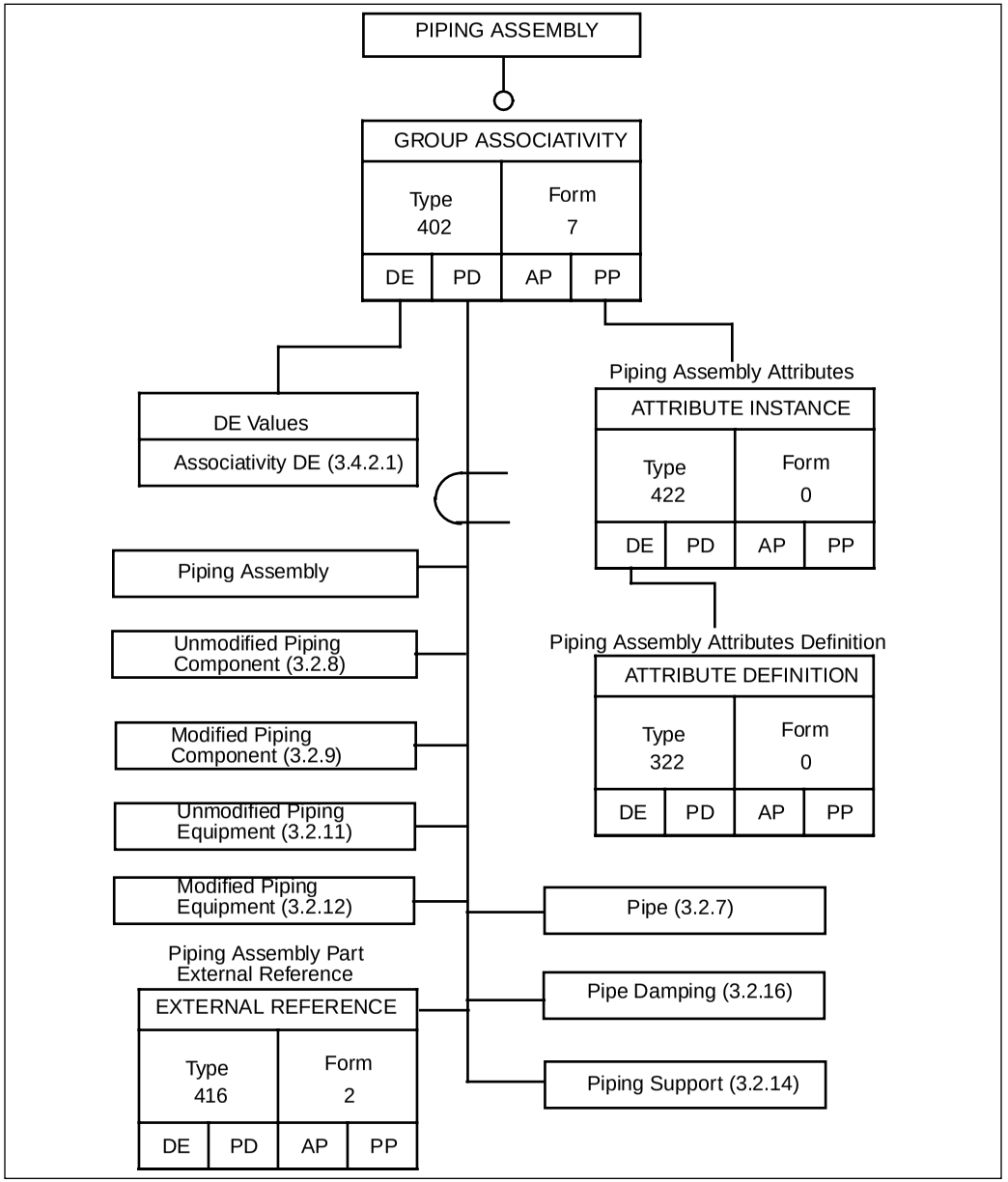
1. A Piping Assembly is a member of at most one Piping Assembly.
2. A Piping Part is a member of at most one Piping Assembly.
3. A Piping Attachment Part is a member of at most one Piping Assembly.
4. A Piping Assembly Part reference is one of
   pipe_identifier
   piping_component_identifier
   piping_equipment_identifier
   pipe_damping_identifier
   piping_support_identifier
5. .Piping Assembly attributes are
   piping_object_type
   piping_assembly_identifier
   piping assembly_type

Translation Usage Notes:

General:

Output:

Input:



3.2.5 Piping Port, External Piping Port, and Piping Port Definition.

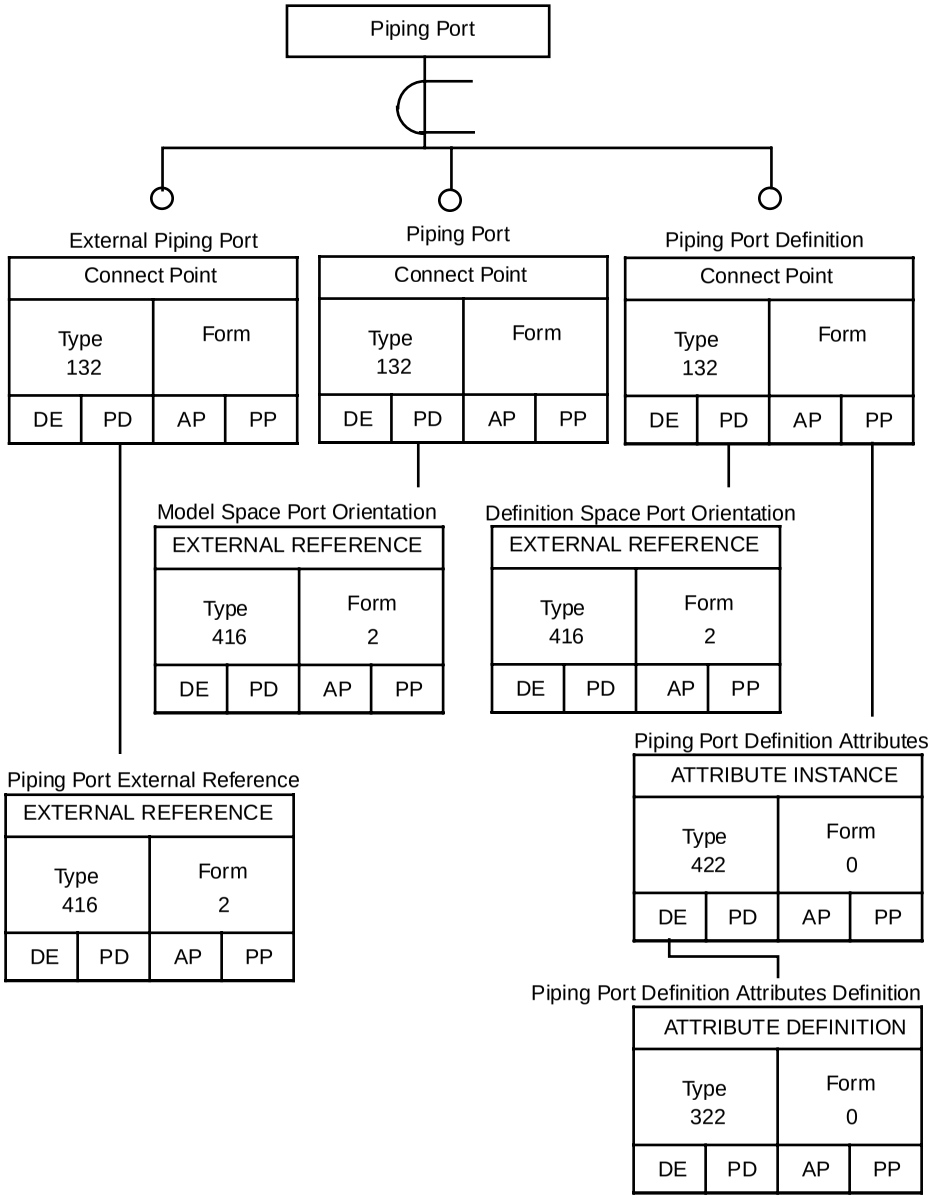
Description:

The Piping Port, External Piping Port, and Piping Port Definition are each implemented as a Connect Point Entity (Type 132).

Requirements/Restrictions:

1. The Piping Port is one of
   pipe_branch_port
   pipe_end_port
   piping_component_port
   piping_equipment_port
2. The Piping Port contains model_space_location and the parameters
   port_type
   port_label
3. Piping Port Definition is one of:
   piping_component_port_definition
   piping_equipment_port_definition
4. Piping Port Definition contains definition space location and the attributes:
   port_definition_type
   port_definition_label
5. Piping Port Definition Attributes are:
   nominal_pipe_size
   nominal_pipe_size_units
   nominal_pipe_size_type
   end_preparation
   wall_thickness
   wall_thickness_units
   schedule
   pressure_rating
   pressure_rating_units
   pipe_fit_up_length
   pipe_fit_up_length_units

Translation Usage Notes:



3.2.6 Object Envelope Definition and Installed Access Envelope.

Description:

The Object Envelope Definition and Installed Access Envelope are each a Selected Component Entity (Type 182) which provides a means of selecting one component of a disjoint constructive solid geometry (CSG).

Requirements/Restrictions:

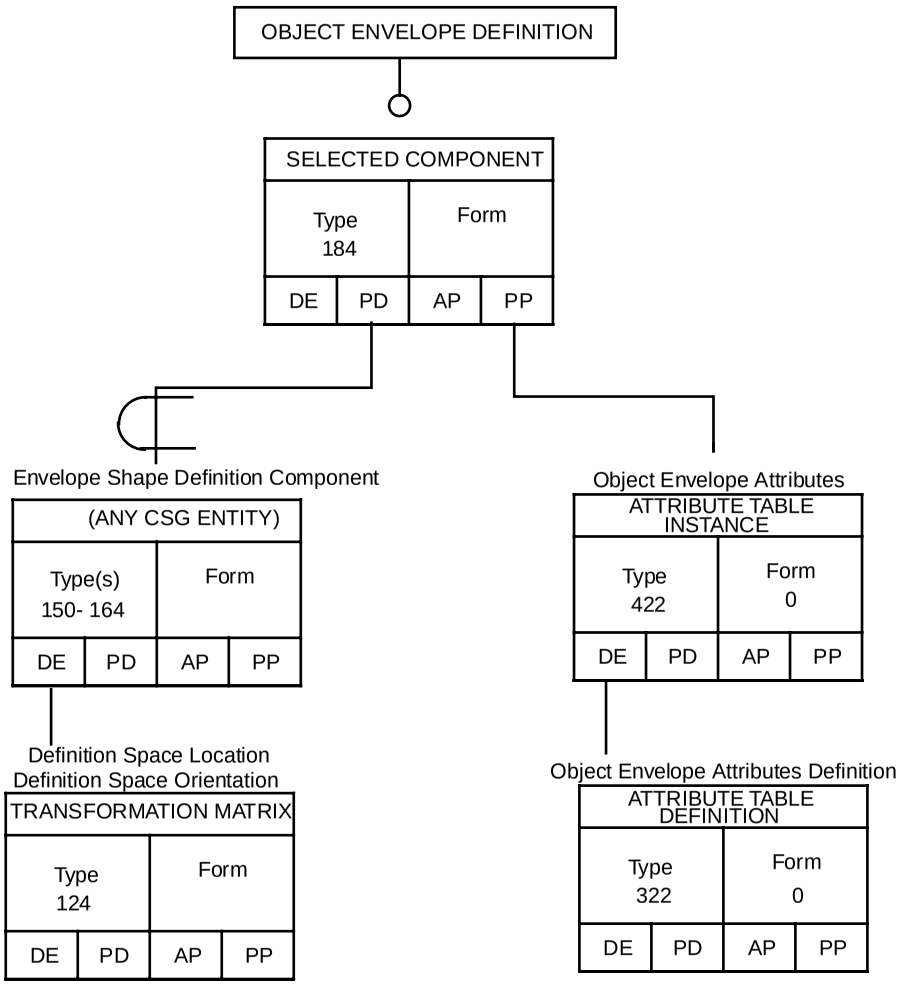
1. Object Envelope Definition is one of:
   access_envelope_definition
   insulation_shape_envelope_definition
   piping_envelope_definition
2. Object Envelope Atribute are:
   object_envelope_type
3. Installed Access Envelope Attributes are:
   object_envelope_type

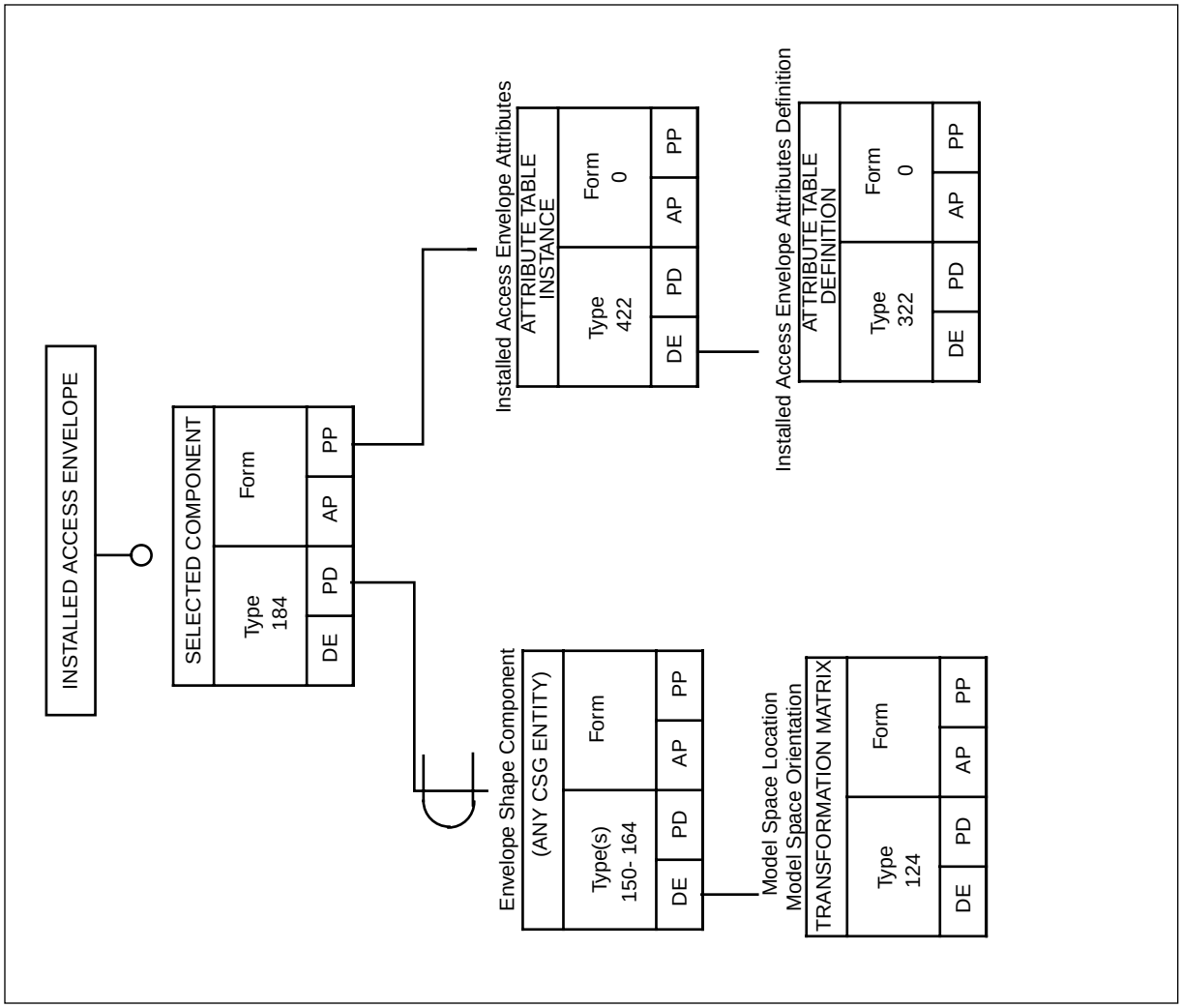
Translation Usage Notes:

General:

Output:

Input:





3.2.6 (continued)

3.2.7 Pipe.

Description:

The Pipe object is a Circular Arc or a Line segment or a combination thereof. The Attribute Table contains the characteristics of the Pipe.

Requirements/Restrictions:

1. Pipe Definition Attributes are:
   nominal_pipe_size
   nominal_pipe_size_type
   nominal_pipe_size_units
   material_name
   material_description
   wall_thickness
   wall_thickness_units
   stock_number
   schedule
   part_class
   pressure_rating
   pipe_outside_diameter
   pipe_outside_diameter_units

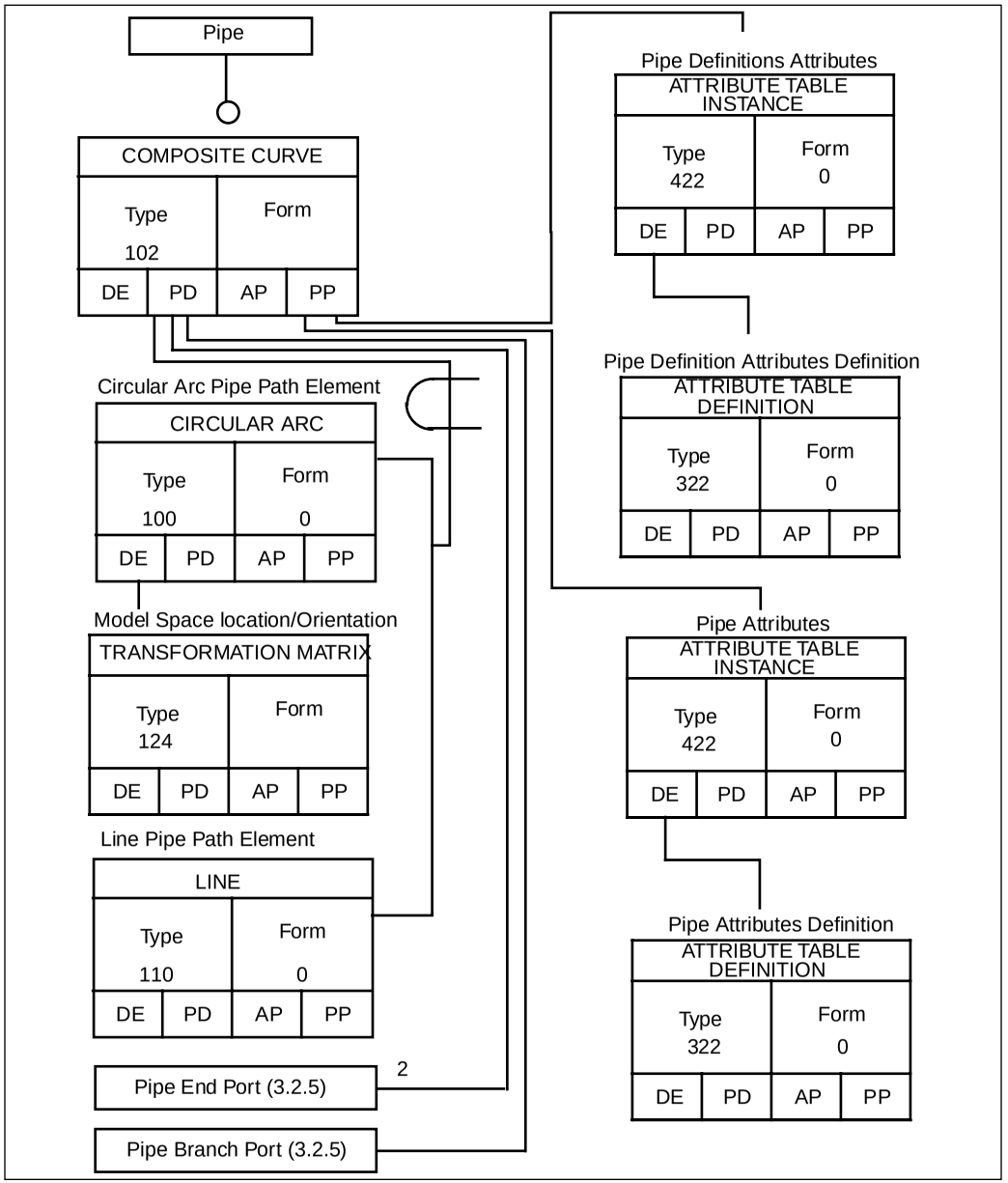
2. Pipe Attributes are:
   pipe_object_type
   pipe_identifier

Translation Usage Notes:

General:

Output:

Input:



3.2.8 Unmodified Piping Component.

Description:

The Unmodified Piping Component object represents a component which does not have an added Piping Port nor an Installed Access Envelope.

Requirements/Restrictions:

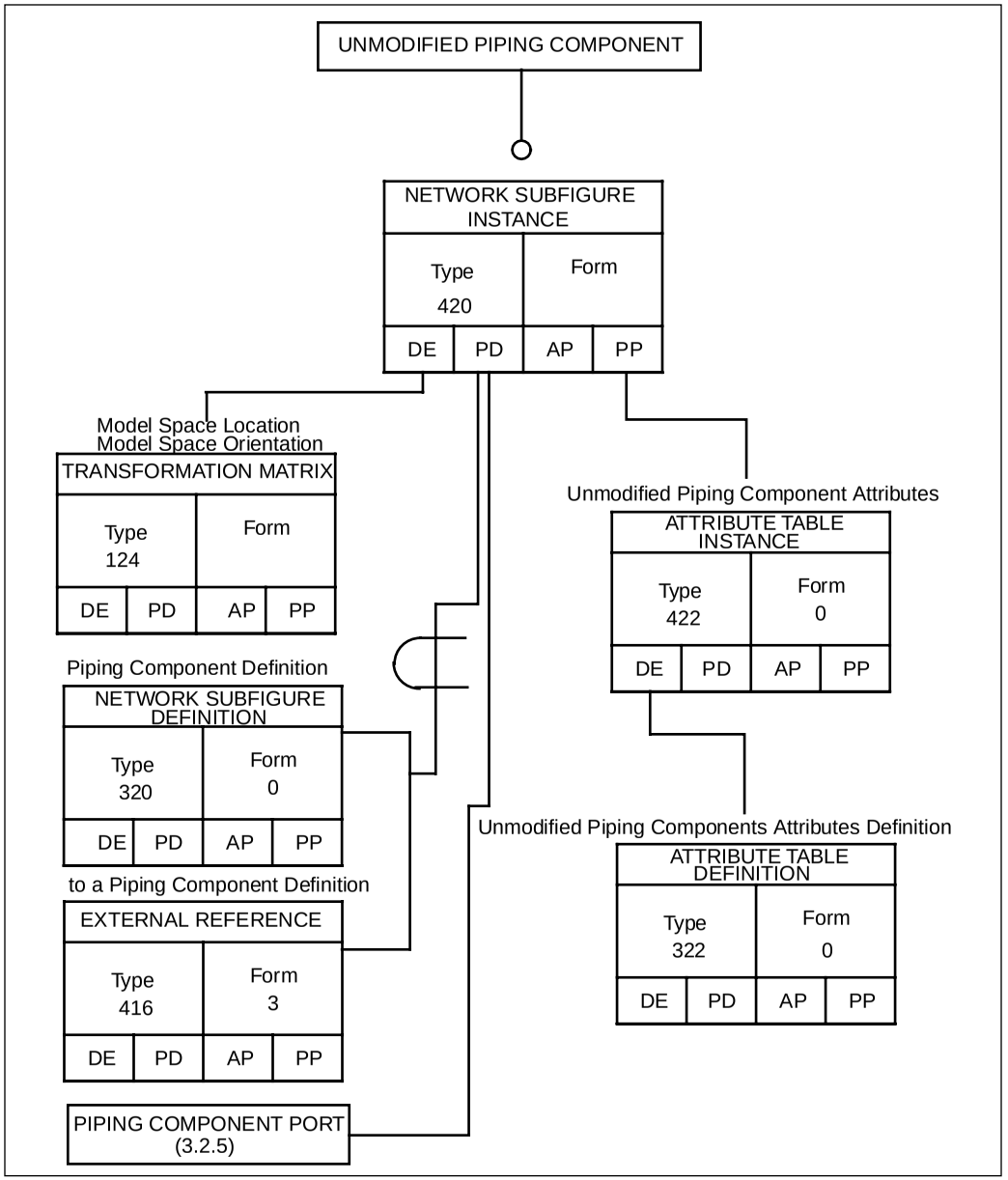
1. Rule: The number of Piping Component Ports, N, in an Unmodified Piping Component shall be the same as the number of Piping Component Port Definitions, NC, in the Piping Component Definition.
2. Note: Unmodified Piping Component Attributes are:
   piping_object_type
   piping_component_identifier

Translation Usage Notes:

General:

Output:

Input:



3.2.9 Modified Piping Component.

Description:

The Modified Piping Component object is a Group Associatvity which collects the additional Connect Point together with a member Installed Access Envelope and any Unmodified Piping Component(s).

Requirements/Restrictions:

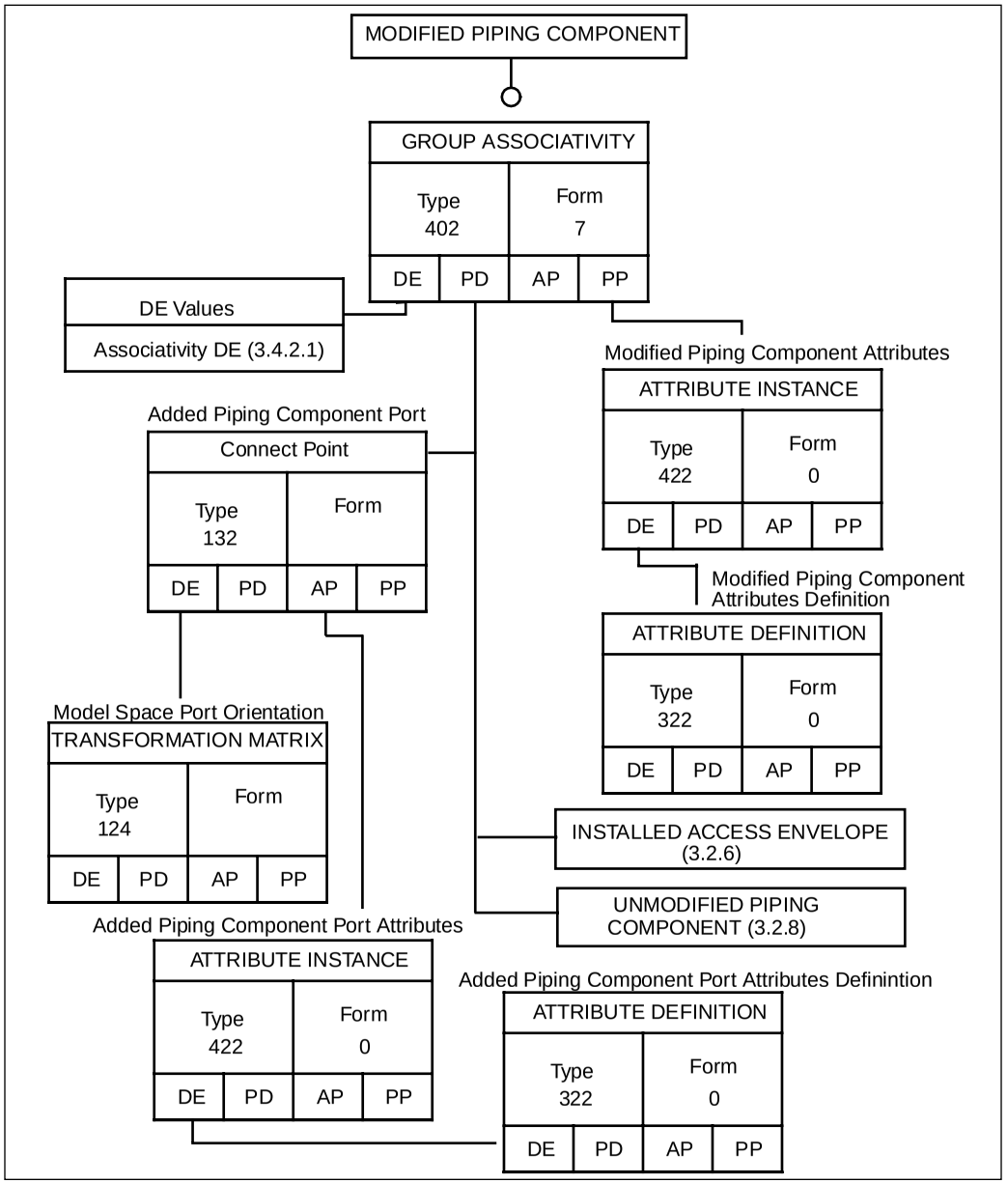
1. The added Piping Component Port contains Model Space Location and the parameters:
   port_type
   port_label
2. The Model Space Port Orientation Entity (Type 124) provides a matrix for piping port orientation in model space.
3. The added Piping Component Port attributes are:
   end_preparation
   pressure_rating
   pressure_rating_units
   pipe_fit_up_length
   pipe_fit_up_length_units.
4. The Modified Piping Component attributes are:
   piping_object_type
   piping_component_identifier
5. Rule: The above attributes for Modified Piping Component take precedence over the same attributes in the UnmodifiedPiping Component.

Translation Usage Notes:

General:

Output:

Input:



3.2.10 Piping Component Definition.

Description:

The Piping Component Definition object is a Network Subfigure Definition Entity (Type 320) together with associated entities as shown in referenced figures.

Requirements/Restrictions:

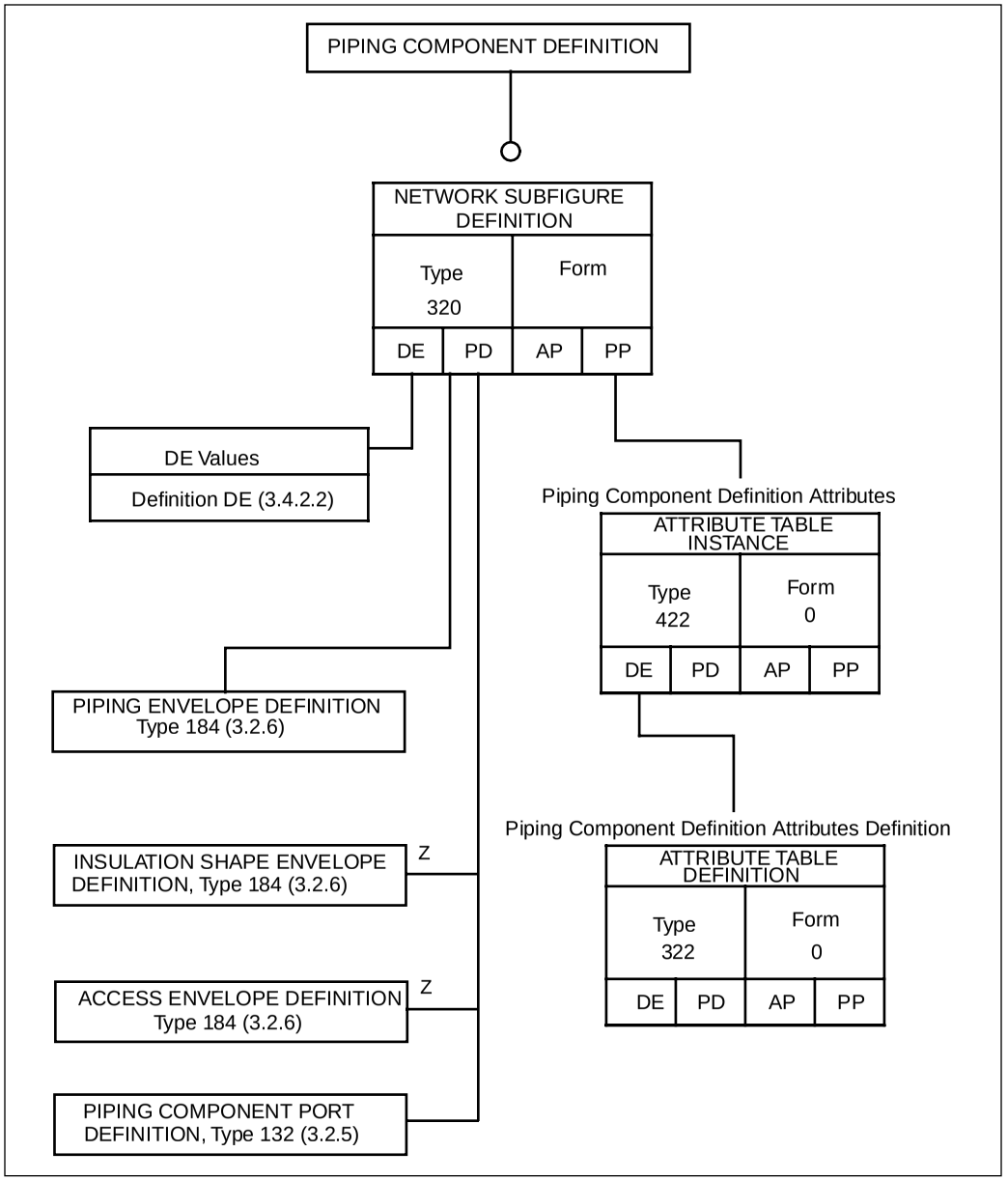
1. Rule: The number of Piping Component Ports N, in an Unmodified Piping Component shall be the same as the number of Piping Component Port Definitions, NC, in the Piping Component Definition.
2. Note: Piping Component Definition Attributes are:
   piping_object_type
   material_name
   material_description
   stock_number
   part_class
   piping_component_type

Translation Usage Notes:

General:

Output:

Input:



3.2.11 Unmodified Piping Equipment.

Description:

The Unmodified Piping Equipment object represents equipment which does not have an added Piping Port nor an Installed Access Envelope.

Requirements/Restrictions:

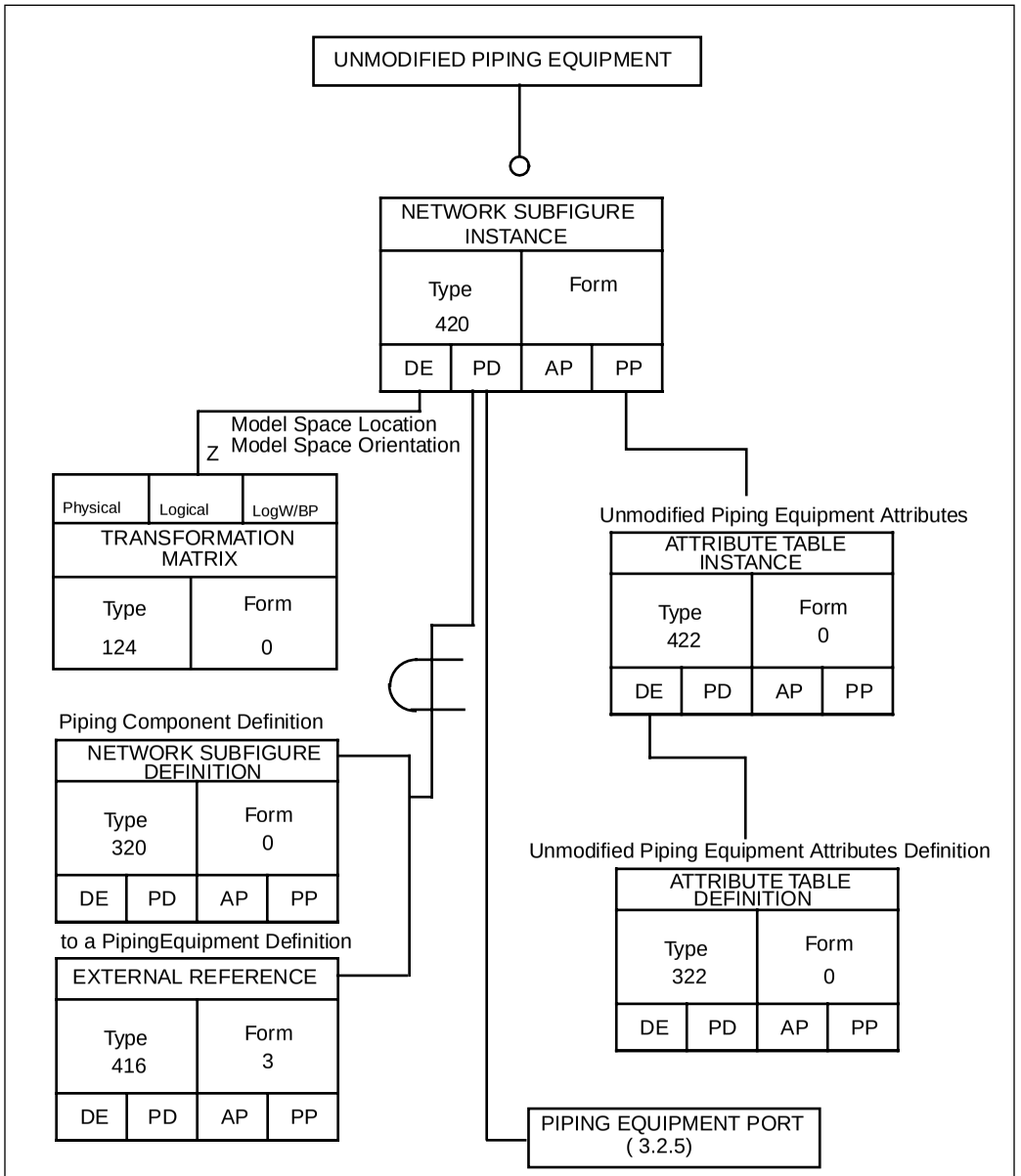
1. Rule: The number of Piping Equipment Ports, N, in an Unmodified Piping Equipment shall be the same as the number of Piping Equipment Port Definitions, NC, in the Piping Equipment Definition.
2. Note: Unmodified Piping Equipment Attributes are:
   piping_object_type
   piping_equipment_identifier

Translation Usage Notes:

General:

Output:

Input:



3.2.12 Modified Piping Equipment.

Description:

The Modified Piping Equipment object is a Group Associatvity which collects member Installed Access Envelope and any Unmodified Piping Equipment(s).

Requirements/Restrictions:

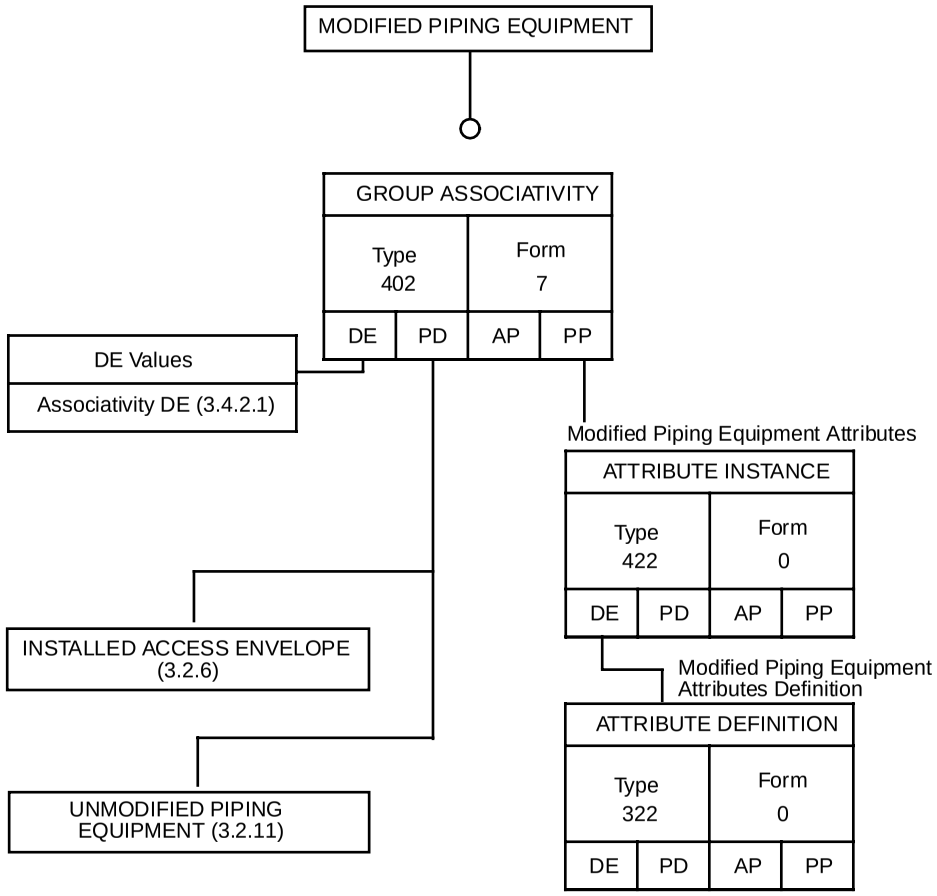
1. Rule: The below attributes for Modified Piping Equipment shall take precedence over the same attributes in the Unmodified Piping Equipment.
2. Note: Modified Piping Equipment Attributes are:
   piping_object_type
   piping_equipment_identifier

Translation Usage Notes:

General:

Output:

Input:



3.2.13 Piping Equipment Definition.

Description:

The Piping Equipment Definition object is a Network Subfigure Definition Entity (Type 320) together with associated entities as shown in referenced figures.

