

U.S. DEPARTMENT OF COMMERCE  
Technology Administration  
National Institute of Standards and Technology



## FIPS PUB 177-1

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FEDERAL INFORMATION PROCESSING STANDARDS PUBLICATION  
(Supersedes FIPS PUB 177—1992 November 30)

# INITIAL GRAPHICS EXCHANGE SPECIFICATION (IGES)

CATEGORY: SOFTWARE STANDARD

SUBCATEGORY: GRAPHICS AND INFORMATION INTERCHANGE

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1996 APRIL 23



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Computer Systems Laboratory  
National Institute of Standards and Technology  
Gaithersburg, MD 20899-0001

Issued April 23, 1996



**U.S. Department of Commerce**  
Michael Kantor, Secretary

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## Foreword

The Federal Information Processing Standards Publications Series of the National Institute of Standards and Technology (NIST) is the official publication relating to standards and guidelines adopted and promulgated under the provisions of Section 5131 of the Information Technology Management Reform Act of 1996, and the Computer Security Act of 1987, Public Law 104-106. These mandates have given the Secretary of Commerce and NIST important responsibilities for improving the utilization and management of computer and related telecommunications systems in the Federal Government. The NIST through its Computer Systems Laboratory provides leadership, technical guidance, and coordination of Government efforts in the development of standards and guidelines in these areas.

Comments concerning the Federal Information Processing Standards Publications are welcomed and should be addressed to the Director, Computer Systems Laboratory, National Institute of Standards and Technology, Gaithersburg, MD 20899.

Shukri A. Wakid, Director  
Computer Systems Laboratory

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## Abstract

This revision supersedes FIPS PUB 177 in its entirety. It provides a substantial, upward-compatible enhancement of IGES Version 4.0. FIPS PUB 177-1 specifies new conformance requirements, the addition and use of application protocols (APs), and increased enhancement, correction, and clarification of the existing specification. It does not contain any new requirements that would make an existing conforming implementation nonconforming. FIPS PUB 177-1 adopts the American National Standard Digital Representation for Communication of Product Definition Data, ANSI/US PRO/IPO (United States Product Data Association/IGES PDES Organization)-100-1993, Version 5.2, and the specified application protocols. FIPS PUB 177-1 addresses IGES implementation and data file acquisition, interpretation, and conformance.

Key words: CAD/CAM; digital data exchange; Federal Information Processing Standard (FIPS); graphics and information interchange; IGES; product definition data; software standard.

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**Announcing the Standard for**

**INITIAL GRAPHICS EXCHANGE SPECIFICATION (IGES)**

Federal Information Processing Standards Publications (FIPS PUBS) are issued by the National Institute of Standards and Technology (NIST) after approval by the Secretary of Commerce pursuant to Section 5131 of the Information Technology Management Reform Act of 1996 and the Computer Security Act of 1987, Public Law 104-106.

- 1. Name of Standard.** Initial Graphics Exchange Specification (IGES) (FIPS PUB 177-1).
- 2. Category of Standard.** Software Standard; Graphics and Information Interchange.
- 3. Explanation.** This publication is a revision of the FIPS PUB 177 and supersedes FIPS PUB 177 in its entirety. It provides a substantial, upward-compatible enhancement of IGES Version 4.0. FIPS PUB 177-1 specifies new conformance requirements, the addition and use of application protocols (APs), and increased enhancement, correction, and clarification of the existing specification. It does not contain any new requirements that would make an existing conforming implementation nonconforming.

FIPS PUB 177-1 adopts the American National Standard Digital Representation for Communication of Product Definition Data, ANSI/US PRO/IPO (United States Product Data Association/IGES PDES Organization)-100-1993, Version 5.2, and the specified application protocols. FIPS PUB 177-1 addresses IGES implementation and data file acquisition, interpretation, and conformance.

