NOTE: This document identifier and heading has been changed on this page to reflect that this is a performance specification. There are no other changes to this document. The document identifier on subsequent pages has not been changed, but will be changed the next time this document is revised.

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PERFORMANCE SPECIFICATION

DIGITAL REPRESENTATION FOR COMMUNICATION OF PRODUCT DATA: IGES APPLICATION SUBSETS AND IGES APPLICATION PROTOCOLS

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1. Scope. This specification identifies the requirements to be met when product definition data is delivered in the digital format of the Initial Graphics Exchange Specification (IGES) as specified by its American Society of Mechanical Engineers standard, ASME Y14.26M. Discrete subsets and/or application protocols of the ASME Y14.26M entities are identified by class according to the application for which the digital data was prepared.

1.2. Classification. The digital representation of product definition data shall be one or more of the following classes as specified by the contract or other form of agreement:

Class I	- Technical Illustration Subset
Class II	- Engineering Drawing Subset
Class III	- Electrical/Electronic Applications Subset
Class IV	- Geometry for NC Manufacturing Subset
Class V	- 3D Piping Application Protocol

Additional classes are expected to be added in future versions of this specification as soon as the technical work codifies their requirements and validates fitness for use.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: ATTN: CALS Digital Standards Office, DISA, Center for Standards, Code JIEO/JEBEB, 10701 Parkridge Blvd, Reston, VA 22091-4398, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A
AREA IPSC

2. Applicable documents

2.1. Government documents.

2.1.1. Specifications and standards. The following specifications and standards form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation. (See 6.2)

Military specification

MIL-T-31000 - Technical Data Packages, General Specification for

Federal information processing standard

FIPS PUB 79 - Magnetic Tape Labels and File Structure for Information Interchange

(Copies of the Federal Information and Processing Standards (FIPS) are available to Department of Defense activities from the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094. Others must request copies of FIPS from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161-2171.)

Military standards

DOD-STD-100 - Engineering Drawing Practices

MIL-STD-1840 - Automated Interchange of Technical Information

(Copies of the referenced military specifications and standards are available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.1.2. Other government documents. The following other Government documents form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation.

National institute of standards and technology

IGES Technical Illustrations Application Guide, issue date July 19, 1990, NISTIR 4379

IGES 5.0 Recommended Practices Guide - May 1991, NISTIR 4600

IGES Electrical Application Guide, March 1987 (Draft)

3D Piping IGES Application Protocol, Version 1.1, March 1992, NISTIR 4797

(Application for copies of the above documents shall be addressed to the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.)

IGES V5.0 Initial Graphics Exchange Specification, Version 5.0, September 1990, NISTIR 4412

(Application for copies of the above document shall be addressed to: National Computer Graphics Association, 2722 Merrilee Drive, Suite 200, Fairfax VA, 22031, ATTN: IPO Administrator)

2.2. Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the issue of the DODISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation. (See 6.2)

ASME Y14.26M Digital Representation for Communication of Product Definition Data 1989 Edition

(Application for copies shall be addressed to: The American Society of Mechanical Engineers, 345 East 47th Street, New York, N.Y. 10017).

(Nongovernment standards and other publications are normally available from the organizations which prepare or which distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3. Order of precedence. In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

3. Requirements

3.1. General requirements. All digital product data files complying with this specification shall conform to the identified subset or application protocol class. The specific subset or application protocol class shall be identified by entry in the start section of the file.

3.1.1. Restrictive nature of subsets. A data file conforming to this specification shall utilize only those specific entities identified in the referenced subset or application protocol class for representing the product definition. Additional "volunteer" entity types may be present as long as these entity types are:

a. Valid ASME Y14.26M entities.

b. Not necessary to the product data representation .

c. Solely for the purpose of regenerating the same development environment when the file is transferred back to the same computer aided design (CAD) system which originally generated the file and may be ignored by other CAD systems.

These volunteer entities do not include geometry. Rather, they typically include IGES-defined properties, user-defined properties, and associative or color definition entities. A post-processor (see 6.6.13) is not required to translate these "volunteer" entity types into the data base of its CAD/CAM system, but is required to continue processing the remainder of the data file.

3.1.2. Limits on parameter data. A data file conforming to this specification shall not contain scalar values of parameter data outside the ranges specified by the identified subset or application protocol class.

3.1.3. Physical file structure. All digital product data files complying with this specification shall be written in the ASCII form specified by ASME Y14.26M. The binary form shall not be used.

3.1.4. Physical media for delivery. Unless otherwise specified in the solicitation all data files complying with this specification shall be delivered on 9-track magnetic tape as specified in MIL-STD-1840. Tape format shall be in accordance with FIPS PUB 79 with tape volume labels and file labels complying with Level 3 or Level 4 of the standard. Acceptable tape densities are 1600 and 6250 CPI only.

3.2. Specific requirements. The following subsections define the requirements for each defined subset or application protocol class. A conforming data file shall use the specified ASME Y14.26M entity types and form numbers for representation of data in the identified class subset. All references to entity types, form numbers, and data fields are references to ASME Y14.26M for classes I-IV. Class V, the 3D Piping Application Protocol, uses IGES Version 5.1 entities, see the "3D Piping IGES Application Protocol" document for details.

3.2.1. Class I subset - technical illustrations. The Technical Illustration subset of ASME Y14.26M addresses entities that support the exchange of figures and illustrations normally found in a technical publication. In this application, emphasis is on visual clarity of figures and illustrations designed for human interpretation. The IGES Technical Illustrations Application Guide provides additional guidance on this usage of IGES.

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

a. Simple 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. Text annotation.

d. Data relationships, including the concept of subfigures.

3.2.1.2. ASME Y14.26M entity subset specification. Table I lists the entities of this subset. Only ASME Y14.26M entities which are enumerated in this table shall be used for representing technical publication illustration product definition data. Other valid ASME Y14.26M entity types may be present in the file as described by 3.1.1. Additional requirements are placed on the Global Section of a file, and certain field value restrictions are also placed on the range of parameter values in both the directory entry (DE) and the parameter data (PD) sections of a valid ASME Y14.26M file.

3.2.1.3. File construction.

3.2.1.3.1. Start section. The following information shall be placed in the Start Section of the file:

a. Statement of conformance to this application subset, 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.

TABLE I. - *ASME Y14.26M entity content of technical illustration subset*

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

	ENTITY	FORM	ENTITY NAME	NOTES DE	NOTES PD
*	0		Null		
	100		Circular Arc	3	2
	102		Composite Curve	1	4
	104		Conic Arc	3	2
	104	1	Conic Arc	3	2
	104	2	Conic Arc	3	2
	104	3	Conic Arc	3	2
	106	11	2D Linear String	1	15
	106	63	Simple Closed Planar Curve	1	
	110		Line	1	2
	112		Parametric Spline Curve	1	2,5
	124	0	Transformation Matrix	6	7
	126		Rational B-Spline Curve	1	8
	212		General Note	10	2,11
	230		Sectioned Area	1	2
	308		Subfigure Definition	6	4
	404		Drawing	9	
	406	15	Name		16
	406	16	Drawing Size Property		12
	406	17	Drawing Units		
*	406	18	Intercharacter Spacing	1	
	408		Subfigure Instance	3	2
	410		View	6	13
	412		Rect Array Sub Instance	3	2,14
	414		Circ Array Sub Instance	3	2,14

* Denotes an ASME Y14.26M Appendix J, Untested Entities, capability

NOTES FOR TABLE I:

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 Index 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 Index values shall point only to other entity types within this subset.

5. PD Index 3, Planar, shall be 2

6. DE Field 7, Transformation Matrix, shall be 0.

7. Translation and rotation are restricted to XY plane. PD Indices R13, R23, R31, R32 and T3 shall be 0.0, and R33 shall be 1.0 or -1.0

8. PD Index 3, PROP1 (Planar), shall be 1, ZK shall be 0.0, XNORM and YNORM shall be 0.0 ZNORM shall be 1.0 or -1.0.

9. PD Index 1, Number of view pointers, shall be 1
   PD Index 5, Number of annotation entities, shall be 0
   PD Index 6, Number of associativity pointers, shall be 0
   PD Index 7, Number of property pointers, shall be 1, 2 or 3
   PD Index 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 Index 5, Font Characteristic, shall be 1, 1001, 1002, or 1003.
    If a pointer to a property entity (406, Form 18) is used to control intercharacter spacing, then any ASME Y14.26M font value may be used.

12. DE Field 5, Level, shall be 0.

13. PD Index 2, Scale, shall be 1.0.
    PD Indices 3-8 shall be 0.

* Denotes an ASME Y14.26M Appendiz J, Untested Entities, capability

14. PD Index 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. N1 (the number of Points, PD Index 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.