Requirements/Restrictions:

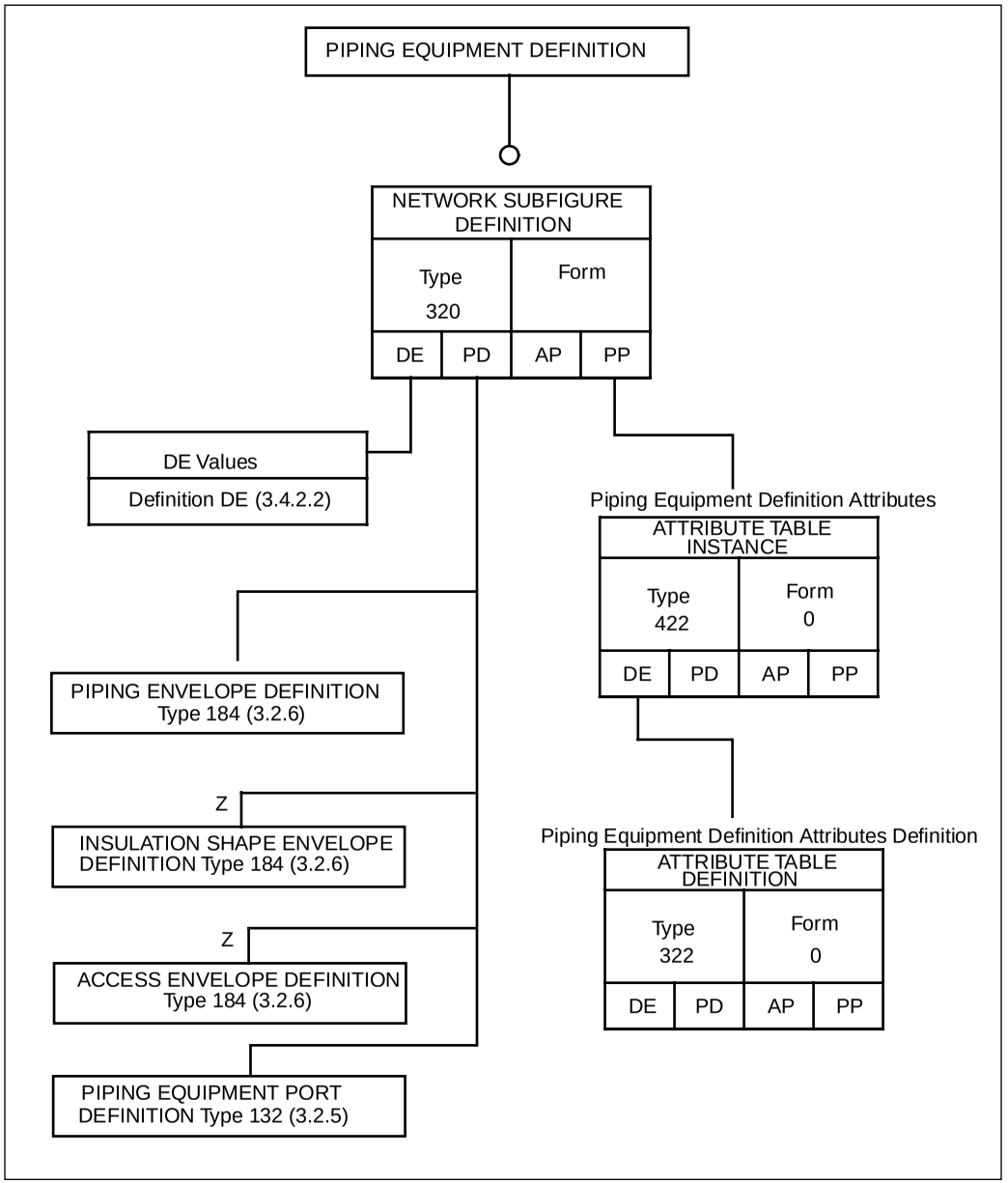
1. Rule: The number of Piping Equipment Ports, N, in an Unmodified Piping Equipment shall be the same as the number of Piping Equipment Port Definitions, NC, in the Piping Equipment Definition.
2. Note: Piping Equipment Definition Attributes are:
   piping_object_type
   stock_number

Translation Usage Notes:

General:

Output:

Input:



3.2.14 Piping Support.

Description:

The Piping Support object is represented by a Network Subfigure Definition (Type 320) and Connect Point Entities (Type 132) representing the attachment point, together with defining attributes.

Requirements/Restrictions:

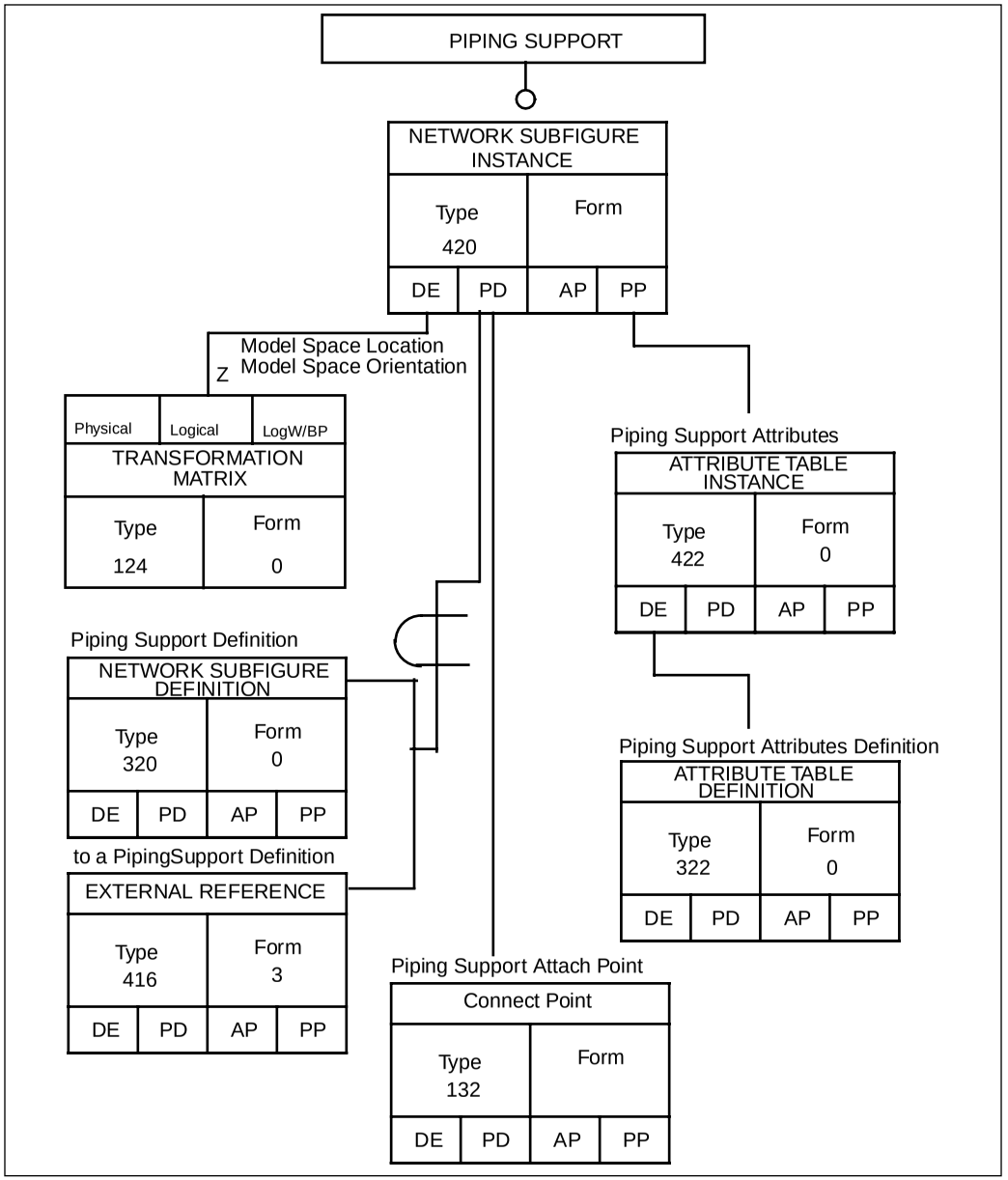
1. Rule: The number of Piping Support Attach Points, N, in an Piping Support shall be the same as the number of Piping Support Attach Point Definitions, NC, in the Piping Support Definition.
2. Note: Piping Support Attributes are:
   piping_object_type
   piping_support_identifier

Translation Usage Notes:

General:

Output:

Input:



3.2.15 Piping Support Definition.

Description:

The Piping Support Definition object is represented by a Network Subfigure Definition (Type 320), a Piping Envelope Definition, Connect Point Entities (Type 132) representing the attachment point, and defining attributes.

Requirements/Restrictions:

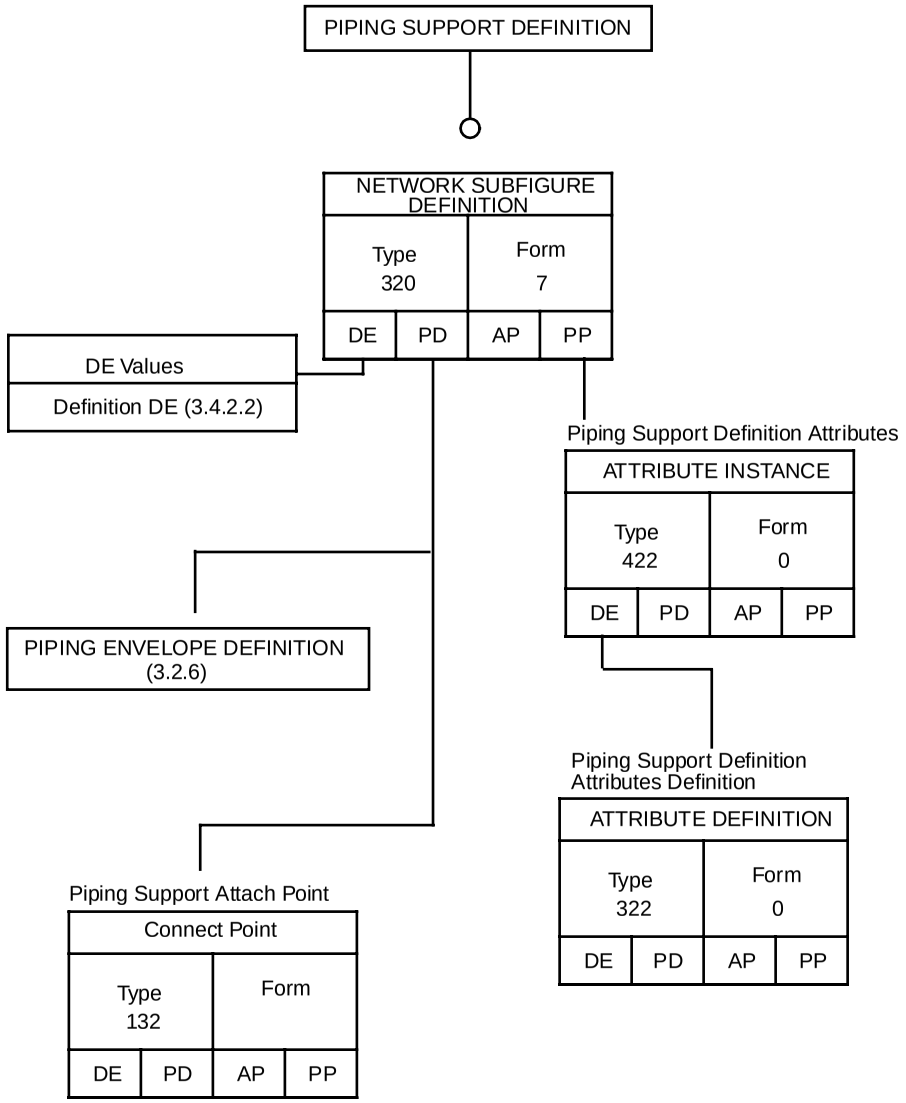
1. Rule: The number of Piping Support Attach Points, N, in a Piping Support shall be the same as the number of Piping Support Attach Point Definitions, NC, in the Piping Support Definition.
2. Note: Piping Support Definition Attributes are:
   piping_object_type
   stock_number
   part_class
   material_description

Translation Usage Notes:

General:

Output:

Input:



3.2.16 Piping Damping.

Description:

The Piping Damping object is represented by a Composite Curve (Type 102) referencing one or more Line Entities (Type 110) together with defining attributes.

Requirements/Restrictions:

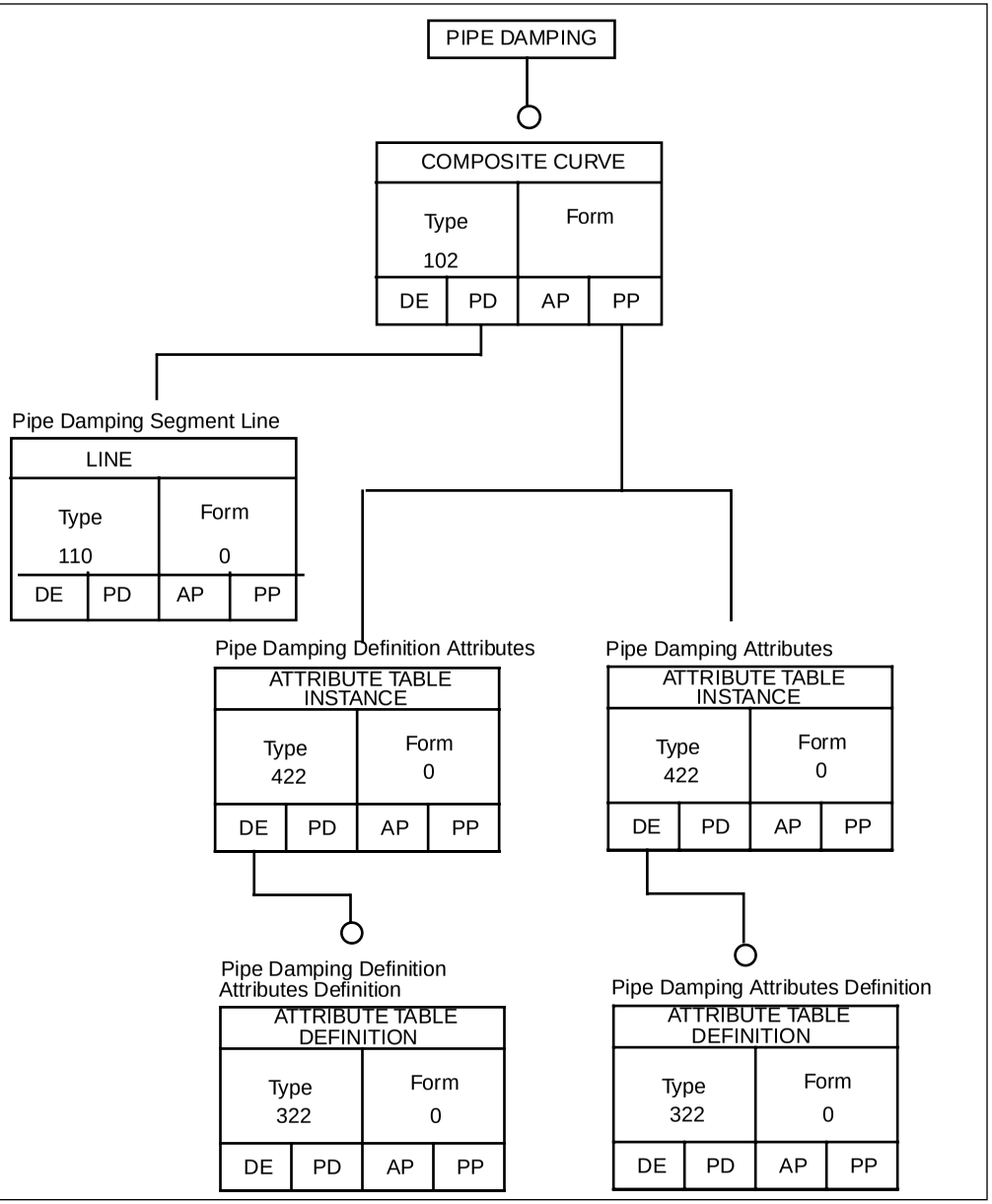
1. Note: Piping Damping Definition Attributes are:
   piping_object_type
   stock_number
2. Note: Piping Damping Attributes are:
   piping_object_type
   pipe_damping_identifier

Translation Usage Notes:

General:

Output:

Input:



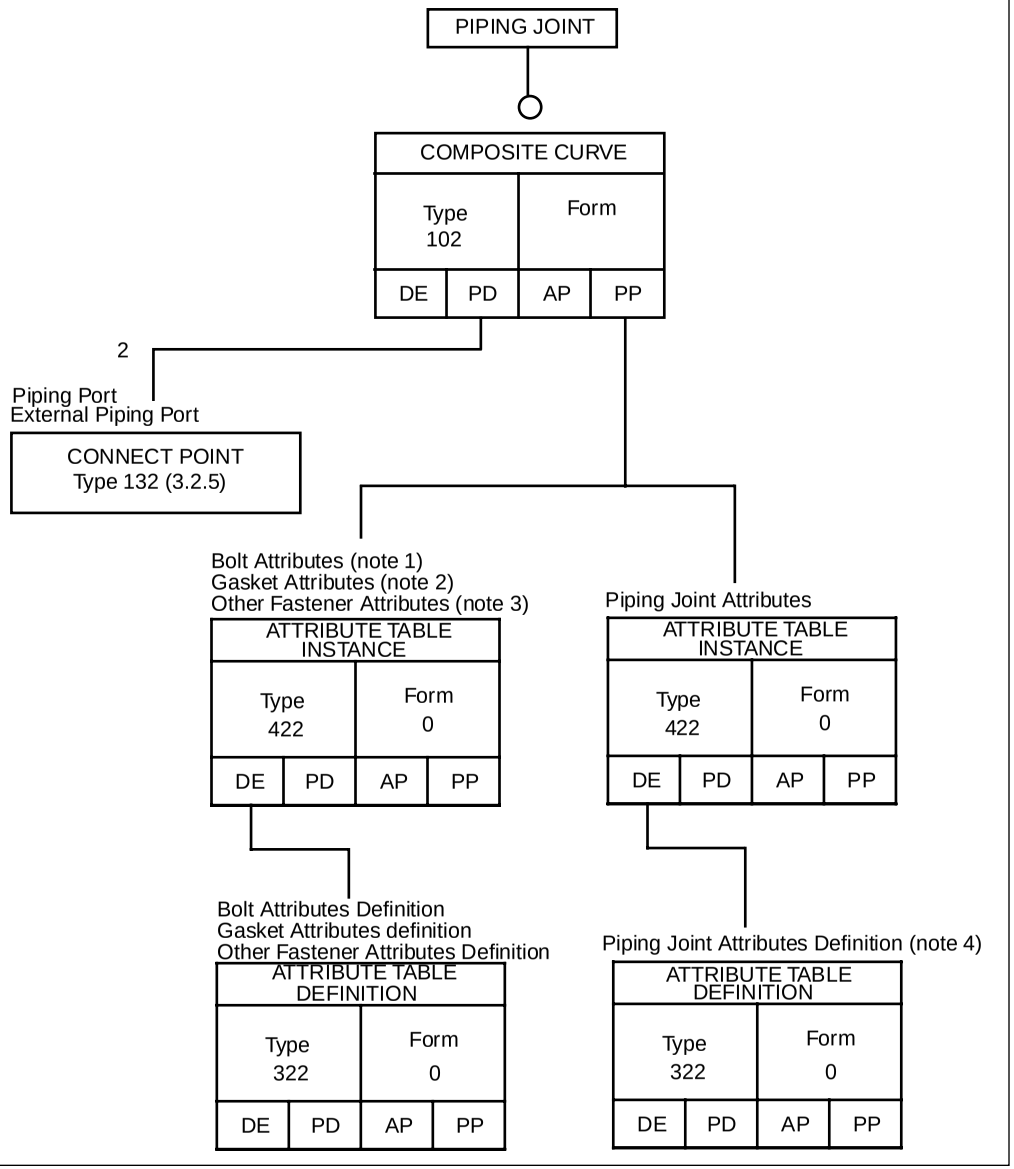
3.2.17 Piping Joint.

Description:

The Piping Joint object is represented by a Composite Curve Entity (Type 102), Connect Point Entities (Type 132) representing the attachment points, together with defining attributes.

Requirements/Restrictions:

1. Note: Bolt Attributes are:
   piping_object_type
   fastener_type
   stock_number
   material_description
   bolt_type
   bolt_length
   bolt_length_units
   bolt_diameter
   bolt_diameter_units
   quantity
   quantity_units
2. Note: Gasket Attributes are:
   piping_object_type
   fastener_type
   stock_number
   material_description
   gasket_thickness
   gasket_thickness_units
3. Note: other fastener attributes are:
   piping_object_type
   fastener_type
   stock_number
   material_description
   quantity
   quantity_units
4. Note: Piping Joint Attributes are:
   piping_object_type
   joint_identification_number
   joint_fabrication_location



3.2.18 Piping Damping Attachment.

Description:

The Piping Damping Attachment object is represented by a Pipe object, a Pipe Damping object, together with defining attributes.

Requirements/Restrictions:

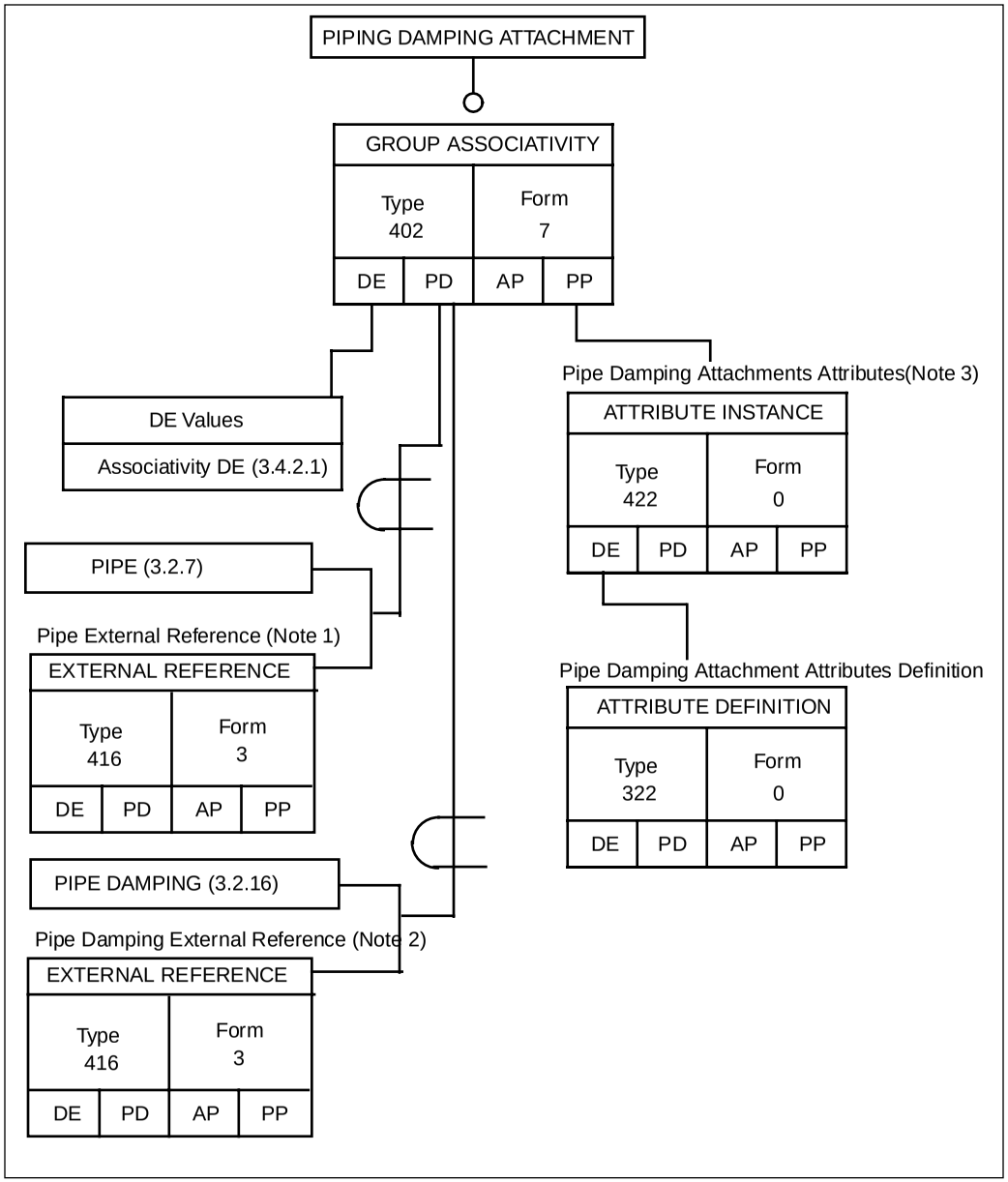
1. Note: Pipe External Reference attribute is: piping_identifier
2. Note:Pipe Damping External Reference attribute is: pipe_damping_identifier
3. Note: Pipe Damping Attachment attributes are: pipe_object_type

Translation Usage Notes:

General:

Output:

Input:



3.2.19 Piping Support Attachment.

Description:

The Piping Support Attachment object is represented by Group Associativity Entity (Type 402, Form 7) which references a Pipe object, or an Unmodified Piping Component object, or a Modified Piping Component object, or an External Reference, together with defining attributes.

Requirements/Restrictions:

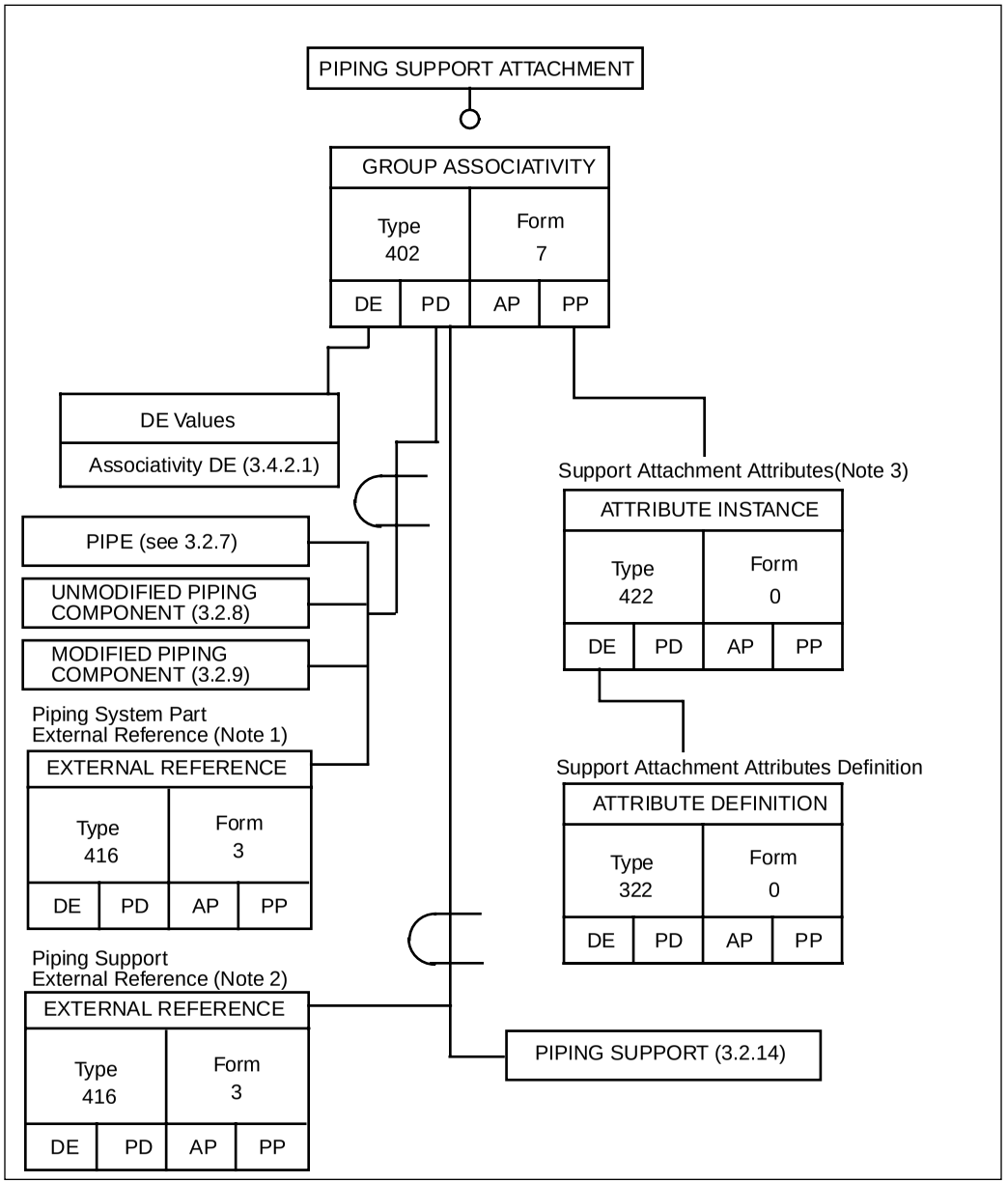
1. Note: Pipe System Part External Reference attribute is one of:
   piping_identifier
   piping_component_identifier
2. Note:Pipe Support External Reference attribute is:
   pipe_support_identifier
3. Note: Support Attachment attributes are:
   piping_object_type

Translation Usage Notes:

General:

Output:

Input:



3.2.20 Piping Insulation.

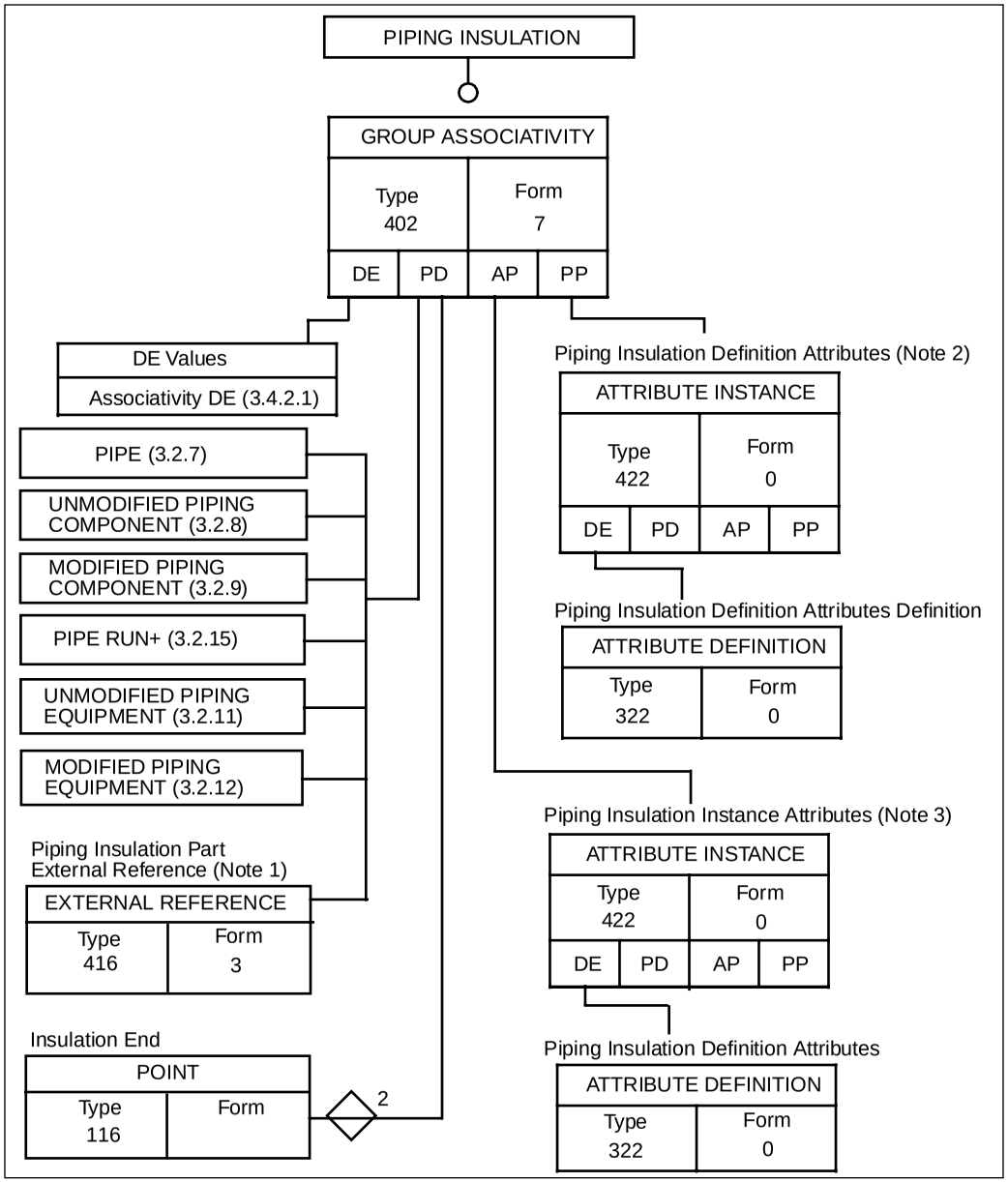
Description:

The Piping Insulation object is represented by Group Associativity Entity (Type 402, Form 7) which references a selection of component objects, an Insulation End object, together with defining attributes.

Requirements/Restrictions:

1. Note: Piping Insulation Part External Reference attribute is one of:
   pipe_identifier
   piping_component_identifier
   pipe_run_identifier
   piping_equipment_identifier
2. Note:Piping Insulation Definition attribute are:
   piping_object_type
   stock_number
   insulation_specification
   material_description
   insulation_thickness
   insulation_thickness_units
3. Note: Piping Insulation attributes are:
   piping_object_type
   piping_insulation_identifier
4. Rule: At most one Pipe Run shall occur in a Pipeing Insulation structure. A Pipe Run or Piping Part (Pipe, Unmodified Piping Component, Modified Piping Component, Unmodified Piping Equipment, Modified Piping Equipment) will be insulated by at most one Piping Insulation.

Translation Usage Notes:



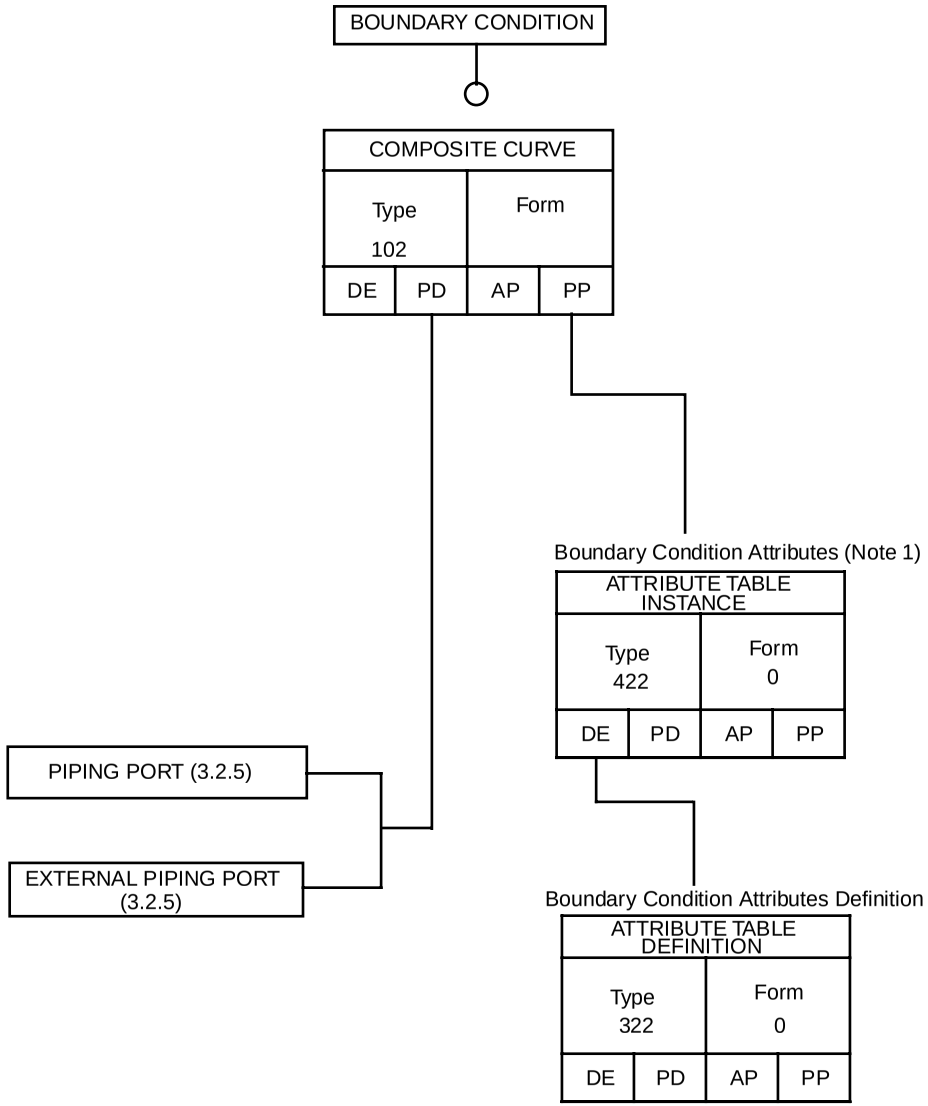
3.2.21 Boundary Condition.

Description:
The Boundary Condition object is represented by Composite Curve Entity (Type 102) which references a Piping Port object, or an External Piping Port object, together with defining attributes.

Requirements/Restrictions:

1. Note: Boundary Condition attributes are:
   flow_rate
   flow_rate_units
   operating_pressure
   operating_pressure_units
2. Rule: A Boundary Condition may specify a flow into a port or pressure at a port but not both.

Translation Usage Notes:
General:
Output:
Input:



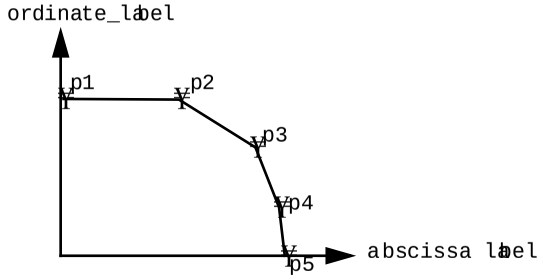
3.2.22 Transfer Function Definition.

Description:

The Transfer Function Definition object is represented by a Linear Path Entity (Type 106, Form 11) together with defining attributes.

Requirements/Restrictions:

1. Note: Transfer Function Definition attributes are:
   abscissa_units
   ordinate_units
   abscissa_label
   ordinate_label
2. Rule: Transfer Function Definition defines a piecewise linear curve to describe the pressure versus flow characteristic for flow devices like pumps and tanks. If the values defined here were plotted, the graph would look similar to the following.

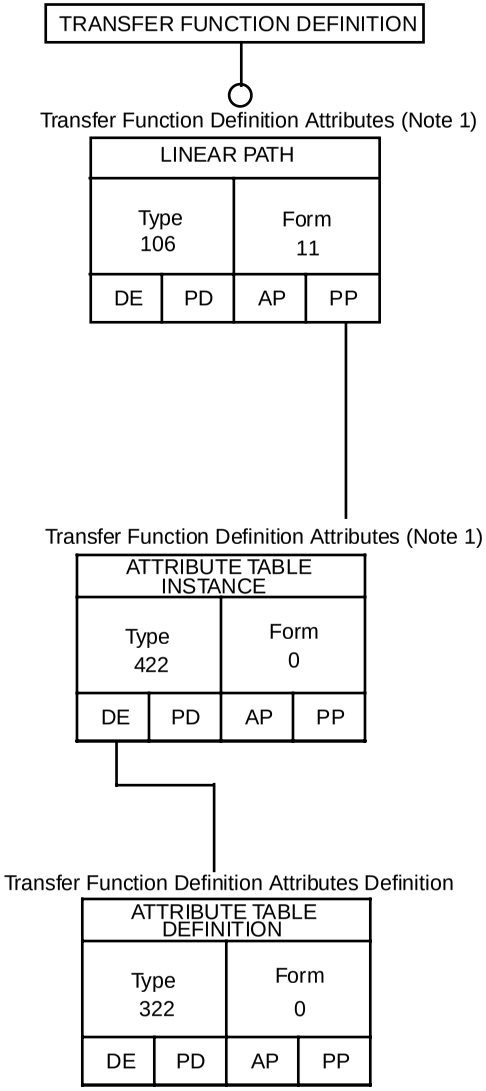


Translation Usage Notes:

General:

Output:

Input:



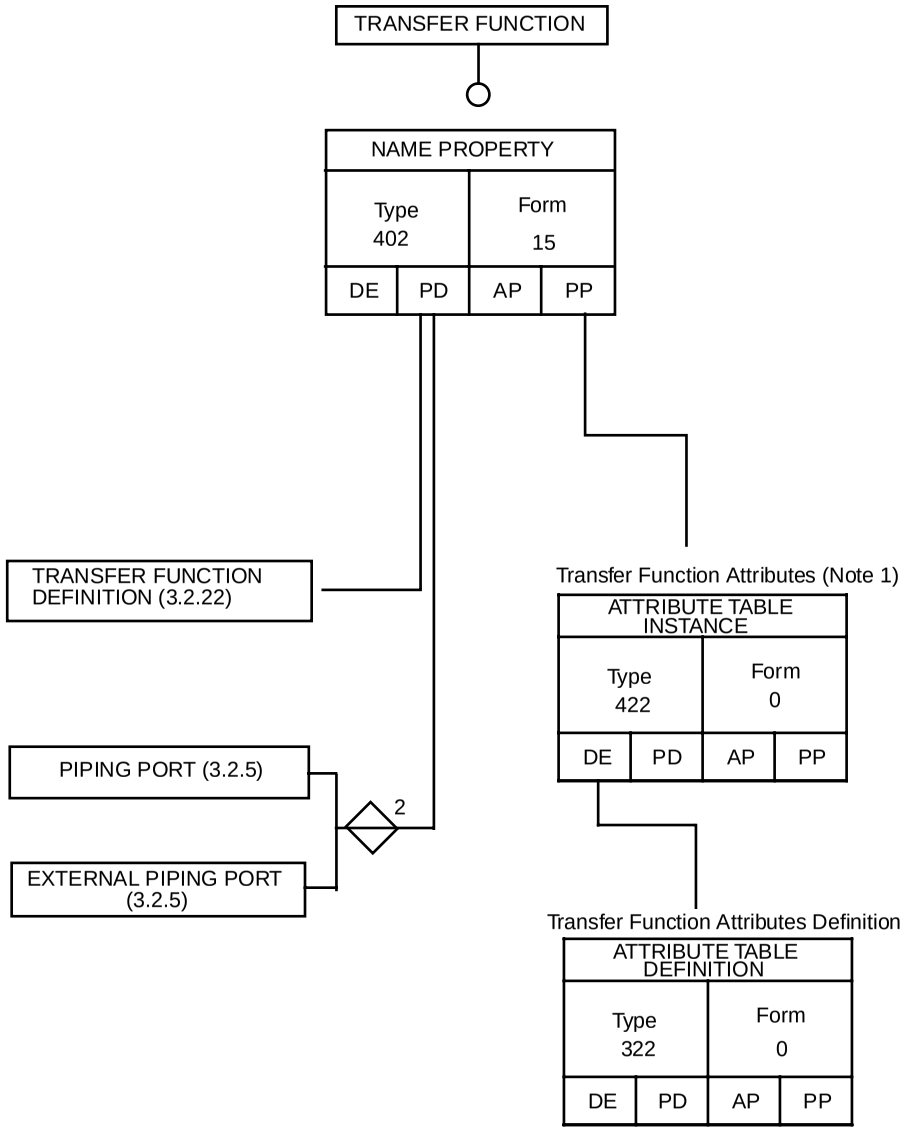
3.2.23 Transfer Function.

Description:
The Transfer Function object is represented by Name Property Entity (Type 402, Form 15) which references a Piping Port object, or an External Piping Port object, together with defining attributes.

Requirements/Restrictions:

1. Note: Transfer Function attributes are:
   operating_point_abscissa
   operating_point_ordinate

Translation Usage Notes:
General:
Output:
Input:



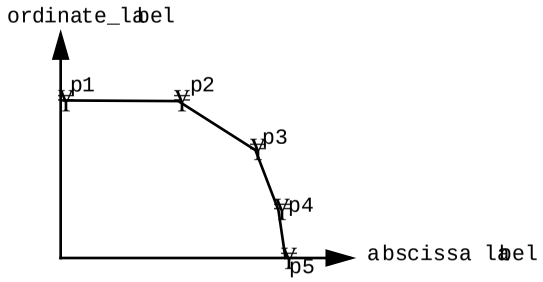
3.2.24 Tank Curve Definition.