3.2.1.3.2. Global section. Fields in the global section shall be restricted to certain ranges and shall not be defaulted except as noted below for parameters 1, 2, 12, 20, and 24.

Field	Value	Required	
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	
16-19		Y	
20		N	Default to Field 1
21		N	
22		N	
23	4-6	Y	
24	0-7	N	Default to zero

3.2.1.3.3. Directory entry section. See Notes for Table I for restrictions placed on the parameters in the directory entry section.

3.2.1.3.4. Parameter data section. See Notes for Table I for restrictions placed on the parameters in the parameter data section.

3.2.1.4. Mapping of information content to ASME Y14.26M subset entities. Illustration geometry shall be mapped into two dimensional ASME Y14.26M 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 font information shall be represented by the appropriate global and directory entry 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 text annotation 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. Use of ASME Y14.26M constructs, like the intercharacter spacing property for proportional text, is encouraged to reduce file lengths. (See 6.3.) Lines, splines, linear curves, arcs, and conic arcs shall not have a zero arc length (e.g. zero length curves).

3.2.1.5. 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.

3.2.1.6. 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 being created on all receiving systems.

3.2.2. Class II subset - engineering drawings. This engineering drawing subset of ASME Y14.26M shall be used to encode product data being acquired in accordance with MIL-T-31000 for delivery in digital form. The data exchange shall preserve the requirements of style and content as set forth by DOD-STD-100 and MIL-T-31000. Exchange emphasis is on completeness, visual equivalency for human interpretation, and functionality of the received drawing.

3.2.2.1. Information requirements and data functionality. Currently, engineering drawings form the mainstay of product definition and form the accepted medium for viewing computer generated data. Geometry and text annotation form the majority of data items. Extensive use is made of dimensions, sectioned areas, text notes, and feature control symbols. Non-geometric information in the form of color, line weight, line font, and level is needed as well. Finally, relationships among the data help to structure the large quantities of data. Information requirements for this application subset include (but are not limited to):

a. Simple geometry in the form of points, lines, circular arcs, conic arcs, and spline curves.

b. Non-geometric attributes of color, line weight, and line font.

c. Data relationships, including the concept of subfigures.

d. Data organization methods such as level.

e. Part name, drawing number, formal identification, and drawing revision.

f. Annotation represented by the corresponding ASME Y14.26M entity type thus retaining its intended functionality.

3.2.2.2. ASME Y14.26M entity subset specification. Table II lists the entities of this subset. Only ASME Y14.26M entities which are enumerated in this table shall be used for representing engineering drawing product definition data. Other valid ASME Y14.26M entity types may be present in the file as described by 3.1.1. Additional requirements are placed on the global section of a file, and certain field value restrictions are placed on the range of parameter values in both the directory entry(DE) and the parameter data(PD) sections of a valid ASME Y14.26M file.

TABLE II. - *ASME Y14.26M entity content of engineering drawing subset*

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

	ENTITY	FORM	ENTITY NAME	NOTES DE	NOTES PD
*	0		Null		
	100		Circular Arc	1	
	102		Composite Curve	1	2
	104		Conic Arc	1	5
	104	1	Conic Arc	1	5
	104	2	Conic Arc	1	5
	104	3	Conic Arc	1	5
	106	11	2D Linear String	1	6
	106	12	3D Linear String	1	6
	106	20	Centerline Through Points	1	
	106	21	Centerline Through Circle Centers	1	
	106	31	Section (parallel line segments)	1	
	106	32	Section (parallel line seg.in pairs)	1	
	106	33	Section (alternating solid & dash seg.)	1	
	106	34	Section (parallel lines in quad.)	1	
	106	35	Section (triples of parallel lines)	1	
	106	36	Section (parallel sets of dash seg.)	1	
	106	37	Section (two perpendicular sets of parallel lines)	1	
	106	38	Section (2 perpendicular sets of parallel lines-principal solid & 2nd dashed)	1	
	106	40	Witness Line	1	11
	106	63	Simple Closed Planar Curve	1	
	108	0	Unbounded Plane	1	7
	108	1	Bounded Plane	1	15
	110		Line	1	
	112		Parametric Spline Curve	1	8,17
	114		Parametric Spline Surface	1	8,17
	116		Point	1	
	118		Ruled Surface	1	2
	120		Surface of Revolution	1	2

* Denotes an ASME Y14.26M Appendix J, Untested Entities, capability

TABLE II. - *ASME Y14.26M entity content of engineering drawing subset* - Continued

	ENTITY	FORM	ENTITY NAME	NOTES DE	NOTES PD
	124	1	Transformation Matrix	1	
	126		Rational B-Spline Curve	1	17
	128		Rational B-Spline Surface	1	17
	130		Offset Curve	1	2
	140		Offset Surface	1	2
	142		Curve on a Parametric Surface	1	2
	144		Trimmed Parametric Surface	1	2
	202		Angular Dimension	1	
	206		Diameter Dimension	1	
	210		General Label	1	
	212		General Note	1	3
	214		Leader Arrow	1	9
	216		Linear Dimension	1	
	218		Ordinate Dimension	1	
	220		Point Dimension	1	12
	222	0	Radius Dimension	1	
*	222	1	Radius Dimension	1	
	228	0	General Symbol	1,10	2
*	228	1	General Symbol	1,10	2
*	228	2	General Symbol	1,10	2
*	228	3	General Symbol	1,10	2
	230		Sectioned Area	1	2
	304		Line Font Definition		
	308		Subfigure Definition	1,13	2
	314		Color Definition	1	
	402	3	Views Visible	1	
	402	4	Views Visible, Color, Line Font	1	
	402	7	Group w/o Back Pointer	1	
	404		Drawing	1	4,16
	406	1	Definition Levels	1	
	406	3	Level Function	1	
	406	5	Line Widening	1	14
	406	15	Name	1	
	406	16	Drawing Size	1	
	406	17	Drawing Units	1	
	408		Subfigure Instance	1	
	410		View	1	

* Denotes an ASME Y14.26M Appendix J, Untested Entities, capability

NOTES FOR TABLE II:

1. DE Field 8, Label Display Pointer, shall be 0.

2. PD Pointer values shall point only to other entity types within this subset.

* 3. Font Characteristic shall be 1, 1001, 1002, or 1003.

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

5. Conic coefficient B (PD Index 4) shall be zero (0). An associated matrix shall be used to rotate/translate the conic to its position in space.

6. N1 (the number of Points, PD Index 2) shall be 3 or more.

7. Shall only appear in the file if it is used with an entity type 410 as a clipping plane.

8. CTYPE (PD Index 1) shall be 2 or 3.

9. Shall have at least one segment. Neither arrowhead height nor width shall be zero except for Form 4 where both shall be zero or Form 9 where the height can be zero.

10. Can be used only for annotation.

11. Shall contain at least two segments. Only first segment can be zero length.

12. Leader shall be Form 4.

13. DE Field 7 shall be 0.

14. Only allowed use of the line widening property shall be when physical model space width is important.

15. Shall always point to a boundary curve. Parameter fields 6-9 shall be ignored.

16. One or more drawing entities is required.

17. Due to computation stability, the use of the 126 and 128 entities is encouraged instead of the use the 112 and 114 entities.

* Denotes an ASME Y14.26M Appendix J, Untested Entities, capability

3.2.2.3. Entity construction. The following entities (in entity number order) have particular meanings when used for engineering drawings. The requirements in this section shall be met in all conforming data files and by all translator implementations of the Class II subset of ASME Y14.26M.

102 Composite Curve. Composite curves are intended for showing connectivity and continuity. They shall contain a minimum of two entities one of which shall be a curve the line entity included.

124 Transformation Matrix. Defining matrices are used to position an entity into model space from its definition space. When entities share the same plane of definition, they shall use the same transformation matrix to avoid multiple identical matrices being included in the file. If an entity contains translation information in its PD section, a transformation matrix shall not be used to translate the entity.

202 Angular Dimension. This entity shall have two leaders, and a vertex point. The Z displacement of the vertex point can be attained from any of the subordinates.

206 Diameter Dimension. This entity shall specify its arc center (may not be defaulted). The Z displacement of the arc center can be obtained from the subordinates. The arc center shall be valid. If multiple leaders occur, the first segment of each leader shall be collinear and opposite in direction.

212 General Note. General notes shall use a font code to minimize the number of text strings in the note. At least one string is required, but the number of different strings shall be minimized. Form numbers plus position information on each string shall be used. The Rotation Angle field shall contain the string angle. Transformation matrices shall not be used for string angles. Null strings are allowed and may be used to pattern a note into one of the standard forms.

216 Linear Dimension. When there are two witness lines, they shall be parallel to each other. 218 Ordinate Dimension. This entity shall not be used in place of the general label. The leader shall contain only one segment.