Description:

The Tank Curve Definition object is represented by a Linear Path Entity (Type 106, Form 11) together with defining attributes.

Requirements/Restrictions:

1. Note: Tank Curve Definition attributes are:
   abscissa_units
   ordinate_units
   abscissa_label
   ordinates_label
   density_value
   density_units
2. Rule: Tank Curve Definition defines a piecewise linear curve to describe the pressure versus flow characteristic for storage devices like tanks. If the values defined here were plotted, the graph would look similar to the following.

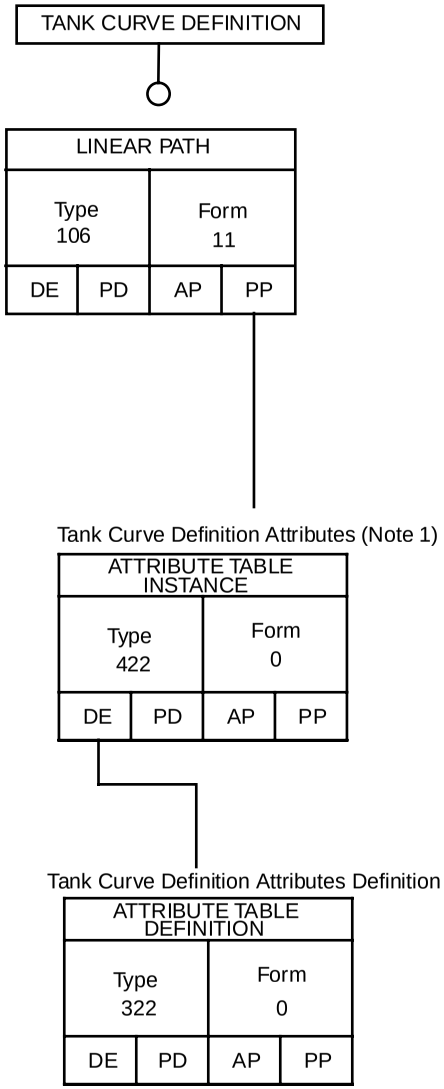


Translation Usage Notes:

General:

Output:

Input:



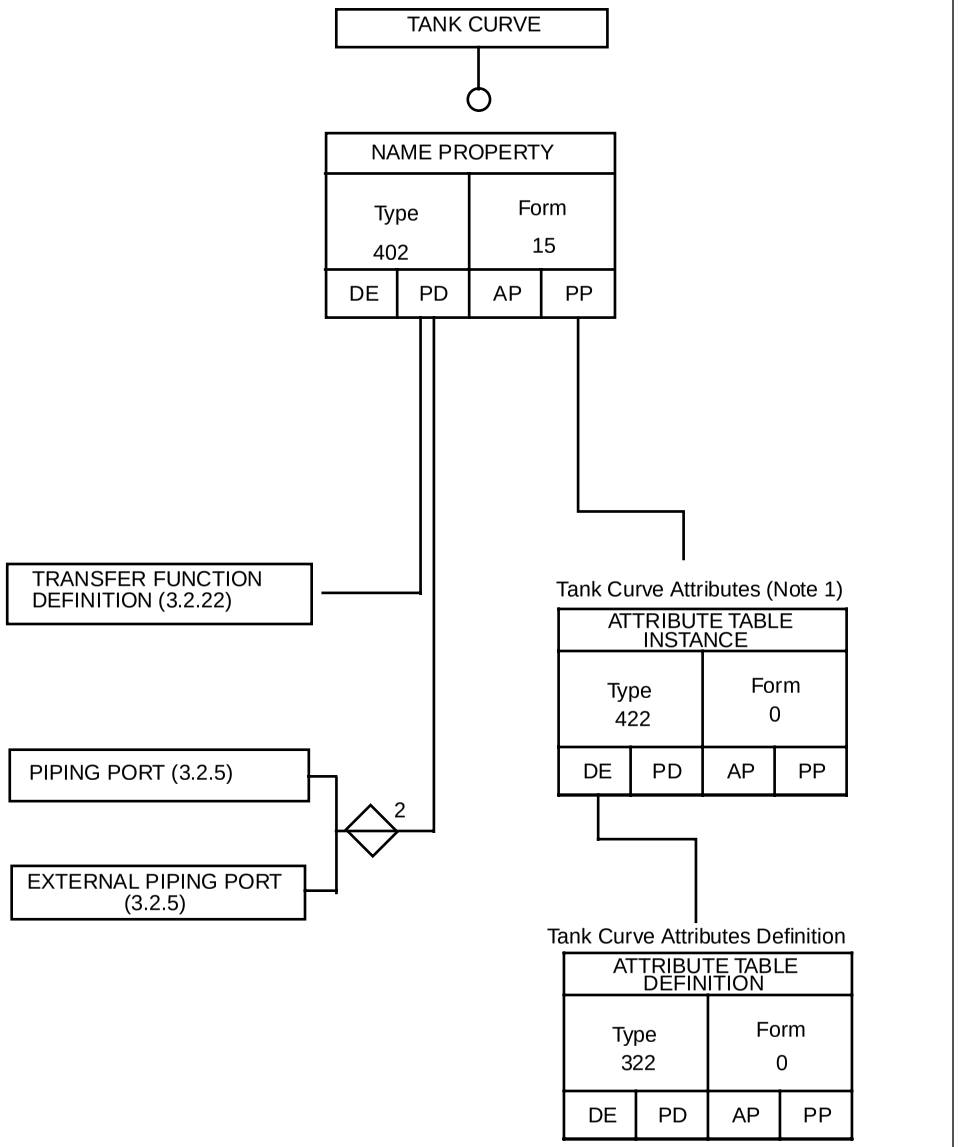
3.2.25 Tank Curve.

Description:
The Tank Curve object is represented by Name Property Entity (Type 402, Form 15) which references a Piping Port object, or an External Piping Port object, together with defining attributes.

Requirements/Restrictions:

1. Note: Tank Curve attributes are:
   operating_point_abscissa
   operating_point_ordinate

Translation Usage Notes:
General:
Output:
Input:



3.3 LEP AIM Object Models

The scope of this AIM section is currently limited[1] to LEP representation information contained in computer-aided design (CAD or CAE) systems. These systems are in widespread use and translation between dissimilar systems is a high priority in the user community. IGES serves as the implementation for this information because many CAE suppliers are familiar with the specification and support it in their software packages.

The scope is also inclusive of connectivity information (as contained in some CAE systems) in IGES files in addition to more conventional graphic (presentation) constructs. This connectivity information may be of significant value for future product representations. These future applications could combine display graphics with constructs better supporting concurrent engineering.

A broader scope for this AP section that includes manufacturing, test, simulation, behavior and documentation is desired by users and manufacturers of LEPs. Much of this information is outside the scope (see also Abstract) of most CAE systems. Some of this information is beyond the scope of the IGES specification.

1. See Section 2.3.2.2 for the declaration of products which are within the scope of this AP.

3.3.1 Interface Object Models.

Two categories of object models have been defined for interfaces. Interfaces to a LEP part library IGES file, and to a LEP physical layout IGES file are included.

3.3.1.1 LEP Part Library IGES File.

Description:

The *LEP PART LIBRARY IGES FILE* object is an interface model which enables computer-aided systems to write or read a library of LEP parts (e.g., Package Figure Definitions, Padstack Definitions, or Generic Part Definitions).

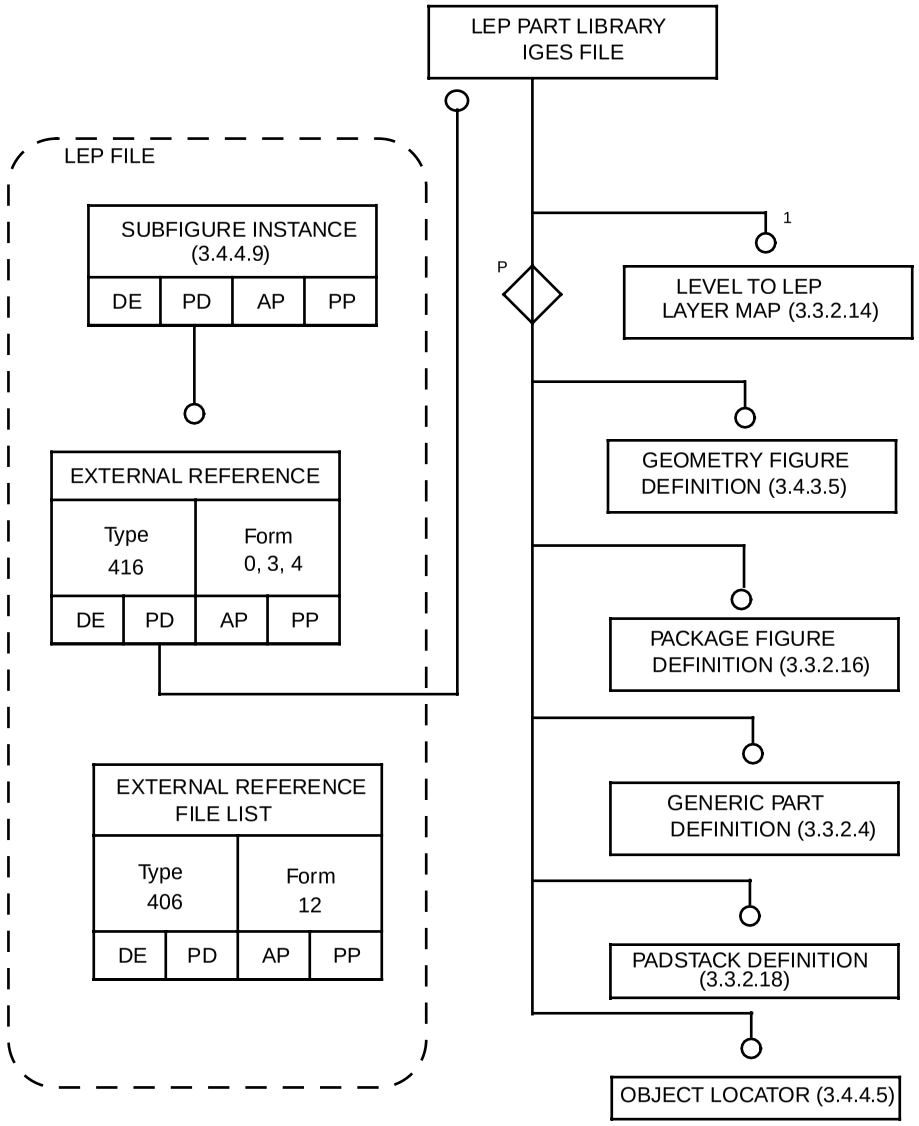
Requirements/Restrictions:

1. An LEP file containing a Type 416, Form 0 shall also contain a Type 406, Form 12 entity. The Type 406, Form 12 is not included when a Type 416, Form 3 references a file in the native system format, nor when a Form 4 references a library figure in the native system format.

Translation Usage Notes:

See Section 3.6.4 of IGES Version 6.0 “External Reference Linkage” for entities serving to call a library file from a *LEP PHYSICAL LAYOUT IGES FILE*.

General:
Output:
Input:



3.3.1.2 LEP Physical Layout IGES File.

Description:

The *LEP PHYSICAL LAYOUT IGES FILE* object is an interface model which enables computer aided systems to write or read LEP Physical Layout data.

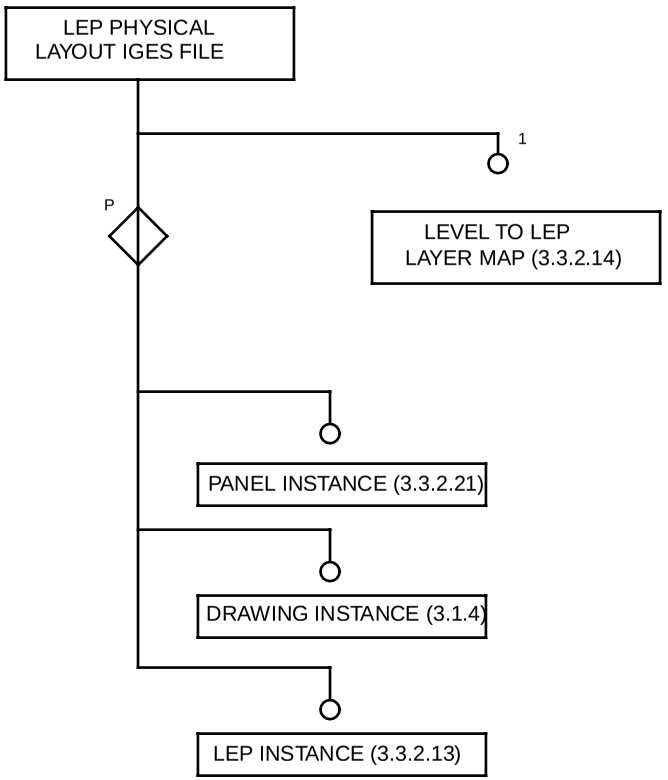
Requirements/Restrictions:

1. When this object defines the layout of an LEP Panel, the *LEP SEMANTIC PROPERTY*which is referenced from the *LEP INSTANCE* object shall specify
   panel_offset

Translation Usage Notes:

General:
These files contain geometry, annotation, structure, and connectivity information.
Output:

Input:



3.3.1.3 LEP Simulation/Analysis IGES File.

Description:

The *LEP SIMULATION/ANALYSIS IGES FILE* object is an interface model which enables computer-aided systems to write or read attributes associated with the graphic presentation of LEP data. This interface model describes only attribute annotation constructs.

The use of the annotation entities is not required for an LEP file; the entities provide information intended primarily for Circuit Analysis and Finite Element Modeling applications. The entities may also be used within specification control drawings for annotation.

Requirements/Restrictions:

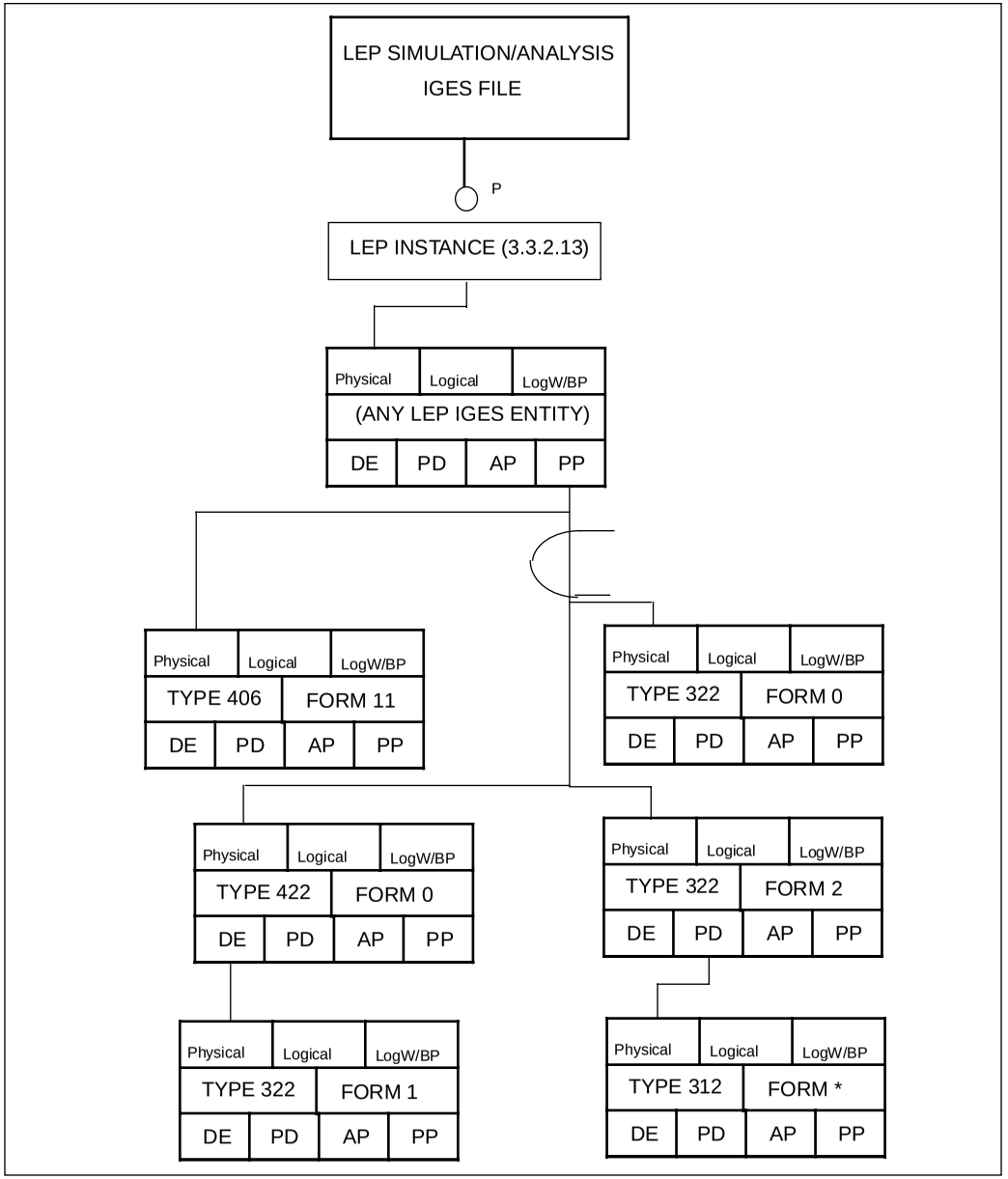
1. The Attribute Table Definition Entity (Type 322) and Attribute Table Instance Entity (Type 422) shall be associated with other IGES entities as defined in IGES Section 3.6.7.

Translation Usage Notes:

General:
IGES 5.3 added LEP physical design rules to the Attribute Definition Entity (Type 322); these rules shall be included in files intended to support design rule analysis.

Output:

Input:



3.3.2 LEP Features.

These objects are higher-level structures of entities which are identified with LEP designs and with CAE system usage terminology.

3.3.2.1 Component Placement Keepin/Keepout.

Description:

The *COMPONENT PLACEMENT KEEPIN/KEEPOUT* object is a *CLOSED CURVE*, which bounds within or excludes the instantiation of all Package Figure Instances.

Requirements/Restrictions:

The IGES file shall have one or more *COMPONENT PLACEMENT KEEPIN/KEEPOUT* per placement layer.

Translation Usage Notes:

General:

The values for the *LEP SEMANTIC PROPERTY* shall be as follows:

component_keep_outline

with a value of either “in,” or “out” to state that the component shall be inside or outside the region defined by the closed curve. (NOTE: The CAE system is expected to utilize this object to provide component placement control or rules checking.)

Output:

Input:

see KEEPIN/KEEPOUT (3.3.2.10).

3.3.2.2 Component Thermal Outline.

Description:

The *COMPONENT THERMAL OUTLINE* object is a *CLOSED CURVE*, which represents the area of the *PACKAGE FIGURE INSTANCE* that has associated thermal characteristics.

Requirements/Restrictions:

Translation Usage Notes:

General:

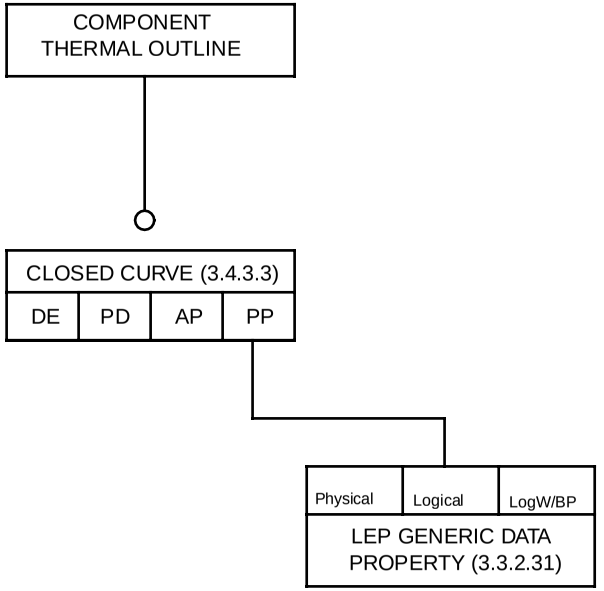
The value for the *LEP GENERIC DATA PROPERTY* shall be:

thermal_outline

to state that the component has a thermal boundary defined at the closed curve.

Output:

Input:



3.3.2.3 LEP Drawing Definition.

Description:

The LEP*DRAWING DEFINITION* object is a Subfigure Definition which represents an engineering drawing of the *LEP*, a *PANEL*, or some portion of the *LEP*.
See 3.1.4 for Drawing Instance.

Requirements/Restrictions:

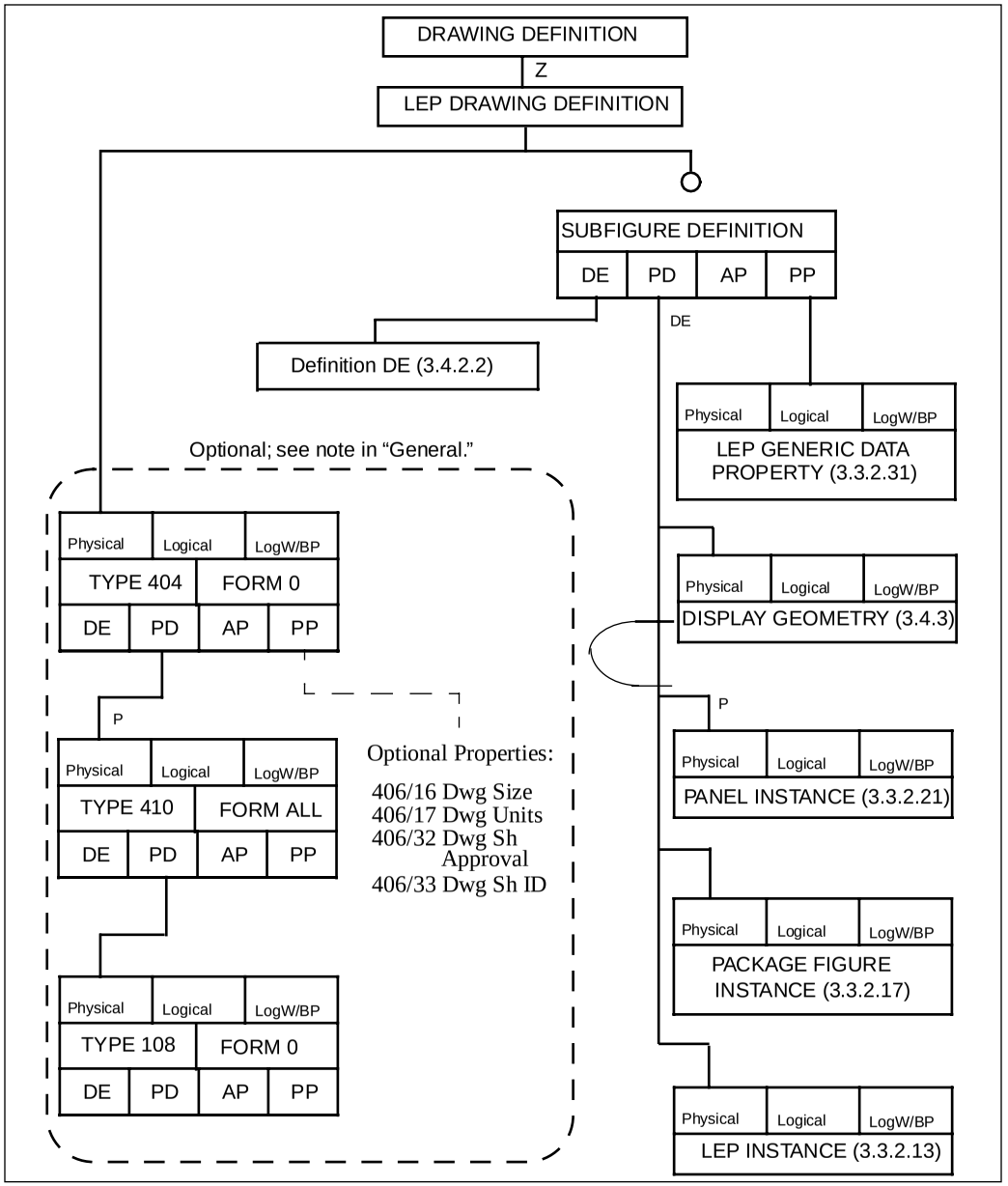
1. The *GENERIC DATA PROPERTY* which is referenced from the *SUBFIGURE DEFINITION* object shall specify
   date
   schematic_number or assembly_number
2. The *GENERIC DATA PROPERTY* which is referenced from the *DISPLAY GEOMETRY* object, when appropriate, shall specify
   physical_outline
3. The NAME field in the *SUBFIGURE DEFINITION* shall be unique within the scope of the IGES File.

Translation Usage Notes:

General:
The Drawing Entity (Type 404), View Entity (Type 410), Plane Entity (Type 108) and properties as appropriate optionally appears in *LEP TECHNICAL ILLUSTRATION*. See Section 3.6.5 of IGES for association of these entities.

Output:

Input:



3.3.2.4 Generic Part Definition.

Description:

The *GENERIC PART DEFINITION* object is a *SUBFIGURE DEFINITION*, which lists a set of constituent objects for the purpose of treating them like a fixed set or group (e.g., heatsink).

Requirements/Restrictions:

1. A *ROUTING KEEPIN/KEEPOUT* or *COMPONENT PLACEMENT KEEPIN/KEEPOUT* shall not be subordinate to a *GENERIC PART DEFINITION*.
2. The *LEP GENERIC DATA PROPERTY* values referenced from the *GENERIC PART DEFINITION* are specifed by the *PACKAGE SYMBOL DEFINITION*.
3. The NAME field in the Subfigure Definition Entity (Type 308) shall be unique (for all *GENERIC PART DEFINITIONS*) within the scope of the IGES File.
4. The *LEP GENERIC DATA PROPERTY*
   substrate_physical_outline,
   and as appropriate, placement_outline
   shall reference the appropriate *CLOSED CURVE* object.

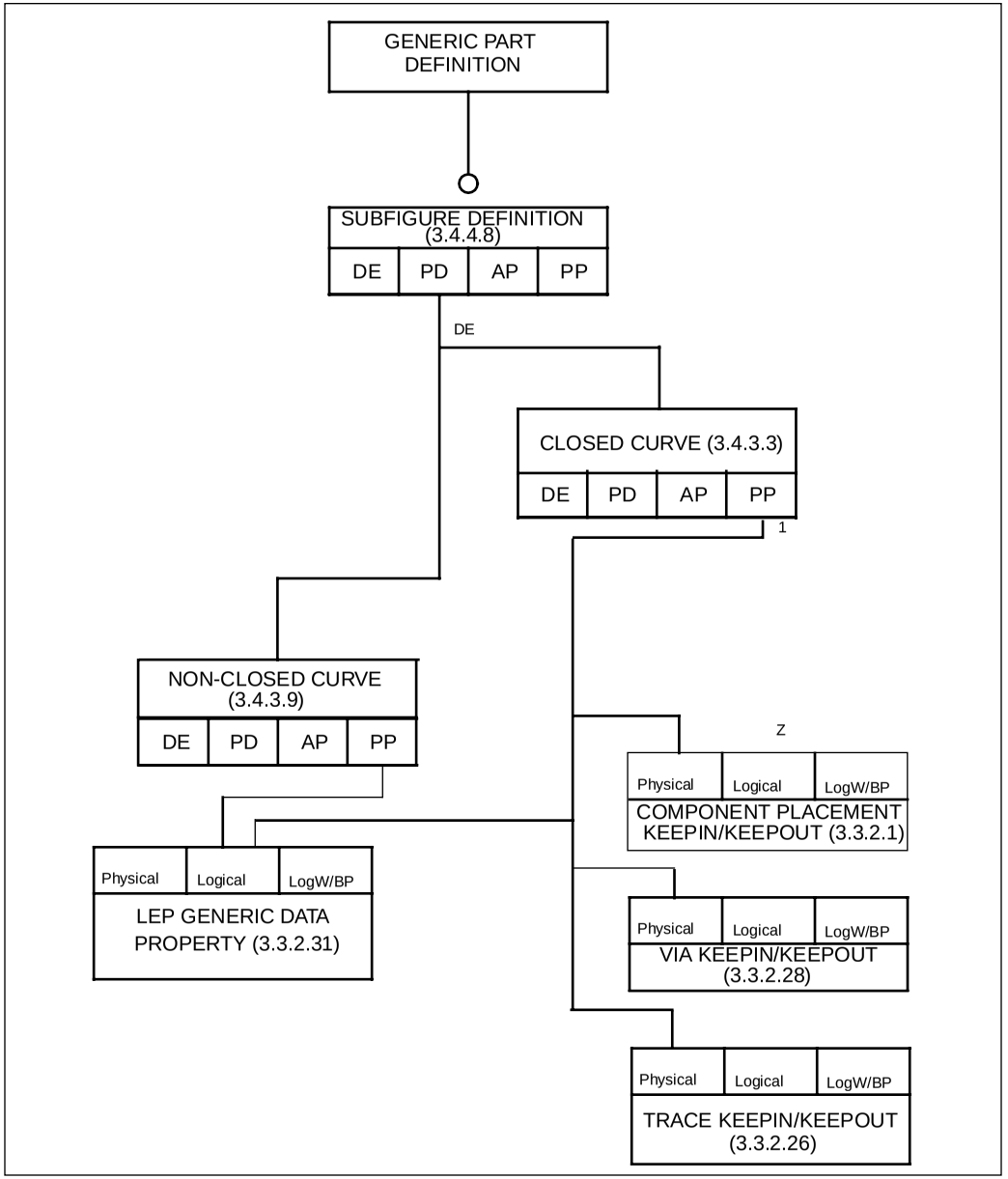
Translation Usage Notes:

General:

NOTE: This *GENERIC PART DEFINITION* is not applicable to electrical parts; see *NETWORK SUBFIGURE DEFINITION*.

Output:

Input:



3.3.2.5 Generic Part Instance.

Description:

The *GENERIC PART INSTANCE* object is an instantiation of a *GENERIC PART DEFINITION*.

Requirements/Restrictions:

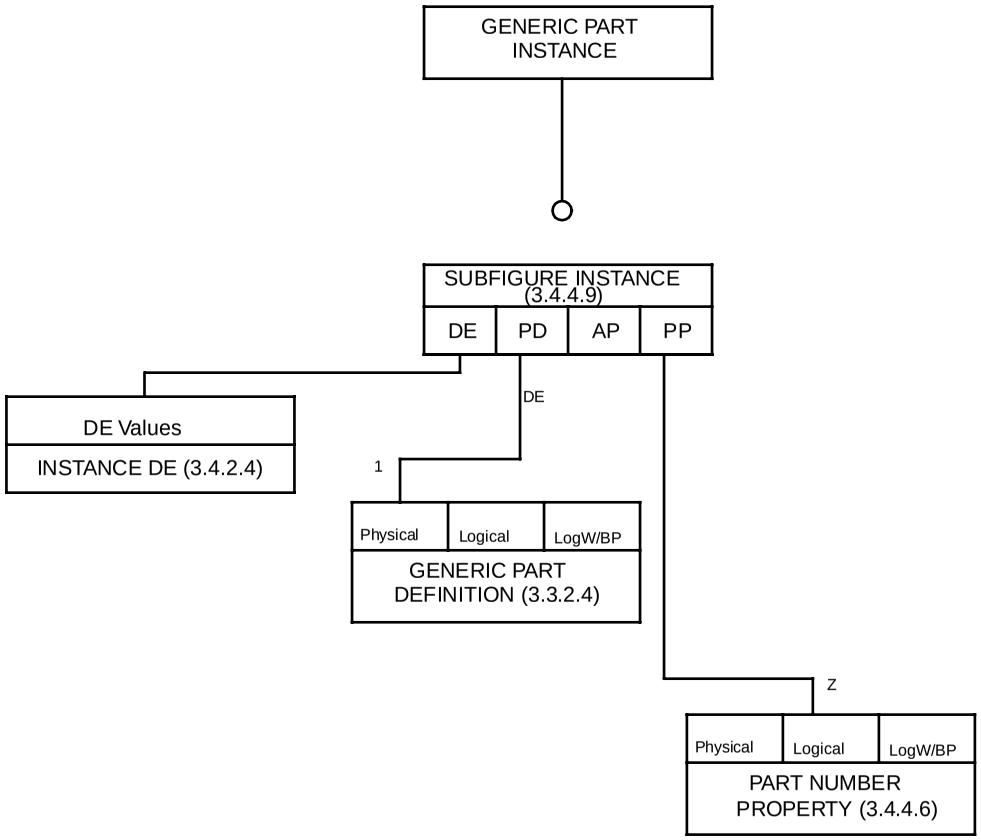
1. The *LEP GENERIC DATA PROPERTY* which is referenced from the *SUBFIGURE INSTANCE* object shall specify the name and value appropriate to the usage of this object. In particular, the
   schematic_number,
   lep_number,
   assembly_number
   of the top level LEP shall be referenced by the *SUBFIGURE INSTANCE* depicting
   substrate_physical_outline

Translation Usage Notes:

General:

Output:

Input:



3.3.2.6 Hole.

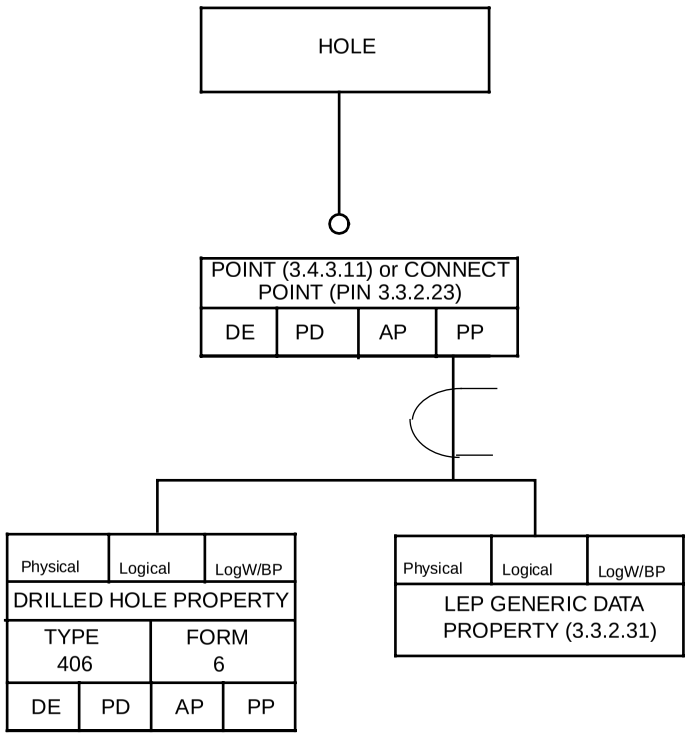
Description:
The *HOLE* object documents the location of a hole in one or more layers of the LEP. The hole may be any shape and may be manufactured in a variety of ways (e.g., drilled, punched, milled, or burned).

Requirements/Restrictions:

1. If the *HOLE* is subordinate to a definition that is intended to be instantiated on the LEP (e.g., Package Figure Definition), it shall reference a *PADSTACK DEFINITION*. If the *HOLE* is subordinate to a *LEP DEFINITION*, it shall reference a *PADSTACK INSTANCE*.
2. The *LEP GENERIC DATA PROPERTY*, which is referenced from the *POINT* or *CONNECT POINT* object, shall specify
   physical_outline
3. The Drilled Hole Property Entity (Type 406, Form 6) shall be attached to a Point Entity (Type 116) or Connect Point Entity (Type 132). Either the Point or Connect Point may be independent or dependent (e.g., padstack).
4. Two Hole objects may exist at a single X, Y location if the LEP layer ranges are different for each of the Drilled Hole Property Entity instances. A single (continuous) hole through adjacent layers shall be preferred over co-located holes through corresponding successive layers.

Translation Usage Notes:
General:

Output:
Input:



3.3.2.7 Join (aka “trace” or “conductor”).

Description:

The *JOIN* object logically represents any physical conductive material (e.g., conductive filled area, conductive path, or via) that is electrically common within a Net.

Requirements/Restrictions:

1. A *JOIN* object shall be part of (pointed to from) a *NET.*
2. The *LEP GENERIC DATA PROPERTY*which is referenced from each *JOIN* object shall be specified as follows:

LEP GENERIC DATA PROPERTY “Name” values

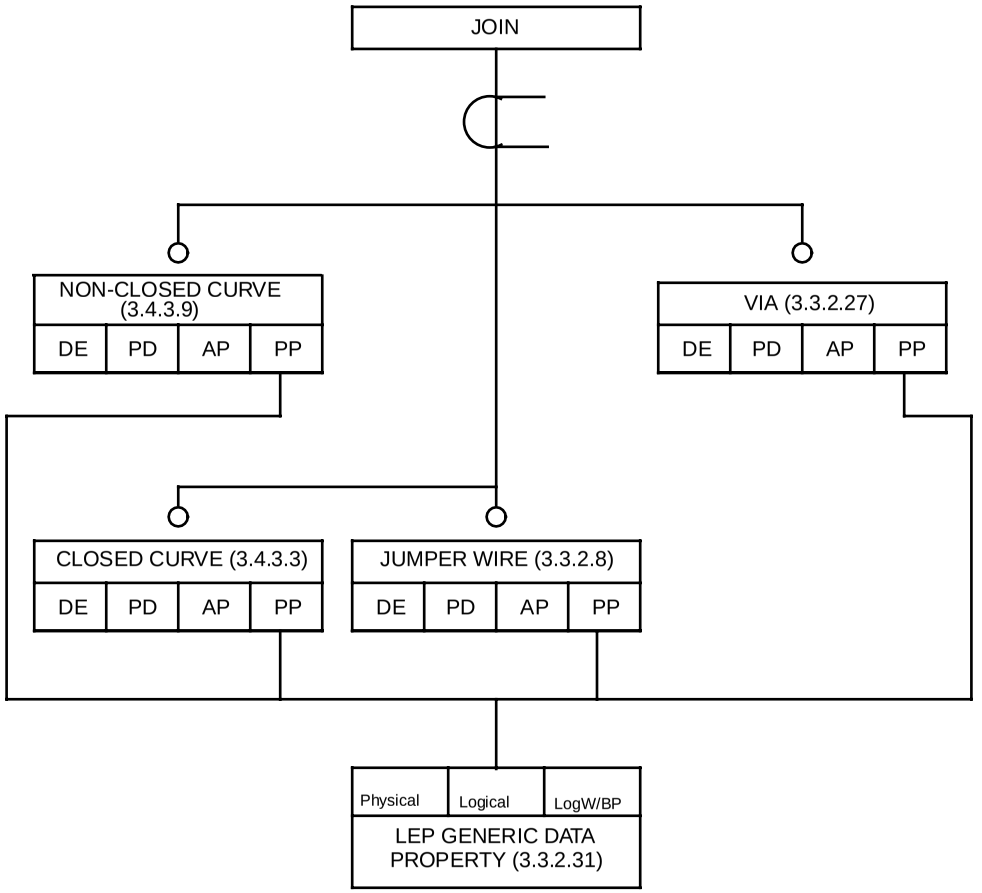
LEP object	LEP Name Value
Non-Closed Curve	Path
Closed Curve	Area
Jumper Wire	Jumper Wire
Via	Via

Translation Usage Notes:

General:

Output:

Input:
Each LEP *JOIN* object shall include an *LEP GENERIC DATA PROPERTY* as defined in requirement 2 above.



3.3.2.8 Jumper Wire.

Description:

The *JUMPER WIRE* object (often called a “haywire,”) is a conductive wire that is used when necessary to electrically connect two or more conductive paths. It is typically used to join two separate substrate nets into one design net.

Wire wrap applications are not to be considered as Jumper Wire objects (see 3.3.10.4).

A *WIRE BOND* (3.3.2.29) is to be encoded as a *JUMPER WIRE* object.

Requirements/Restrictions:

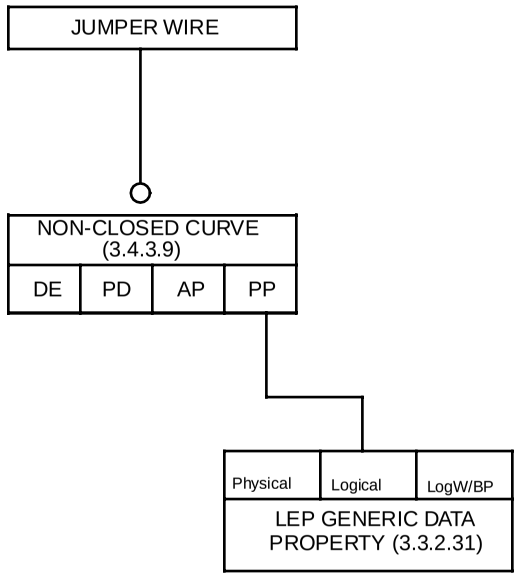
1. The non-closed curve object shall be tagged with an *LEP GENERIC DATA PROPERTY* specified as follows:
   jumper_wire, or
   wire_bond.

Translation Usage Notes:

General:

Output:

Input:



3.3.2.9 Keepin/Keepout.

Description:

A closed-geometry-defined region of an LEP identified as having a design placement restriction.

Requirements/Restrictions:

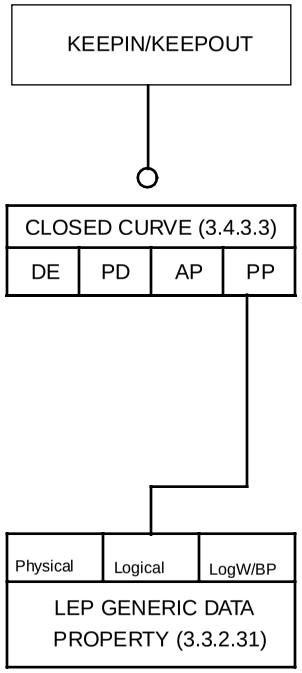
Translation Usage Notes:

General:

See *COMPONENT PLACEMENT KEEPIN/KEEPOUT, ROUTING KEEP/INKEEPOUT, TRACE KEEPIN/KEEPOUT* and *VIA KEEPIN/KEEPOUT* for the appropriate *GENERIC DATA PROPERTY* which applies.

Output:

Input:



3.3.2.10 Land.

Description:

The *LAND* object records and depicts the geometry of a conductive pattern which is used for electrical connection or package *PIN* attachment.