222 Radius Dimension. This entity shall specify its arc center (may not be defaulted). Z displacement of the arc center can be attained from any of its subordinates. Arc center shall be valid. If multiple leaders occur, the first segment of each shall be collinear. If two leaders are used, one and only one shall be of Form 4.

228 General Symbol. This entity shall be used for annotation. Flags in the subordinate entities (even geometry) shall be set to annotation. This entity shall not be used in place of a subfigure or group. All subordinate entities to the general symbol entity shall be coplanar.

230 Sectioned Area. This entity is used to provide for area fills. The normal distance between lines is constant and shall not be zero. Wider spaces between lines are to be considered blank lines with regard to normal distances. Boundary curve and islands are closed and not self- intersecting. Island interiors are mutually disjoint. Islands lie in the interior of the boundary curve. Boundary curve and islands can be logically dependent and do not need to be marked as annotation if they are not annotation.

404 Drawing. The drawing entity defines the basic engineering drawing format for each sheet. One drawing entity shall exist in the file for each sheet, or collection of sheets, of an engineering drawing. An example of a collection of sheets would be several B size sheets placed in an H size engineering drawing. All entities pointed to by the drawing entity shall be physically dependent and shall be flagged as annotation.

406 Form 5 Line Widening. The only allowed use of the line widening property is the case when physical model space width is important. It shall not be used to indicate plotter width or line weight.

406 Form 15 Name. This entity is used to convey the drawing name. A Drawing Name using Entity 406, Form 15 is required. If there is no name available in the architecture of the system, the preprocessor shall insert one, a reasonable default being global parameter 3.

406 Form 16 Drawing Size. A drawing size property shall be included for each drawing entity in the file. If drawing size is not in the architecture of the system, the preprocessor shall insert one and the drawing size for each sheet shall match the drawing size letter defined in the start section (see 3.2.2.4.1).

406 Form 17 Drawing Units. A drawing units property shall be included for each drawing entity in the file. If drawing units is not in the architecture of the system, the preprocessor shall use the defaults given in global parameters 14 and 15.

The simplest entity type shall be used to represent each piece of geometry, and zero size entities shall not be used. For instance, a B-Spline curve shall not be used to represent a circular arc. A zero length line entity or a zero diameter circle shall not occur in the file.

All 200 series entities shall be flagged as annotation and shall be parallel to the viewing plane, except for crosshatching. All dependent entities with parent 200 entities shall be flagged as annotation and shall be coplanar with their parent. The only exception is for geometry entities associated with the Sectioned Area (230 and 106 Forms 31-38). Any annotation entity which points to multiple leaders and multiple witness lines shall order those leaders and witness lines so that leader-1 corresponds logically to witness-1 and leader-2 to witness-2.

3.2.2.4. File construction.

3.2.2.4.1. Start section. The following information shall be given in the Start Section of the file:

a. Statement of conformance to this application subset, 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. All part and drawing identification required in the drawing title block by DOD-STD-100 and MIL-T-31000.

c. Revision letters of most recent change to each drawing sheet in the file.

d. Performing organization, date of the ASME Y14.26M file preprocessing and contract number.

e. Intended drawing size letter and number of drawing sheets in this file.

f. Data organization method with contents of each level, for example:

Level	Description
1	model entities
201	dimension
202	crosshatching

3.2.2.4.2. Global section. Fields in the global section shall be restricted to certain ranges and shall not be defaulted except as noted below for parameters 1, 2, 12, 20, and 24.

Field	Value	Required
1	,	N Default to ,
2	;	N Default to ;
3-11		Y
12		N Default to Field 3
13	1.0	Y
14	1-11	Y
15-19		Y
20		N Default to Field 1
21		Y
22		Y
23	4-6	Y
24	0-7	N Default to zero

3.2.2.4.3. Directory entry section. See notes for Table II for restrictions placed on the parameters in the directory entry section. In addition, the following capabilities shall be provided and shall be supported for all entities as required by ASME Y14.26M. ASME Y14.26M defines the actions of the preprocessors and postprocessors for the directory section parameters on an entity specific basis:

a. Line font pattern.
b. The level number field shall be zero or positive except where necessary to maintain the meaning of the referenced entity.
c. View pointer.
d. Translation matrix.
e. Blank status flag.
f. Subordinate entity switch.
g. Entity use flag.
h. Hierarchy status flag.
i. Line weight number.
j. Color number.
k. Form number.

3.2.2.4.4. Parameter data section. See notes for Table II for restrictions placed on the parameters in the parameter data section.

3.2.2.5. Mapping of information content to ASME Y14.26M subset entities. Engineering drawing geometry shall be mapped into ASMEY14.26M geometry entities and organized as necessary with the composite curve, subfigure definition, and subfigure instance entities. Text shall be represented by the general note entities and

shall not be represented as geometry. Geometry that also happens to be text, such as a company's logo printed on a PC board, is not held to this restriction. Annotation which has a named ASME Y14.26M representation, such as dimensions, general symbols, and centerlines shall be represented by their named ASME Y14.26M entity and shall not be represented as geometry. Use of ASME Y14.26M constructs such as the dotted line font (DE Field 4-5) is encouraged to reduce large file lengths. (See 6.3.)

3.2.2.6. Data accuracy requirements. All data transformations shall maintain an accuracy of 1.0 x 10-6 units on all parametric and coordinate values and all measurable dimensions.

3.2.2.7. User conventions and data organization. A minimum complexity drawing and view entity combination shall be used to assure a part model being created on all destination systems. A drawing size property shall be used to define drawing limits. As specified in the contract or other form of agreement, data shall be organized as one drawing per file with multiple sheets permitted, or shall be restricted to one sheet per file.

3.2.3. Class III subset - electrical/electronic applications. The electrical/electronic applications subset of ASME Y14.26M defined herein addresses the representation and exchange of data for electrical and electronic products including printed wiring boards, printed wiring assemblies, hybrid microassemblies, flexible printed wiring harnesses, cables, and conventional wiring harnesses. Emphasis is on component and circuit element descriptions, their placement, their connectivity, and the routing of electrical paths. This subset supports both the physical view of the product and the logical view of the product. The physical view includes product representations such as the assembly placement, the etch artwork, pad layouts, etc., while the logical view of the product includes representations such as the netlist, schematic, etc. Production of drawings and direct extraction of information for subsequent computerized process steps are supported. Inclusion of both the logical view information and the physical view information in the same file is not precluded. Completeness and functionality requirements of the received model for design, manufacturing, and testing purposes are the basis of this subset. The IGES Electrical Application Guide provides additional guidance in this usage.

3.2.3.1. Information requirements and data functionality. ASME Y14.26M files for electronic products rely heavily on both geometry and logical relationships. Components or circuit elements are defined to include graphic outline and appearance features, logical references to properties, logical ownership of connection points, and logical relations to other components or circuit elements. The relationships include connectivity between components or circuit elements, connecting geometry, signal information, and property and file data structure relationships. Examples include properties (component or circuit element value, drill-hole size, line trace thickness), attributes (current, resistance, wattage), transformation matrices, text display templates, and simple, predefined display symbols.

Three dimensional geometry and text annotation form the majority of data items. Non-geometric information in the form of color, line weight, line font, and level is required as well. Finally, relationships among the data such as subfigures and connectivity are required to help structure the large quantities of data.
Information requirements for this application subset include (but are not limited to):

a. Component or circuit element descriptions of three dimensional geometry in the form of points, lines, circular arcs, and curves.

b. Non-geometric attributes of color, line weight, and line font.

c. Electrical/electronic attributes of current, resistance, and wattage.

d. Data relationships including the concept of subfigures, network subfigures, external references, connect points, connectivity, and signals.

e. Data organization methods such as Level, for example:

Level	Description
1	model entities
201	dimension
202	crosshatching

f. Part name, drawing number, formal identification, and change history.

g. Text annotation for display.

h. Drafting entities such as dimensions and text notes.

i. Printed wiring board layering for interconnection routing, power planes, and ground planes.

j. Back annotation using a file containing only the changes to the netlist.

3.2.3.2. Connectivity. Forming a logical connection between two or more items requires the ability to represent the following:

- The logical connection between a unique network subfigure (e.g., component) and each of its logical points of connection.
- The signal and its identification (if any) at the components unique connection point.

Forming a physical connection between two or more items requires the ability to represent the following:

- The exact location of each connection point.
- The ability to represent a physical connection between the two items (whether by path, via, or wire).

The term "connect node" refers to a data base entity which represents the logical and, optionally, the physical location of connection. The term "link" refers to the logical representation of the signal formed. and "signal name" refers to the signal identifier. The term "join" refers to the data base entity or entities which represent the physical connection between the items.

Each item to be connected requires a connect point to represent each possible connection point of the item. A signal may be formed between any such items by a link which references the connect points to be connected. This creates an associativity between the connect points, and thus the connected items. The signal name may be used to uniquely identify the particular signal formed. The join may be used to provide a graphical representation of the signal. In electrical applications, the join is most often represented by a line (schematic) or a widened line (printed wiring board).

In printed circuit electrical/electronic applications, the items to be connected are typically electrical components (e.g., resistor, 16-pin DIP) or, for schematics, circuit elements (e.g., gates). Most often these items are represented by subfigures which are defined once, then referenced (instanced) in the data base for each occurrence of the item. For example, each pin of a component is a potential connection point in a signal; thus each component subfigure has a connection place defined for each pin. When such a subfigure is instanced, its

connect points shall also be instanced. This allows each connect point to participate in the unique signal to which it belongs. An instanced connect point, when added to a signal, is different from its definition which is not a member of any signal. Note that components and connect points may be instanced without specifying spatial information. This occurs, for instance, in a netlist file.

These subfigures, representing electrical components, often contain text describing the component and its pins. In some cases (e.g., part number), this text is fixed and unchanging. In other cases (e.g., reference designator), the text may be variable and thus may not be filled in until the subfigure is instanced. This text (both fixed and variable), like the connect point, is instanced along with its parent subfigure. In some cases, a connect point and a text template are related (e.g., the connect point represents a component pin and the text node labels the pin number).

3.2.3.3. ASME Y14.26M entity subset specification. The subset of entities used is dictated by the application data being transferred. However, a base level support for driving almost all design, manufacturing, and documentation applications includes, but is not limited to, processing the following entities:

Geometry - circle, copious data, line, point, transformation matrix, flash, and connect point.

Annotation - text display template, general note.

Drafting - witness line, leader arrow, general label, angular/diameter/linear/ordinate/point/radius dimension.

Structure - network subfigure definition and instance, and flow associativity.

Table III lists the entities of this subset. Only ASME Y14.26M entities which are enumerated in this table shall be used for representing electrical and electronic application product definition data. Other valid ASME Y14.26M entity types may be present in the file as described by 3.1.1. Additional requirements are placed on the global section of a file, and certain field value restrictions are also placed on the range of parameter values in both the directory entry (DE) and the parameter data (PD) sections of a valid ASME Y14.26M file.

TABLE III. - *ASME Y14.26M entity content of electrical/electronic applications subset*

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

	ENTITY	FORM	ENTITY NAME	NOTES DE	NOTES PD
	0		Null		
	100		Circular Arc	1	
	102		Composite Curve	1	
	104		Conic Arc	1	
	104	1	Conic Arc	1	
	104	2	Conic Arc	1	
	104	3	Conic Arc	1	
	106	11	2D Linear String	1	5
	106	12	3D Linear String	1	5
	106	20	Centerline Through Points	1	
	106	21	Centerline Through Circle Centers	1	
	106	40	Witness Line		
	106	63	Simple Closed Planar Curve	1	
	108		Plane - Unbounded		
	110		Line	1	
	112		Parametric Spline Curve		
	116		Point	1	
	124	0	Transformation Matrix		
	124	1	Transformation Matrix		
	125		Flash		
	126		Rational B-Spline Curve		
	132		Connect Point		
	202		Angular Dimension		
	206		Diameter Dimension		
	210		General Label		
	212		General Note	1	2
	214		Leader Arrow	1	
	216		Linear Dimension	1	
	218		Ordinate Dimension	1	
	220		Point Dimension	1	
	222	0	Radius Dimension	1	
*	222	1	Radius Dimension	1	

* Denotes an ASME Y14.26M Appendix J, Untested Entities, capability

TABLE III. - *ASME Y14.26M entity content of electrical/electronic applications subset* - Continued

	ENTITY	FORM	ENTITY NAME	NOTES DE	NOTES PD
	228	0	General Symbol	1	
*	228	1	General Symbol	1	
*	228	2	General Symbol	1	
*	228	3	General Symbol	1	
	230		Sectioned Area		
	302		Associativity Definition		
	308		Subfigure Definition	1	
	312	0	Text Display Template - Abs		
	312	1	Text Display Template - Incr		
	320		Network Subfigure Definition		
*	322		Attribute Table Definition		
	402	1	Group with BP Instance		
	402	7	Group with out BP Instance		
	402	12	External Reference File Index		
	402	18	Flow Associativity		3
	402	>5000	Associativity Instance		
	404		Drawing		
	406	1	Definition Levels Property		
	406	2	Region Restriction Property		
	406	3	Level Function Property		
	406	5	Line Widening Property		
	406	6	Drilled Hole Property		
	406	12	External Reference File List		
	406	15	Name		4
	406	16	Drawing Size		
	406	17	Drawing Units		
	408		Subfigure Instance		
	410		View		
	412		Rect Array Sub Instance		
	414		Circ Array Sub Instance		
	416		External Reference		
	420		Network Subfigure Instance		
*	422		Attribute Table Instance		

* Denotes an ASME Y14.26M Appendix J, Untested Entities, capability

NOTES FOR TABLE III:

1. DE Field 4, Line Font Pattern, shall be 1, 2, 3, 4, or 5
   DE Field 5, Level, shall be 0 or positive
   DE Field 6, View Pointer, shall be 0
   DE Field 8, Label Display Pointer, shall be 0
   DE Field 13, Color Number, shall be 0-8.

* 2. Font Characteristic shall be 1, 1001, 1002, or 1003.

3. PD Index 8, Type Flag, shall be set to 1 or 2 when both logical and physical product definitions coexist in the same file. PD Index 9, Function Flag, shall be set to 1.

4. The Name Property entity shall take precedence over a name in DE field 18, Entity Label, for any entity which has a name property.

5. N1 (the number of Points, PD Index 2) shall be 3 or more.

* Denotes an ASME Y14.26M Appendix J, Untested Entities, capability

3.2.3.4. Entity construction. The following entities (in entity number order) have particular meanings when used for electrical product data. The requirements in this section shall be used in all conforming data files and by all translator implementations of the Class III subset of ASME Y14.26M.

100 Circular Arc Entity. The electrical use of this entity is in the geometric representation of component parts and their symbolic representations. In such usage, it is usually part of a subfigure. It may also be used as connection geometry.

102 Composite Curve Entity. The electrical use of this entity is in the geometric representation of component parts and their symbolic representations. In such usage, it is usually part of a subfigure. It may be used as connection geometry.

104 Conic Arc Entity. The electrical use of this entity is in the geometric representation of component parts and their symbolic representations. In such usage, it is usually part of a subfigure. It may be used as connection geometry.

106 Copious Data Entity. Forms 11 and 12 of this entity may be used as connection geometry. Forms 20, 21, and 40 are used in the drafting documentation of the product. Form 63, Simple Closed Planar Curve, may be used to define an auto-router restriction area or a PC-defined (or IC-defined) area having special attributes.

108 Plane Entity. Certain layers of PC design are designated as ground, power, or heat sink, and as such are large conductive areas. These layers, as well as larger curved or rounded conductive areas on other layers, are best defined by the Plane entity. Note that the form number indicates whether the bounded region is positive or void (i.e., copper-clad area or cutout).

110 Line Entity. The Line entity has several important uses in the electrical application. It may be used to construct component outlines, or to represent connection geometry.

112 Parametric Spline Curve Entity. The electrical use of this entity is in the geometric representation of component parts and their symbolic representations. In such usage, it is usually part of a subfigure. It may be used as connection geometry.

116 Point Entity. The point entity is used to locate features that do not participate in connectivity (e.g., a mounting hole).

124 Transformation Matrix Entity. Electrically, a transformation matrix entity may be used to rotate subfigures to other than normal (top up) positions or may be used to reverse the direction of an arc draw (determinant is negative one). Generally, rotations are about the Z axis for PC and IC constructs, but may be about any axis for 3D cabling files.

125 Flash Entity. The Flash entity may be used to represent a repetitive artwork feature which is usually produced by photo-optical means. Examples include PC pads, clearances, and hybrid and IC features.

126 Rational B-Spline Curve Entity. The electrical use of this entity is in the geometric representation of component parts and their symbolic representations. In such usage, it is usually part of a subfigure. It may be used as connection geometry.

132 Connect Point Entity. The Connect Point entity is used to represent a point of connection. A subfigure defining an electrical component typically uses the Connect Point entity to represent a pin of the logical or physical component or symbol. A Connect Point may also be used in a stand-alone mode, representing a via hole for example. The drilled hole property may be attached to the connect point if appropriate.

212 General Note Entity. A General Note is used to display constant text. Design notes would require a General Note, for example.

230 Sectioned Area Entity. The electrical use of this entity is in the geometric representation of large plated or unplatted board areas (e.g., power and ground planes or keep-out areas). It may be used as connection geometry.

302 Associativity Definition Entity. When the originating system provides for a relationship not included among the ASME Y14.26M predefined associative, this entity is required. Possible uses are to relate subfigures to entities in other data bases (e.g., circuit analysis or text requirements) or for back-annotation purposes.