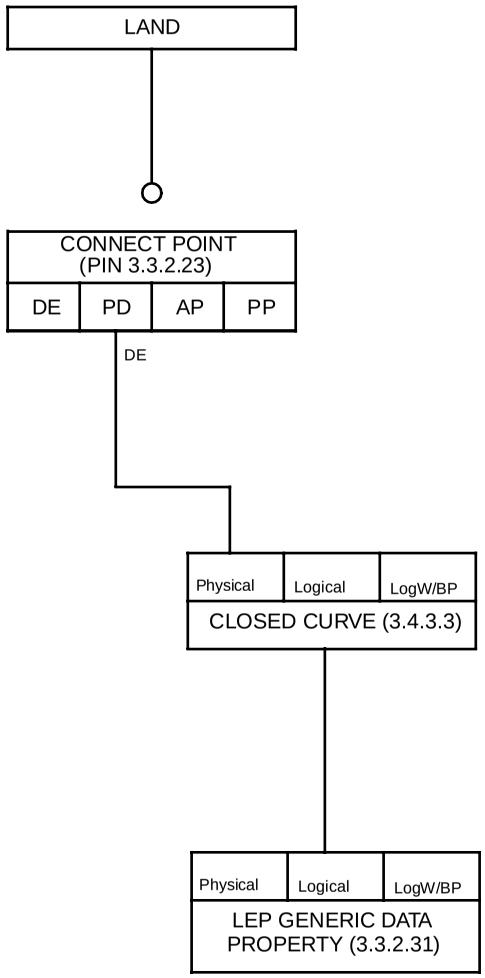
Requirements/Restrictions:

1. The *LEP GENERIC DATA PROPERTY* which is referenced from the *CLOSED CURVE* shall specify
   pad_tech_type

Translation Usage Notes:

General:

When a *LAND* object is subordinate to a *PADSTACK DEFINITION*, the IGES file may have distinct land geometry for each possible *LAND* subtype. When a *LAND* object is subordinate to a *PADSTACK INSTANCE*, the IGES file shall have only one land geometry (anti, regular or thermal) for a particular padstack. The IGES file may have only one *LAND* object for each LEP functional layer that the particular padstack pierces.



3.3.2.11 Layer Outline.

Description:

The *LAYER OUTLINE* object depicts the outline (boundary) for a specific physical layer of the LEP (i.e., substrate, power plane, etc.).

Requirements/Restrictions:

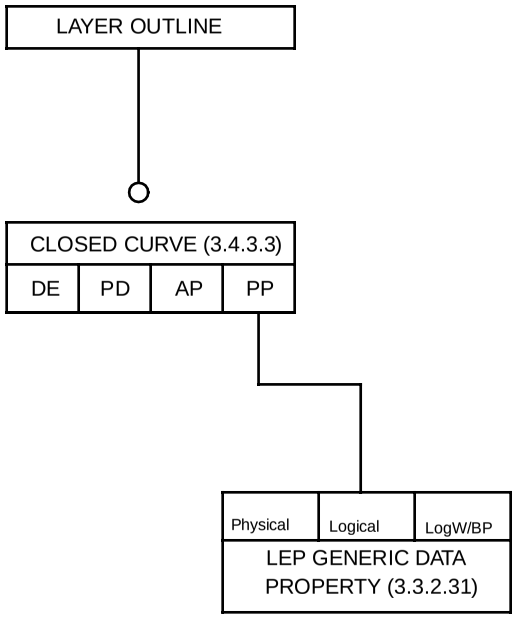
1. At least one LAYER OUTLINE shall be included in an LEP file to assure that the design area is delimited; this object may be omitted from or included in photoplot tooling as required.
2. The *LEP GENERIC DATA PROPERTY* which is referenced from the *CLOSED CURVE* shall specify lep_physical_outline

Translation Usage Notes:

General:

Output:

Input:



3.3.2.12 LEP Definition.

Description:

The *LEP DEFINITION OBJECT* is a *NETWORK SUBFIGURE DEFINITION* object, which relates all of the constituent objects that are required to define the LEP.

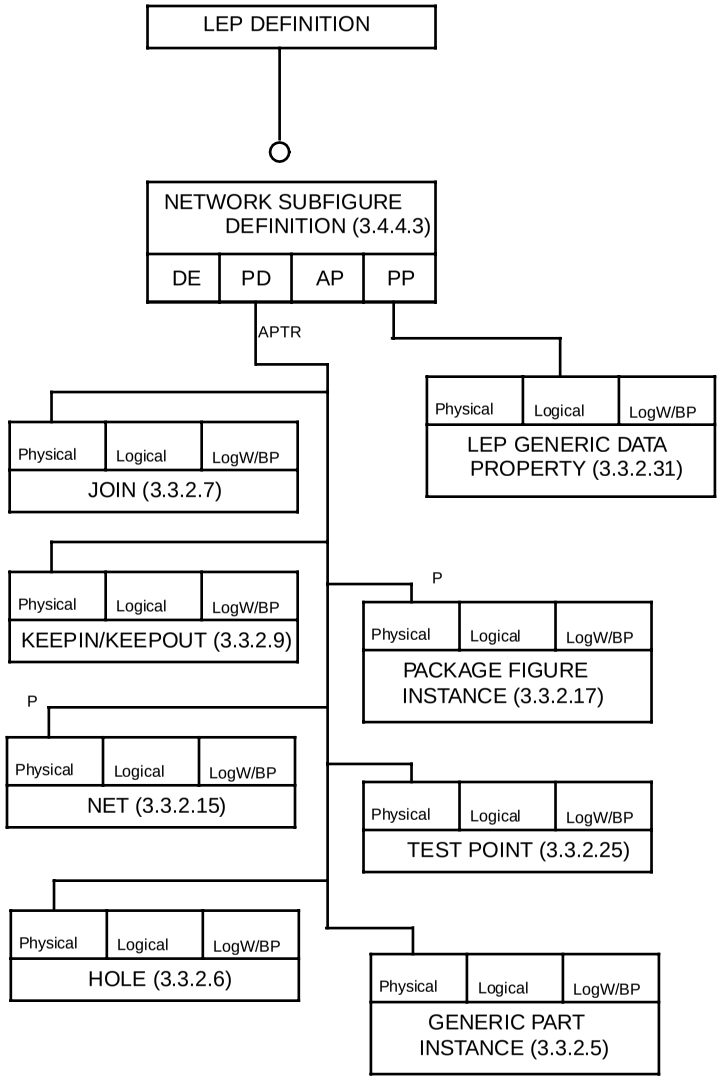
Requirements/Restrictions:

1. The LEP GENERIC DATA PROPERTY, which is referenced from the *NETWORK SUBFIGURE DEFINITION* object, shall specify
   date and
   (schematic_number, or
   assembly_number)
2. The NAME field in the Network Subfigure Definition Entity (Type 320) shall be unique (for all LEP Definitions) within the scope of the IGES File.

Electrical and LEP Manufacturing Attribute List (ALT=5)

20 Electrostatic Discharge Rating
22 LEP Design Thickness

Translation Usage Notes:
General:
Output:
Input:



3.3.2.13 LEP Instance.

Description:

The LEP Instance object is an instantiation of an LEP Definition.

Requirements/Restrictions:

1. The *GENERIC DATA PROPERTY,* which is referenced from the Network Subfigure Instance object, shall specify
   top_level_assembly_instance
2. The following Attribute Table Definition Entities (Type 322) may be referenced from the LEP Instance:

Electrical Attribute List (ALT=2)

570 Generic Design Rule

Electrical & LEP Manufacturing Attribute List (ALT=5)

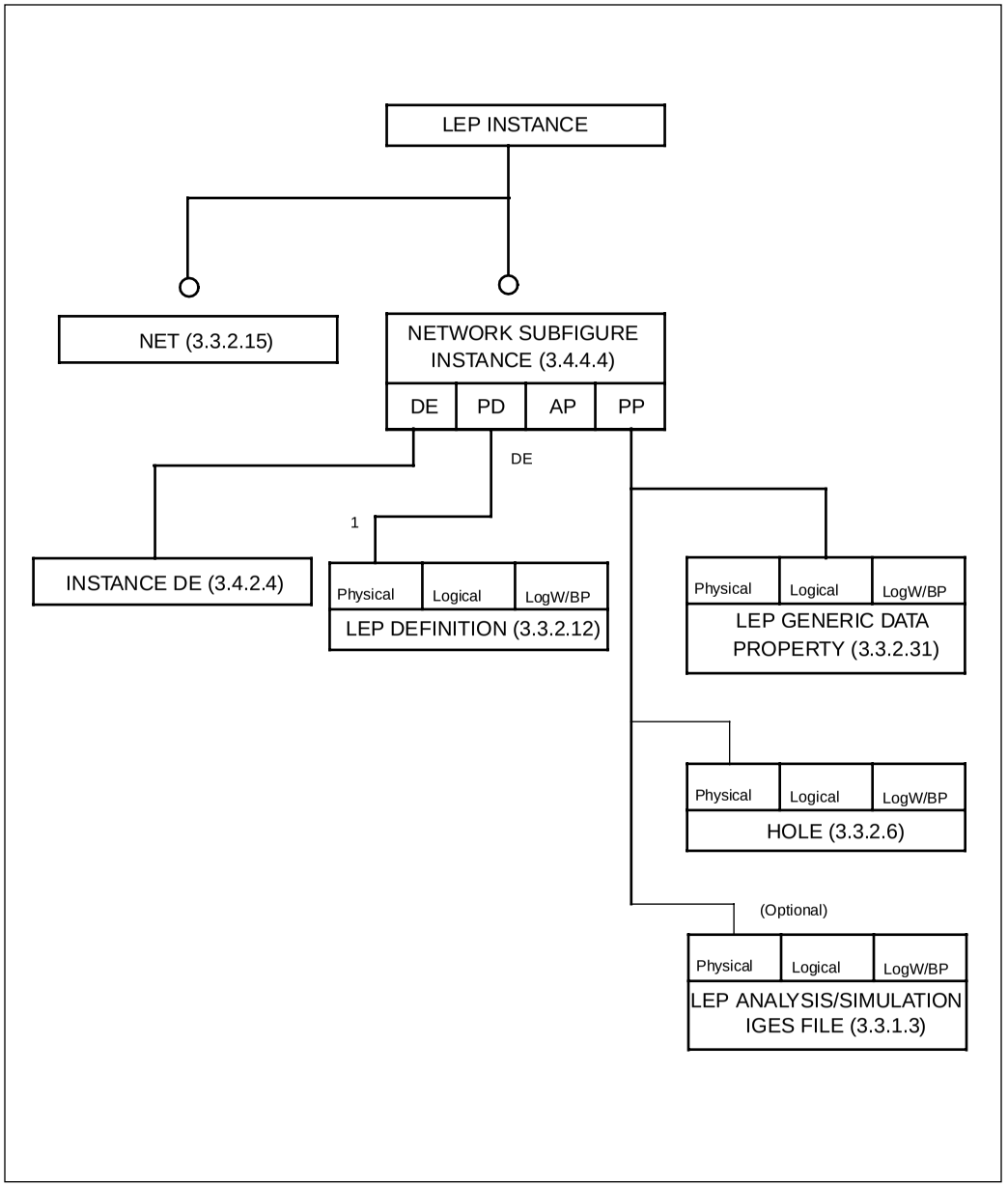
1 Component Physical Orientation
3 Component Physical Thickness
20 Electrostatic Discharge Rating
22 LEP Design Thickness

Translation Usage Notes:

General:

Output:

Input:



3.3.2.14 Level to LEP Layer Map.

Description:

The *LEVEL TO LEP LAYER MAP* object maps directly to the IGES Level To LEP Layer Map Property (Type 406, Form 24). Please refer to IGES Volume 1 for additional information.

Requirements/Restrictions:

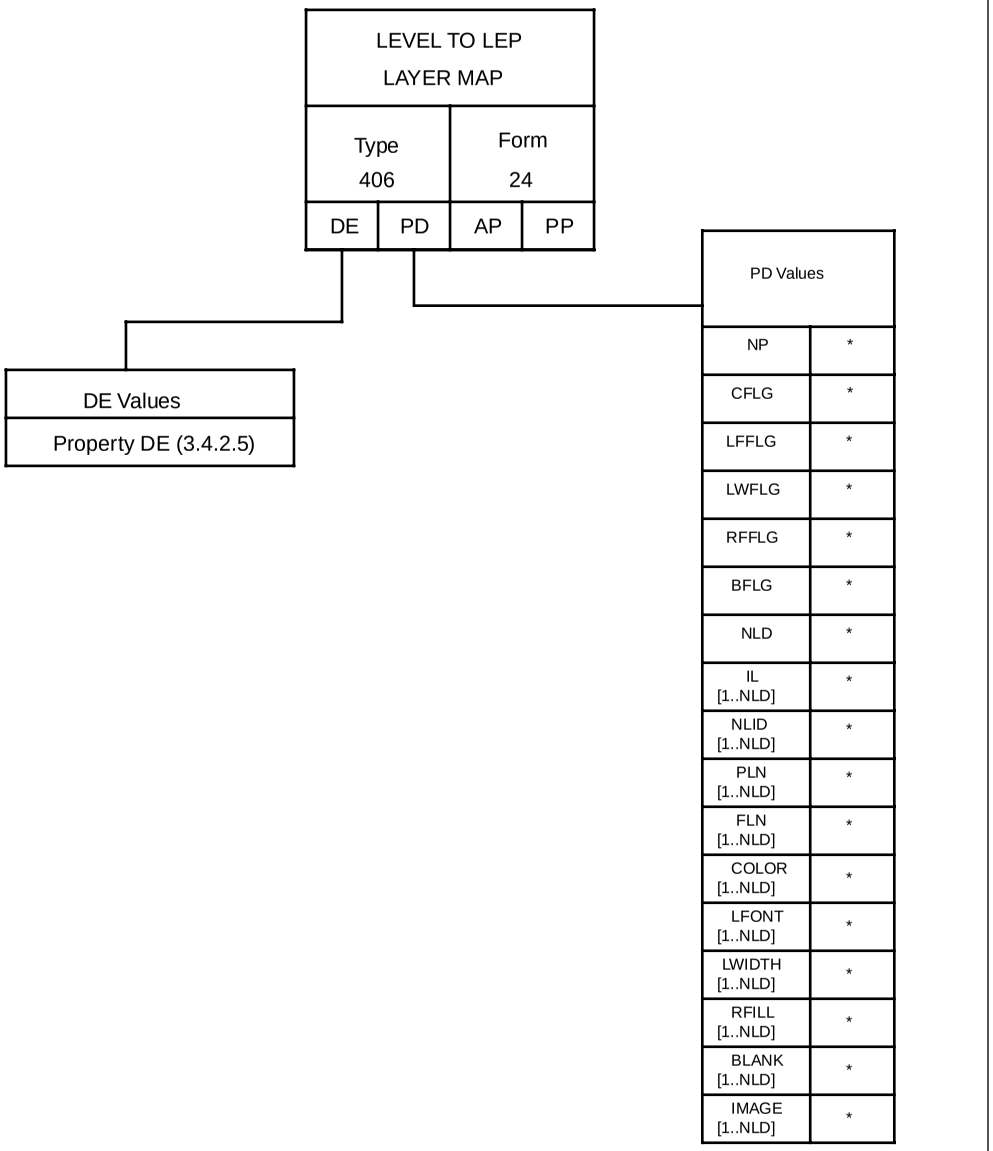
1. The Level To LEP Layer Map Property Entity (Type 406, Form 24) shall always be independent (DE Subordinate Entity Switch equals 0) within the IGES file, thus it pertains to all other entities in the file.

Translation Usage Notes:

General:
Each IGES level (DE-5 or Type 406, Form 3) may have a level function property such as {trace_top, trace_bot, trace_2, trace_n, silkscreen_top ...}

Output:

Input:



3.3.2.15 Net.

Description:

The *NET* object associates all of the electrically common *PIN*s and physical *JOIN* geometry (i.e., conductive filled areas, conductive paths and vias). The *NET* serves to represent the LEP design net. If you are concerned with the substrate net you may analyze the structure of the *JOIN*s to determine which Pins are electrically connected at the substrate level (i.e., not through the use of *JUMPER WIRE*s).

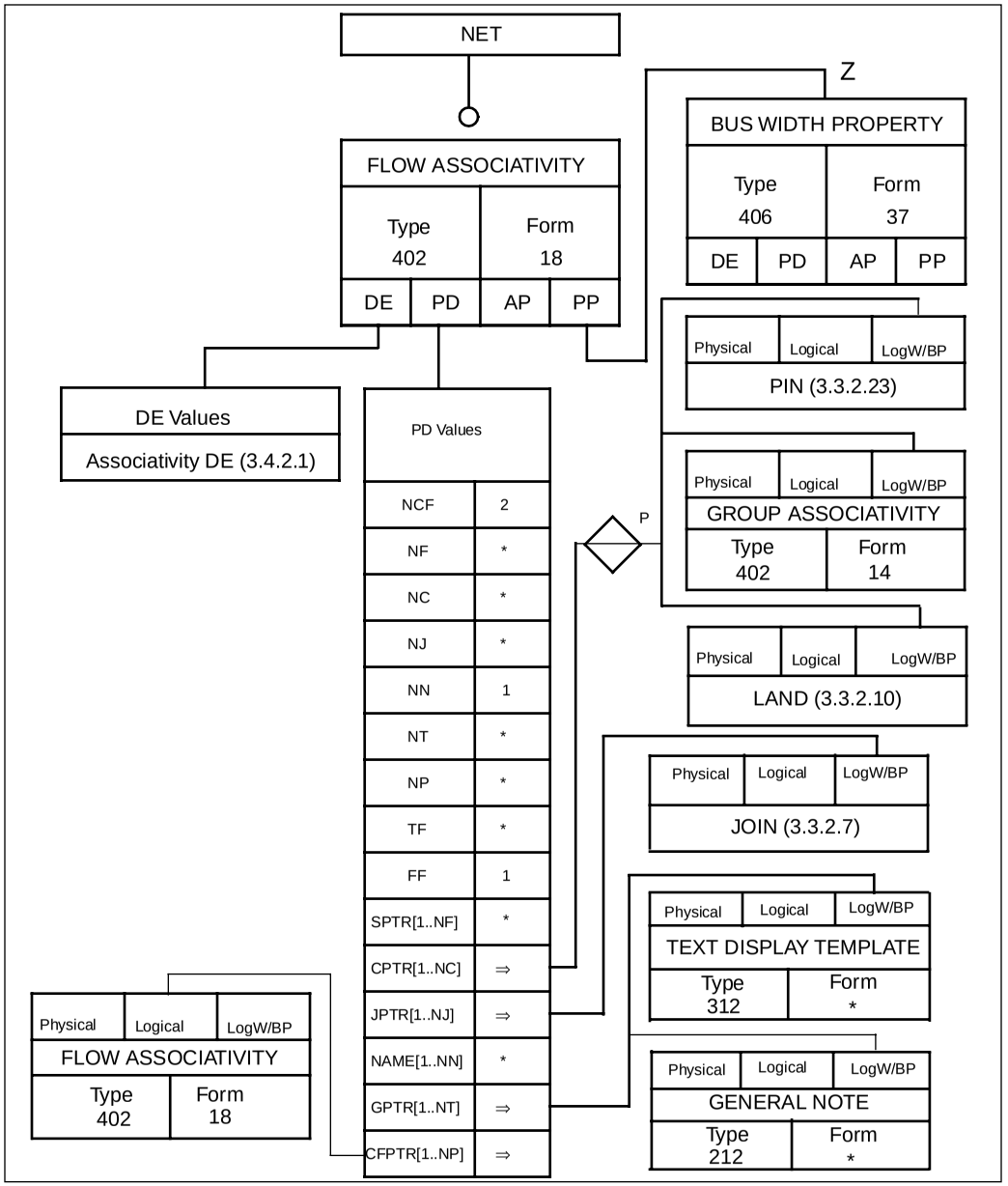
Requirements/Restrictions:

1. The NAME field in the Flow Associativity Entity (Type 402, Form 18) shall be unique (For all *NET*s) within the scope of the LEP Definition.
2. Pins shall be referenced by a *PIN* object.
3. All objects that are subordinate to the Flow Associativity Entity (Type 402, Form 18)—with the exception of Pins—shall be physically dependent on the same parent as the Flow Associativity.
4. There shall be 2 or more objects subordinate to the *NET*, which are either *PIN* objects, *LAND* objects, *VIA* objects, or *JUMPER* objects.
5. The Bus Width Property Entity (Type 406, Form 37) shall be included when the Net object is used to represent a logical signal bus (of more than one physical nets).

Translation Usage Notes:

General:

Alternate connection entity for PD CPTR: IGES 5.3 added the Group associativity as an entity which may be pointed to from



parameter CPTR when a group of entities defines a place for connection.

Alternate flow name display entity for PD GPTR: The use of the Text Display Template Entity (Type 312) to display the net name or identification (parameter NAME) is strongly recommended; however, the General Note Entity (Type 212) is also allowed in IGES 5.3. When it serves to display the net name, the string in the first General Note referenced in parameter GPTR shall be identical to the string in the first NAME parameter.

Output:

Input:

3.3.2.16 Package Figure Definition.

Description:

The *PACKAGE FIGURE DEFINITION* object is a Subfigure Definition Entity (Type 308) or a Network Subfigure Definition Entity (Type 320), which specifies all of the constituent objects required to define, as a minimum, the "footprint" of a package figure which is assembled to the LEP.

Requirements/Restrictions:

1. The *GENERIC PART DEFINITION* object shall be used to represent the definition of a non-electrical component (an attached part).
2. The NETWORK SUBFIGURE DEFINITION object shall be used to represent the definition of an electrical component (an attached electrical part).
3. The *GENERIC DATA PROPERTY*, which is referenced from the *PACKAGE FIGURE DEFINITION* object, shall specify
   component_std_name
   component_version
   component_pkg_type
   component_tech_type
   component_layout_surface
   component_insertion_origin
   component_placement_feeder_location (*)
   component_insertable (*)
   component_height
   component_max_size
   component_outline_overhang (*).

* When applicable.

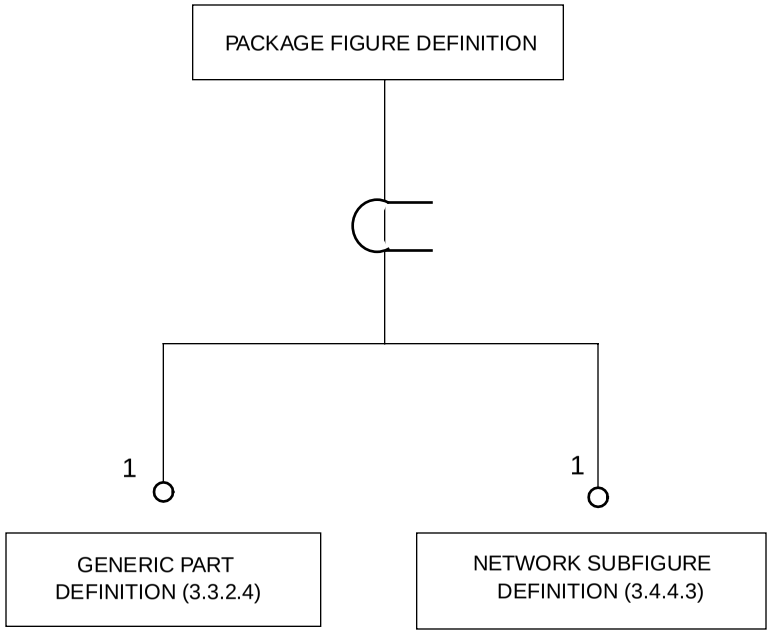
Translation Usage Notes:

General:

The part representation may be a symbolic figure, a minimal outline, a 2-dimensional detail, or a 3-dimensional detail as required for the application.

Output:

Input:



3.3.2.17 Package Figure Instance.

Description:

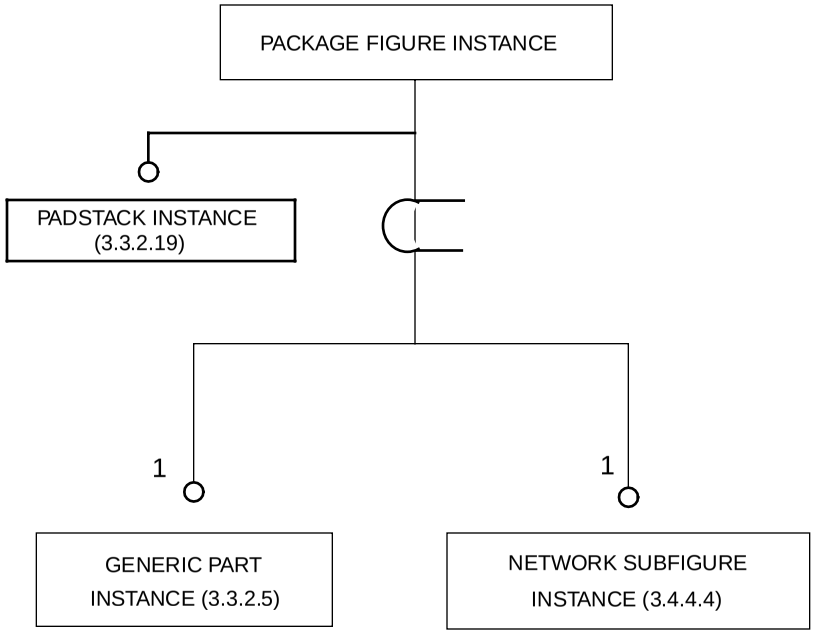
The *PACKAGE FIGURE INSTANCE* object is a Subfigure Instance Entity (Type 408) or a Network Subfigure Instance Entity (Type 420), which specifies all of the constituent objects required to define, as a minimum, the “footprint” of a package figure which is assembled to the LEP.

Requirements/Restrictions:

1. The *GENERIC PART INSTANCE* object shall instanciate the definition of a non-electrical component (an attached part).
2. The *NETWORK SUBFIGURE INSTANCE* object shall instanciate the definition of an electrical component (an attached electrical part).
3. The *LEP GENERIC DATA PROPERTY*, which is referenced from either sub-type of the *PACKAGE FIGURE INSTANCE* object, shall specify
   - abs_voltage_max(*)
   - component_instance_side
   - component_preplace (*)
   - component_via (*)
   - standalone_via (*)

* When applicable.

Translation Usage Notes:
General:
Output:
Input:



3.3.2.18 Padstack Definition.

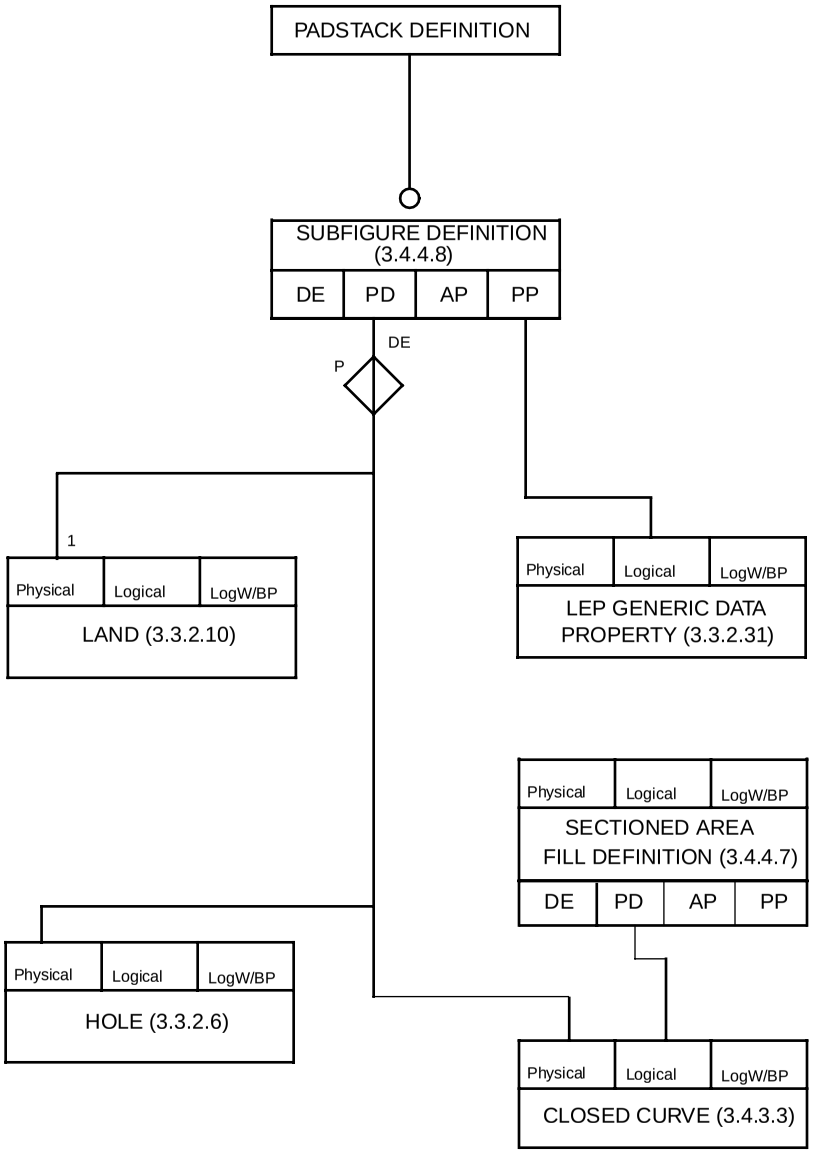
Description:

The *PADSTACK DEFINITION* object is a Subfigure Definition Entity (Type 308), which documents and depicts all of the constituent objects, that are required to list the characteristics of the volume in which a package figure is electrically connected to the LEP.

Requirements/Restrictions:

1. The characteristics of each layer that is associated with the padstack shall be defined within the *PADSTACK DEFINITION*.
2. The *LEP GENERIC DATA PROPERTY*, which is referenced from the *PADSTACK DEFINITION* object, shall specify
   physical_padstack_definition,
   component_pkg_type (= pad)

Translation Usage Notes:
General:
The DE Level attribute of the *HOLE* shall be used to specify which levels (physical layers) the padstack pierces. In order to affect more than one level, a *LEVEL DEFINITION* object shall be used.
Output:
Input:



3.3.2.19 Padstack Instance.

Description:

The *PADSTACK INSTANCE* object is an instantiation of a *PADSTACK DEFINITION*.

Requirements/Restrictions:

1. The *LEP GENERIC DATA PROPERTY*, which is referenced from the *GENERIC PART DEFINITION* object, shall specify
   (allowable_test_point or not_allowable_test_point),
   component_default_padstack,
   pad_tech_type (= smt), or
   pad_tech_type (= thru_hole_anti), or
   pad_tech_type (= thru_hole_regular), or
   pad_tech_type (= thru_hole_thermal)

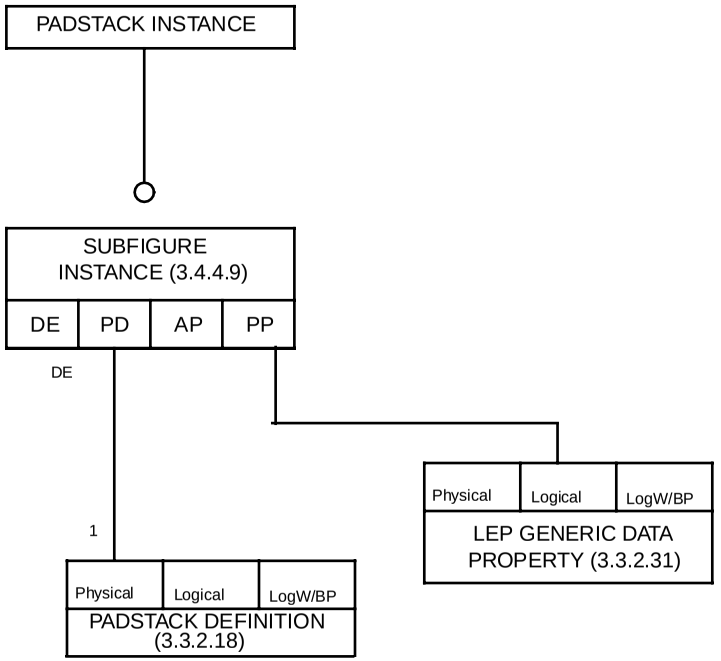
Translation Usage Notes:

General:

The DE Level attribute serves to indicate which levels (physical layers) the padstack affects. In order to affect more than one level, a *LEVEL DEFINITION* object shall be used.

Output:

Input:



3.3.2.20 Panel Definition.

Description:

The *PANEL DEFINITION* object is a Subfigure Definition Entity (Type 308), which relates all of the constituent objects that are required to depict a manufacturing panel.

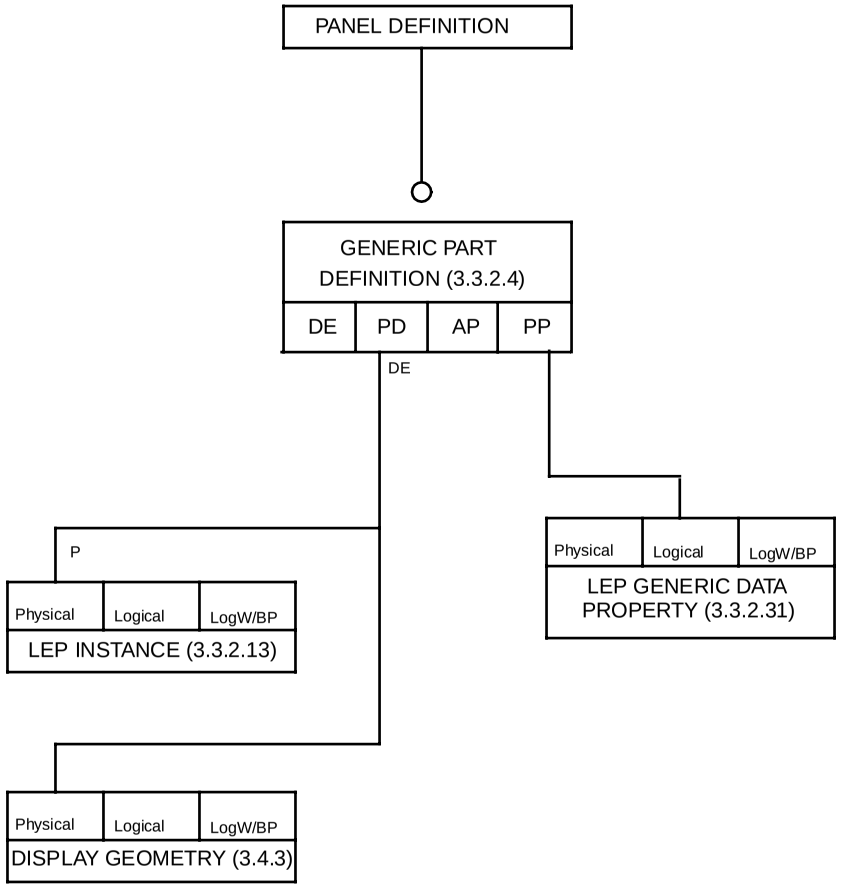
Requirements/Restrictions:

1. The *LEP GENER P DATA ROPERTY,* which is referenced from the *GENERIC PART DEFINITION* object, shall specify
   panel
2. The NAME field in the *SUBFIGURE DEFINITION* shall be unique (for all *PANEL DEFINITION*s) within the scope of the IGES File.

Translation Usage Notes:

General:
The *DISPLAY GEOMETRY* is included only as needed to describe the Panel. *DISPLAY GEOMETRY* may also reference an LEP SEMANTIC PROPERTY with a value of fiducial.
Output:

Input:



3.3.2.21 Panel Instance.

Description:

The *PANEL INSTANCE* object is an instantiation of a *PANEL DEFINITION*.

Requirements/Restrictions:

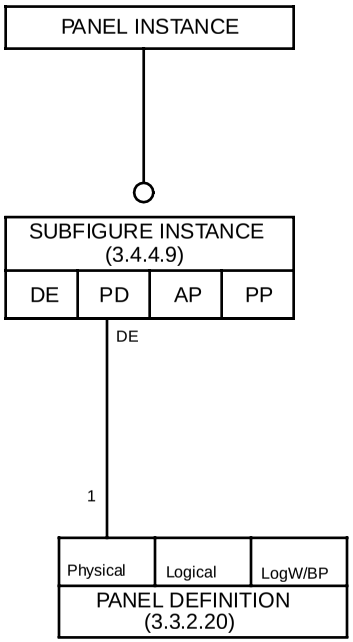
1. When present in an LEP file, the *PANEL INSTANCE* shall be implemented using a Subfigure Instance Entity (Type 408).

Translation Usage Notes:

General:

Output:

Input:



3.3.2.22 Part Placement Boundary.

Description:

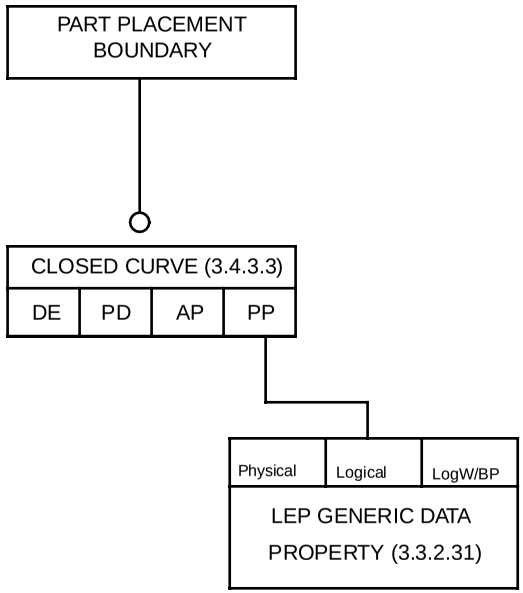
The *PART PLACEMENT BOUNDARY* object is a closed curve, which shows the area on the LEP that a Package Figure Definition encompasses. The Part Placement Boundary encompasses a volume formed by an XY area plus a lower and upper height for the area.

Requirements/Restrictions:

1. The *CLOSED CURVE* shall only be an Circular Arc, a Simple Closed Planar Curve Entity (Type 106, Form 63), or a Subfigure Definition Entity (Type 308) which is coplanar, closed, and non-crossing. A Composite Curve which references these entities may be used where the resultant geometry is coplanar, closed, and non-crossing.
2. The *LEP GENERIC DATA PROPERTY*, which is referenced from the *GENERIC PART DEFINITION* object, shall specify
   component_max_size,
   component_keep_outline.

Translation Usage Notes:
This object may exist on any level.
General:
Output:

Input:
LEP ‘Part Placement_Outline’ Property is an IGES LEP SEMANTIC PROPERTY.



3.3.2.23 Pin.

Description:

The *PIN* object documents the location, and functional characteristics of the electrical connection of a package pin to the LEP. There is no subordination associated with the Subfigure Instance (PSFI) pointer. It is an informational reference only.

Requirements/Restrictions:

1. The Connect Point Identifier (CPID) field in the Connect Point shall be unique within the scope of the Package Figure Definition or Package Figure Instance.

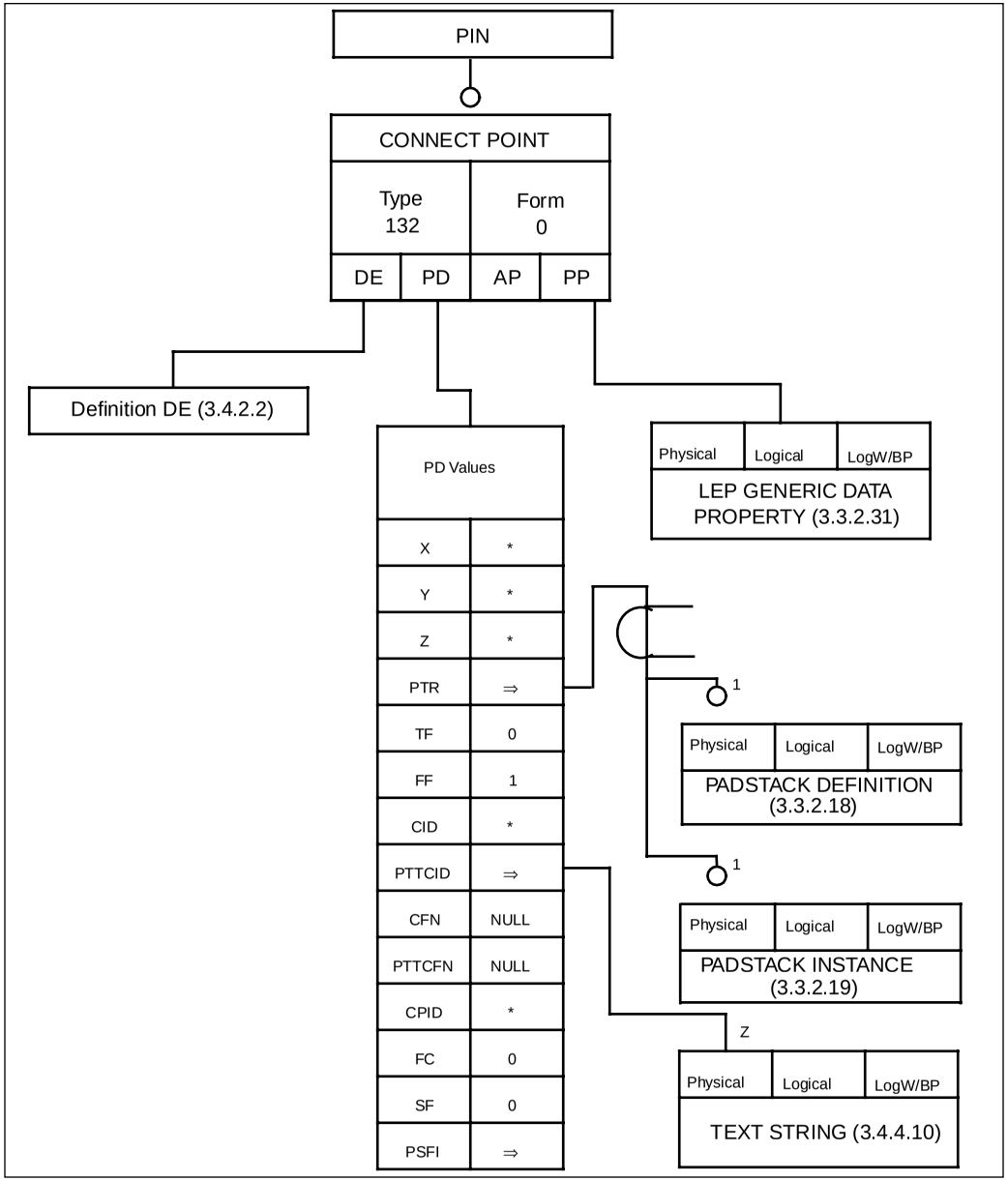
Translation Usage Notes:

General:
The value for the *LEP GENERIC DATA PROPERTY* for the *PIN* designated as “pin 1” shall be:

pin1

Output:

Input:



3.3.2.24 Routing Keepin/Keepout.

Description:

The *ROUTING KEEPIN* object is a *CLOSED CURVE*, which represents an outline which either totally encloses or excludes all routing objects (e.g., conductive filled areas, conductive paths, and vias).

Requirements/Restrictions:

1. The *LEP GENERIC DATA PROPERTY*, which is referenced from the *CLOSED CURVE* object, shall specify
   trace_keep_outline, and
   keepin or keepout

Translation Usage Notes:

General:

Output:

Input:

see *KEEPIN/KEEPOUT* (3.3.2.9).

3.3.2.25 Test Point.

Description:

The *TEST POINT* object indicates a location which is designated for probing during a specific electrical test procedure (e.g., in-circuit, bare board, functional).

Requirements/Restrictions:

1. An *LEP GENERIC DATA PROPERTY* shall specify
   allowable_test_point
which shall be referenced from the object representing the *TEST POINT.*

Translation Usage Notes:

General:

Output:

Input:

see *LEP SEMANTIC PROPERTY* (3.3.2.31).

3.3.2.26 Trace Keepin/Keepout.

Description:

The *TRACE KEEPIN/KEEPOUT* object is a closed curve, which represents an outline in which all traces (e.g., conductive areas or conductive paths) are enclosed or excluded.

Requirements/Restrictions:

The inclusion or exclusion shall be specified by a definitive Closed Curve.

Translation Usage Notes:

General:
The values for the *LEP GENERIC DATA PROPERTY* shall be:

trace_keep_outline and
(keepin or
keepout)

Output:

Input:

see *KEEPIN/KEEPOUT* (Section 3.3.2.9).

3.3.2.27 Via.

Description:

The *VIA* object represents a special type of Join. It serves to electrically connect conductive material of two or more physical layers of the LEP.

Requirements/Restrictions:

1. The *GENERIC DATA PROPERTY,* if referenced from the *PIN* object, shall specify
   component_via
2. If the Via is subordinate to a definition that is intended to be instantiated on the LEP (i.e., Package Figure Definition), it shall reference a Padstack Definition. If the Via is subordinate to a LEP Definition, it shall reference a Padstack Instance.

Translation Usage Notes:

General:

Output:

Input:

see *PADSTACK OBJECTS* (3.3.2.18 and 3.3.2.19).

3.3.2.28 Via Keepin/Keepout.

Description:

The *VIA KEEPIN/KEEPOUT* object is a *CLOSED CURVE*, which represents an outline in which all Vias are enclosed or excluded.

Requirements/Restrictions:

The inclusion or exclusion shall be specified by a definitive Closed Curve.

Translation Usage Notes:

General:
The values for the LEP GENERIC DATA Property shall be as follows:

via_keep_outline and
(keepin or
keepout)

Output:

Input:

see *KEEPIN/KEEPOUT* (Section 3.3.2.9).

3.3.2.29 Wire Bond.

Description:

The *WIRE BOND* object is a special type of *JOIN*. It may serve to electrically connect a pre-packaged IC or HMA to the surface of an MCM. A Wire Bond is typically soldered, thermally bonded, or compression bonded to a special type of Padstack (wire bond pad).

Requirements/Restrictions:

1. The *LEP GENERIC DATA PROPERTY*, which is referenced from the Non-Closed Curve object, optionally specifies:
   gauge

Translation Usage Notes:

General:

Output:

Input:

see *JUMPER WIRE* (Section 3.3.2.8).

3.3.2.30 Generic Data Property.

Description:

The *GENERIC DATA PROPERTY* object maps directly to the IGES Generic Data Property Entity (Type 406, Form 27). Please refer to IGES Volume 1 for additional information.

Requirements/Restrictions:

1. Certain objects in this AP require specific values for a Generic Data Property (Type 406, Form 27) Name Value as defined in the following list.

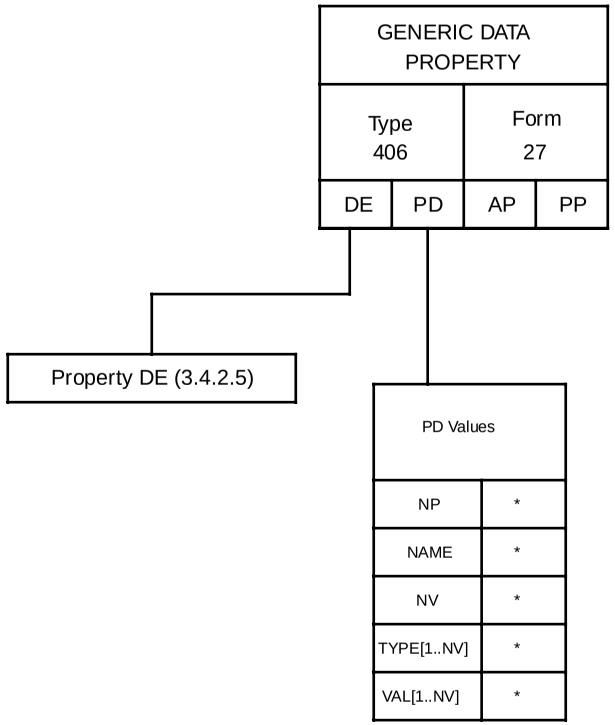
Translation Usage Notes:

For general (i.e., user extendable) use of this IGES Property see Section 3.3.5 LEP SEMANTIC PROPERTY. Where possible, select the PD Name value from the pre-defined list beginning on the next page, allowing the receiving system to interpret the meaning of the Name string consistent with this AP.

General:

Output:

Input:



Predefined values for the Generic Property “Name” parameter:

abs_voltage_max The property (of the *PACKAGE SYMBOL INSTANCE*) which provides simulation and analysis programs an upper limit on the expected EMF to be applied to the component.

allowable_test_point The logical property (of a Connect Point Entity (Type 132)) indicating it MAY be probed by the tester.

area The logical property of a *JOIN* object indicating that the surface bounded is conductive and is associated with a *NET*.

assembly_number The property (of the *LEP PHYSICAL LAYOUT IGES FILE*) which provides the text string name of the LEP assembly drawing file (assigned by the enterprise that created the LEP design).

back_pad_polarization The logical property (of a Connect Point Entity (Type 132)) indicating it is in direct contact with the substrate and specifies a value of +, -, key, gnd, or pin(n).

component_default_padstack The logical property (of a *PADSTACK DEFINITION*) to indicate that nothing special has been added or removed from the Padstack selected to be generic.

component_height The length measure (of the *PACKAGE SYMBOL DEFINITION*) which provides insertion processes a z dimension measured from the nearer surface of the LEP below which the component shall reside after insertion (or an indication no value is provided).

component_insertable The logical property (of the *PACKAGE SYMBOL DEFINITION*) which provides insertion processes an indication as to whether the component lends itself to processing or not.

component_insertion_force A real number providing the maximum insertion force to be applied (in units defined for the insertion equipment).

component_insertion_height A length measure providing the maximum difference in the z direction between the nearer surface of the LEP and the farthest point, edge, or surface of the component.

component_insertion_origin The length measure (of the *PACKAGE SYMBOL DEFINITION*) which provides insertion processes the real X and Y offset from the definition space origin to the origin used by the inserter.

component_instance_side The text string (of the *PACKAGE SYMBOL INSTANCE*) which provides other processes a text string indicating on which side (top or bottom) of the LEP the component will be found.

component_keep_outline The logical property of a *CLOSED CURVE* in the Z = 0.0 plane flagging it as an X, Y region of inclusion or exclusion of LEP Components.

component_layout_surface The text string(of the *PACKAGE SYMBOL DEFINITION*) which indicates which LEP surface the component defined occupies. { front/back/top/bottom/both/unknown }

component_outline_overhang The property (of the *CLOSED CURVE*) depicting the outline of a connector or other component which extends beyond the edge of the LEP outline.

component_max_size The property (of the *PACKAGE SYMBOL DEFINITION*) which provides insertion processes three maximum dimensions inside which the component can be contained.

component_physical_thickness The property (of the *PACKAGE SYMBOL DEFINITION*) which provides insertion processes with the depth space in which the component body is contained.

component_pkg_type The textual property (of the *PACKAGE SYMBOL DEFINITION*) which provides the package type name of the component defined.

component_placement_angle An angular measure providing the insertion

machinery the rotation to be applied between grasp and insertion relative to the default component rotation.

component_placement_body A string providing a text code corresponding to the package type of the component to be inserted.

component_placement_center The length measures providing the insertion machinery the X, Y, and Z offset from the component origin to the origin presumed by the inserter.

component_placement_form_code An integer providing the insertion machinery an integer code to indicate the forming needed for the referencing component.

component_placement_form_code_description A string providing a text description of the forming needed for the referencing component.

component_placement_lead_diameter A length measure providing the insertion machinery the nominal diameter of the pin to be inserted.

component_placement_yn A logical property indicating whether the referencing entity models a component which is to be inserted or not.

component_placement_zspan A string providing a text code corresponding to the insertion machine depth stop.

component_preplace The property (of the *PACKAGE SYMBOL INSTANCE*) which provides placement systems a predefined location and/or mounting side for that particular component instance.

component_std_name The textual property (of the *PACKAGE SYMBOL DEFINITION*) which provides the name of the component defined.

component_tech_type The textual property (of the *PACKAGE SYMBOL DEFINITION*) which provides the name of the technology type (SMT or through-hole) of the component defined.

component_version The textual property (of the *PACKAGE SYMBOL DEFINITION*) which provides the (alphanumeric) version identifier of the component defined.

component_via The marking of the *VIA* instance to indicate it will be built around a component *PIN*.

conductive_trace_function The descriptive text property of an open curve defining a conductive *JOIN* on a particular layer or set of layers of an LEP intended to connect Pins, Pads and Vias to a power source, a ground return or a particular signal.

date The textual property (of an LEP) providing a value of the form mm/dd/yyyy plus a second value from the set {file_creation, last_revision, revision_effective }.

fiducial The compound textual property (of an LEP *CLOSED CURVE*) to indicate its use as a positional reference. The first value indicates the nature of the owning entity. {component/cluster/board/panel} The second value indicates whether the locating symbol appears on the top or the bottom surface of the LEP { top/bottom }.

jumper_wire The logical property of a *JOIN* object indicating that the object is conductive and is associated with a *NET*.

junction_max_t The temperature measure (of the *PACKAGE SYMBOL INSTANCE*) which provides simulation and analysis programs a value of the maximum temperature rating of the semi-conductor junction in the component.

keepin The logical property (of an LEP *CLOSED CURVE*) which indicates the curve represents the physical outline of the outer perimeter where components, traces, or vias may be located.

keepout The logical property (of an LEP *CLOSED CURVE*) which indicates the curve represents the physical outline of the outer perimeter of an area restricted from the placement of components, traces, or vias.

lep_physical_outline The logical property (of an LEP *CLOSED CURVE*)

which indicates the curve represents the physical outline of the LEP substrate.

no_connection The logical property (of a Connect Point Entity (Type 132) indicating it shall NOT be pointed to by the Flow Associativity Entity (Type 402, Form 18).

not_allowable_test_point The logical property (of a Connect Point Entity (Type 132) indicating it shall NOT be probed by the tester.

pad_tech_type The textual property (of the Connect Point Entity (Type 132) modeling the *PAD*, *PIN*, or socket acting as Port to the LEP or one of its components) which indicates the type of technology (and for thru_holes the design of the pad) used in implementing the port (or the no_connection).

panel The logical property of a *PANEL DEFINITION* object indicating that the object is an LEP manufacturing item created to facilitate the fabrication of one or more PWBs.

panel_offset A pair of length measures providing the X, Y offset from the *LEP PHYSICAL LAYOUT IGES FILE* to the origin of the fabrication panel.

path The logical property of a *JOIN* object indicating that the non-closed curve is conductive and is associated with a *NET*.

photoplot_aperture The textual property of a CLOSED CURVE which is a LAND object with values of type string; supplied when it is desired to record the information about the particular tool (e.g., photoplotter wheel) and aperture index of the tool identified to produce the required shape on the photoplot.

physical_outline The required property of a *CLOSED CURVE* surrounding the silhouette viewed in a plane parallel to a layer of the LEP.

physical_padstack_definition The logical property (of the set of entities depicting the sequence of *PAD*s at a particular X, Y location of an LEP) which tags the parent entity as the definition. Some of the *PAD*s are to be connected to each other and to any conductor penetrating the hole at the X, Y location. Other *PAD*s may be intentionally isolated electrically from any conductor penetrating the hole at the X, Y location.

pin1 The logical property (of the Connect Point Entity (Type 132) modeling the *PAD*, *PIN*, or socket acting as Port to the LEP or one of its components) which tags the port as “Pin 1” of the device.

placement_outline The orientational and positional property of a *CLOSED CURVE* indicating the intended position of a particular component on a physical layer of the LEP.

planar_shape_function The textual property of a *CLOSED CURVE* defining a conductive region of a particular layer or set of layers of an LEP intended to connect *PINS*, *PAD*s and *VIA*s to a power source, a ground return or a particular signal.

pwb_number The textual property (of the *LEP PHYSICAL LAYOUT IGES FILE* defining the substrate) which provides the name of the LEP design drawing file (assigned by the enterprise that created the LEP design).

registration_mark The logical property (of LEP GEOMETRY) indicating that the geometry purpose is the alignment of layers of an LEP or its artwork or photo-tool.

schematic_number The textual property (of the *LEP TECHNICAL ILLUSTRATION IGES FILE*) which provides the name of the schematic drawing file (assigned by the enterprise that created the LEP design),

selected_test_point The logical property [of a Connect Point Entity (Type 132)] indicating it has been targeted to be probed by the tester.

silkscreen_bot The property indicating the referencing Text and/or graphics are to be applied to the Bottom Layer of the LEP.

silkscreen_top The property indicating the referencing Text and/or graphics are to be applied to the Top Layer of the LEP.

standalone_via The tagging of the *VIA* instance to indicate it will not be built around a component Pin.

station_action The textual property (of the *SUBFIGURE INSTANCE* representing the work station where some processing is to occur) which indicates what kind of processing is to be done.

station_number A string providing the I. D. of the work station where some processing is to occur.

test_point_pwb_id The textual property (of a stand-alone *VIA*) to provide a unique name to facilitate test descriptions.

test_point_nail_id The property (of a tester probe) to uniquely identify the probe to be put in contact with the referencing LEP feature.

therm_cond The textual property (of the Component Instance) which provides simulation and analysis programs a value of the nominal thermal conductivity coefficient (see IGES Tabular Data Property Entity (Type 406, Form 11), PTYPE=19) of the component case material.

therm_jc The property (of the Component Instance) which provides simulation and analysis programs a value of the nominal thermal resistance between the semiconductor junction and the outer case surface in watts per degree Centigrade.

therm_r The property (of the *PACKAGE SYMBOL INSTANCE*) which provides simulation and analysis programs a value of the nominal thermal resistance from case to ambient in watts per degree Centigrade.

thermal_outline The graphic property of a *CLOSED CURVE* indicating the extent of thermal emission or sensitivity of the component(s) mounted in the vicinity.

thru_hole The property (of a HOLE object) which indicates penetration of all physical layers of the LEP.

tolerance The permitted range of the value referencing referencing this property.

top_level_assembly_instance The logical property (of the LEP entity) tagging it as the highest level instance within the scope of the model.

trace_bot The logical property of a *JOIN* indicating it appears on the Bottom layer of the LEP.

trace_keep_outline The property (of a *CLOSED CURVE* in the Z = 0.0 plane) defining an X, Y region of inclusion or exclusion of LEP Traces.

trace_n The property of a *JOIN* indicating it appears on layer number n of the LEP.

trace_top The logical property of a *JOIN* indicating it appears on the Top layer of the LEP.

trace_2 The property of a *JOIN* indicating it appears on layer number 2 of the LEP.

via The logical property of a *JOIN* object indicating that a hole is conductive and is associated with a *NET*.

via_keep_outline The property (of a *CLOSED CURVE* in the Z = 0.0 plane) defining an X, Y region of inclusion or exclusion of LEP *VIA*s.

wire_wrap The logical property (of the *PIN*) indicating the connection is wire wrapped.

gauge The numeric property (of the *JOIN*) indicating the wire gauge (usually 26 or 30; occasionally others)

wire_bond The logical property of a *JOIN* object indicating that the object is conductive and is associated with a *NET*.

wire_color The color of wire insulation for maintenance and ease of assembly

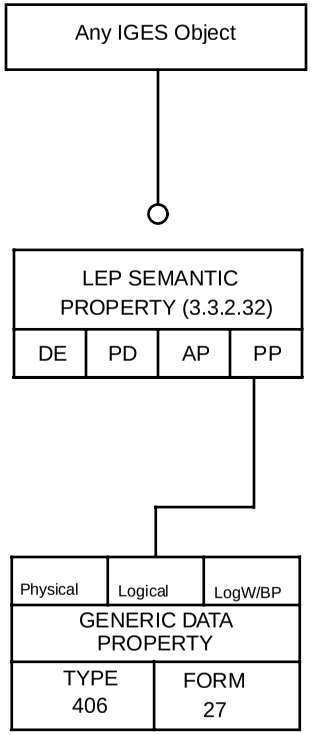
twisted_pair The logical property (of the *JOIN*) indicating multiple wires are twisted together for better signal integrity; signal names are usually assigned to sort together (e.g., reset_D+ and reset_D-) to designate pairing.

wrap_class The (optional) textual property (of the *JOIN*); values are “A,” “B,” “MODIFIED-B”, indicating how many wraps around the post, and the “tightness” of wrap.

3.3.2.31 LEP Semantic Property.

The *LEP SEMANTIC PROPERTY* object maps directly to the IGES Generic Data Property Entity (Type 406, Form 27). Please refer to the IGES Volume 1 for additional information. The following LEP object types and sub-types reference the LEP Property object:

3.3.1.2	LEP Physical Layout IGES File
3.3.2.1	Component Placement Keepin/Keepout
3.3.2.2	Component Thermal Outline
3.3.2.3	Drawing Definition
3.3.2.4	Generic Part Definition
3.3.2.5	Generic Part Instance
3.3.2.6	Hole
3.3.2.7	Join
3.3.2.8	Jumper Wire
3.3.2.9	Keepin/Keepout
3.3.2.11	Layer Outline
3.3.2.12	LEP Definition
3.3.2.13	LEP Instance
3.3.2.16	Package Figure Definition
3.3.2.17	Package Figure Instance
3.3.2.18	Padstack Definition
3.3.2.19	Padstack Instance
3.3.2.20	Panel Definition
3.3.2.22	Part Placement Boundary
3.3.2.23	Pin
3.3.2.27	Via
3.3.2.28	Via Keepin/Keepout
3.3.2.29	Wire Bond



3.4 General Object Models

This section contains objects which may be referenced from any application protocol. The subsections define Directory Entry (DE) referenced objects, DE Section objects, display geometry objects, and miscellaneous objects.

3.4.1 DE Referenced Object Models.

These objects, including the Transformation Matrix, are referenced from IGES Directory Entry (DE) file section.

3.4.1.1 Level Definition.

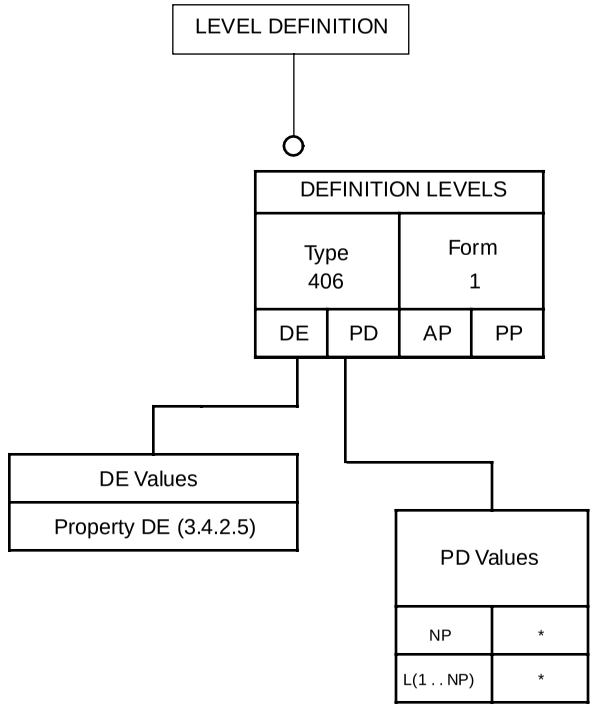
description:

The *LEVEL DEFINITION* object enables an entity to exist on one or more levels.

Requirements/Restrictions:

1. For the entity to be defined on a single level, its DE field 5 shall contain that Level number.
2. For the entity to be defined on two or more levels, its DE field 5 shall contain a negated pointer to the appropriate Definition Levels Property Entity (Type 406, Form 1).

Translation Usage Notes:
General:
Output:
Input:



3.4.1.2 Line Width Definition.

Description:

The *LINE WIDTH DEFINITION* object enables an entity to have specific line width characteristics which include width, justification, and specific end conditions.

Requirements/Restrictions:

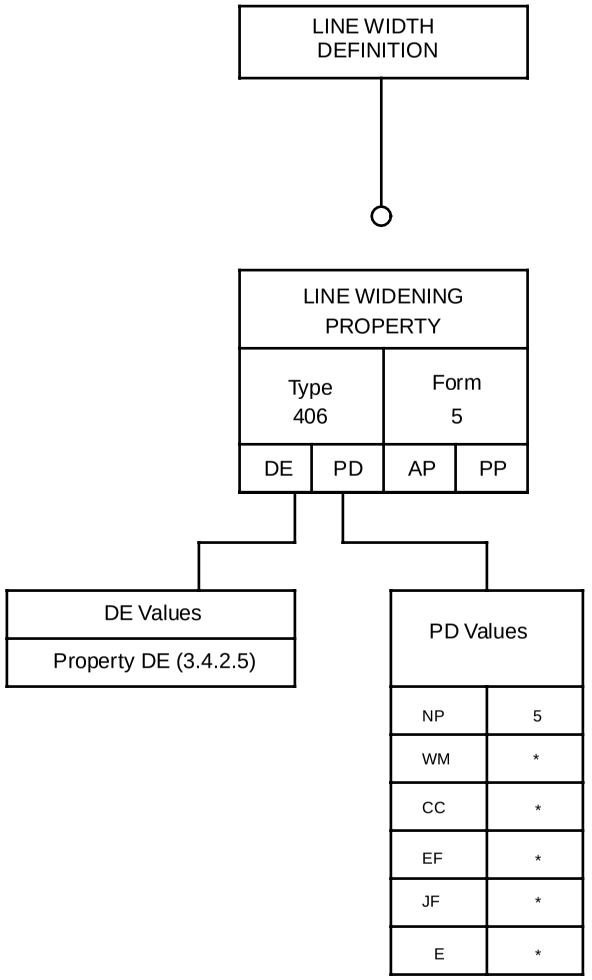
1. The *LINE WIDTH DEFINITION* shall only be invoked by *DISPLAY GEOMETRY* objects.

Translation Usage Notes:

General:

Output:

Input:



3.4.1.3 Transformation Matrix.

Description:

The *TRANSFORMATION MATRIX* object is either a Transformation Matrix (Normal) or a Transformation Matrix (Mirrored) Entity (Type 124).

Requirements/Restrictions:

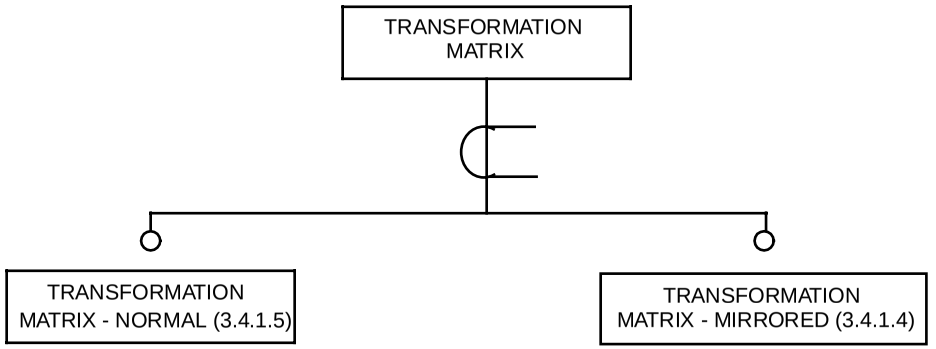
1. The determinant of the matrix shall be equal to plus one or minus one.

Translation Usage Notes:

General:

Output:

Input:



3.4.1.4 Transformation Matrix (Mirrored).

Description:

The *TRANSFORMATION MATRIX (MIRRORED)* object calls for an X,Y, Z rotation and an X,Y, Z offset in a left-handed coordinate system.

Requirements/Restrictions:

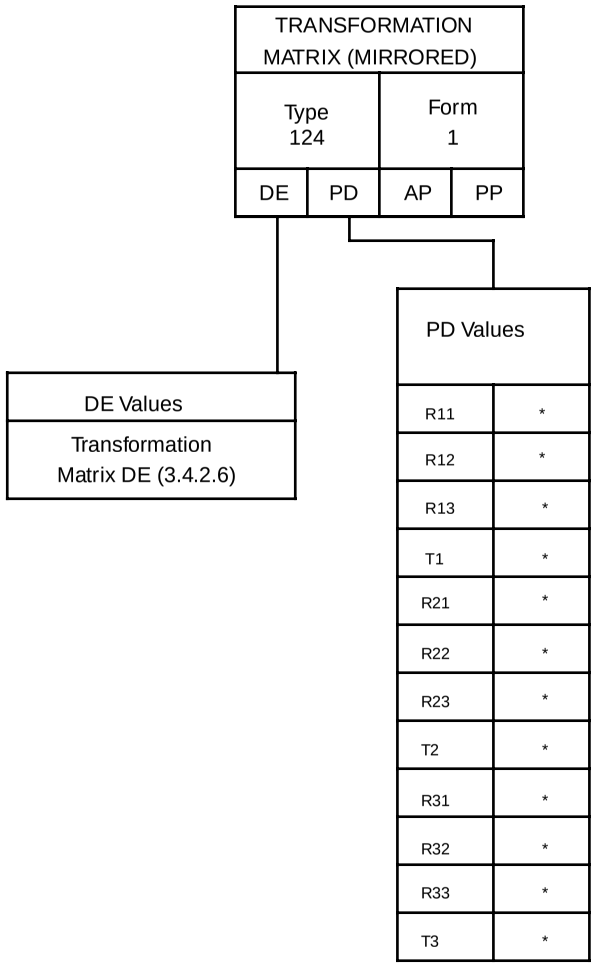
1. The determinant of the matrix shall be equal to minus one.

Translation Usage Notes:

General:

Output:

Input:



3.4.1.5 Transformation Matrix (Normal).

Description:

The *TRANSFORMATION MATRIX (NORMAL)* object calls for an X,Y, Z rotation (and an X,Y, Z offset) in a right-handed coordinate system.

Requirements/Restrictions:

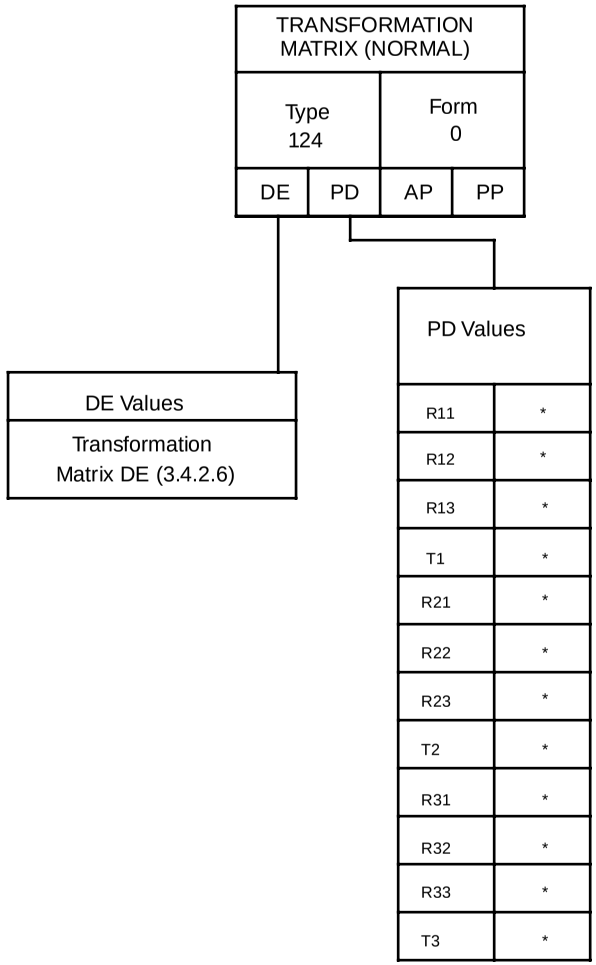
1. The determinant of the matrix shall be equal to plus one.

Translation Usage Notes:

General:

Output:

Input:



3.4.2 DE Section Object Models.

Default values for the DE section are provided for six classes of objects.

3.4.2.1 Associativity DE

Description:

The *ASSOCIATIVITY DE* object is an IGES Directory Entry Section template to be used by all associativity entities.

Requirements/Restrictions:

Translation Usage Notes:

General:

Output:

Input:

DE Values		
Entity Type		402
Parameters		--
Structure		N/A
Line Font		N/A
Level		N/A
View		N/A
TM		N/A
LDis Assoc		N/A
Status Number	Blank	N/A
	Subord	*
	Entity Use	3
	Hierarchy	N/A
Sequence		--
Entity Type		402
Line Weight		N/A
Color		N/A
Parm Count		--
Form number		*
Reserved		--
Reserved		--
Label		N/A
Subscript		N/A
Sequence		--

3.4.2.2 Definition DE.

Description:

The *DEFINITION DE* object is an IGES Directory Entry Section template to be used by all definition entities.

Requirements/Restrictions:

1. The Hierarchy Status shall indicate independence.

Translation Usage Notes:

General:

Output:

Input:

DE Values		
Entity Type		*
Parameters		--
Structure		N/A
Line Font		N/A
Level		N/A
View		N/A
TM		N/A
LDis Assoc		N/A
Status Number	Blank	N/A
	Subord	*
	Entity Use	02
	Hierarchy	01
Sequence		--
Entity Type		*
Line Weight		N/A
Color		VALUE
Parm Count		--
Form number		*
Reserved		--
Reserved		--
Label		N/A
Subscript		N/A
Sequence		--

3.4.2.3 Geometry DE.

Description:

The *GEOMETRY DE* object is an IGES Directory Entry Section template to be used by all display geometry entities.

Requirements/Restrictions:

1. The *REGION FILL DEFINITION* only applies to the *CLOSED CURVE* and the *PREDEFINED PLANAR SHAPE* objects.
2. The Line Width Definition only applies to geometry and Text String objects.
3. The Color Definition Entity (Type 314) is out of scope except for technical illustrations and documentation.

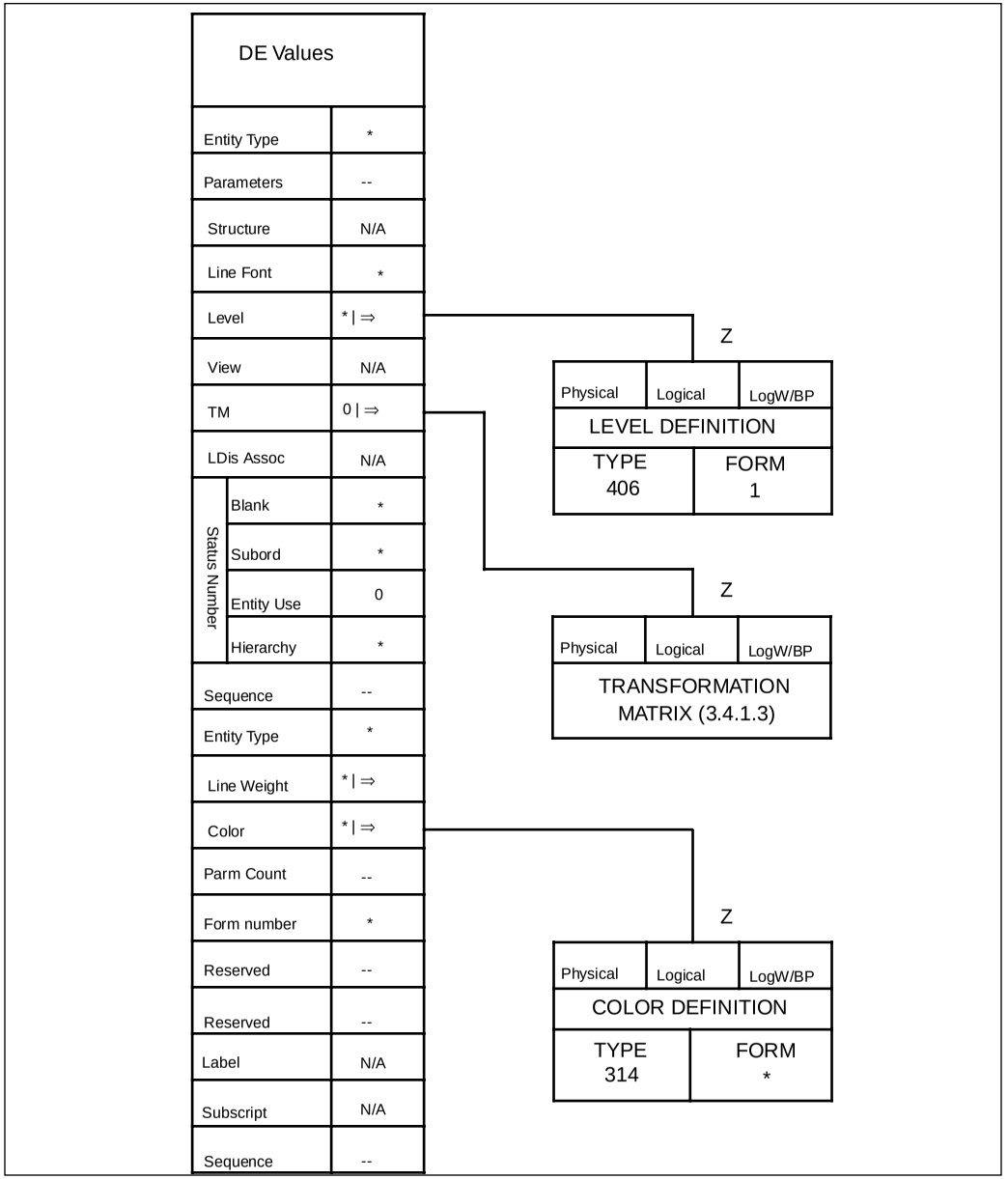
.

Translation Usage Notes:

General:

Output:

Input:



3.4.2.4 Instance DE.

Description:

The *INSTANCE DE* object is an IGES Directory Entry Section template to be used by all instance entities.

Requirements/Restrictions:

Translation Usage Notes:

General:

Output:

Input:

DE Values	
Entity Type	*
Parameters	--
Structure	N/A
Line Font	N/A
Level	0 | ⇒
View	N/A
TM	0 | ⇒
LDis Assoc	N/A
Status Number: Blank	*
Status Number: Subord	*
Status Number: Entity Use	0
Status Number: Hierarchy	*
Sequence	--
Entity Type	*
Line Weight	N/A
Color	VALUE
Parm Count	--
Form number	*
Reserved	--
Reserved	--
Label	N/A
Subscript	N/A
Sequence	--

Z

Physical	Logical	LogW/BP
LEVEL DEFINITION		
TYPE 406	FORM 1	

Z

Physical	Logical	LogW/BP
TRANSFORMATION MATRIX (3.4.1.3)		

3.4.2.5 Property DE.

Description:

The *PROPERTY DE* object is an IGES Directory Entry Section template to be used by all property and attribute entities.

Requirements/Restrictions:

1. For the Level to *LEP LAYER MAP PROPERTY*, the Subordinate Entity Switch shall be 00.

Translation Usage Notes:

General:

Output:

Input:

DE Values		
Entity Type		*
Parameters		--
Structure		N/A
Line Font		N/A
Level		N/A
View		N/A
TM		N/A
LDis Assoc		N/A
Status Number	Blank	N/A
	Subord	00
	Entity Use	3
	Hierarchy	N/A
Sequence		--
Entity Type		*
Line Weight		N/A
Color		VALUE
Parm Count		--
Form number		*
Reserved		--
Reserved		--
Label		N/A
Subscript		N/A
Sequence		--

3.4.2.6 Transformation Matrix DE.

Description:

The *TRANSFORMATION MATRIX DE* object is an IGES Directory Entry Section template to be used by all Transformation Matrix entities.

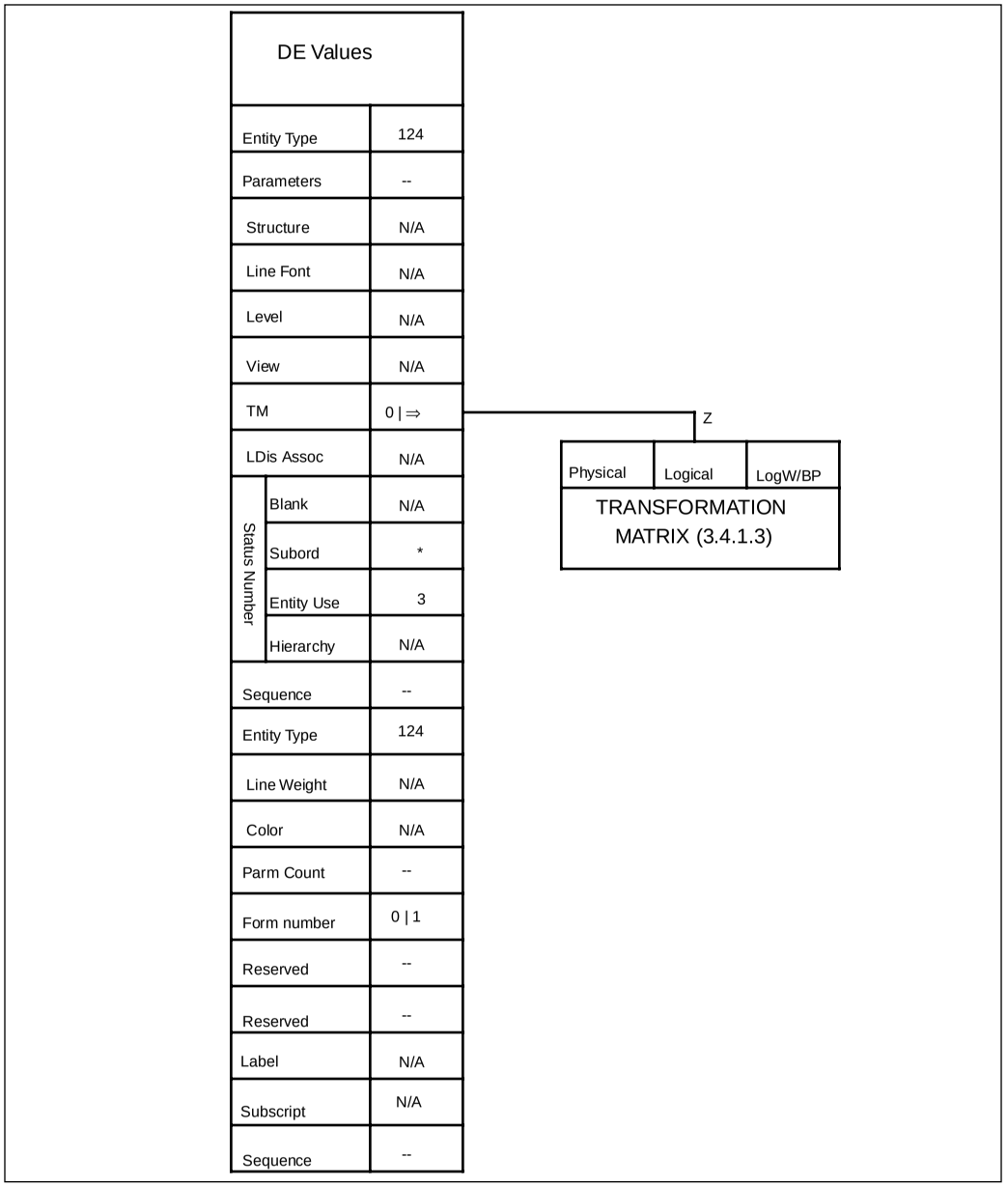
Requirements/Restrictions:

Translation Usage Notes:
A Transformation Matrix can reference another Transformation Matrix.

General:

Output:

Input:



3.4.3 Display Geometry Object Models.

3.4.3.1 Arc.

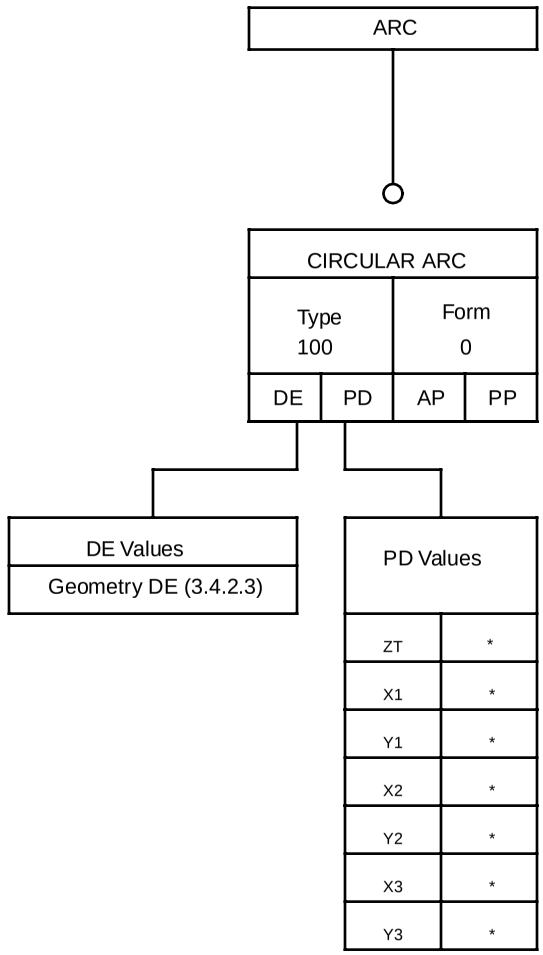
Description:

The *ARC* object represents a non-closed circular arc.

Requirements/Restrictions:

1. The start and terminate point of the IGES Circular Arc Entity (Type 100) shall not be coincident (with respect to the Global Section Minimum User-Intended Resolution).
2. The radius shall be greater than or equal to the Minimum User-Intended Resolution.

Translation Usage Notes:
General:
Output:
Input:



3.4.3.2 Circle.

Description:

The *CIRCLE* object represents a closed circular arc.