308 Singular Subfigure Definition Entity. This entity may exist in a library of physical or logical primitive parts in the originating system. This entity shall not be used for components which participate in connectivity.

312 Text Display Template Entity. The Text Display Template may be used to display text which may be unique in each instance of the defined entity (a pin number, for example).

320 Network Subfigure Definition Entity. For PC, cable, IC, hybrid, and gate array usage, a subfigure usually represents a component and its required contacts. This entity is normally a library physical or logical figure in the originating system.

322 Attribute Table Definition Entity. This entity provides electrical and electronic attributes which apply to the components and circuit elements.

402 Associativity Instance Entity. This entity relates other entities within a file to provide a set with a common meaning. Those associative which are predefined by ASME Y14.26M are identified by ASME Y14.26M form numbers (e.g., form 18: Flow). The user-defined associative are defined by an entity 302 and its form number.

406 Property Entity. The use of a property to indicate the meaning or purpose of a geometric entity applies to electrical constructs as well as general graphics. A Connect Point entity may point to the Drilled Hole property. A Plane entity or Simple Closed Area entity may point to the Region Restriction property. Any property, however, may point to the Text Display Template, with the text string specified in the property. In this case, the Text Display Template locates the text display.

408 Singular Subfigure Instance Entity. This entity allows a non-electrical primitive component to be instanced in a number of unique locations. This entity shall not be used for components which participate in connectivity.

412 Rectangular Array Subfigure Instance Entity. This entity may be used to instance multiple subfigures, but shall not be used for instancing connectivity related entities (e.g., Connect Point entity (132), Network Subfigure Instance entity (420)).

414 Circular Array Subfigure Instance Entity. This entity may be used to instance multiple subfigures, but shall not be used for instancing connectivity related entities (e.g., Connect Point entity (132), Network Subfigure Instance entity (420)).

416 External Reference Entity. This entity provides a link between an entity in a referencing file and the definition or a logically related entity in a referenced file. The capability is essential to the concept of component libraries.

420 Network Subfigure Instance Entity. This entity allows an electrical component to be instanced in a number of unique locations. Note that owned Connect Point entities shall be instanced with this entity.

422 Attribute Table Instance Entity. This entity provides electrical/electronic attributes which apply to components and circuit elements.

Several of the geometry entities may be used to implement physical connections on schematics or physical products such as printed circuit boards, hybrids, integrated circuits, and flex cables. The use of the entity may be defined by the level function property or DE level field. When the geometry is used for display purposes, its width will usually be determined by DE field 12, line weight number. When the geometry is used for physical implementation, its width will usually be determined by use of the Line Widening property (406 form 5).

3.2.3.5. File construction.

3.2.3.5.1. Start section. The following information shall be given in the Start Section of the file:

a. Statement of conformance to this application subset, 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. All part and drawing identification required in the drawing title block by DOD-STD-100 and MIL-T-31000.

c. Revision level of the file.

d. Performing organization, date of the ASME Y14.26M file preprocessing, and contract number.

e. Data organization method with contents of each level, for example:

Level	Description
1	model entities
201	dimension
202	crosshatching

3.2.3.5.2. Global section. Fields in the global section shall be restricted to certain ranges and shall not be defaulted except as noted below for parameters 1, 2, 12, 17, 20, and 24.

Field	Value	Required
1	,	N Default to ,
2	;	N Default to ;
3-11		Y
12		N Default to Field 3
13	1.0	Y
14	1-11	Y
15		Y
16		Y
17		N
18		Y
19		Y
20		N Default to Field 1
21		Y
22		Y
23	4-6	Y
24	0-7	N Default to zero

3.2.3.5.3. Directory entry section. See Notes for Table III for restrictions placed on the parameters in the directory entry section. In addition, the following capabilities shall be provided and shall be supported for all entities as required by ASME Y14.26M. ASME Y14.26M defines the actions of the preprocessors and post processors for the directory section parameters on an entity specific basis:

a. Level Number Field. All values shall be zero or positive except where necessary to maintain the meaning of the referenced entity.
b. Subordinate Entity Switch.
c. Entity Use Flag.
d. Hierarchy Status Flag.
e. Blank Status Flag.

3.2.3.5.4. Parameter data section. See Notes for Table III for restrictions placed on the parameters in the parameter data section.

3.2.3.6. Mapping of information content to subset entities. A connect node is represented by the connect point entity while a text node is represented by the text display template entity. The flow associativity entity is used to represent a signal and contains the link, signal name, and pointers to the join entities. The network subfigure entities (definition and instance) represent electrical components which participate in signals. A number of property entities are also used, as explained below.

3.2.3.6.1. Network subfigure construction. A component is constructed using a network subfigure definition entity. The graphics represent the component geometry the same as referenced by the singular subfigure definition entity. A separate set of pointers is provided which points to the defining connect point entities. These connect point entities define the locations and characteristics of the component's pins. Properties (for example the Part Name property) may be attached to the network subfigure definition entity.

3.2.3.6.2. Connect points. A component pin (or surface mounted device pad, IC I/O port, lead frame, schematic symbol lead, etc.) is represented by a connect point entity. The connect point entity is used in both logical and physical product designs. The physical location may be specified, along with several characteristic flags (connection type, function type, I/O direction). There is a pointer to the parent network subfigure entity (definition or instance) which provides a much needed association for signal processing. An additional subfigure instance pointer is provided for connect point display. This allows a graphical symbol to be displayed, representing the connect point. The pin number is provided in the function connect point identifier field along with a pointer to a text display template for pin number display. A pin function name is provided in the connect point function name field along with a pointer to a text display template for its display.

3.2.3.6.3. Signal construction. A signal representing one set of electrically common connect points is constructed using the flow associativity entity. It contains pointers to other associated flow associativity entities, the connect point entities participating in the signal (this is the link), and the join entities representing the geometry of the signal (logical or physical). Also contained is a list of signal names which may be used to identify the signal, along with a set of pointers to text display template entities which may be used to display the first signal name in a number of locations. Two characteristic flags determine the signal type (logical or physical), and the function type (fluid flow or electrical signal).

A signal, then, is represented by one flow associativity entity pointing to a set of electrically common connect points. This is the link. The join entities represent the physical display geometry of the signal. For a schematic (logical), a line without width is typically used. For a printed board (physical), geometry with the line widening property is typically used. A number of signal names may be associated with the signal. Multiple displays of the first, or primary, name are possible. The components participating in a signal are represented by the network subfigure instance entity. Note that the connect point entities belonging to a component are instanced along with the subfigure. This is necessary to allow a subfigure to participate in a number of different signals while retaining unique component/pin identification. Each component is usually identified by a reference designator, supplied by the Primary Reference Designator field.

3.2.3.6.4. Information display. Throughout this discussion references have been made to the text display template entity. This entity allows text embedded in an entity to be displayed without the redundant specification of the text string. There are two reasons for this feature. First, it eliminates a possible source of error by allowing the information to be specified in only one place. Second, it reduces the file size overhead. This entity exists in two forms, absolute and incremental. The absolute form provides an exact location for display of the information. The incremental form provides an offset to be applied to the parent entity's location which provides the exact location for display of information such as pin numbers. When a direct pointer for information display is provided, the base location is readily determined from the parent entity's location, such as when displaying a pin number. In the case of property value display, the base location shall be determined by remembering the location of the property entity's parent entity. This would occur when displaying the part

name. Also, in this case, the pointer to the text display template entity is located in the additional pointers section of the property entity parameters.

3.2.3.6.5. Attributes. Each electronic device has various properties, or attributes, which describe the behavior and characteristics of the device. These attributes must also be represented in the entities of ASME Y14.26M. The Attribute Table Definition and Instance entities are used to do this. These entities use one extensible format which can hold a variety of attribute definitions, either singly or in combination. By defining the various attribute combinations once, they can be referred to by all entities which have those attributes.

3.2.3.6.6. Additional considerations. The situation is exactly the same for both logical and physical representations. The only differences arise in the subfigure and join entities used. In fact, an ASME Y14.26M file may contain representations for both the schematic and the board. The flow associativity entity contains a type flag to indicate the connection type (logical or physical). In this case, one flow associativity entity would represent the logical connection and a second flow associativity entity would represent the physical connection. The two associative would be related by the pointers provided in the flow associativity.

3.2.3.7. Data accuracy requirements. All data transformations shall maintain an accuracy of 1.0 x 10-6 units on all parametric and coordinate values and all measurable dimensions.

3.2.3.8. User conventions and data organization. None

3.2.4. Class IV subset - geometry for NC manufacturing. This numerical control machining subset of ASME Y14.26M shall be used to encode product data for the subsequent purposes of manufacturing by numerical control. As such, it is designed to directly support the geometry data needs of process planning and numerical control cutter path generation. The data exchange shall preserve the precision and accuracy of all wire frame and surface geometry as well as the first order continuity between geometry entities. Exchange emphasis is on completeness and functionality of the received part model.