Requirements/Restrictions:

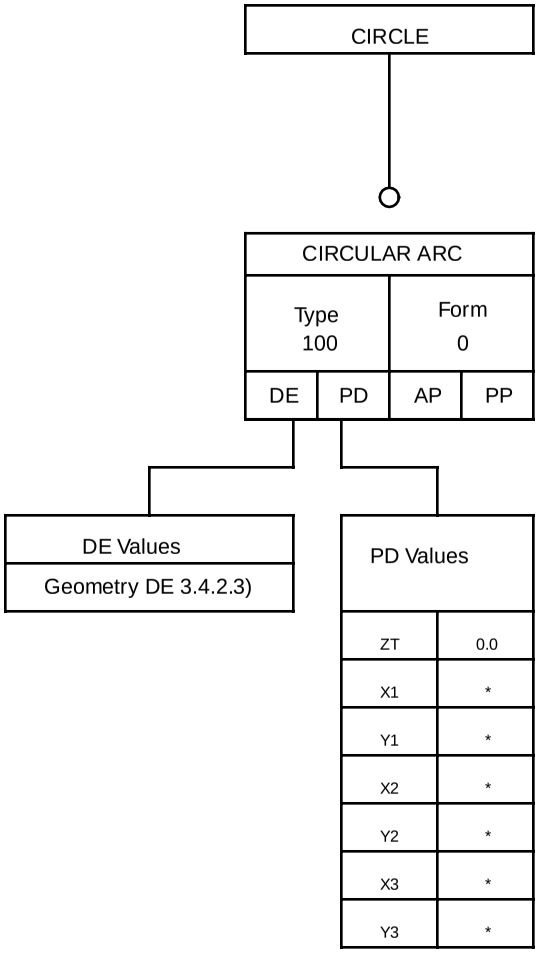
1. The start and end point of the IGES Circular Arc Entity (Type 100) shall be coincident (with respect to the Global Section Minimum User-Intended Resolution).
2. The radius shall be greater than or equal to the Minimum User-Intended Resolution.

Translation Usage Notes:

General:

Output:

Input:



3.4.3.3 Closed Curve.

Description:

The *CLOSED CURVE* object is any one of the predefined curves which is capable of defining a closed curve.

Requirements/Restrictions:

1. A *CLOSED CURVE* shall not self intersect or become tangent with itself at any point other than the start point which shall be coincident with the terminate point.

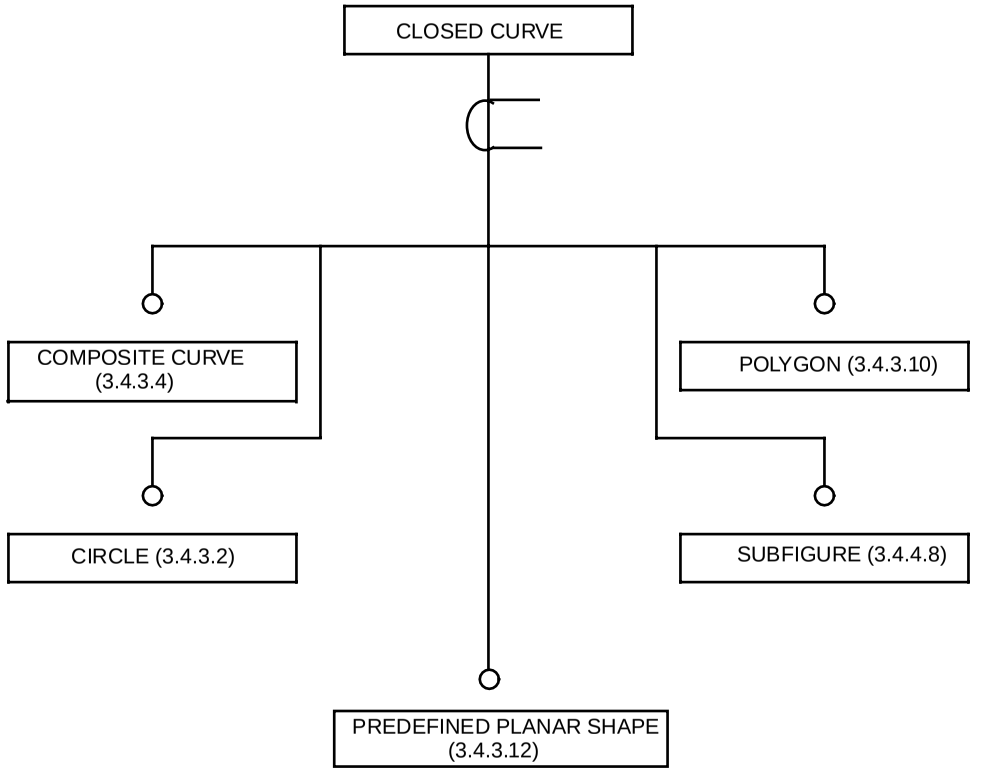
Translation Usage Notes:

General:

Certain IGES entities are not inherently closed; these shall point to a Closure Property Entity (Type 406, Form 36) when used in physical LEP Designs.

Output:

Input:



3.4.3.4 Composite Curve.

Description:

The Composite Curve object is a contiguous curve made up of a set of two or more subordinate curves.

Requirements/Restrictions:

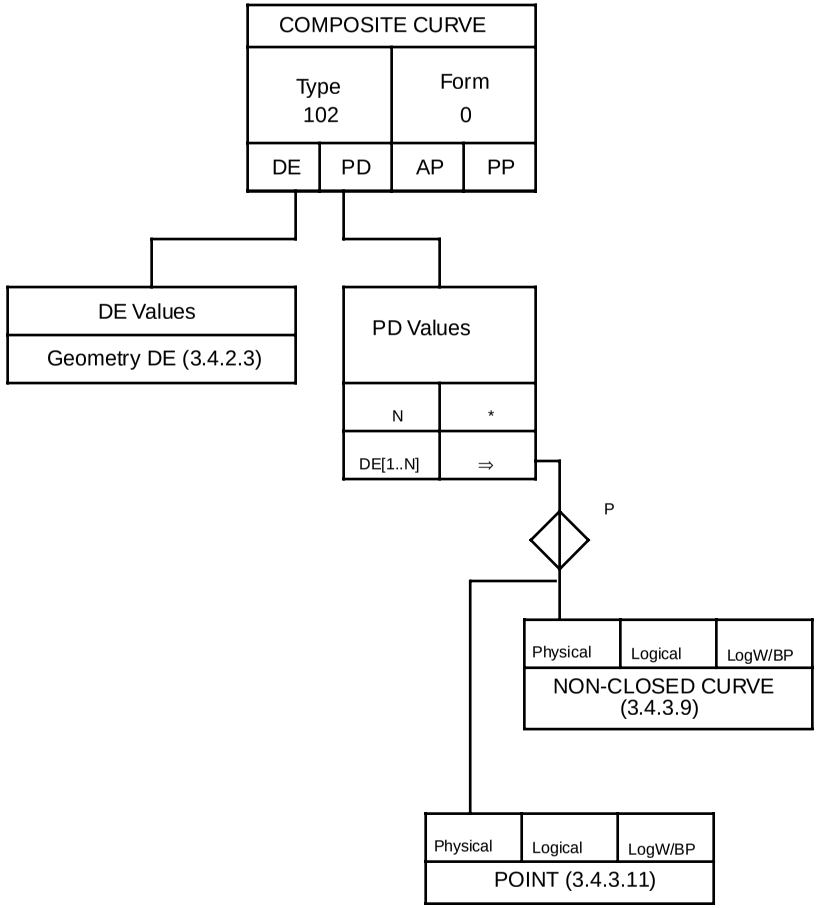
1. There shall be two or more subordinate curves.
2. The Composite Curve shall not reference another Composite Curve as a subordinate entity.
3. The Composite Curve may or may not be closed.
4. Two Points or Connect Points shall not appear consecutively in the defining list (see IGES Volume 1, section 4.4).

Translation Usage Notes:

General:

Output:

Input:



3.4.3.5 Geometry Figure Definition.

Description:

The *GEOMETRY FIGURE DEFINITION* object is a Subfigure Definition Entity (Type 308), which contains only graphic display geometry objects.

Requirements/Restrictions:

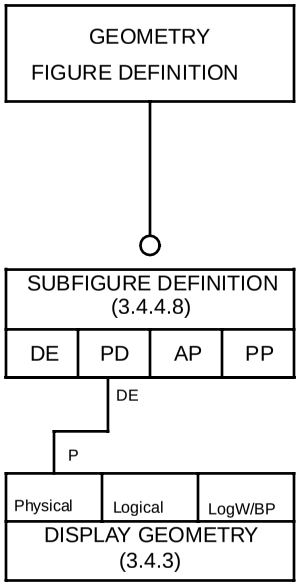
1. The LEP Object Type/Sub-Type property, which is referenced from the Subfigure Definition object, shall specify (*otype*=Geometry_Figure, *stype*=*).
2. The NAME field in the Subfigure Definition shall be unique (for all Geometry Figure Definitions) within the scope of the IGES File.

Translation Usage Notes:

General:

Output:

Input:



3.4.3.6 Geometry Figure Instance.

Description:

The *GEOMETRY FIGURE INSTANCE* Object is a Subfigure Instance Entity (Type 408).

Requirements/Restrictions:

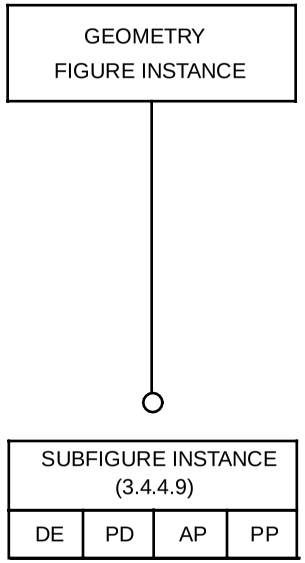
1. The LEP Object Type/Sub-Type property, which is referenced from the Subfigure Instance object, shall specify (*otype*=Geometry_Figure, *stype*=*).

Translation Usage Notes:

General:

Output:

Input:



3.4.3.7 Line.

description:

The *LINE* object represents a line segment.

Requirements/Restrictions:

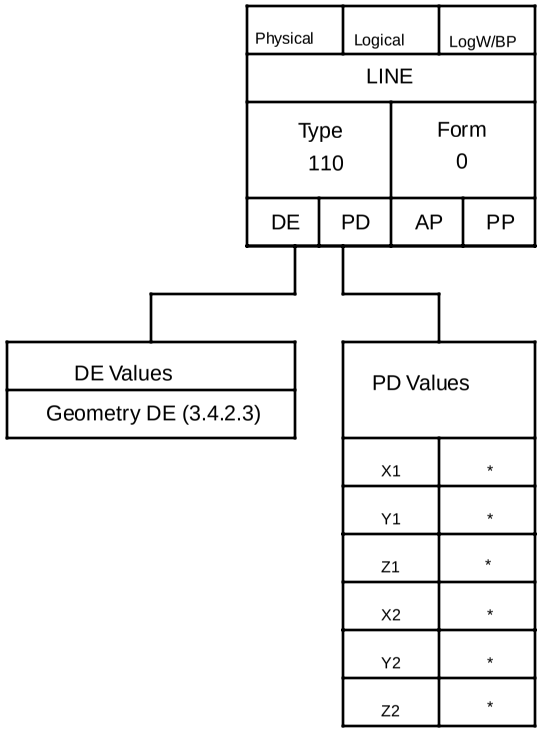
1. Form 0 (Bounded) shall be used.
2. The start and end point of the IGES Line Entity (Type 110) shall not be coincident (with respect to the Global Section Minimum User-Intended Resolution).

Translation Usage Notes:

General:

Output:

Input:



3.4.3.8 Multi-Line.

Description:

The *MULTI-LINE* object represents more than two points connected by a series of line segments. Multi-Lines are not necessarily closed curves.

Requirements/Restrictions:

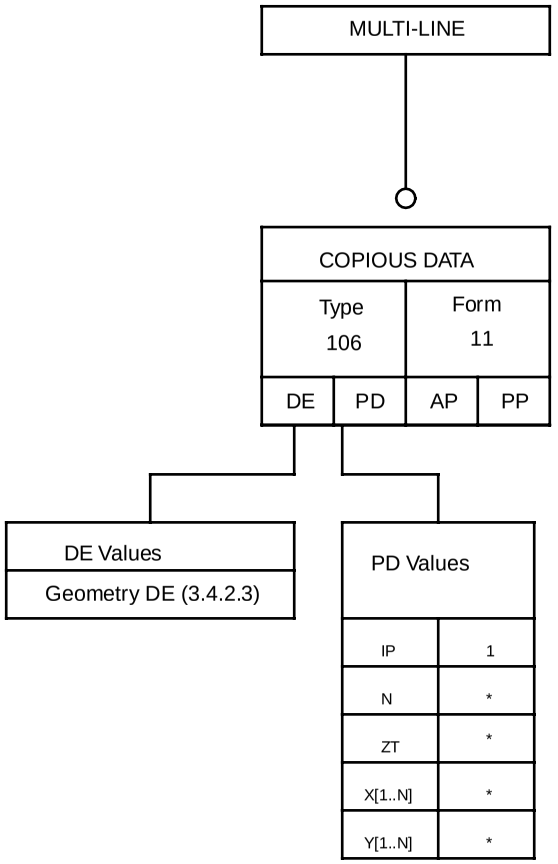
1. The *MULTI-LINE* may or may not be closed.
2. The *MULTI-LINE* shall contain more than two points.

Translation Usage Notes:

General:

Output:

Input:



3.4.3.9 Non-Closed Curve.

Description:

The *NON-CLOSED CURVE* object is any one of the predefined curves which is capable of defining an open curve.

Requirements/Restrictions:

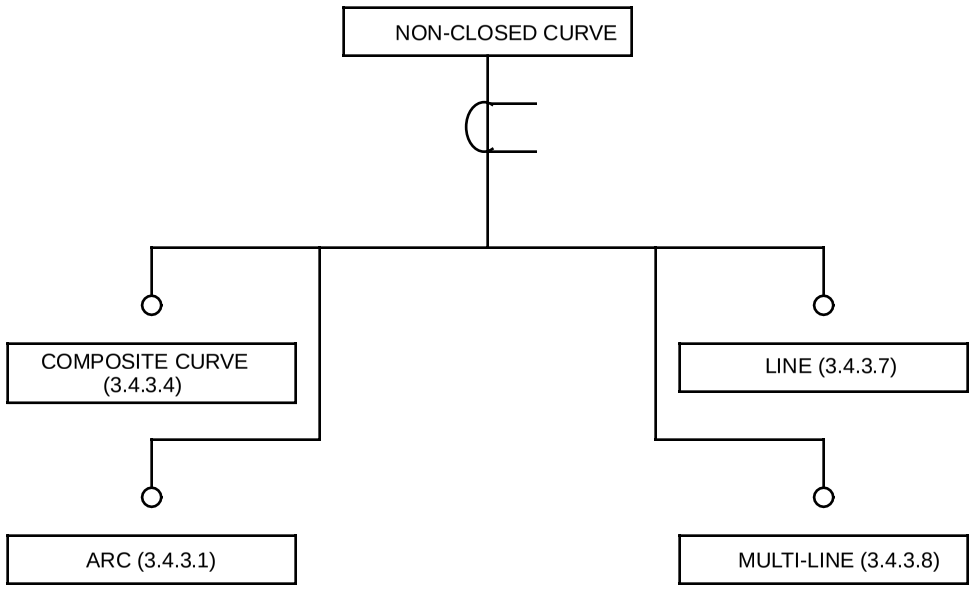
1. A *NON-CLOSED CURVE* shall not self intersect or become tangent with itself at any point, nor shall the start point be coincident with the end point.

Translation Usage Notes:

General:

Output:

Input:



3.4.3.10 Polygon.

Description:

The *POLYGON* object is a closed multi-line consisting of three or more distinct lines that does not self intersect nor become tangent with itself at any point, other than the start and end point.

Requirements/Restrictions:

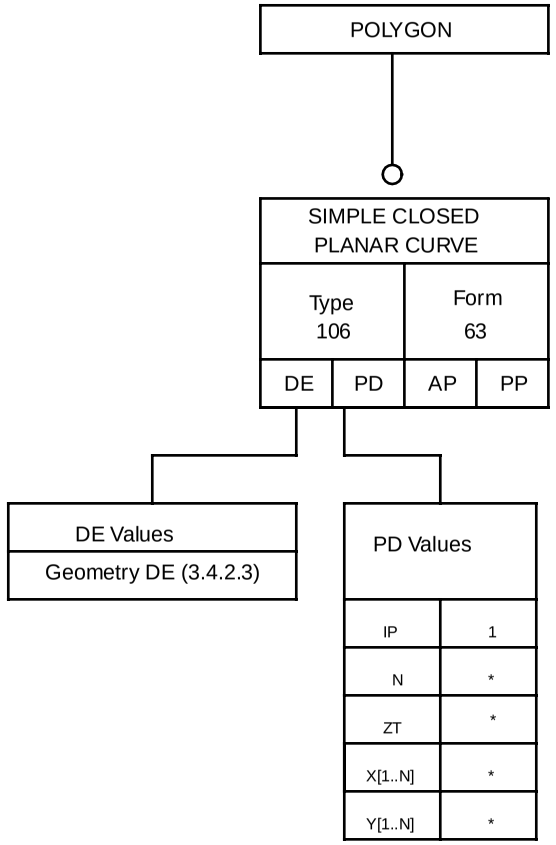
1. Because the polygon is a *CLOSED CURVE*, the start point and end point shall be coincident.

Translation Usage Notes:

General:

Output:

Input:



3.4.3.11 Point.

Description:

The *POINT* object represents a 2-D geometric construction point.

Requirements/Restrictions:

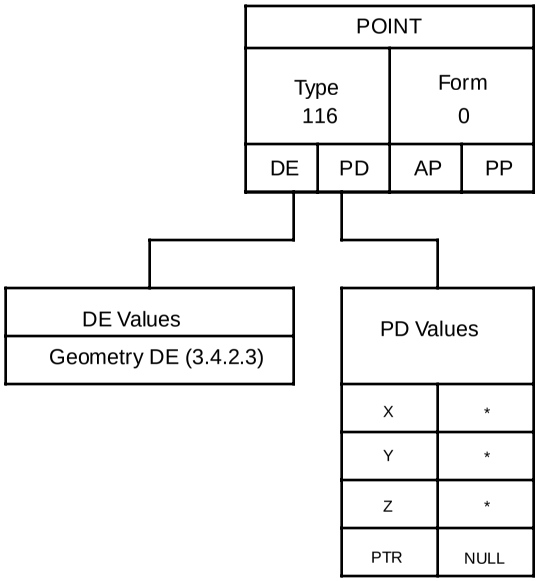
The Point object shall be represented in the IGES files as shown in the accompanying model graphic.

Translation Usage Notes:

General:

Output:

Input:



3.4.3.12 Predefined Planar Shape.

Description:

The *PREDEFINED PLANAR SHAPE* object is a closed curve, which represents one of a set of predefined shapes, where the specific shape is defined by three floating point parameters. (This object is defined as the Flash Entity (Type 125); see IGES Volume 1 section 4.19).

Requirements/Restrictions:

The Predefined Planar Shape object shall be represented in the IGES files as shown in the accompanying model graphic.

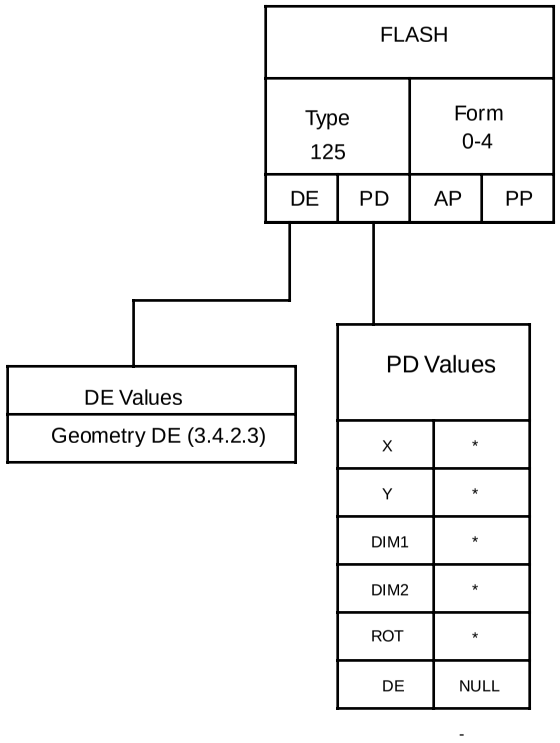
Only Forms 0-4 are valid in this AP.

Translation Usage Notes:

General:

Output:

Input:



3.4.4 Miscellaneous Object Models.

The following objects are not peculiar to any single AP object, but may be needed for its description.

3.4.4.1 Hierarchy Property.

Description:

The *HIERARCHY* object maps directly to the IGES Hierarchy Property Entity (Type 406, Form 10). Please refer to IGES Volume 1 for additional information.

Requirements/Restrictions:

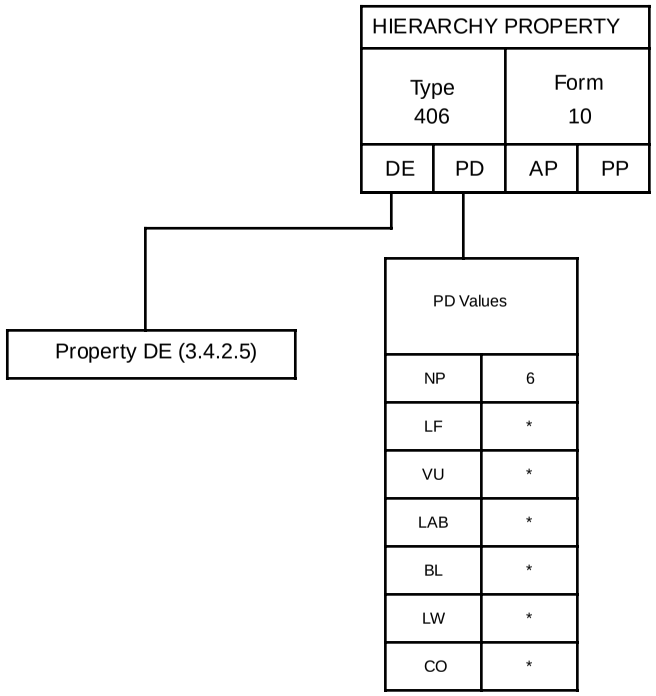
1. The *HIERARCHY* object shall be referenced from the Property Pointer list of any object that references physically subordinate children.

Translation Usage Notes:

General:

Output:

Input:



3.4.4.2 Name.

Description:

The *NAME* object maps directly to the IGES Name Property Entity (Type 406, Form 15). Please refer to IGES Volume 1 for additional information.

Requirements/Restrictions:

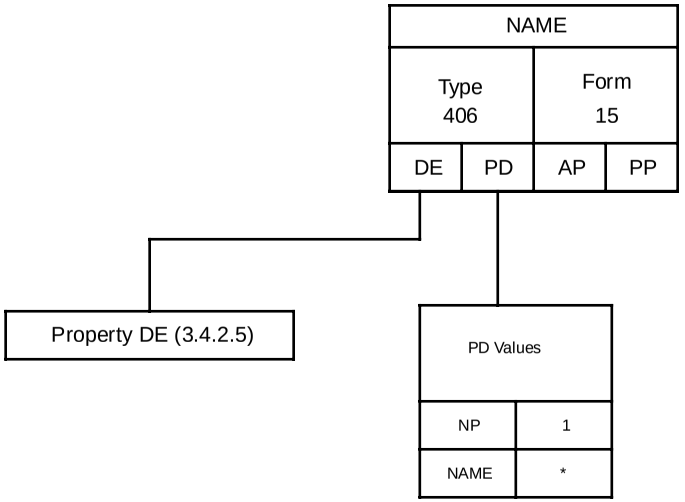
1. The *NAME* object may be referenced by any other object that does not have an explicit name field in its parameter data.
2. The Name shall be unique within the scope of the file in which it appears.

Translation Usage Notes:

General:

Output:

Input:



3.4.4.3 Network Subfigure Definition.

Description:

The *NETWORK SUBFIGURE DEFINITION* object maps directly to the IGES Network Subfigure Definition Entity (Type 320, Form 0). Please refer to IGES Volume 1 for additional information.

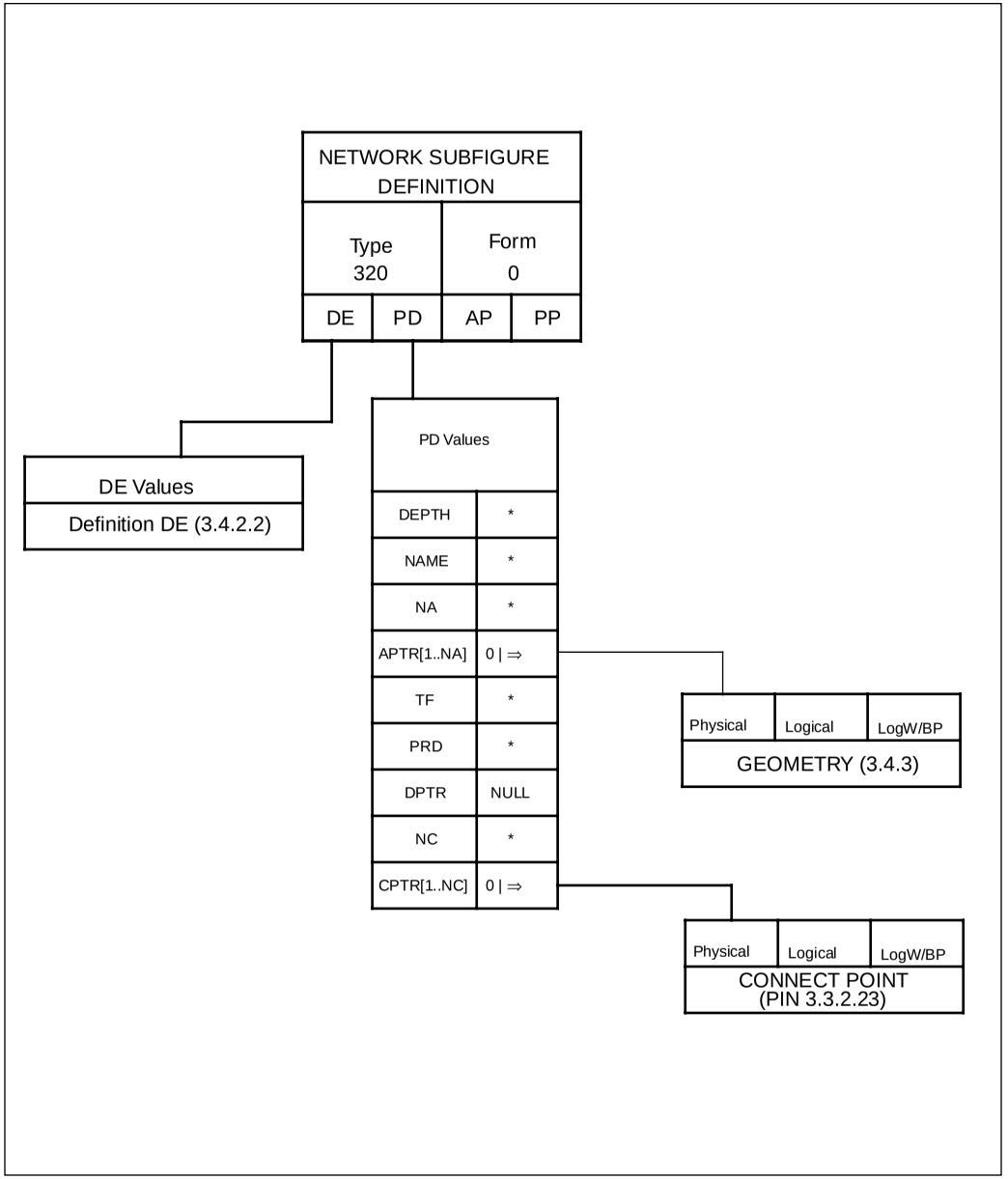
Requirements/Restrictions:

1. The NAME field in the Network Subfigure Definition Entity (Type 320) shall be unique (for all *NETWORK SUBFIGURE DEFINITION*s of the same object type) within the scope of the IGES File.
2. The *LEP SEMANTIC PROPERTY* object referenced from the *CONNECT POINT*, if appropriate, shall specify
   back_pad_polarization

Translation Usage Notes:

General:
The values for the primary reference designator (PRD) and the pointer to the display of the primary reference designator (DPTR) are defaulted or set to null.
Output:

Input:



3.4.4.4 Network Subfigure Instance.

Description:

The *NETWORK SUBFIGURE INSTANCE* object maps directly to the IGES Network Subfigure Instance Entity (Type 420, Form 0). Please refer to IGES Volume 1 for additional information.

Requirements/Restrictions:

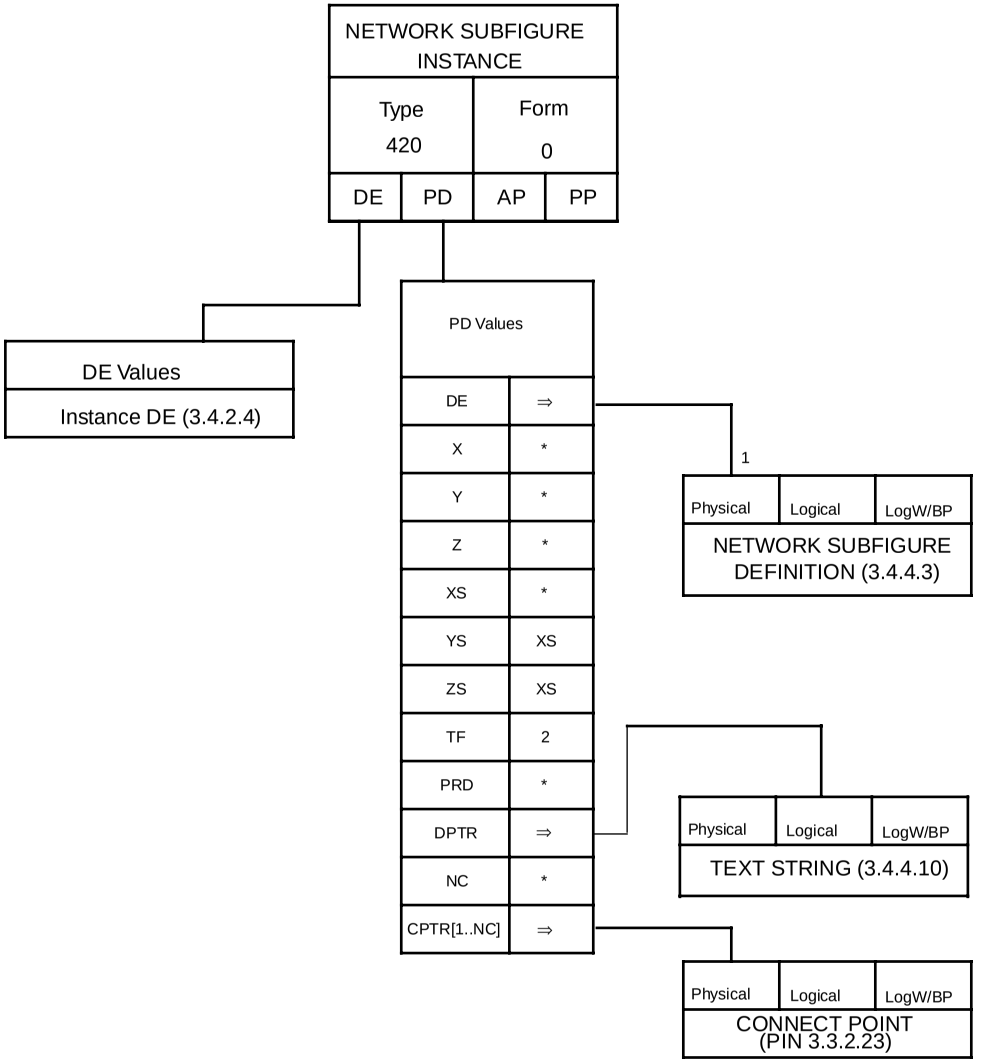
1. The reference designator shall be entered in the PD PRD (A *TEXT STRING* object shall not be used for the reference designator).
2. The pointer (PD DPTR) shall be to the DE of the Text Display Template Entity (Type 312) for display of the primary reference designator (PD PRD).

Translation Usage Notes:

General:

Output:

Input:



3.4.4.5 Object Locator.

Description:

The *OBJECT LOCATOR* object is any lesser object which documents location.

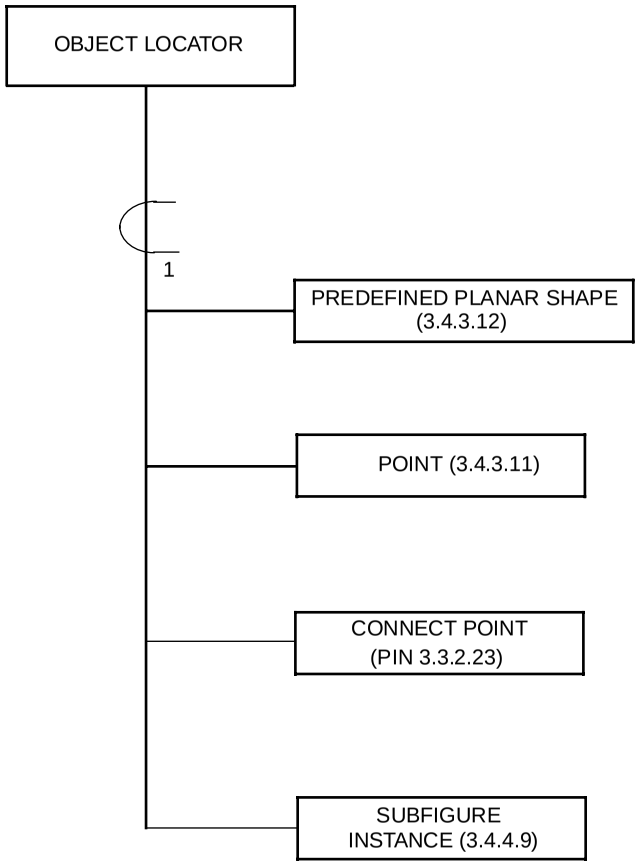
Requirements/Restrictions:

Translation Usage Notes:

General:

Output:

Input:



3.4.4.6 Part Number Property.

Description:

The *PART NUMBER PROPERTY* object maps directly to the IGES Part Number Property (Type 406, Form 9). Please refer to IGES Volume 1 for additional information.

Requirements/Restrictions:

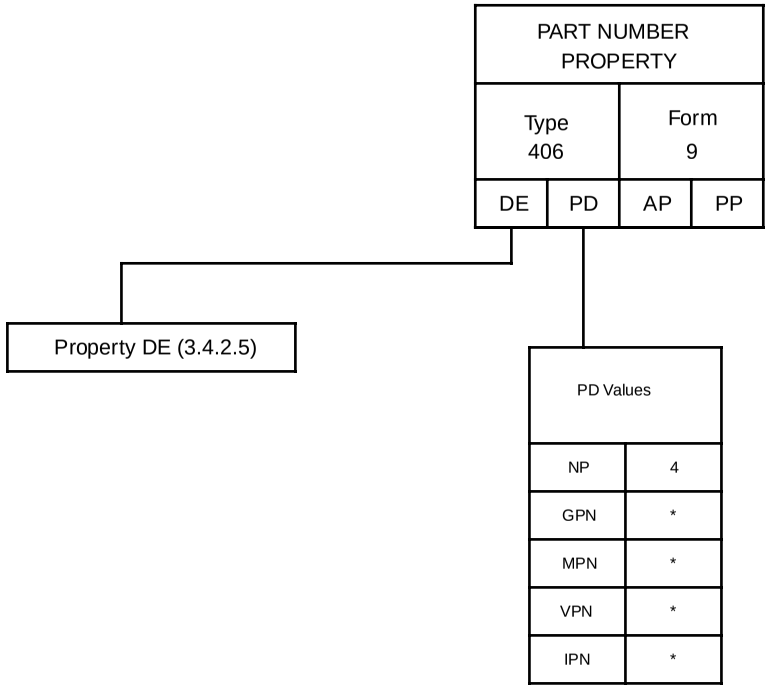
1. Shall attach to a Subfigure Instance Entity (Type 408) or a Network Subfigure Instance Entity (Type 420).

Translation Usage Notes:
One or more of four strings may be supplied as the generic part number (GPN), the Military Standard part number (MPN), the vendor part number or name (VPN), and/or the internal part number (IPN).

General:

Output:

Input:



3.4.4.7 Sectioned Area Fill Definition.

Description:

The *SECTIONED AREA FILL DEFINITION* object enables a *CLOSED CURVE* entity to be displayed with specific fill characteristics of solid or blank fill.

Requirements/Restrictions:

The *SECTIONED AREA FILL DEFINITION* shall only be referenced by the following *DISPLAY GEOMETRY* objects which represent closed planar boundaries.

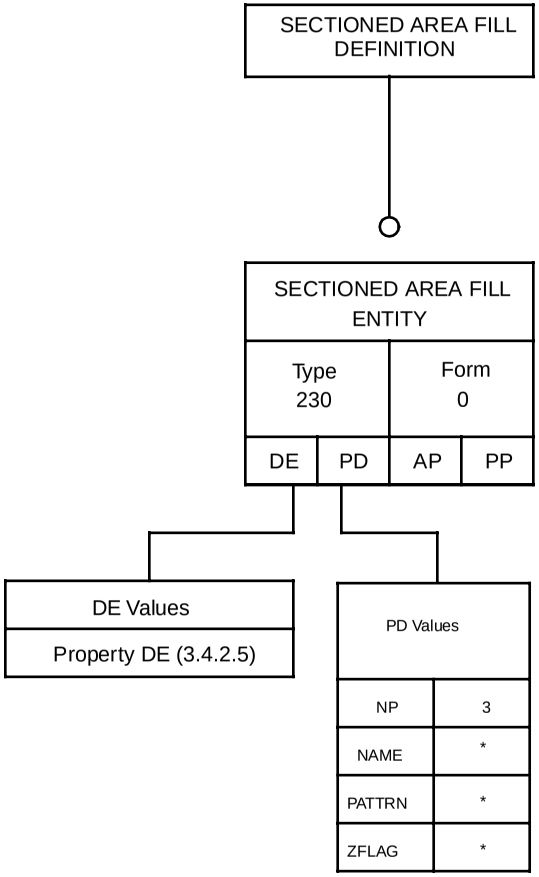
1. The following *DISPLAY GEOMETRY* objects may reference the Sectioned Area Fill Definition.
   - A) *CLOSED CURVE*
   - B) *PREDEFINED PLANAR SHAPE*
   - C) *POLYGON*
2. The fill pattern shall be code 0 or code 19.

Translation Usage Notes:

General:

Output:

Input:



3.4.4.8 Subfigure Definition.

Description:

The *SUBFIGURE DEFINITION* object maps directly to the IGES Subfigure Definition Entity (Type 308, Form 0). Please refer to IGES Volume 1 for additional information.

Requirements/Restrictions:

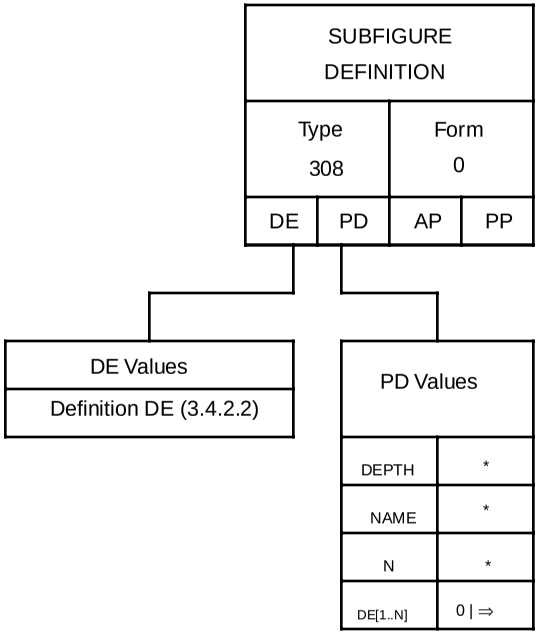
1. The NAME field in the Subfigure Definition shall be unique (for all *SUBFIGURE DEFINITION*s of the same object type) within the scope of the IGES File.

Translation Usage Notes:

General:

Output:

Input:



3.4.4.9 Subfigure Instance.

Description:

The *SUBFIGURE INSTANCE* object maps directly to the IGES Subfigure Instance Entity (Type 408, Form 0). Please refer to IGES Volume 1 for additional information.

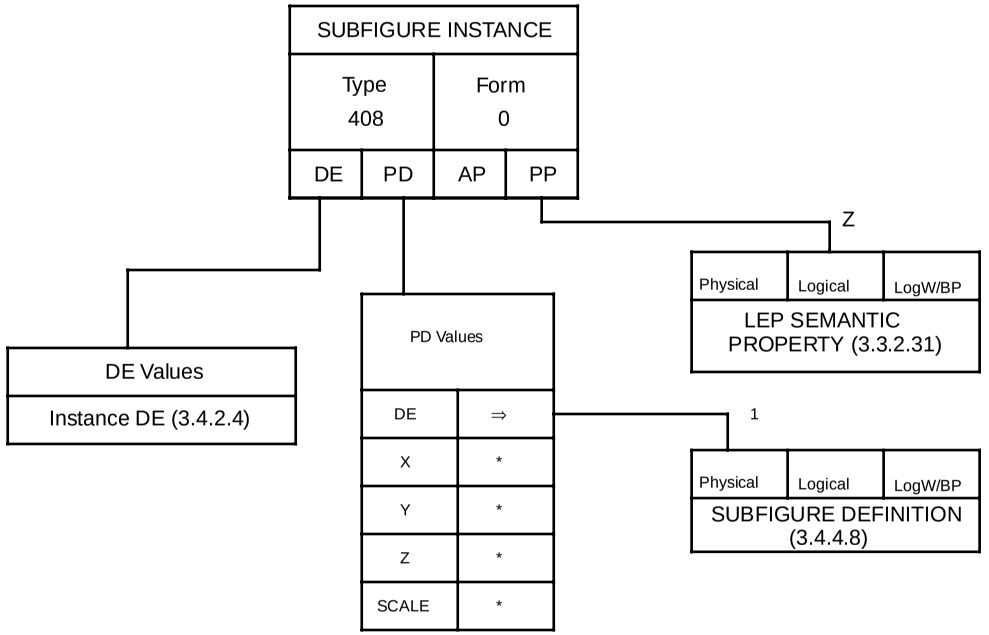
Requirements/Restrictions:

Translation Usage Notes:

General:
A suitable *SEMANTIC PROPERTY* may indicate the kind of object referencing the *SUBFIGURE INSTANCE*, and is required when a constituent of some LEP objects.

Output:

Input:



3.4.4.10 Text String.

Description:

The *TEXT STRING* object is a General Note Entity (Type 212) containing one or more related character strings or a Text Display Template (Type 312) which displays a *TEXT STRING* derived from a particular parameter value of the referencing entity. This enables internal annotation and provision of human interpretable semantics.