3.2.4.1. Information requirements and data functionality. Geometry and text annotation form the majority of data items. Geometry data is used to describe the nominal shape of the product either as a 2-D wire frame or as a 3-D wire frame model with surfaces. (NOTE: As used herein, nominal is defined as an attribute set which describes the size for specification or design purposes, but does not describe the actual or true size. The designation 2x4, as used in the lumber industry, is an example of such an attribute.) 2-D descriptions are used to describe the profile of turned parts or of 2-D parts such as found in sheet metal work. 3-D descriptions are used for multi-axis machining.

Nominal dimensions given in text annotation shall agree with the corresponding values in the geometry data description. A major purpose of text annotation shall be to represent tolerances on the geometry. Annotation is also used to describe material specifications and administrative data. Non-geometric information in the form of color, line weight, line font, and level is needed as well. Finally, relationships among the data are defined to help structure the large quantities of product data.

3.2.4.2. ASME Y14.26M entity subset specification. Table IV lists the entities of this subset. Only ASME Y14.26M entities which are enumerated in this table shall be used for representing geometry for NC manufacturing. Other valid ASME Y14.26M entity types may be present in the file as described by 3.1.1. Additional requirements are placed on the global section of a file, and certain field value restrictions are placed on the range of parameter values in both the directory entry (DE) and the parameter data (PD) sections of a valid ASME Y14.26M file.

TABLE IV. - *ASME Y14.26M entity content of geometry for NC manufacturing subset*

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

	ENTITY	FORM	ENTITY NAME	NOTES DE	NOTES PD
*	0		Null		
	100		Circular Arc	1	12
	102		Composite Curve	1	12
	104		Conic Arc	1	2,12
	104	1	Conic Arc	1	2,12
	104	2	Conic Arc	1	2,12
	104	3	Conic Arc	1	2,12
	106	1	Coordinate Pairs	1	3
	106	2	Coordinate Triples	1	3,12
	106	11	2D Linear String	1	4,12
	106	12	3D Linear String	1	4,12
	106	20	Centerline Through Points	1	
	106	21	Centerline Through Circle Centers	1	
	106	40	Witness Line	1	
	106	63	Simple Closed Planar Curve	1	
	108		Plane	1	
	110		Line	1	13
	116		Point	1	5,12
	118	1	Ruled Surface	1	12
	120		Surface of Revolution	1	12
	122		Tabulated Cylinder	1	12
	124	0,1	Transformation Matrix	6	
	126		Rational B-Spline Curve	1	
	128		Rational B-Spline Surface	1	12
	130		Offset Curve	1	15
	140		Offset Surface	1	15
	142		Curve on a Parametric Surface	1	
	144		Trimmed Parametric Surface	1	12

* Denotes an ASME Y14.26M Appendix J, Untested Entities, capability

TABLE IV. - *ASME Y14.26M entity content of geometry for NC manufacturing subset* - Continued

	ENTITY	FORM	ENTITY NAME	NOTES DE	NOTES PD
	214	2	Leader Arrow, Triangle	1,9	10
	214	3	Leader Arrow, Filled Triangle	1,9	10
	214	11	Leader Arrow, Open Triangle	1,9	10
	216		Linear Dimension	1	
	218		Ordinate Dimension	1	
	220		Point Dimension	1	
	222	0	Radius Dimension	1	
*	222	1	Radius Dimension	1	
	228	0	General Symbol	1	
*	228	1	General Symbol	1	
*	228	2	General Symbol	1	
*	228	3	General Symbol	1	
	402	3	Associativity, Views Visible		
	402	4	Associativity, Views Visible, Color,Line Font		
	402	7	Associativity,Group w/o Back Pointer	1	
	402	9	Associativity, Single Parent	1	11
	404		Drawing		
	406	15	Name		14
	406	16	Drawing Size Property		
	406	17	Drawing Units Property		
	410		View		

NOTES FOR TABLE IV:

1. DE Field 4, Line Font Pattern, shall be 1, 2, 3, 4, or 5 DE Field 9c, Entity Use, shall be 00, 01, 02, 03, or 05
   DE Field 9d, Hierarchy, shall be 01.

2. The conic shall be defined in the standard position.

3. PD Index 2, Number of n-tuples, shall be greater than 1.

4. PD Index 2, Number of n-tuples, shall be greater than 2.

5. PD Index 4, PTR, shall be 0.

6. DE Field 7, Transformation Matrix, shall be 0.

* Denotes an ASME Y14.26M Appendix J, Untested Entities, capability

7. PD Index 2, Number of Leaders, shall be non-zero. All of the pointer fields, DENOTE and DE1 through DEN, are required to be present and shall point to valid entities.

* 8. PD Index 5, Font Characteristic, shall be 1, 1001, 1002, or 1003.

9. DE Field 9b, Subordinate Status, shall be 01
DE Field 7, Transformation Matrix, shall be 0.

10. PD Index 4, ZT, shall be 0.0.

11. PD Indices 3 through 2+NC, pointers to parent and children, shall be pointers to planes (Type 108).

12. If 2-D wire frame descriptions are used, Z-coordinates of this entity shall be 0.0.

13. If 2-D wire frame descriptions are used, Z-coordinates of this entity shall be 0.0, unless this entity is being used as the axis of revolution for a surface of revolution entity.

14. The Name Property entity shall take precedence over a name in DE field 18, Entity Label, for any entity which has a name property.

15. If 2-D wire frame descriptions are used, index 12, VZ, shall be 0.0.

* Denotes an ASME Y14.26M Appendix J, Untested Entities, capability

3.2.4.3. Entity construction. The following entities (in entity number order) have particular meanings when used for NC Manufacturing. The requirements in this section shall be met in all conforming data files and by all translator implementations of the Class IV subset of ASME Y14.26M.

100 Circular Arc. The circular arc is used to represent circular edges of a part. When using the circular arc to represent a complete circle, the start point and the terminate point shall be the same and shall be on the positive XT axis (PD indices 5 and 7 shall be identical, and PD indices 4 and 6 shall be identical).

102 Composite Curve. Composite curves are intended for showing connectivity and continuity among a number of component geometry entities. For example, composite curves are used to represent the profile of a part.

104 Conic Arc. The conic arc is used to represent elliptical, hyperbolic, and parabolic edges of the part. When
using the conic arc to represent a full ellipse, the start point and the terminate point shall be the same and shall be on the positive XT axis. (PD indices 9 and 11 shall be 0.0,
and PD indices 8 and 10 shall be identical).

124 Transformation Matrix. Defining matrices are used to position an entity into model space from its definition space. When entities share the same plane of definition, they shall use the same transformation matrix to avoid multiple identical matrices being included in the file. If an entity contains translation information in its PD section, a transformation matrix shall not be used to translate the entity.

126 Rational B-spline Curve. The rational B-spline curve is used to represent free-form edges of a part. It shall not be used to represent linear, circular, or conic edges of a part since more appropriate entities exist for these shapes.

202 Angular Dimension. This entity shall have two leaders and a vertex point. The Z displacement of the vertex point can be attained from any of the subordinates.

206 Diameter Dimension. This entity shall specify its arc center (may not be defaulted). The Z displacement of the arc center can be attained from the subordinates. The arc center shall be valid. If multiple leaders occur, the first segment of each leader shall be collinear and opposite in direction.

212 General Note. General notes shall use a font code to minimize the number of text strings in the note. At least one string is required, but the number of different strings shall be minimized. Form numbers plus position information on each string shall be used. The Rotation Angle field shall contain the string angle. Transformation matrices shall not be used for string angles. Null strings are allowed and may be used to pattern a note into one of the standard forms.

216 Linear Dimension. When there are two witness lines, they shall be parallel.

218 Ordinate Dimension. This entity shall not be used in place of the general label. The leader shall contain only one segment.

222 Radius Dimension. This entity shall specify its arc center (may not be defaulted). Z displacement of the arc center can be attained from any of its subordinates. Arc center shall be valid. If multiple leaders occur, the first segment of each shall be collinear. If two leaders are used, one and only one shall be Form 4.

404 Drawing. The drawing entity defines the basic engineering drawing format for each sheet. One drawing entity shall exist in the file for each sheet of an engineering drawing.

406 Form 15 Name. This entity is used to convey the drawing name. A drawing name using Entity 406, Form 15 is required. If there is no name available in the architecture of the system, the preprocessor shall insert one, a reasonable default being global parameter 3.

406 Form 16 Drawing Size. A drawing size property shall be included for each drawing entity in the file. If drawing size is not in the architecture of the system, the preprocessor shall insert one.

406 Form 17 Drawing Units. A drawing units property shall be included for each drawing entity in the file. If drawing units is not in the architecture of the system, the preprocessor shall use the defaults given in global parameters 14 and 15.