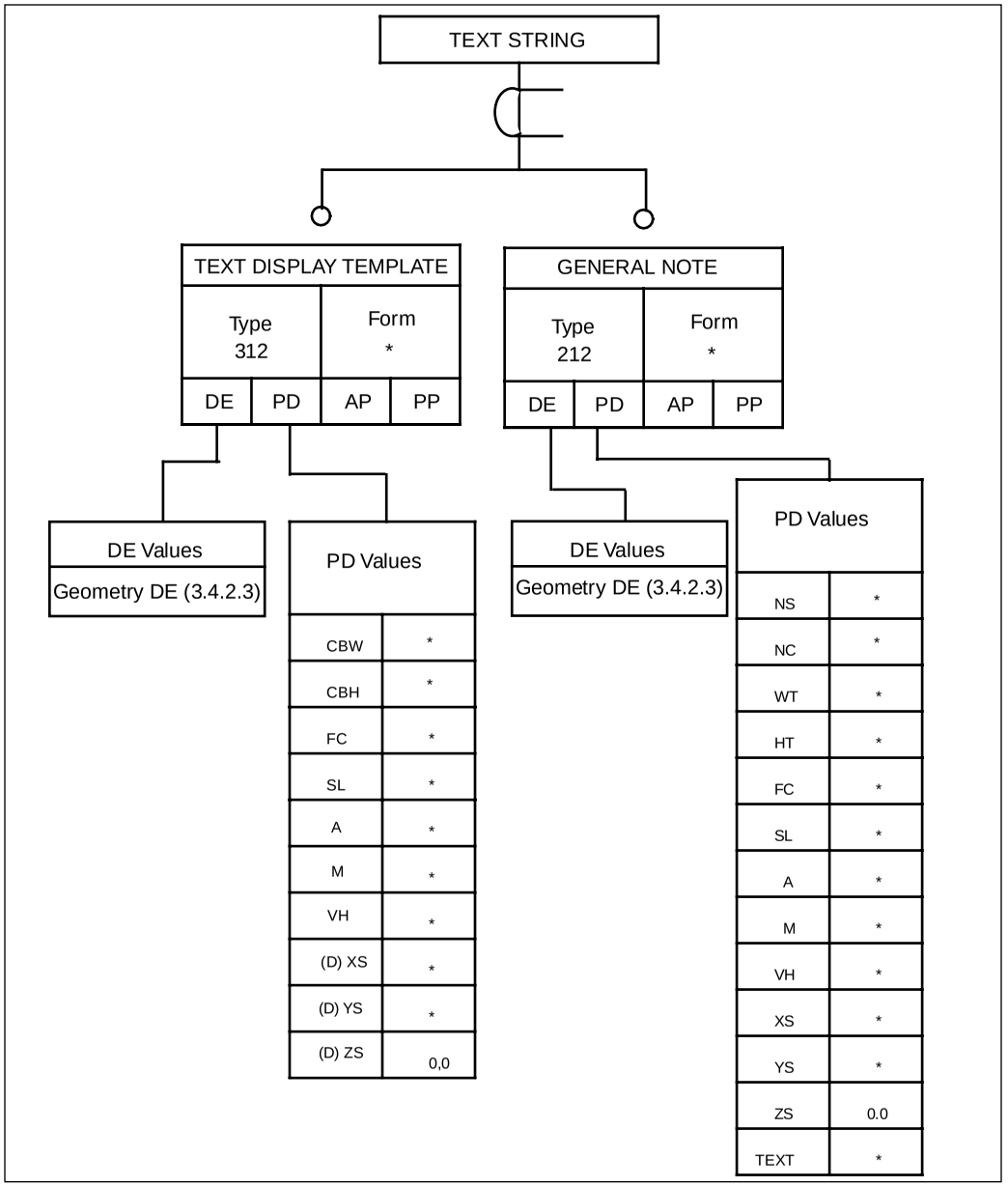
Requirements/Restrictions:

1. The General Note shall be Form 0.
2. The General Note FC field shall be one of {1, 1001, 1002, or 1003}.
3. The General Note shall not be used to display
   - The primary reference designator of a Network Subfigure Instance Entity (Type 420),
   - The pin name of a Connect Point Entity (Type 132),
   - The flow name of a Flow Associativity Entity (Type 402, Form 18)
4. The Incremental Text Display Template Entity (Type 312, Form 1) shall be used to display
   - The primary reference designator of a Network Subfigure Instance Entity (Type 420),
   - The pin name of a Connect Point Entity (Type 132) whenever such display is desired or required.
5. The Absolute Text Display Template (Type 312, Form 0) shall be used to display the flow name of a Flow Associativity Entity (Type 402, Form 18) whenever such display is desired or required.

Translation Usage Notes:

General:

The General Note Entity (Type 212, Forms 1,6, 7, or 8), in addition to Form 0, is valid for Technical Illustration files and drawings.



The Underscore Property Entity (Type 406, Form 34) and the Overscore Property Entity (Type 406, Form 35) may be associated with the *TEXT STRING*.

Output:

Input:

Appendix A Glossary

Appendix A Glossary

The previous versions of each of the application protocols included a set of definitions consisting of both general definitions and application-specific definitions. All general definitions have been combined into Section 1 below. Section 2 consists of three subsections, each pertaining to a specific application protocol.

This glossary may contain terms which are also defined in IGES Volume 1, Appendix K. Where terms have been included in both, the definitions included herein are intended as extensions to that found in Volume 1; further defining the term as it applies to the application protocol.

A.1 IGES Application Protocol General Glossary.

application: An enterprise process that produces or uses product data. The scope of an application is defined by the class of product, the supported stages in the life cycle of the product, the uses of the product data, and the disciplines that use the product data.

application activity model (AAM) *included in prior APs only* - A description of the activities which use product data in a specific application context. An AAM is used to establish an understanding and agreement concerning the application activities and processes.

application implementation model (AIM) - An information model that describes object structures and specifies the required IGES entity structures. The objects and IGES entities are combined using an IGES-specific graphical notation.

application interpreted model (AIM) *included in prior APs only* - An information model that specifies the constructs required for an implementation of an associated application reference model.

application protocol (AP) - A specification which defines the context, scope, and information requirements for the designated application(s), the implementation constructs to satisfy those requirements, and conformance requirements to test implementations of the AP.

application reference model (ARM) *included in prior APs only* - An information model that describes the information structures and constraints for an application(s). The information model uses application specific terminology and rules familiar to experts in the application(s). The model is independent of any physical implementation.

entity - The basic unit of data in an IGES file. The term applies to single units which may be individual elements of geometry, individual elements of annotation, or collections of geometry or annotation elements that are combined to form more complex data structures.

IGES postprocessor - A software unit that transfers CAD information from the IGES format to the CAD database format of a particular system. The software is usually developed and maintained by a commercial CAD system vendor.

IGES preprocessor - A software unit that translates CAD information from the CAD database format of a particular CAD system to the IGES format. The software unit is usually developed and maintained by a commercial CAD system vendor.

information configuration control - An approach that consists of specifying, documenting, and controlling both the creation and modification of information and the subsequent translation and exchange of the information between different systems and formats. The approach requires substantial documentation for both the syntax (the format) and the semantics (the meaning) attached to an item of information.

product - A result produced by specified activities or used for specified activities.

product data - The set of data elements needed to fully support a product and its in-service needs over its expected life cycle. The set of data elements includes geometry, topology, features, tolerances, relationships necessary to define a component part or an assembly of parts, and other data pertaining to the operation and

maintenance of the product until it is removed from service.

semantics - The meaning that is given or assigned to an item of information. The meaning is assigned to an item of information on the basis of its application(s) area.

syntax - The structure of expressions in a language. This structure is described in a specification such as IGES.

A.2.1 Drafting Glossary.

annotation Drawings include text or graphics which are not product geometry. Such information is called annotation, and it is used for documenting product features, defining product characteristics, aiding drawing administration, and for facilitating the interpretation of the drawing. Annotation elements may be used alone or in combination to annotate a drawing. These elements are built-up of geometry, text, cross hatching, centerlines, dimensions, symbols and subfigure instances. For this application protocol, annotation shall be non-associative.

annotation - dimensions Dimensions define the size, location and shape of a product in a readable format. Dimension text is made up of a dimension value, text symbols, tolerance, extension lines and dimension lines.

annotation - symbols Symbols are visual constructs built-up of geometry elements alone, or geometry elements in combination with text which perform one of three possible functions: (1) Communicate information essential to interpreting the drawing; (2) identify, communicate or reference geometric characteristics, features, or dimensional requirements of the product; or (3) represent physical elements or aspects of the product.

appearance As explained earlier, the model-view-draw concept allows the same entity to be displayed in multiple views. How an entity is displayed in each view is governed by appearance attributes.

Appearance, which may be applied to both geometry and annotation, does not affect the physical characteristics of an entity, only the way it is displayed. It may affect one view of one entity, all the views of the same entity, or an entire class of entities.

data - administrative Administrative data is the class of data, usually textual, that contains information necessary to catalog, store and reference the model and drawing. Examples include the drawing numbers, revision, title, date last modified, etc. The administrative data may or may not be viewable on the drawing hardcopy.

data organization Elements on a drawing or in a model may be categorized according to the information they represent. The ability to organize information into categories allows for better management and control of this information. Several informational structures may be used to define these relationships between entities.

An information structure provides the functionality to classify, name or associate data. Three of the more commonly used organizational tools are defined below.

data organization - layer Layering describes the CAD function of classifying a number of entities on the same level, or layer, of a model or drawing. For example, all the dimensions of a part could be defined on a layer called DIM. A layer is defined as logical relationship. Members of a layer are identified by their common layer ID.

data organization - group A group is an explicit relationship between model or drawing sheet entities. A group contains a list of identifiers for its members. Groups may contain a hierarchy of groups, with the restriction that a group may not reference itself. A member of a group may be annotation, geometry, another group or a subfigure instance. Groups may or may not be named.

data organization - subfigure A subfigure is a fundamental form of structuring annotation or shape

definition data. A subfigure definition collects an arrangement of graphic data, (e.g., for representing furniture or equipment that needs to be repeated in the model or on the drawing), to specify the optional subfigure name and to catalog its members. It can then be repeated in single or multiple locations by a subfigure instance. An instance of the subfigure does not repeat all of the definition geometry; rather, it provides a graphical representation of the geometry. Subfigures are sometimes called assemblies.

precision Realistically, a model cannot be assembled to an infinite degree of accuracy; therefore, there must be an acceptable degree of error between features in the model and the dimensions defining the distances. This degree of error is known as precision.

Precision cannot be an absolute or standard number for all models. It must be determined on an individual case basis. Precision must not be confused with tolerance, which is the permissible variation in the size of an object.

text On a drawing, text serves several functions. It may be used to set fixed formats for lists and to provide notes and administrative data about the drawing. As dimension text, it may define the size, shape and location of an entity. And, although text is usually part of the annotation, it may serve in a particular view as geometry (Section 2.1.3.4.2).

Text characters consist of the standard alpha-numeric characters, plus symbol characters from special font tables. Although these characters are usually placed on a drawing sheet so that they are readable, they may be mirrored so that they appear upside-down or backwards. In addition to text characters, there is an associated set of parameters to determine display characteristics, such as font style, height, width, slant angle and character spacing.

text - dimension This is the alpha-numeric and symbol text that may define an object's size, location and shape in a readable format. There are many possible components of dimension text. The following is a description of some of them. The dimension value is the numeric value of the feature being dimensioned. This is the base value that tolerances will be taken from. A dual dimension, or equivalent dimension, measures a dimension value in two different ways (such as English and metric). Prefix text or symbol is used to supply information which cannot be described by the dimension. It is located immediately preceding the dimension value. Suffix text or symbol is the same as prefix text but it is located immediately following the dimension value (such as the units of the dimension value). Dimension text may also have a lower or upper tolerance where the lower tolerance is the minimum value of the dimension value and the upper tolerance is the maximum value of the dimension value.

text - model Text that is part of the product itself is called model text. Examples include stenciling on PC boards and engraved information on products or label plates. In this case, the text is not annotation; rather, it is part of the model. The exact physical replication of the text after the exchange of the drawing may be required, in which case, a different modeling method may be necessary.

text - tabular Tabular text is fixed format, usually column dependent, text for items such as bill of materials, drawing lists and the like. Usually a constant width font is used, i.e., the "I" and the "W" are equal in width. Such text is frequently fed into the drawing directly from a database. This protocol does not explicitly recognize this type of text.

views Views are established as specific orientations of the model, each via a coordinate system and transformation matrix. The same geometric entity may appear in more than one view with different representations in each. Because each view may have its own particular scale, it is possible to see a different degree of detail within each view.

A.2.2 Piping Glossary.

a**ccess envelope definition** - A volume of space associated with a definition of a piping component or piping equipment that serves to reserve space for access or maintenance.

added piping component port - A type of piping port which is added to an unmodified piping component. This port locates where the piping component may join to a pipe, another piping component, or a piece of piping equipment. The additional piping component ports are not part of the piping component definition. They are used to represent field modification of a component.

alternative reference attribute - For many entities in this application protocol, an alternative reference attribute will be used to indicate that the particular entity is included in another IGES file which is external to the one being transferred.

attribute - A single datum that describes a specific characteristic of a piping entity.

block - Constructive solid geometry (CSG) block object used in the generation of complex piping entities.

bolt - A type of fastener for flanged piping joints. The geometry of a bolt is not included in the piping model.

bolt diameter - An attribute of a bolt which defines the diameter of the bolt, even though the actual bolt geometry is not included in the piping model.

bolt diameter units - Unit of measure used for defining the attribute of bolt diameter.

bolt length - An attribute of a bolt which defines the length of the bolt, even though the actual bolt geometry is not included in the piping model.

bolt length units - Unit of measure used for defining the attribute of bolt length.

bolt set - A collection of items associated with all the bolts required for one particular piping joint.

bolt type - An attribute of a bolt which defines whether it is a machine bolt (which requires a single nut per bolt), a stud bolt (which requires two nuts per bolt), or some other type of bolt.

boundary condition - A statement of a physical property which exists at a network boundary point at a particular point in time. (i.e. pressure, temperature, flow into network, flow out of network, head.)

boundary point - A point which is at the end of the model being transferred. (i.e., A pipe, piping component, or piping equipment starting at this point in at least one direction will be part of this model.)

brazed - A connection between two pipes or piping components where the joint is made by using brazing applied with heat. The end inserted into the socket is the male end, while the end containing the socket is the female end.

butt weld - A type of mating between two pipes or piping components where two parallel end faces are attached together by welding.

circular arc pipe path element - A circular arc that represents part of a pipe path.

definition space location - The three-dimensional position of a piping entity's origin relative to the definition space coordinate system.

definition space orientation - The three-dimensional rotation of a piping entity's origin relative to the definition space coordinate system.

definition space port orientation - The three-dimensional rotation of a piping port's location relative to the definition space coordinate system.

end preparation - The physical configuration for a type of connection of a piping port. The primary types of connection for joining piping parts at ports are: butt weld, socket weld, brazed, flanged, threaded, flareless tube, and slip joint. Each type of connection supports one or more end preparations.

Appendix A Glossary

envelope shape component - A volume of space that represents the shape of an installed access envelope.

envelope shape definition component - A volume of space that represents the shape of a piping component definition, piping equipment definition, or piping support definition.

external piping port - A type of piping port that locates a point where two piping objects are joined, one of which is not included in the piping model transfer.

fastener - An item used to affix two piping ports to make a completed piping joint. There are three classes of fastener: bolt, gasket, and other (e.g., glue or sealing compound).

fastener type - An attribute of a fastener that identifies the type of fasteners permitted (e.g., bolt or gasket).

flanged - A mechanical connection between two piping components where the flanged ends of each component are placed parallel to each other and attached by bolts.

flareless tube - A mechanical joint between two pipes or piping components where the connection is made by a ferrule inserted in a socket and attached by a mechanical coupling.

gasket - A ring of material used to seal a flanged connection between piping parts. The exact geometry of a gasket is not included in the piping model, but the compressed thickness of a gasket is accounted for at the flanged joint.

gasket thickness - An attribute of a gasket which defines the thickness of the gasket, even though the actual gasket geometry is not included in the piping model.

gasket thickness units - Unit of measure used for defining the attribute of gasket thickness.

heat tracing - A heating element used for controlling the temperature along a pipe or a pipe run.

installed access envelope - An access envelope associated with an occurrence of a piping component or piping equipment. It is used when the access envelope of the component or equipment definition does not satisfy the access requirements at the occurrence level.

insulation end - The location of the start or the end of piping insulation.

insulation shape envelope definition - The shape of a component or equipment definition entity to which insulation thickness is added to form an insulation envelope. The insulation shape envelope may be different than the piping envelope definition. For example, it may contain less detail and would not include portions of the part that are not covered by insulation such as a hand wheel.

insulation ipecification - The source document that defines the allowable materials for a given process or insulation requirements.

insulation thickness - An attribute of insulation which defines the amount of insulation placed around a pipe or component.

insulation thickness units - Unit of measure used for defining the attribute of insulation thickness.

joint fabrication location - An attribute of a piping joint which identifies where a piping joint will be assembled (e.g., at the fabrication shop or at the construction site).

joint identifier number - Identifier serving to uniquely indicate a particular joint.

line pipe path element - A line that represents part of a pipe path.

material description - An attribute of a piping part which describes the piping part for purchasing purposes. The material description is usually associated with a stock number and, depending upon company practices, may not contain size information.

material name - An attribute of a piping part which describes the primary material from which the piping part is manufactured.

model space location - The three-dimensional position of a piping entity's origin relative to the model space coordinate system.

model space orientation - The three-dimensional rotation of a piping entity's origin relative to the model space coordinate system.

model space port orientation - The three-dimensional rotation of a piping port's location relative to the model space coordinate system.

modified piping component - A type of piping component that has zero, one, or many added piping component ports and may have zero or one installed access envelope. A modified piping component must have at least one of these two objects added to an unmodified piping component.

modified piping equipment - A type of piping equipment that has one and only one installed access envelope added to an unmodified piping equipment.

nominal pipe size - An attribute of a pipe which describes the size of the pipe bore for specification purposes, but does not describes the true bore (i.e., internal diameter) or outside diameter.

nominal pipe size type - An attribute of a pipe or a piping port which identifies the nominal pipe size as inside diameter (ID), or outside diameter (OD), or iron pipe size (IPS).

nominal pipe size units - Unit of measure used for defining the attribute of nominal pipe size.

object envelope definition - A volume of space that is reserved with the definition of a piping part.

object envelope type - An attribute of an object envelope that defines the envelope as being a piping envelope, access envelope, insulation shape envelope, or installed access envelope.

one dimensional flow network analysis - A specific engineering activity which determines the flow through every component and the pressure differential across every component in a piping network.

operating point - An attribute of a transfer function which specifies the abscissa and ordinate of a specific equipment setting.

other fastener - A type of fastener which is not a bolt or gasket (e.g., glue or sealing compound).

part class - An attribute of a piping entity which identifies a unique set of characteristics of the entity. Part Class is the “type” of piping entity, e.g., elbow, tee, pipe, reducer, etc.

pipe - A hollow cylindrical conveyance, with a constant radius for the cross-sectional circle, for directing fluid or gas flow. It is not restricted to any length, diameter, or wall thickness. A pipe may be metallic or plastic and semi-rigid in nature.

pipe branch port - A type of piping port, located along a pipe centerline, that locates where a component or another pipe may be joined via a piping joint (refer to Figure 10).

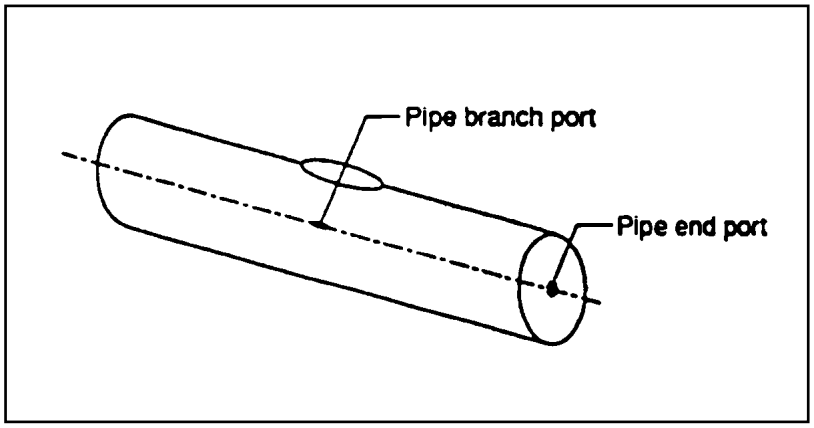


Figure 10: Pipe Branch Port

pipe damping - Material added to a section of pipe for the purpose of reducing vibration or noise. Damping material commonly used are metallic strips with a tape underlay that are banded to the outside wall of a pipe

parallel to the pipe centerline (refer to Figure 11). Pipe damping does not provide support.

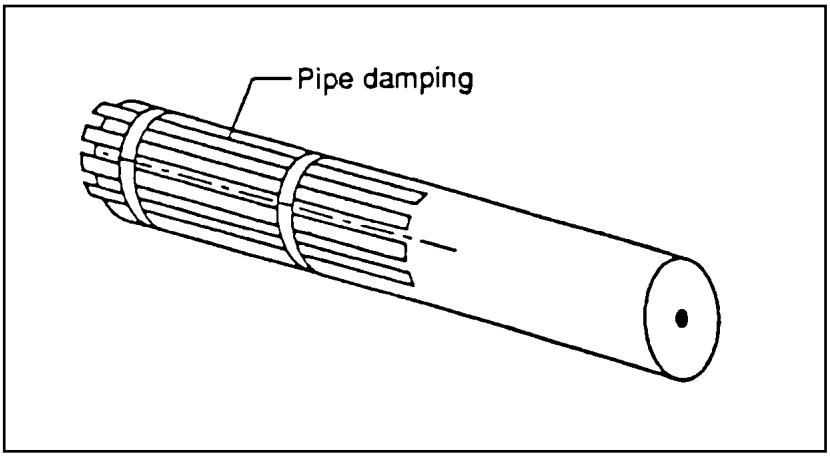


Figure 11: Pipe Damping

pipe damping attachment - A logical entity which connects a pipe damping to a piping part.

pipe damping definition - A standard set of attributes used for representing a type of pipe damping.

pipe damping identifier - Identifier serving to uniquely indicate a particular item of pipe damping.

pipe damping placement - Pipe damping surrounds the pipe between the start and end points of the identified pipe damping segment line. The location of the pipe damping segment line is coincident with the pipe centerline.

pipe damping segment - The geometric representation of the pipe damping length.

pipe definition - A set of attributes that define raw pipe stock.

pipe end port - A type of piping port located at the start or end of a pipe that locates where a component, a piece of equipment or another pipe may be joined via a piping joint.

pipe fit-up length - Extra material added at a pipe end port or a pipe branch port to support assembly requirements.

pipe fit-up length units - Unit of measure used for defining the attribute of Pipe Fit-Up Length.

pipe identifier - Identifier serving to uniquely indicate a particular pipe.

pipe outside diameter - The actual outside diameter of a pipe.

pipe outside diameter units - Unit of measure used for defining the attribute of pipe outside diameter.

pipe path - A curve consisting of one or more lines and circular arcs that represents the centerline of a pipe.

pipe path element - An entity (circular arc or line) that represents part of a pipe path.

pipe run - A single path through a portion of a piping system having a common specification, common attribute values, and having one start and one end point. It is represented by a string of connected pipes and components originating and terminating at a component with more than two ports, at a change in pipe run attributes, or at a boundary point in the piping system. A pipe run may originate, terminate, or pass through a component with more than two ports. Although multiple pipe runs may originate or terminate at a component with more than two ports, the component and each port must belong to at most one pipe run.

pipe run identifier - Identifier serving to uniquely indicate a particular pipe run.

pipe run part - A pipe or piping component which belongs to a specified pipe run.

pipeline - A portion of a piping system composed of one or more pipe runs.

Appendix A Glossary

piping assembly - A collection of piping parts, piping attachment parts, and/or other piping assemblies, e.g., for the purpose of construction. A packaged system or a shop spool piece would be represented as a piping assembly. A piping assembly thus tends to represent a standalone unit for construction. It does not have a hierarchy among pipe run, pipeline, or piping system.

piping assembly identifier - Identifier serving to uniquely indicate a particular piping assembly.

piping assembly type - An attribute of a piping assembly which identifies the assembly as a type of fabrication unit (e.g., detail, sub-assembly, pre-assembly).

piping attachment part - A piping support or pipe damping that connects to a pipe via a piping attachment.

piping attachment - A logical entity which connects a pipe damping or a piping support to a piping part. An attachment differs from a piping joint in that there is no potential for flow and the connectivity is to a piping part not to a piping port. This allows the piping support or pipe damping to move along a pipe without modifying the pipe.

piping component - An element of a pipe run which is not a pipe. A piping component is an instance of a piping component definition. Examples of piping components are flanges, bosses, valves, elbows, tees, steam traps, filters, expansion joints, control valves, nozzles, relief valves, and orifice plates. It does not include equipment, supports, or pipe damping. This AP classifies piping components as unmodified or modified piping components.

piping component definition - A set of data, describing a component, that is defined once and instanced zero, one, or many times at different locations and potentially different orientations within the piping model.

piping component identifier - Identifier serving to uniquely indicate a particular piping component.

piping component port - A type of piping port that locates where a component may join to a pipe, another component or a piece of equipment. The number of component ports must be equal to the number of component port definitions referenced by the piping component definition when the piping component definition is instanced.

piping component port definition - A point within the piping component definition that carries the definition space location, definition space orientation, and the port definition attributes when the component definition is instanced.

piping component type - An attribute of a piping component which identifies the component as a commodity item, engineered item, or instrument.

piping envelope - A volume of space in the piping model that is used to represent the shape of piping parts or piping supports.

piping envelope definition - A volume of space associated with a piping component definition, piping equipment definition, or piping support definition that serves to reserve space for the piping entity.

piping equipment - Piping equipment encompasses a wide variety of piping parts. Examples of piping equipment are pumps, vessels and machinery. Piping equipment, unlike a piping component, is not part of a pipe run. It must be connected to the start or the end of one or more pipe runs. This AP classifies piping equipment as unmodified or modified piping equipment.

piping equipment definition - A set of data, describing a piece of equipment, that is defined once and instanced zero, one or many times at different locations and potentially different orientations within the piping model.

piping equipment identifier - Identifier serving to uniquely indicate a particular piece of piping equipment.

piping equipment port - A type of piping port that locates where a piece of equipment may join to a pipe, component, or another piece of equipment. The number of equipment ports must be equal to the number of equipment port definitions referenced by the piping equipment definition when the piping equipment definition is instanced.

Appendix A Glossary

p**iping equipment port definition** - A point within the piping equipment definition that carries the location, orientation, type, and label of a equipment port when the piping equipment definition is instanced.

piping insulation - An entity that insulates a piping part. It is defined by a piping insulation definition.

piping insulation definition - A standard combination of one or more layers of insulation with a material type and thickness.

piping insulation identifier - Identifier serving to uniquely indicate a particular piece of piping insulation.

piping joint - A logical entity which connects two piping ports belonging to two piping parts. Flow may occur through a piping joint.

piping object type - An attribute of a piping entity which identifies it as one of several enumerated types. The possible values are: pipe, unmodified piping component, modified piping component, unmodified piping equipment, modified piping equipment, piping system, piping assembly, pipeline, pipe run, piping support, pipe damping, bolt, gasket, other fastener, piping joint, pipe damping attachment, piping support attachment, or piping insulation.

piping part - A pipe, piping component, or piping equipment which belongs to a specified piping assembly.

piping port - A point that locates where a piping object may join to another piping object.

piping port definition - A set of data, describing a piping port, that is defined once and instanced zero, one, or many times at different locations and potentially different orientations within the piping model.

piping specification - A source document that defines the set of piping components from which a piping system designer may select for building a piping system for a given process service. The definition of a piping component within a piping specification is complete enough to enable the purchase of the item.

piping support - An attachment part that supports one or more piping parts.

piping support attach point - The location at which a piping support is attached to a piping entity.

piping support attach point definition - The location and label for the attach points of a piping support definition.

piping support attachment - A logical entity which connects a piping support to a piping part.

piping support definition - A standard combination of geometric constructs and attributes used for representing a type of piping support.

piping support identifier - Identifier serving to uniquely indicate a particular piping support.

piping system - A collection of one or many pipe runs, zero, one, or many pipelines, and zero, one, or many pieces of equipment that performs a specific design function.

piping system identifier - Identifier serving to uniquely indicate a particular piping system.

port definition label - An alphanumeric identifier for a port definition.

port definition type - An attribute of a piping port definition connect point which identifies the port definition as belonging to a piping component or a piping equipment.

port label - An alphanumeric unique identifier for a port on a specific piping part.

port type - An attribute of a piping port connect point which identifies the port as a pipe end port, a pipe branch port, a piping component port, an added piping component port, or a piping equipment port.

pressure rating - A value that indicates the pressure/temperature bearing capacity at a piping port.

pressure rating units - Unit of measure used for defining the attribute of pressure rating.

quantity - An attribute of an entity defining the integer number of occurrences of that entity.

quantity units - Unit of measure used for defining the attribute of quantity.

right angular wedge - Constructive solid geometry (CSG) wedge object used in the generation of complex piping entities.

right crcular cone frustum - Constructive solid geometry (CSG) frustum object used in the generation of complex piping entities.

right circular cylinder - Constructive solid geometry (CSG) cylinder object used in the generation of complex piping entities.

schedule - A string (e.g., Schedule 40) that designates a standard wall thickness as defined by ANSI or some other standards organization.

slip joint - A connection formed by slipping a flange over the end of a pipe or component and welding the flange in place.

socket weld - A type of mating between a pipe and a piping component or between two piping components where one end of the pipe or component is inserted into a socket of the mating component before welding. The end inserted into the socket is the male end, while the end containing the socket is the female end.

solid of linear extrusion - Constructive solid geometry (CSG) extrusion object used in the generation of complex piping entities.

solid of revolution - Constructive solid geometry (CSG) object used in the generation of complex piping entities.

sphere - Constructive solid geometry (CSG) sphere object used in the generation of complex piping entities.

stock number - An identifier used for referencing a description of a part which is contained in a catalog. Depending upon company conventions, the stock number may or may not uniquely identify an item sufficiently for purchase. For example, the size(s) of the item may not be encoded into the stock number. Common aliases for Stock Number are “part number” or “commodity code.”

tank curve - A mathematical function which relates the pressure at a tanks boundary to the flow rate of fluid at the boundary based on the volume of fluid in the tank and the physical laws governing the tank.

threaded - A mechanical mating between two piping components where one component is screwed over the other via a threaded connection. The end screwed over the other is the female end, while the end on the inside is the male end.

torus - Constructive solid geometry (CSG) torus object used in the generation of complex piping entities.

transfer function - A mathematical function based on physical network properties which allows flow network parameters at one point in the network to be calculated based on known parameters at another point in the network.

unmodified piping component - A type of piping component which is defined by a piping component definition and does not have an added piping port or an installed access envelope. Compare with modified piping component.

unmodified piping equipment - A type of piping equipment which is defined by a piping equipment definition and does not have an installed access envelope. Compare with modified piping equipment.

wall thickness - The thickness of a pipe wall (pipe outside radius minus pipe inside radius).

wall thickness units - Unit of measure used for defining the attribute of wall thickness.

A.2.3 LEP Glossary.

annotation - Text or legend pertinent to a design; text may appear as data related to legend on a multilayer substrate, lettering on a drawing, or other types of symbols.

Appendix A Glossary

aperture code - Code representing aperture number used in plot file intended for a photoplotter such as a Gerber™ Plotter.

aperture number - The number for a photoplotter aperture setting, number used in pin and pad tables, and formatter table corresponding to a position on the aperture wheel.

aperture shape - Shape of aperture, such as one of the following: round, square, donut.

aperture size - The x,y dimensions of the aperture such as width or diameter where appropriate.

artwork (T50) - An accurately-scaled configuration that is used to produce the artwork master used for production.

artwork geometry (target) (outside circuit) - A collection of primitive shapes such as arcs, areas, and lines.

artwork text - Identifying text which calls out the product number and configuration number as well as program configuration for the artwork. It identifies layer, revision, product number.

aspect ratio (of Deposition Resistor) - The ratio of the length of a thick or thin film resistor to its width, or the ratio between the resistance of the resistor and the sheet resistivity of the ink. This is also the number of effective “squares” in the design of a resistor.

assembly consumables - A type of consumable that becomes part of the finished product. See also Consumable.

attachment - Method used to describe how a component can be fastened to the substrate such as with solder or epoxy.

autoinsertion - An automated process by which through-hole components are selected, grasped, and positioned into the appropriate component holes in a PCB. Bonding of the component to the PCB may employ solder paste, glue or other consumables.

back pad polarization - Description of which pin of a component such as a diode or IC chip is surface-mounted to an LEP. (The terminal so mounted is the *back pad*.)

back pad polarization name - Name associated with the back pad such as anode.

behavior requirement - The performance needed from a circuit (specified through the use of a “hardware description language”) which is to be or has been packaged in an LEP.

bill of materials - A formatted list of products (instances of LEP Assembly Components) used for a particular assembly.

blind via - A via that is visible from only one side or the other of a design. (Derived from Via attributes.)

bonding pads - Areas of metallization on the component and the LEP substrate that permit connection of the wire or circuit elements.

buried via - A via hole not extending to the surface. A buried via is completely contained within the inner layers of a design and therefore is not visible from the outside layers. May be referred to as an interstitial via hole. (Derived from Via attributes.)

CAD layer - A method of separating information in a CAD system for the purpose of display or processing. Some CAD layers correspond to artwork layers.

CAGE number - The military-assigned identification of the manufacturer responsible for the product definition.

capacitor component - A kind of component used to add capacitance to a circuit.

capacitor material - The type-name for a capacitor derived from the dielectric material of the capacitor

catch pad - Metallization patterns on a conductive layer associated with a via which aid in the interconnection of a via with its associated traces.

Appendix A Glossary

component - A Part which has been installed in an LEP, thereby acquiring a Reference Designator and a location within the LEP. The Component does not lose its Part characteristics as described in the catalogue of parts as a result of the installation.

component attach - The placing of a component (chip) on a substrate or header in a manner which causes it to mechanically bond.

component location placement tolerance - The amount of displacement from the specified location which is acceptable.

component location X Y - The coordinates specified for the location of a component within an assembly.

component orientation (T50) - The direction in which the components on a printed board or other assembly are lined up electrically with respect to the polarity of polarized components, with respect to one another, and with respect to the board outline.

component placement restriction - An area on a substrate where components must not be placed lest they violate a design constraint.

component position - The location at which a component is placed.

component tolerance - The range of acceptable component values; usually specified as a percentage of the nominal specified value.

component value - The parameter associated with some component types which may be used in the fabrication of the assemblies.

component value tolerance - A range of permissible product's values.

component voltage rating - Maximum voltage specified that may safely be placed across a component.

conductive pattern - The configuration or design of the conductive material on the substrate. For a LEP, the pattern includes conductors, lands, and through connections (vias) when these connections are an integral part of the manufacturing process.

conductivity, electrical - The capability of a material to carry an electrical current. The reciprocal of resistivity.

consumable - An in-process or an end item material supplied in bulk form.

consumable name - The name given to bulk-purchase materials used in the assembly process, such as solder, flux, and epoxy.

consumable property - Properties of a consumable such as shelf life, expiration date.

consumable property name - The name of a Consumable Property.

consumable property value - The measurement value associated with a Consumable Property.

consumable type - The generic classification given to consumables, such as epoxy.

crossover - The transverse crossing of metallization paths without mutual electrical contact achieved by the deposition of an insulating layer between the conducting paths at the area of crossing. Dielectrics may be used with crossover conductive patterns, acting as a bridge over previously screened conductive material (derived from trace geometry).

default design rule - The specifications which are followed during layout of the patterns on the layers of an electronic assembly. Examples are the maximum trace width, or the minimum conductor spacing.

default design rule description - The description of a Design Rule that is employed when no other rule is specified.

default design rule name - The name associated with a Design Rule.

deposition component - Components which are fabricated coincidentally with the interconnects as

opposed to components which are attached to the substrate after the interconnect network is complete.

deposition resistor - The deposition of resistor material which is formed as part of the conductive circuitry on a substrate layer. The resistor is a component in the sense of the electrical function of the circuit, but not in the sense of a separate product to be assembled to the completed substrate.

deposition sequence number - A particular layer's position on the LEP substrate with respect to the first layer.

deposition type - A category used to describe the technology used (THICK or THIN film) to create the component.

derating - A factor which is applied to a product parameter to insure that reliability requirements are met; such as derate resistor power rating by 50%.

design rule - A guideline that determines behavior with respect to specified design parameters. Becomes a constraint on the functional and physical layout. An example is a rule that ensures that a given minimum distance between elements in a design file is maintained.

design rule check (DRC) - A process to help enforce the design rules.

design rule value - The measurement assigned to a particular restriction for a product's design.

device pin associativity - Functional relationships among pins that are needed to allow operations such as gate swapping or pin swapping to improve trace routing

die - The uncased and normally leadless form of an electronic component that may be an active or passive discrete device or integrated circuit.

die bonding - The attachment of an integrated circuit chip to a substrate or header.

dielectric - An insulating material used to electrically and physically separate conductors.

dielectric constant - The ratio of the capacitance, Cx, of a given configuration of electrodes with a specified dielectric, to the capacitance Cv, of the same electrode configuration having a vacuum as a dielectric.

dielectric loss angle - The difference between 90 degrees and the dielectric phase angle given a set of operating conditions. May be referred to as the dielectric phase difference.

dielectric outline - The boundary of an insulating layer.

dielectric strength - The maximum voltage that a dielectric can withstand, under specified conditions, without resulting in a voltage breakdown. Usually expressed as volts per unit length.

digital logic behavior - Performance of circuit elements with each port having two known stable states of interest; a type of Behavior Requirement.

dissipation - The tendency for fluids or energy to distribute evenly within a medium. This tendency is usually associated with the ability of a material shape to remove heat or power from physical devices and circuits.

dissipation factor - A measure of insulating or dielectric materials to absorb some of the energy in an alternating current signal.

documentation text - Words (text strings) which exists on documentation.

drawing number - The unique identification of a drawing within an originating enterprise.

edge connector - (from IPC: "Edge-Board Connector" -) A patterned group of conductive terminals that is used specifically for making interconnections between the LEP traces and the next higher assembly or among regions of the LEP. An edge connector may be a set of PCB features or a discrete component bonded to the PCB. Not all discrete connectors are mounted at the edge of the PCB (i.e., within a few trace widths of the PCB outline).

ee component - (from AP 210 3.4.2) An occurrence of a part having electrical characteristics used in an

assembled layered electrical product. Each EE Component has one or more circuit connections and a unique reference designator.

ee connectivity - (from AP 210 3.4.6) The flow or association of EE_Signal information, or energy between objects in an electrical product. Connectivity focuses more on the logical need for a “link” between two or among many terminals. The physical “join” guides the packaging and testing of the physical conductors providing the required connectivity.

equipment - The identification name of machine types that are used as the means to complete a process step during manufacture of a device. Examples are a pick-and-place machine or a solder-joint inspection machine.

electronic package - (See package.)

fiducial - (See registration mark.)

film - (See thick film or thin film.)

film material - Material used in thin and thick film processes to fabricate components and circuitry.

flex cable - A type of LEP which conducts one or more signals between attached devices (e.g., connectors) and which is fabricated on non-rigid substrate material.

flex circuit - A type of LEP which is fabricated on non-rigid material.

footprint - (from IPC: “land pattern” -) A pattern of lands and associated features that defines the allowable interconnection space for the mounting, interconnection, and possibly the testing of a particular component. The lands in the footprint provide part of the connectivity between the substrate conductors and the component terminals (or cell ports).

function type - The category describing the use of a particular artwork geometry such as Pad, Registration Mark, Conductor, Dielectric Edge, Text.

generic name - A commonly accepted product type identification, such as 54LS04 or 2N2222.

geometry - The constructs which are used to describe shapes of objects to be depected, or to which a product is to be fabricated. The description is usually in terms of a set of spatial coordinates and the identification of the curve-type to be constructed from the coordinates.

geometry element - A feature serving to identify the meaning of, or use for, a collection of geometries. Examples from assemblies are countersink, keyway or threads. Examples from electrical planar designs are line, circle, area, etc.

geometry line width - A measurement of the distance across a line (i.e., normal to the line). This value is often specified for circuitry artwork lines to regulate or check the actual or the artwork image produced from a computer plot or other image master.

geometry type - A classification of the basic geometry such as Line, Arc, and Polygon.

glaze - An insulating film material used to protect underlying circuitry.

heat sink - (IPC: “heatsink” -) A mechanical device that is made of a high thermal-conductivity and low specific-heat material that dissipates heat generated by a component or assembly.

hole - A void in the product formed by drilling, etching, or laser eroding, and which may be intended for use in mounting components or (when e.g., plated) to provide electrical continuity between layers of a board or substrate.

hybrid microcircuit assembly (HMA) - In general an integrated circuit that is not monolithic. The term hybrid denotes that the circuit elements are made by two or more different technologies. A typical hybrid may consist of semiconductor chips and capacitors attached to a ceramic substrate with printed resistors and interconnections which are screen printed and fired.

integrated circuit (IC) - A type of LEP. An electronic part which has been fabricated upon a monolithic

semiconductor substrate.

intelligence - A capability to support queries about relationships among and values of uniquely specified layered electrical product data.

internal part number - A part identifier unique within the assigning enterprise to enable distinctions based on the business needs of the enterprise.

jumper - A conductor expressly connected to a particular pair of circuit access locations to provide required connectivity.

keepin - A design rule determining the definition of an area or volume within which specified features are to be contained.

keepout - A design rule determining the definition of an area or volume from which specified features are to be excluded.

land - A portion of a conductive pattern (also called Pad by some) usually used for electrical connection, component attachment, or both, or a Via feature to one or more traces on the associated layer of the LEP.

layer - A stratum of material such as conductor, dielectric, or resistor material which forms part of the LEP structure.

layer display color - The display color of a layer on a color drawing or on a CAD machine.

layer name - The name of a particular layer (dielectric or conductive) such as Glaze or top conductor.

layer sequemce number - A particular layer of material (conductor or dielectric) position on the LEP substrate with respect to the first layer. Usually begins with the first material placed on a substrate. These layers relate to process layers as contrasted with e.g., CAD layer.

layer type - A category denoting the function performed by a deposited layer such as Conductor, Dielectric, Fill, Glaze, Resistor, Epoxy, Solder.

layer restriction - A design restriction which is imposed on a particular layer of the product.

lead frame - The metallic portion of the device package that completes the electrical connection path from the die or substrate conductors to the external circuitry.

leakage current - The flow of electrons through the dielectric of a capacitor, usually expressed as a maximum which will be acceptable for the component.