In general, the simplest entity type shall be used to represent each piece of geometry, and zero size entities shall not be used. For instance, a B-Spline curve shall not be used to represent a circular arc. A zero length line entity or a zero diameter circle shall not occur in the file.

All 200 series entities shall be flagged as annotation and shall be parallel to the viewing plane. All dependent entities with parent 200 entities shall be flagged as annotation and shall be coplanar with their parent. Any annotation entity which points to multiple leaders and multiple witness lines shall order those leaders and witness lines so that leader-1 corresponds logically to witness-1 and leader-2 to witness-2.

3.2.4.4. File construction.

3.2.4.4.1. Start section. The following information shall be given in the Start Section of the file:

a. Statement of conformance to this application subset, 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. All part and drawing identification data required in the drawing title block by DOD-STD-100 and MIL-T-31000.

c. Revision level of the file.

d. Performing organization, date of the ASME Y14.26M file preprocessing, and contract number.

e. Data organization method with contents of each level, for example:

Level	Description
1	model entities
201	dimension

3.2.4.4.2. Global section. Fields in the global section shall be restricted to certain ranges and shall not be defaulted except as noted below for parameters 1, 2, 12, and 24.

Field	Value	Required	
1	,	N	Default to ,
2	;	N	Default to ;
3-11		Y	
12		N	Default to Field 3
13	1.0	Y	
14	1-11	Y	
15-19		Y	
20		N	Default to Field 1
21		Y	
22		Y	
23	4-6	Y	
24	0-7	N	Default to zero

3.2.4.4.3. Directory entry section. See notes for Table IV for restrictions placed on the parameters in the directory entry section. In addition, the following capabilities shall be provided and shall be supported for all entities as required by ASME Y14.26M. ASME Y14.26M defines the actions of the preprocessors and postprocessors for the directory section parameters on an entity specific basis:

a. Line font pattern.
b. The level number field shall be zero or positive except where necessary to maintain the meaning of the referenced entity.
c. Translation matrix.
d. Blank status flag.
e. Subordinate entity switch.
f. Entity use flag.

g. Hierarchy status flag.
h. Line weight number.
i. Color number.
j. Form number.

3.2.4.4.4. Parameter data section. See notes for Table IV for Restrictions placed on the parameters in the parameter data section.

3.2.4.5. Mapping of information content to ASME Y14.26M subset entities. NC Manufacturing geometry shall be mapped into ASME Y14.26M geometry entities and linked together as necessary with composite curve entities. Text shall be represented by the general note entities and shall not be represented as geometry. Annotation including dimensions, labels, and centerlines shall be represented by their named ASME Y14.26M entity and shall not be represented as geometry. Line weight, color, and line font information shall be represented by the appropriate global and directory entry parameters. Level attributes shall be represented by the appropriate directory entry parameter.

3.2.4.6. Data accuracy requirements. All data transformations shall maintain an accuracy of 1.0 x 10-6 units on all parametric and coordinate values and all measurable dimensions.

3.2.4.7. User conventions and data organization. A minimum complexity drawing and view entity combination shall be used to assure a part model being created on all destination systems. A drawing size property shall be used to define drawing limits. As specified in the contract or other form of agreement, data shall be organized as one drawing per file with multiple sheets permitted, or shall be restricted to one sheet per file.

3.2.5. Class V application protocol - 3D piping. The 3-D Piping IGES Application of three dimensional piping and related equipment models, and the exchange of these models from one piping modeling application to another. In this application, emphasis is on exchange requirements for the fabrication and assembly of piping systems. It should be noted that this protocol uses some entities from IGES Version 5.1 which are not included in ASME Y14.26M.

A Class V file shall be created in accordance with the "3D Piping IGES Application Protocol" document identified in 2.1.2.

4. Quality assurance provisions.

4.1. Responsibility for inspection. Unless otherwise specified in the contract or other form of agreement, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract or other form of agreement, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.2. Responsibility for compliance. All items shall meet all requirements of section 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

4.3. Inspection procedures.

4.3.1. Technical illustration subset. Start, global, directory entry, parameter data, and terminate sections shall each be analyzed for conformance to ASME Y14.26M with an appropriate software utility. The start section shall be displayed and checked visually with requirements of 3.2.1.3.1. The global section shall be displayed and compared against the requirements of 3.2.1.3.2. Entities in the directory entry section shall be checked against Table I by an appropriate software utility. Ranges of parameter values shall be compared against requirements of Table I. A conforming MIL-D-28000 Class I preprocessor shall translate native CAD file constructs into the appropriate Class I entities. A conforming MIL-D-28000 Class I postprocessor shall translate all MIL-D-28000 Class I entities into the appropriate native CAD file constructs. For example, translating a circle into many straight line segments would not be acceptable.

4.3.2. Engineering drawing subset. Start, global, directory entry, parameter data, and terminate sections shall each be analyzed for conformance to ASME Y14.26M with an appropriate software utility. The start section shall be displayed and checked visually with requirements of 3.2.2.4.1. The global section shall be compared against the requirements of 3.2.2.4.2. Entities in the directory entry section shall be checked against Table II by an appropriate software utility. Ranges of parameter values shall be compared against requirements of Table II. A conforming MIL-D-28000 Class II preprocessor shall translate native CAD file constructs into the appropriate Class II entities. A conforming MIL-D-28000 Class II post-processor shall translate all MIL-D-28000 Class II entities into the appropriate native CAD file constructs. For example, translating a circle into many straight line segments would not be acceptable.

4.3.3. Electrical/Electronic applications subset. Start, global, directory entry, parameter data, and terminate sections shall each be analyzed for conformance to ASME Y14.26M with an appropriate software utility. The start section shall be displayed and checked visually with requirements of 3.2.3.5.1. The global section shall be compared against the requirements of 3.2.3.5.2. Entities in the directory entry shall be checked against Table III by an appropriate software utility. Ranges of parameter values shall be compared against requirements of Table III. A conforming MIL-D-28000 Class III preprocessor shall translate native CAD file constructs into the appropriate Class III entities. A conforming MIL-D-28000 Class III postprocessor shall translate all MIL-D-28000 class III entities into the appropriate native CAD file constructs. For example, translating a circle into many straight line segments would not be acceptable.

4.3.4. Geometry for NC manufacturing subset. Start, global, directory entry, parameter data, and terminate sections shall each be analyzed for conformance to ASME Y14.26M with an appropriate software utility. The start section shall be displayed and checked visually with requirements of 3.2.4.4.1. The global section shall be compared against the requirements of 3.2.4.4.2. Entities in the directory entry section shall be checked against table IV by an appropriate software utility. Ranges of parameter values shall be compared against requirements of Table IV. A conforming MIL-D-28000 Class IV preprocessor shall translate native CAD file constructs into the appropriate Class IV entities. A conforming MIL-D-28000 Class IV post processor shall translate all MIL-D-28000 Class IV entities into the appropriate native CAD file constructs. For example, translating a circle into many straight line segments would not be acceptable.

4.3.5. 3D piping application protocol. Start, global, directory entry, parameter data, and terminate sections shall each be analyzed for conformance to the requirements of the 3D Piping IGES application protocol (AP) document identified in 2.1.2. Processors must completely support the functionality defined in the 3D Piping IGES application protocol document to claim conformance to this AP. An AP compliant preprocessor must convert each piping construct of the Application Reference Model (ARM) into the specified IGES constructs of the Application Interpreted Model (AIM), with the required attributes and values. An AP compliant post-processor must convert each IGES construct of the AIM into native constructs which match the geometry, attributes, and relationships of the piping constructs specified in the ARM. The functionality of the piping constructs shall be preserved. (See the Implementation and Conformance Testing Guidelines section of the 3D Piping IGES Application Protocol document for details.)

5. Packaging.

The requirements for packaging shall be in accordance with MIL-STD-1840.

6. Notes.

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1. Intended use. This specification is designed to be incorporated into a contract to define the technical requirements to be met when it is desired to purchase product definition data or product data in digital form. ASME Y14.26M is a standard for representing digital product definition data in a neutral, public domain format. ASME Y14.26M provides a neutral format for the representation and transfer of vector graphics data used for illustration purposes between CAD systems and application programs. Information is transferred by entities that represent geometry, annotation, attribute, and logical relationships of the product model. ASME Y14.26M files are composed of five sections; Start, Global, Directory Entry, Parameter Data, and Terminate. An additional section is required for the Compressed physical format.

This specification defines the technical requirements for the exchange of digital product data in specific application subsets of ASME Y14.26M. The essential content and general requirements of application subsets are given by this specification and specific application subsets are identified. The definition of the Class V 3D Piping Application Protocol is identified by this specification. In particular the definition and use of the following specific application areas are defined:

a. Technical Illustrations - Class I subset
b. Engineering Drawings - Class II subset
c. Electrical/Electronic Applications - Class III subset
d. Geometry for NC Manufacturing - Class IV subset
e. 3D Piping - Class V Application Protocol

The number of defined applications is expected to grow as product data exchanges become commonplace, as technical groups identify and define specific application areas, and as these application subset or protocol requirements can be validated.

Listed below are other application areas being characterized and defined.

a. Process Plant Flowsheets
b. 3-D Mechanical Design/Drawing
c. Finite Element Modeling
d. Architecture, Engineering, and Construction
e. Mechanical Solid Modeling

In some cases, work is well underway to define ASME Y14.26M subsets or application protocols for these application areas.

Assuring completeness of information exchange with this subset concept relies on a careful encoding of the information into the ASME Y14.26M entities. This specification is a first attempt at this encoding. But a more rigorous method has been developed called an Application Protocol. It involves a formal information model with the rigorous mapping to the IGES entities; see the 3D Piping IGES Application Protocol document identified in 2.1.2 for further details. This specification may evolve further in the direction of application protocols to ensure quality data exchanges.

6.2. Acquisition requirements. Acquisition documents must specify the following:

a. Title, number, and date of this specification.

b. Issue of the DODISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2).

c. The type of product data being procured as Class I, Class II, Class III, Class IV, or Class V. (See 1.2)

d. The form of the ASME Y14.26M or IGES Version 5.0 (in the case of Class V) data file as ASCII or Compressed ASCII. (See 3.1.3.)

e. The physical media to be used if not magnetic tape. (See 3.1.4.)

f. For Class II, engineering drawings, specify:

1. One drawing per file with multiple sheets per file permitted. (See 3.2.2.7.)

2. One sheet per file. (See 3.2.2.7.)

6.3. File size and efficiency considerations. ASME Y14.26M files are often quite large, and implementors are urged to make use of the most efficient entity constructs.

Several of the entity constructs included in the subset classes of this specification were selected to keep the file sizes to acceptable levels. For instance, the use of subfigures greatly reduces file size where details are repeated; however, more verbose entity construct may be essential, such as stroking text characters to obtain special appearance like proportional spacing or using multiple line segments to provide a dotted line font.

Use of more efficient constructs like the dotted line font (Classes I, III, and IV) or the intercharacter spacing property (Class I) for proportional text spacing is encouraged to reduce file sizes.

6.4. Summary of start section requirements. The start section of an ASME Y14.26M data file is used to contain human-readable notes to aid in interpreting the data in the file. This specification makes use of such capability, and requirements are stated in appropriate places in the class subset descriptions. Specifically, the following paragraphs reference notes to be placed in the start section:

3.1
3.2.1.3.1
3.2.2.4.1
3.2.3.5.1
3.2.4.4.1

The format or appearance of the notes is not specified. However, for explanation a sample start section is shown below.

```
S  1
S  2  CONFORMANCE:
S  3    This IFES file conforms to the MIL-D-2800 with
S  4    Amendment 1 (20 Dec 88) Class II subset (Engineering
S  5    Drawings).
S  6  CREATED BY:
S  7    CALS Test Network
S  8    Lawrence Livermore National Laboratory
S  9    7000 East Ave,. P.O. Box 808, L-542
S 10    Livermore, CA  94550
S 11
S 12  DATE:           15 October 1988
S 13  CONTRACT NUMBER:  None
S 14  PART NAME:  LBRACKT
S 15
S 16  DRAWING NAME:  LBRACKT
S 17  DESCRIPTION:
S 18    Reference drawing name L-bracket which is comprised
S 19    of all the IGES structure entities (304-410)
S 20    specified in MIL-D-28000 Class II. Contact the CALS
S 21    Test Network to obtain procedures for conducting the
S 22    test and evaluating the results.
S 23
S 24  REVISION:         C
S 25
S 26  DRAWING SIZE
S 27    AND NUMBER:     One C-Size
S 28
S 29  PART LEVEL SCHEME:
S 30
S 31            LEVEL       ENTITY DESCRIPTION      MODE
S 32
S 33            defaulted   definition entities     model
S 34              1         geometric entities      model
S 35              2         dimension entities      draw
S 36              3         other detailing         draw
S 37              4         subfigure entities      model
S 38
S 39
```

6.5. Additional processing conditions. Certain additional ASME Y14.26M file processing practices are preferred, but are not mandatory. Implementors should be aware of the following Recommended Practices (RP), from the IGES Recommended Practices Guide, which further specify preferred processing algorithms. These include:

RP 2:	Witness Line Suppression
RP 4:	Transformation Matrix Processing
RP 7:	Maximum Coordinate Value
RP 8:	Independent Witness Lines
RP 15:	Zero Radius Arcs
RP 16:	Translation Vector
RP 17:	Model Space Scale
RP 19:	Independent and Dependent Processing
RP 21:	Comments in PD Records
RP 24:	Representation of Linear Strings
RP 27:	Limitations on Level Identifiers
RP 41:	Entity Identifiers
RP 42:	Unique Names

6.6. Definitions.

6.6.1. Acronyms used in this specification. Acronyms used in this specification are defined as follows:

a. ASME The American Society of Mechanical Engineers

b. CAD. Computer Aided Design systems make use of interactive graphics to enhance a designers ability to define the intended product.

c. DE. The Directory Entry section of an ASME Y14.26M file.

d. IC. Integrated Circuit.

e. NC. Numerical Control.

f. PC. Printed Circuit.

g. PD. Parameter data section of an ASME Y14.26M file.

6.6.2. Annotation. Text or symbols, not part of the geometric model, which provide information.

6.6.3. Application interpreted model. An information model that describes the logical information structures required for accomplishing a physical implementation of an associated application reference model. The AIM is prepared at a level of abstraction that is sufficient for selecting the necessary IGES entities for an application protocol.

6.6.4. Application protocol. Defines the context for the use of product data and specifies the use of the standard in that context to satisfy an industrial need.

6.6.5. Application reference model. An information model that describes the information structures and constraints for an application area. The information model uses application specific terminology and rules familiar to an expert from the application area.

6.6.6. Application subset. A set of specific ASME Y14.26M entities which are used to completely and unambiguously represent the information requirements of a product for a specified application.

6.6.7. Associativity. A structure entity which defines a logical link between different entities.

6.6.8. Attribute. Information which serves to qualify entity definition.

6.6.9. Directory entry section. That section of an ASME Y14.26M file consisting of fixed field data items for an index and attribute list of all entities in a file.

6.6.10. Entity. The basic unit of information in an ASME Y14.26M file. The term applies to single items which may be individual elements of geometry, collections of annotation to form dimensions, or collections of entities to form structured entities.

6.6.11. Form number. An integer which is used to further define a specific entity.

6.6.12. Parameter data section. A section of an ASME Y14.26M file consisting of specific geometric or annotative information about the entities or pointers to related entities.

6.6.13 Postprocessor. A program which translates a file of product definition data from the ASME Y14.26M format into the data base of a specific CAD/CAM system.

6.6.14. Preprocessor. A program which translates a file of product definition data from the data base of a specific CAD/CAM system into the ASME Y14.26M format.

6.6.15. Product data. All data elements necessary to define the geometry, the function, and the behavior of a piece part or an assembly of parts over its entire life span. The term includes all product definition data elements as well as additional logistics elements for reliability and maintainability.

6.6.16. Product definition data. Denotes the totality of data elements required to completely define a product. Product definition data includes geometry, topology, relationship, tolerances, attributes, and features necessary to completely define a component part or an assembly of parts for the purpose of design, analysis, manufacture, test, and inspection.

6.6.17. Property entity. A structure entity which allows numeric or text information to be related to other entities.

6.6.18. Start section. The section of an ASME Y14.26M file containing the human-readable file prologue.

6.6.19. Wire frame. A type of modeling that represents an object by its edges, forming an "outline" of the object in curve segments.

6.7. Subject term (keyword) listing.

Application subsets
Application protocol
Digital
Engineering drawings
Electrical applications
Electronic applications
IGES
Numerical Control
Piping
Product data
Technical illustrations
Y14.26M.

Custodians:
Army - CR
Navy - SH
Air Force - 24
DLA - DH

Preparing Activity
OSD-CL

Review activities:
Army - AM
Air Force - 01,02
NSA - NS
DCA - DC
NASA - NA
Others - NIST, DOE, GPO, NCS

User activities:
OSD-IR
Army - AL, AT, AV, EA, ER, GL, ME, MI, MR, SM, TE, TM
Navy - AS, EC, OS, SA, YD
Air Force - 11, 13, 14, 17, 18, 19, 68, 79, 99

6.7. Subject term (keyword) listing.

Application subsets
Application protocol
Digital
Engineering drawings
Electrical applications
Electronic applications
IGES
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Technical illustrations
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