LEP - See Layered Electrical Product (Section 2.3.3.1).

LEP assembly component - A product or an assembly which has been identified and located within an assembly.

LEP CAD presentation - The design file that contains the electronically coded data available on a particular design.

LEP name - A descriptive name given to a product that usually describes its function.

LEP number - The product number of a particular type of product.

LEP substitute part number - Other organizations identification (i.e., the customer may have an alternate product number for the same product).

LEP version - The revision level of a product; each change to the product design results in a new product Version.

level of preference - A relative rating assigned to a product in a collection of functionally similar products which indicates its ranking of desirability for use in a product by the rating organization.

library name - The name of a part type in CAD system files of part information.

line resistance - The resistance of a conductor line on a substrate measured in total trace resistance.

line width - (See Geometry Line Width.)

log requirements - Indicates what information about the process step must be recorded and retained such as Machine ID, Component Lot Identification, Start Time, Stop Time.

loss factor - A property of an insulating material that is equal to the product of its dissipation and its dielectric constant.

manufacturer name - The name a company is registered to do business under; may also include a company division name.

max substrate size - The largest size of substrate which can be accommodated by some equipment or process.

mil - A unit equal to 0.0254 millimeter (mm), (or 0.001 in).

mounting hardware - Fasteners applied to attach one or more PCA_component occurrence(s) to the PCB or the PCB to its next assembly.

mounting pad - Metallization pattern on the substrate associated with a component for the purpose of indicating the region for physical attachment of the component to the substrate. See Attach Material Pattern.

multichip module - A complex multilayer circuit containing components (integrated circuit chips) which cover at least half of the available circuit area. Note that this term is not present in the CAD information.

multi-up - (See *panel multi-up*.)

net - An entire sequence of electrical connections from the first source point to the last target point, including lands and vias. The Net is identified by a Net Name which is unique within the product, and may also have a signal name.

net design rule - Specified constraints on parameters related to connectivity. Examples are maximum distributed inductance, or maximum circuit length.

net design rule name - The assigned identification of a specification for some parameter of all conductive elements associated with an individual signal.

net design rule value - The measurement allocated to some parameter of all conductive elements associated with an individual signal.

netlist - A to-from listing of all the interconnections in the design. The netlist should correspond to the to-from listing of all the wires in the schematic. (Model; set of Net.)

net name - A character string used to identify and distinguish nets; the name of the logical connection realized by the trace.

obstruction - A physical entity which restricts where a component or a trace may be placed. See also Component Placement Restriction.

operation value - A parameter associated with a Process Operation.

orientation - The angle of rotation of a component relative to a predetermined direction.

package - An enclosure for an integrated circuit, or an LEP circuit. It provides hermetic or non-hermetic protection, determines the form factor, and serves as the first-level interconnection externally for the device by means of package terminals.

package dimension - The physical measurements of the package. (See Part Outline.)

package pin - A *pin* which is associated with a *part* or *component* enclosure.

package outline - The 3-dimensional curve and surface geometry of a component package.

package pin location - The geometric position of a lead in a part package of an electrical product with respect to the part origin and reference axis.

Appendix A Glossary

package pin name - A referencing word that describes a use for the lead of a component package; such as “Output1.”

package pin number - The identifying number assigned to the lead of a package for electronic components.

package pin type - The name given to the lead of a component package which indicates how the lead is to be attached to the assembly.

pad - The metallized area on a substrate or on the face of an integrated circuit used for making electrical connections. The preferred term is *land*.

pad end feature - The type of joint formed on a wirebond wire at the place where the wire attaches to the circuitry of an assembly.

pad type - The descriptive name that implies the function of a *land*.

padstack - An ECAD construct for all of the pieces of information (features) about a component pin needed to establish the interconnection /layer geometry on the LEP.

pad wirebond end feature - The method of attaching a wirebond to a pad as denoted by the appearance of the joint such as wedge, ball.

panel multi-up (panel) - A fabrication artifact (often with test coupons) intended to contain one or more printed board details. A panel may be defined to realize process efficiencies or to minimize wasted material. E.g., multiples of the same image on one piece of material that will be separated after processing into multiple substrates.

part - An individual functional element in a physically independent body that cannot be reduced or divided without destroying its stated function. When assembled onto the completed film network the part will become a *component* of the circuit assembly. In a CAD system, the part is represented as a graphic symbol with attached annotations. Parts are manufactured items; the information about which is usually stored in a library or listed in a catalogue.

part graphic - The graphic presentation or depiction of a component.

part kind - A category of component describing how it is used electrically such as mechanical, passive, active.

part manufacturer’s name - The corporate name used by the manufacturer of given part types.

part name - Description of the function of the component such as Coil, Cover, IC Chip, Transistor, Resistor Header, Substrate.

part outline - The boundary of a component on the top assembly drawing or the CAD equivalent.

part property - A pair of terms, one indicating the property name (see Part Property Name), the other the value of the property. (See Part Property Value.)

part property name - The name of a measured parameter associated with a device used in an assembly. Examples are capacitance, inductance, gain, resistance, and temperature range.

part property value - The value associated with a Component Property. Examples would be 10K as a value for the resistance property, or 50 as a value for the low frequency gain property of a transistor.

part selection - A set of one or more alternate potential components to be specified in the design of an assembly, one of which is selected at the time of manufacture of a particular product.

passive component - A component which does not exhibit signal gain but does affect one or more other parameters of a signal. Examples are resistor, inductor, and capacitor.

path vertex - The X, Y location which specifies one end point of the linear segment of a trace.

pattern - The configuration of materials on a panel or printed board layer. Pattern also denotes the circuit configuration on related tools, drawings, and artwork masters.

pattern value - The measurement value assigned to a deposited or etched component at some specified stage in the fabrication cycle. An example is 2300 ohms prior to trimming.

pattern value min & max - The tolerance associated to the deposited or etched component.

photolithography - The use of light or ultraviolet rays through a mask to define circuit conductor patterns. (Model; intractable taxonomy.)

photoplot aperture - Mechanism which allows a certain amount and incidence of light to expose film, thereby making a "photograph" of the design being plotted. See *aperture size*.

photoresist - A photosensitive coating that is applied to a laminate and subsequently exposed through a photo tool (film) and developed to create a pattern that can be either plated or etched.

physical layer (1 top) - A conductor, dielectric, or fill for each layer.

pick/place - An automatic process by which SMT (surface mount technology) parts are selected, grasped, and positioned onto an LEP.

pin - The identification of a possible connection to a component providing a reference point for creating a netlist.

pin assignment - The name of the characteristic or electronic function assigned to the lead of a component package in a circuit.

pin end feature - The type of joint formed on a wirebond wire at the place where the wire attaches to a component.

pin location - The physical location of pins on a component package with reference to its assembly origin.

pin name - The generic functional notation for the signal role at the lead of a component package such as E, B, C (representing emitter, base, collector, respectively) on a transistor.

pin number - A number used to distinguish pins on a component or package.

pin type - The name of a characteristic on a pin, such as input, output, tri-state analog.

pin wirebond end feature - The characteristic of the wire at a joint with the material to which the wire is attached. The usual characteristics given are wedge or ball.

placement name / physical name - The name of a component in a CAD library.

placement tolerance - The permitted positional variation of a component on an assembly.

plane - A portion of a roughly planar physical conductive layer of an LEP assigned a particular function or signal implementation, i.e. Ground_Plane, Signal_Plane, and Power Plane.

plating - (1) The metallic deposit on a surface, formed either chemically or electrochemically. (2) the process of the chemical or electrochemical deposition of metal on a surface. (Model; Deposition taxonomy.)

point - A singular location in a given coordinate system.

point X value - The numeric value in one (usually horizontal when viewed from a reference coordinate system) direction from a single point spatial reference.

point Y value - The numeric value of a single point reference, in a direction orthogonal to the x vector direction.

port declaration - The boolean notation describing the behavior at a Port of a digital logic device.

power density - A measure of the concentration of energy, such as 1 watt per square inch.

power dissipation - (T50) [R] In watts/meter^2 (heat flux density), the energy used by an electronic device in the performance of its function.

power plane - A conductive area or set of closed areas on a particular physical layer of an LEP assigned the

function of distributing supply voltage to the appropriate ports of components of the LEP.

preform - For soldering or adhesion functions, a form which is punched out of thin sheets of solder, epoxy, or eutectic alloy. The form is placed on the spot of attachment by soldering or by bonding prior to placing the object there to be heated. (a type of Part Name)

primitive type - The category of simple geometric element that makes up artwork such as geometry or text.

printed circuit assembly - A PCB together with attached components.

printed circuit board - The Printed Circuit Board (PCB) is a processed substrate which provides all or most of the electrical connections among printed and packaged components. The PCB may be single-sided, double- sided, or multi-layered and may be rigid, flexible, or rigid-flex.

printed wiring assembly - (See Printed Circuit Assembly.)

printed wiring board - (See Printed Circuit Board.)

probe pad - A connection point for an external probe used to test some aspect of the LEP circuit function. For example, a probe pad may be used to make connections to a screened resistor during the trimming process.

procedure - A step-by-step description of the activities needed to complete a given operation.

process - The parameters used on one process step during manufacturing.

processing consumable - Material or chemicals which are used in manufacturing processes which do not remain as part of the product being manufactured. Examples include cleaning fluids, flux, and photoresists.

process description - The narrative explanation of an identified step in the fabrication of a product or assembly.

process operation - The procedures sequentially described by a planning document.

process step - A single operation used to manufacture an Assembly Occurrence. Each step corresponds to one block on a flow chart.

process step number - A sequential number assigned to a process step.

process variable name - The identifier assigned to a particular fabrication step.

processing consumable name - The generic identification of a substance used during the fabrication of a product or assembly, but which does not remain as part of the product. Examples are flux, solvent, or resist.

product consumable - Material or chemicals which are used in manufacturing processes and which remain as part of the product being manufactured. Examples include solder, epoxy, and plated metals.

product consumable name - The generic name of material or chemicals which is used in manufacturing processes and which remain as part of the product being manufactured.

product tolerance - The allowable deviation from the specified location of a product feature.

production tolerance - The allowable deviation from the specified location of a product feature.

PROGRAM - A text string indicating the system a LEP was designed for or intended to be used in.

qualified vendor - A company from which components are purchased and which has been identified as meeting specified requirements for certification and/or inspection of the components being sold.

reference designator - A character string which defines an instance of an assembly component; unique within the product or system. The guidelines generally followed are found in ANSI Y32.16-1975 (e.g., R1=Resistor 1, U7=Microcircuit 7, A10= Assembly 10; thus A10R6 is the 6th Resistor in Assembly 10).

registration - The proper alignment of layers with respect to other layers or to the substrate. The accuracy of registration is measured as the concentricity or relative position to a datum.

registration mark - The marks on a wafer or substrate that are used for aligning successive processing masks. Also known as alignment marks or fiducial marks.

registration mark name - The term assigned to a locating orientation feature related to a particular use.

requirement - A particular *behavior requirement*.

requirement type - A categorization of *behavior requirement*.

resistivity - The ability of a material to resist the passage of electric current. See also Resistor, Sheet Resistance or Line Resistance.

resistor - A device that offers resistance to the flow of electric current in accordance with Ohm's law: R = E/I, where R is resistance, E is voltage, and I is current.

resistor geometry - The film resistor outline. The four system generated geometries for many CAD systems are as follows: rectangle, top hat, u - shaped, and serpentine.

resistor max aspect ratio - A greatest-value factor obtained by dividing the specified width by the length and rounding to get a unit integer ratio, such as 4:1. Such a design rule may constrain the automated design system, and is transferred with the design. The rule is not necessarily intended to be applied to the finished product.

resistor min aspect ratio - A least-value factor obtained by dividing the specified width by the length and rounding to get a unit integer ratio, such as 1:6. Such a design rule may constrain the automated design system, and is transferred with the design. The rule is not necessarily intended to be applied to the finished product.

resistor min length - A design rule—or metric—which establishes the least acceptable dimension of a resistance trace length, such as 40 mil. Such a design rule may constrain the automated design system, and is transferred with the design. The rule is not necessarily intended to be applied to the finished product.

resistor min width - A design rule—or metric—which establishes the least acceptable dimension across a resistance trace, such as 20 mil. Such a design rule may constrain the automated design system, and is transferred with the design. The rule is not necessarily intended to be applied to the finished product.

resistor overlap - A thick-film conductor pad that overlaps and makes contact with a thick-film resistor area.

resistor paste value - Material used to create thick film resistors rated with a nominal ohm per square value.

resistor shape - The term which is characteristic of the topology/geometry used for a deposited or etched resistor component.

resistor termination - The contact area between a thick- or thin-film resistor and an adjacent conductor layer.

revision - Number(s) and/or character(s) that uniquely identify a version of documentation and the products built to that documentation.

route region - (T50) Region where routing paths can automatically be placed between points to be interconnected.

schematic - (T50) A drawing that shows, by means of graphic symbols, the electrical connections, components, and functions of a specific circuit arrangement.

screen printing - A process for depositing material in a pre-defined pattern by forcing material through a stencil screen with a squeegee.

screen stencil - A network of metal or fabric strands, mounted snugly on a frame, and upon which the film circuit pattern and configurations are superimposed by photographic means. (From ISHM Industry Guide, 1990.)

sheet resistivity - Electrical resistance of a thin sheet of a material with a uniform thickness as measured across opposite sides of a unit square pattern expressed in ohms per square. (From ISHM Industry Guide, 1990.)

signal conductive pattern - The association of geometry and the electrical characteristic waveform or switch action that is intended to be carried on the material finished to that geometric shape.

signal name - The user defined functional name, usually referring to an electrical impulse of predetermined voltage, current, polarity, and pulse width. (See also Net Name.)

silk screen - A physical layer of the LEP providing text and/or graphic annotation by means of screen printing. The resulting annotation is usually visible from the top side or from the bottom side of the LEP. (IPC: “Screen Printing”) - The transferring of an image to a surface by forcing a suitable medium with a squeegee through an imaged-screen mesh.

SMT - Surface Mount Technology (IPC: “Surface Mounting” -) The electrical connection of components to the surface of a conductive pattern that does not utilize component holes.

surface mount - (See SMT.)

soldering - A process of electrical and physical joining metallic surfaces by melting solder.

specified tolerance - The amount of (usually) dimensional deviation which has been permitted in the product specification.

start layer - The first of one or more layers through which a via or passage will penetrate.

station - The place or the equipment which is identified (in planning) as the location of a processing or an assembly step during the manufacturing of a product.

step X count - The number of patterns in the X direction in a panel multi-up.

step X distance - The incremental X distance between patterns in a panel multi-up.

step Y count - The number of patterns in a Y direction in panel multi-up.

step Y distance - The incremental Y distance between patterns in a panel multi-up.

stop layer - The last layer through which a via or passage will penetrate.

substrate - The supporting structural material into and/or upon which the passivation, metallization and circuit elements are placed. The material is usually aluminum oxide (alumina; MIL-STD-883C) in a hybrid micricircuit, and FR4 fiberglass in a PCB.

substrate outline - The graphical representation of the substrate shape.

substrate material - The name of the substance from which the base layer is formed.

substrate thickness - The nominal material cross section—Z direction—of the base material of a laminated product.

surface resistivity - (See Sheet Resistivity.)

swapping - The process that exchanges connections from one pin to another pin to improve routing, provided the pins are in the same gate and in the same swap group and have identical functional characteristics.

temperature coefficient of capacitance - A multiplier which represents the linear change of a capacitance value per degree change in temperature over a specified range of temperature. It may be positive, negative, or zero and is usually expressed in parts per million per degree Celsius.

temperature coefficient of resistance - A multiplier which represents the linear change of a resistance value per degree change in temperature over a specified range of temperature. It may be positive, negative, or zero and is usually expressed in parts per million per degree Celsius.

terminator mounting - Metallization pattern on the substrate associated with a film component. The purpose of the pattern is to indicate the region for electrical connection of the film component to its connecting traces.

test - The examination of a product during or after fabrication for conformance to specified criteria for that product.

test condition - The set of controlled or observed conditions of the setup needed to carry out a specific test of a product. Examples include supply voltage, temperature, and initializing signals.

test coupon (T50) A portion of quality conformance test circuitry that is used for a specific test, or group of related tests, in order to determine the acceptability of a product. (Test Coupons are often provided to enable detailed testing of adherence, positioning, plating, etching, and other process attributes even if some of the tests are destructive.)

test description - The narrative which outlines the purpose and procedure for the specified test.

test maximum - Value of the upper limit of a range of test values.

test minimum - Value of the lower limit of a range of test values.

test point (from IPC: -) A designated point of access to an electrical circuit that is used for electrical testing purposes.

test sequence number - A number assigned to a particular test in a series of tests.

test symbol - Short character sequence that allows easy reference to a particular test such as Vin.

test tolerance - The acceptable deviation from the expected nominal test results parameter.

test type - Category of test being performed such as Final, Pre-burn, Qual, Sample.

test units - Measurement units of the Test Minimum and Test Maximum values for the test.

text - An ordered sequence of characters (glyphs) to which a particular meaning is ascribed.

text attribute - Any of the characteristics that describe the appearance of text such as size, font, slant, layer.

thermal outline - The boundary of a region within which temperature is a significant packaging consideration.

thermocompression bonding - The process involving the concurrent use of temperature and pressure to join two materials by interdiffusion across a boundary. (From ISHM Industry Guide, 1990.)

thermosonic bonding - The process involving the concurrent use of temperature, pressure and applied ultrasonic energy to join two materials by interdiffusion across a boundary. (From ISHM Industry Guide, 1990.)

thick-film circuit - A circuit that is fabricated by the deposition of paste materials such as screen-printed ceramic material (cermet) pastes on a ceramic substrate. These materials and the substrate are fired in a kiln to create permanent circuit patterns.

thin-film circuit - Conductive, resistive, or dielectric material, usually less than 50,000 angstroms in thickness, that is deposited onto a substrate by vacuum evaporation, sputtering, or other means. (From MIL-STD-883C, Notice 12.)

thru-hole - (See *hole*.) (“Thru” is a spelling variant of the word “through.”)

tool - (See *tool type*.)

tool description - A narrative which indicates the use and appearances of a particular implement.

tool type - The name given to an implement serving as part of product manufacturing to accomplish an operation. Examples include the product traveler, a cutting device, or a machine.

tooling hole - (from T50) A tooling feature in the form of a passage in an LEP or fabrication panel which

may often be a non-plated hole for fixturing, measuring, or testing by means of the measuring feature(s) accessable through the passage.

trace (IPC: “Conductor” -) A single conductive path in a conductive pattern. “Conductive Pattern” - The configuration or design of the conductive material on a base material. (This includes conductors, lands, vias, heatsinks, and passive components when these are an integral part of the printed board manufacturing process.) The role of *join* which provides physical connections is the common characteristic here.

trace keepout - Symbolic representation of a region (layer-specific) associated with a component which may not be used for trace routing.

trace layer - The physical layer on which the given trace exists.

trace width - The physical width of the trace segment. The width data is typically used to control the photoplotter aperture or the pattern generator setting.

trace width tolerance - The allowable range of the dimension across a conductive line.

trim path - The path made by trimming (using an abrasive or a laser) a component to obtain the required design value.

units (e.g., Volt, Meter) - A precisely specified quantity in terms of which the magnitudes of other quantities of the same kind can be stated.

user defined properties - Structured data describing information that is not previously defined. This property is often used for information not yet defined for the product model.

user information - Unstructured text information inserted as user comments, such as drawing notes.

vacuum deposition - The deposition of a metal film onto a substrate in a vacuum by metal evaporation techniques.

variable value - Quantitative data that is associated to a particular named data element.

vendor address - The postal location of the organization from which items are procured.

vendor name - The identifying text of the company, which may include the company division, that supplied materials, equipment, or service.

via - An electrically conductive passage connecting two or more lands on distinct specified layers of an LEP.

via hole - A hole (i.e., a void or passage) through insulating layer (s) used to make a connection (electrical or thermal), but for which there is no intention to insert a component lead or other reinforcing material. The hole may be any shape as defined by a Via Shape.

via keep out - The symbolic representation of a region (layer-specific) associated with a feature where vias cannot exist in products conforming to design constraints.

via layer - A layer which is used principally (in a CAD system) for placing vias holes.

via location - The X, Y position on which a via is centered.

via shape - The shape of the top view of a via.

via size - The width and length or the diameter of a via.

voltage allowance - A design rule that requires extra spacing between specified traces (e.g., to allow higher voltages to be carried).

volume resistivity - The volume resistance between two electrodes (of unit area and unit distance apart) that are in contact with or embedded in a specimen. The value is the ratio of the direct voltage applied to the electrodes in proportion to the current between them that is distributed through the volume of the specimen. Usually expressed in ohms per centimeter.

wire bond - A completed wire connection that provides electrical continuity. Bonding wires are used to

connect between component pads, or package pins, or conductive pads and particular conductive features (e.g., ground plane) on the LEP substrate.

wire bond max length - A design rule—or metric—to limit total length of a wirebond wire, such as 140 mils maximum.

wire bond min length - A design rule—or metric—to limit the least-length parameter of a wirebond wire, such as 10 mils minimum.

wire bonding - The method used to attach very fine wire to make electrical connections between component features and substrate features.

wire bond sequence number - The number assigned to a wire bond that specifies the order in which wire bond is to be made.

wire size - The diameter of wire, such as 0.8, 1, or 5 mils.

Appendix B The IGES 6.0 Edit Change Orders

Appendix B The IGES 6.0 Edit Change Orders (ECO)

This appendix lists the change orders which have been approved by the IGES Project as defining the technical changes that will modify IGES Version 5.3. This appendix, together with IGES Version 5.3, shall constitute an interim definition of the IGES Version 6.0 Volume I for purposes of developing implementations of the application protocols defined in the body of this document. Subsequent to the ANSI approval of IGES 6.0 that version will supercede this appendix.

The technical additions identified herein for Version 6.0 have been frozen as of the June 4, 1997 IGES Project meeting.

ECO 700 Edits to Version 6.0

[Authorizes non-technical corrections.]

ECO 701 Add Bus Signal Width Property Entity (Type 406, Form 37)

The Bus Signal Width Property shall be used to specify how many bits are connected “in parallel” within a single Network Flow Associativity. The property shall be assigned to each entity that is part of the join geometry of such a Network Flow Associativity when it is used to define a multi-bit net. This construct enables a multi-bit link in an electrical schematic to be paired with a multi-bit bundle of joins in the physical realm.

If a join entity within a Network Flow Associativity does not have a Bus Signal Property assigned, the associativity shall have a signal width equal to one bit.

Directory Entry

Number and Name	Value
[1] Entity Type number	406
[3] Structure	< n.a. >
[4] Line Font Pattern	< n.a. >
[5] Level	#, ⇒
[6] View	< n.a. >
[7] Transformation Matrix	< n.a. >
[8] Label display associativity	< n.a. >
[9a] Blank Status	**
[9b] Subordinate Entity Switch	??
[9c] Entity Use Flag	**
[9d] Hierarch	**
[12] Line Weight Number	< n.a. >
[13 Color Number	< n.a. >
[15] Form Number	37

Parameter Data

Index	Name	Type	Description
1	NP	Integer	Number of property values (NP=1)
2	DF	Integer	Specifies the number of bit signals that have conductivity through the join geometry. (Default = 1 bit wide)

Additional pointers as required (see Section 2.2.4.5.2)

Add the following definitions to the Glossary:

BUS A set of proximate electrical conductors capable of carrying multiple signals from origin to destination where each of the individual signals bears a subordinate relationship to the unifying concept denoted by the "flow-name" of the bus.

BUS-PIN An aggregation of proximate conductive pins where each pin functions as a point of access to an electrical or electronic signal conducted through the corresponding "join." Moreover, each signal conducted by each individual pin bears a subordinate relationship to the unifying concept identified by the "flow-name" of the bus.

MULTI-BIT NET A set of "links" each playing a distinct role but common concept denoted by the name of the function performed by the electrical device(s) connected to the set of "links."

ECO 702 Add Intercharacter Spacing Property (Type 406, Form 18)

The intercharacter spacing is used to specify the gap between letters when fixed-pitch spacing is used. It is applicable to text generated by the General Note and Text Template entities. The gap is specified as a percentage of text height. The percentage may be positive, negative, or zero.

Figure 136 [to be included in the released IGES 6.0] shows several examples of the General Note Entity (Type 212) with different values of intercharacter spacing arranged as two groups. In both groups, from top to bottom, they represent system default (no property used), 75% and 0%. Note that the default spacing for systems may be different for each FC or for individual characters.

The top group illustrates text box width (WT) adjustment so as to maintain the character aspect ratio when the text box is maintained, i.e., only the value of the property is changed. Note that the text box width as specified for the General Note Entity does not permit a trailing intercharacter space, so in the bottom group the last character of each string aligns to the same text box width even though the intercharacter spacing changes.

Let CH, CW, and CS represent character height,character width, and intercharacter spacing. Let HT, WT, and NC represent text box height, text box width, and number of characters in the text string. For fixed pitch systems, the following relationships are implied:

WT = (CW*NC) + (CS*(NC-1))

CS = (WT-(CW*NC)) / (NC-1)

CW = (WT (CS*(NC 1))) / NC

In other words, text box width is a function of the character width, the number of characters, and NC-1 spaces. Intercharacter spacing can have an effect on character width if text box width is constrained. Therefore, intercharacter spacing is defined as a function of text box height because both text box height and character height remain constant even if characters are added to or deleated from a text string. (WT is a function of NC and CW, and CW is represented as a function of CH in most systems.) This implies the reciprocal ralationships:

ISPACE = 100.0 * (CS/CH)

CS = CH * (ISPACE/100.0)

These equations can be used by both preprocessors and postprocessors to calculate appropriate values in permitting the the receiving system to preserve the sending system's intercharacter spacing and character

aspect ratio.

Directory Entry

Number and Name	Value
[1] Entity Type number	406
[3] Structure	< n.a. >
[4] Line Font Pattern	< n.a. >
[5] Level	#, ⇒
[6] View	< n.a. >
[7] Transformation Matrix	< n.a. >
[8] Label display associativity	< n.a. >
[9a] Blank Status	**
[9b] Subordinate Entity Switch	??
[9c] Entity Use Flag	**
[9d] Hierarch	**
[12] Line Weight Number	< n.a. >
[13 Color Number	< n.a. >
[15] Form Number	18

Parameter Data

Index	Name	Type	Description
1	NP	Integer	Number of property values (NP=1)
2	ISPACE	Real	Intercharacter Space in percent of text height (Range 0.0 to 100.)

Additional pointers as required (see Section 2.2.4.5.2)

[Note: Figure 136. F40618X,IGX - “Examples Defined Using the Intercharacter Spacing Property” to be included in released IGES 6.0]

ECO 703 Add Multimedia Entity (Type 232)

The Multimedia Entity specifies the path/filename.type, and a rectangular area for display of a file or its icon. Icon behavior is implied when the actual image size is larger than the display rectangle; implementations may be designed to display a full-size image if the icon is clicked.

This entity is primarily intended to (but not restricted to) accommodate the display of a raster image as annotation added to a drawing of the CAD product model. A typical example might be a corporate logo or design mark. IGES files that contain this entity are expected to be displayed through the use of IGES viewers capable of accessing non-IGES file types; CAD (only) modeling systems may ignore the entity.

Parameter DF shall be either a Universal Resource Locator (URL) or a local file name. The file, whose data type is identified by the file name extension in parameter DF, may be any Multipurpose Internet Mail Extension (MIME) [ISI96] data type. Displaying the referenced multimedia file requires capability for

processing file data types other than IGES.

An example of a URL is “45Hhttp://server.location.net/directory/file.gif” where the file is in Graphic Interchange Format (.gif). An example of a file is “8HFILE.GIF”.

Post processors or viewers shall adjust the scale of the image so it is centered and fits entirely within the display rectangle defined in the Parameter Data section. Scaling shall be the same in X and Y so image aspect is unchanged; if the display rectangle is a different aspect than the image, there shall will be two blank spaces within the display rectangle (either on the sides or top and bottom) that shall be filled with the system’s background color. The image shall be displayed when the DE status bits 1-2 equal 00 and shall not be displayed with the DE status bits 1-2 equal 01; when the image is not displayed, the rectangle shall be filled with the system’s backgound color.

The Multimedia Entity shall be planar and confom to anotation entity requirements: the entity may exist in model space; however the display rectangle and referenced file shall always be displayed parallel to the view plane. The Multimedia Entity may exist in drawing spaced when referenced from a Drawing Entity (Type 404).

Directory Entry

Number and Name	Value
[1] Entity Type number	232
[3] Structure	< n.a. >
[4] Line Font Pattern	< n.a. >
[5] Level	#, ⇒
[6] View	#, ⇒
[7] Transformation Matrix	#, ⇒
[8] Label display associativity	< n.a. >
[9a] Blank Status	??
[9b] Subordinate Entity Switch	??
[9c] Entity Use Flag	01
[9d] Hierarch	**
[12] Line Weight Number	< n.a. >
[13 Color Number	< n.a. >
[15] Form Number	0

Note: The level shall be ignored if this property is subordinate (see Sections 4.98 and 1.6.1).

Parameter Data

Index	Name	Type	Description
1	DF	String	Display file/ file name and type extension.
2	XS	Real	Display rectangle start point
3	YS	Real	
4	ZS	Real	Z depth displacement from the XT, YT plane.

5	WT1	Real	Display rectangle width.
6	HT1	real	Display rectangle height.

Additional pointers as required (see Section 2.2.4.5.2)

Add to References the following:

ISI96 Internet Society “Request for Comment” (RFC) 2045 and 2046 found at http://www.isi.edu/in-notes specifies the use of Multipurpose Internet Mail Extensions (MIME). The current MIME Types may be found at http://www.isi.edu/in-notes/iana/assignments/media-types/media-types.

ECO 704 Add URL Anchor Property (Type 406, Form 38)

The Universal Resource Locator Tag Property (Type 406, Form 38) specifies an Internet environment path and filename of a file related to an entity in the exchange file. This property is used by clients capable of displaying any Internet environment file selected by the viewing user.

IGES files containing this entity can be displayed by IGES viewers capable of accessing the identified multimedia file types, and to be ignored by post-processors associated with CAD (only) modeling systems.

This property shall not affect normal CAD system use of the exchange file. If the exchange file is being displayed by software capable of using the property’s information, an action such as double-clicking on the referencing entity shall initiate an attempt to access and view the URL file specified in the property. Situations such as a non-response by an Internet server may prevent display.

The file identified in parameter DF may be of any Multipurpose Internet Mail Extensions (MIME) [ISI96] data type. Since “model/iges” is a valid MIME data type, it is possible to reference another IGES file; however, this shall not be used as a substitute for use of the External Reference Entity (Type 416) in the CAD system environment. Processing of the referenced file requires capability for processing MIME data types which may be other than IGES data.

Example of PD parameter DF for a file in Graphic Interchange Format (.gif):

45Hhttp://server.location.net/directory/file.gif

Directory Entry

Number and Name	Value
[1] Entity Type number	406
[3] Structure	< n.a. >
[4] Line Font Pattern	< n.a. >
[5] Level	< n.a. >
[6] View	< n.a. >
[7] Transformation Matrix	< n.a. >
[8] Label display associativity	< n.a. >
[9a] Blank Status	**
[9b] Subordinate Entity Switch	??

Number and Name	Value
[9c] Entity Use Flag	**
[9d] Hierarch	**
[12] Line Weight Number	< n.a. >
[13 Color Number	< n.a. >
[15] Form Number	38

Parameter Data

Index	Name	Type	Description
1	NP	Integer	Specifies the number of parameter data fields (NP=1).
2	DF	String	Display file URL

Additional pointers as required (see Section 2.2.4.5.2)

ECO 705 Modify Type 110, Forms 1-2 entity use flag

Change the status filed from "????06**" to:

Directory Entry

Number and Name	Value
[9a] Blank Status	??
[9b] Subordinate Entity Switch	??
[9c] Entity Use Flag	??
[9d] Hierarch	**

Add text:

Requirements: Forms 1 and 2 shall specify 06 for the Entity Use flag when semi-bounded and unbounded lines are construction geometry. Forms 1 and 2 shall specify 01 for the Entity use Flag when they are referenced from a Drawing Entity (Type 404). Forms 1 and 2 shall specify 02 for the Entity Use Flag when they are used as part of a definition entity such as the Subfigure Definition (Type 308).

ECO 706 Modify DE fields of B-REP entities

1) Add to Manifold Solid B-REP Object Entity (Type 186) and Edge List Entity (Type 504): DE fields 4, 6, 12 and 13.

2) Add to Loop Entity (Type 508): DE fields 4, 12 and 13.

3) Add to Shell Entity (Type 514, Form 2 ONLY): DE fields 4, 7, 12 and 13.

ECO 707 Explicit closure of the Simple Closed Planar Curve

Change text on page 68 as follows:

A Simple Closed Planar Curve Entity (Type 106, Form 63) defines the boundary of a region in XY coordinate space. This entity shall meet the constraints of a simple closed curve (Appendix K) that lies in the ZT=constant, and the first and last data points shall be coincident. Parameterization for this entity may be

provided: the default parameterization is the same as defined for the Planar Linear Path Entity (Type 106, Form 11). The Simple Closed Planar Curve will be closely related to entities that require the functionality of a closed region.

For IP=1 (X,Y pairs, common Z), i.e., for Forms 11, 63:

Parameter Data

Index	Name	Type	Description
3	ZT	Real	Common Z displacement.
2	X1	Real	First data point in abscissa
°	°	°	
°	°	°	
°	°	°	
6	XN	Real	Last data point in abscissa (=X1)
7	YN	Real	Last data point in ordinate (=Y1)

ECO 708 Clarify distance values

(Problem: In the IGES Drafting entities there exists several references to a distance value, and there is no restriction that the distance value be specified as non-negative.)

In the 212 PD field descriptions for WT1 and HT1 add "(value must be >= 0.0)."

In the 230 PD field description for DIST add "(value must be >= 0.0)."

In the 312 PD field descriptions for CBW and CBH add "(value must be >= 0.0)."

ECO 709 Renaming the IGES entity 406:19 to a 304:3

Add a parqagraph into Line Font Definition Entity (Type 304):

Form Number 3 in a Line Font Definition Entity specifies a line font pattern code from a predefined list. Illustrations of line font patterns are found in figure 78.

The following forms of the Property Entity (Type 406) are obsolete:

(Type 406, Form 4) - Region Fill

(Type 406, Form 19) - Line Font

ECO 710 Add Planarity Property

Planarity Property

The Planarity Property (Type 406, Form 39) specifies planarity for curve, surface, or annotation entities. This property offers different functionality than the Planar Associativity (Type 402, Form 16). This property does not specify association, and it is more efficient when large numbers of entities are involved since it can be applied to one or more entity levels.

Requirements: Multiple entities may reference an instance of this property if they have the same planarity characteristics. Independent usage also is allowed; this specifies that all entities on the same level(s) as the property have the same planarity characteristics.

Directory Entry

Number and Name	Value
[1] Entity Type number	406

Number and Name	Value
[3] Structure	< n.a. >
[4] Line Font Pattern	< n.a. >
[5] Level	#, ⇒
[6] View	< n.a. >
[7] Transformation Matrix	< n.a. >
[8] Label display associativity	< n.a. >
[9a] Blank Status	00
[9b] Subordinate Entity Switch	01
[9c] Entity Use Flag	03
[9d] Hierarch	00
[12] Line Weight Number	< n.a. >
[13 Color Number	< n.a. >
[15] Form Number	39

Parameter Data

Index	Name	Type	Description
1	NP	Integer	Number of property values (1, 4, or 7; may not be defaulted)
2	PLANF	Integer	Planarity flag: 0=not specified (default) [NP=4] 1=XY plane at Z=0 [NP=1] 2=XY plane at Z=PLANZ [NP=4] 3=plane defined by point and normal vector in the following six PD values [NP=7]
3	PLANPX	Real	X coordinate of a point on the plane (required if PLANF=3, otherwise ignored)
4	PLANPY	Real	Y coordinate of a point on the plane (required if PLANF=3, otherwise ignored)
5	PLANPZ	Real	Z coordinate of a point on the plane (required if PLANF=3, otherwise ignored)
6	PLANVX	Real	X component of vector normal to the plane (required if PLANF=3, otherwise ignored)
7	PLANVY	Real	Y component of vector normal to the plane (required if PLANF=3, otherwise ignored)
8	PLANVZ	Real	Z component of vector normal to the plane (required if PLANF=3, otherwise ignored)

Additional pointers as required (see Section 2.2.4.5.2)

ECO 711 Add Continuity Property (Type 406, Form 40)

The Continuity Property (Type 406, Form 40) specifies the *minimum* continuity required for the entire curve or entire surface entity which references it; the *actual* continuity may be everywhere greater than specified.

Requirements: Multiple entities may reference an instance of this property if they have the same continuity.

Independent usage is not allowed. C continuity applies to curves and surfaces and G continuity applies only to surfaces. Entities other than curves and surfaces shall not *explicitly* reference this property; however, indirect reference (such as applying this property to one or more levels that also contain non-geometry entities) is allowed. Post-processors shall ignore any references by other than curves and surfaces.

The default values are equivalent to omitting this property since C0 continuity is the minimum continuity required by this Specification.

Directory Entry

Number and Name	Value
[1] Entity Type number	406
[3] Structure	< n.a. >
[4] Line Font Pattern	< n.a. >
[5] Level	< n.a. >
[6] View	< n.a. >
[7] Transformation Matrix	< n.a. >
[8] Label display associativity	< n.a. >
[9a] Blank Status	00
[9b] Subordinate Entity Switch	01
[9c] Entity Use Flag	03
[9d] Hierarch	00
[12] Line Weight Number	< n.a. >
[13 Color Number	< n.a. >
[15] Form Number	40

Parameter Data

Index	Name	Type	Description
1	NP	Integer	Specifies the number of property values (1-4, may not be defaulted).
2	CONTUC	Integer	C continuity (U) for curves or surfaces (value is ignored if entity referencing property is not a curve or surface): 0=C0 continuous (default), 1=C1 continuous, 2=C2 continuous, *etc.*
3	CONTUG	Integer	G continuity (U) for curves or surfaces (value is ignored if entity referencing property is not a curve or surface): 0=G0 continuous (default), 1=G1 continuous, 2=G2 continuous, *etc.*
4	CONTVC	Integer	C continuity (V) for curves or surfaces (value is ignored if entity referencing property is not a curve or surface): 0=C0 continuous (default),

			1=C1 continuous, 2=C2 continuous, *etc.*
5	CONTVG	Integer	G continuity (V) for curves or surfaces (value is ignored if entity referencing property is not a curve or surface): 0=G0 continuous (default), 1=G1 continuous, 2=G2 continuous, *etc.*

Additional pointers as required (see Section 2.2.4.5.2)

Add the following definitions to the Glossary:

C1 CONTINUITY Refer to CONTINUITY below.

C2 CONTINUITY Refer to CONTINUITY below.

CONTINUITY

A function *f(u)* is C_n continuous if and only if both it and all of its derivatives of degree less than or equal to *n* are continuous.
A function *f(u,v)* is C_n continuous if and only if both it and all of its mixed partial derivatives of total degree less than or equal to *k* are continuous for $0 \le k \le n$.
A curve defined by *B(t) = (x(t),y(t),z(t))* is C_n continuous if and only if *x, y,* and *z* are C_n continuous.
A surface defined by *S(u,v) = (x(u,v),y(u,v),z(u,v))* is C_n continuous if and only if *x,y,* and *z* are C_n continuous.
A curve is G_1 continuous if and only if its unit tangent vector is continuous as a function of position.
A curve is G_2 continuous if and only if its curvature is continuous as a function of position.
A surface is G_1 continuous if and only if unit normal vector is continuous as a function of position.
A surface is G_2 continuous if and only if its second fundamental form is continuous as a function of position.

G1 CONTINUITY Refer to CONTINUITY above.

G2 CONTINUITY Refer to CONTINUITY above.

ECO 712 Add Taxonomy

Add Section 3.7 which classifies the IGES entities into categories [the entries within each of these categories is omitted from this Appendix];

1. Special Purpose Category [contains the Null Entity (Type 0, Form 0)]
2. Curve Category
3. Multi-Entity Curve Category
4. Point Category
5. Annotation Category
6. Surface Category
7. Positioning Category
8. Electrical Category
9. Relative Category
10. Finite Element Modeling Category
11. Quasi-topological Curve Category
12. Quasi-topological Surface Category
13. Constructive Solid Geometry Category
14. B-REP Solid Category
15. B-REP Surface Category
16. B-REP Collector Category

17. Definition Category
18. Instantiation Category
19. Tabular Data Category
20. Drawing Category
21. Property Category

ECO 713 Modify edge use for B-Reps with analytic surfaces

Change the description of how edges are used in shells and MSBOs. This is a minimal change to the specification with no modification to the syntax of the B-rep entities. It preserves upwards compatibility and probably represents how translators currently create these entities.

1.G.9, last sentence of paragraph 4 reads

> Each edge is used once in each orientation and therefore should be referenced exactly twice in an MSBO.

Replace with

> Each edge must be used exactly twice in an MSBO. See the shell discussion for further details.

2.G9, last sentence of paragraph 9 reads

> Each edge must be used exactly twice, once in each orientation, in the shell.

Replace with

> Each edge must be used exactly twice in a shell. If the orientation flags of the faces using the edge are identical, each edge is used once in each orientation. If the orientation flags are not identical, one of the two edge orientations will not be used and the other will be used twice.

3.G.48, last sentence of paragraph 2 reads:

> An edge-use is only used once in the shell.

Replace with

> An edge-use may be used zero, one, or two times in the shell. See the shell discussion in G.9 for further details.

ECO 714 Clarify use of solid assemblies in IGES

[Adds text to improve the consistency of implementations of the Constructive Solid Assembly (CSG) Solid Assembly Entity (Type 184).]

ECO 715 Approval tracking for IGES Volume 2 (this document)

ECO 716 Add double arrowhead forms to Entity Type 214

Add four forms 13-16:

For consistency with the existing IGES X-file for this entity (see Figure F214X.IGS), these examples use the same AD1 values (1.2 inches) as the other trianglar and rectangular examples, but AD2 has been halved from 0.6 to 0.3 inches. (This maitains the 2:1 aspect ratio of the other examples.)

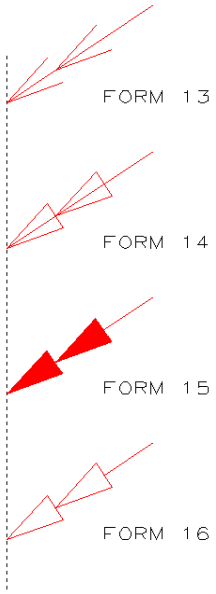


Figure (F214X.IGS)