The purpose of the FIPS for IGES is to enable the compatible exchange of product definition data used by dissimilar computer-aided design and computer-aided manufacturing (CAD/CAM) systems. Utilizing a neutral database format the IGES processor can create or translate two-dimensional (2-D) or three-dimensional (3-D) vector-based digital product model data. The standard specifies file structure and syntactical definition, and defines the representation of geometric, topological, and nongeometric product definition data. The exact specification is in Section 10 of this standard.

- 4. Approving Authority.** Secretary of Commerce.
- 5. Maintenance Agency.** U.S. Department of Commerce, National Institute of Standards and Technology (NIST), Computer Systems Laboratory (CSL).
- 6. Cross Index.**
  - a. American National Standard Digital Representation for Communication of Product Definition Data, ANSI/US PRO/IPO-100-1993, Version 5.2.
  - b. American Society of Mechanical Engineers/American National Standards Institute (ASME/ANSI) Y14.26M-1989, Digital Representation for Communication of Product Definition Data, IGES Version 4.0.
  - c. MIL-D-28000A, Continuous Acquisition and Life-Cycle Support Specification, Digital Representation for Communication of Product Definition Data: IGES Application Subsets and IGES Application Protocols, February 10, 1992.
  - d. American National Standard, 3-D Piping IGES Application Protocol, ANSI/US PRO/IPO-110-1994.

e. IGES Layered Electrical Product Application Protocol, Committee Draft SAND94-2375, December 1, 1994.

## 7. Related Documents.

a. Federal Information Resources Management Regulations (FIRMR) subpart 201.20.303, Standards, and subpart 201.39.1002, Federal Standards.

b. Federal ADP and Telecommunications Standards Index, U.S. General Services Administration, Information Technology Management Service, October 1994 (updated periodically).

c. FIPS PUB 29-3, Interpretation Procedures for Federal Information Processing Standards for Software.

d. NISTIR 4379, IGES Technical Illustrations Application Guide.

e. NISTIR 4600, IGES 5.0 Recommended Practices Guide.

f. NISTIR 5541, Initial Graphics Exchange Specification (IGES): Procedures for the NIST IGES Validation Test Service.

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

**8. Objectives.** Federal standards for electronic interchange permit Federal departments and agencies to exercise more effective control over the production, management, and use of the government's information resources. The primary objectives specific to IGES are to:

- Reduce the overall life-cycle cost for digital systems by establishing a common exchange format that allows for the transfer of product definition data across organizational boundaries and independent of any particular CAD/CAM system.
- Exchange digital representations of product definition data in various forms: illustrations, 2-D drawings, 3-D edge-vertex models, surface models, solid models, and complete product models.
- Provide CAD/CAM implementation manufacturers with a guideline for identifying useful combinations of product definition data capabilities in any CAD/CAM system.
- Specify APs that can be used by Federal departments and agencies to support the exchange of product data when applicable.

## 9. Applicability.

**9.1** This FIPS for IGES is intended for the computer-interpretable representation and exchange of CAD/CAM product definition data among applications and programs that are either developed or acquired for government use. Each CAD/CAM system acquired or developed by a Federal agency shall include an IGES preprocessor and IGES postprocessor capability. FIPS for IGES is designed to support the exchange of 2-D or 3-D product definition data with rich attribute information. It provides a data format for describing product design and manufacturing information that has been created and stored in a computer-readable, device independent form.

**9.2** The FIPS for IGES shall be used when one or more of the following situations exist:

- The product definition application or program is under constant review, and changes may result frequently.
- It is anticipated that the life of the data files will be longer than the life of the presently utilized CAD/CAM system.
- The application is being designed centrally for a decentralized system that may employ computers of different makes and models and different CAD/CAM devices.

- The product definition application may run on equipment other than that on which it was developed.
- The product definition data is to be used and maintained by other than the original designer.
- The product definition data is or is likely to be used by organizations outside the Federal Government.
- It is desired to have the design understood by multiple people, groups, or organizations.

**9.3** For layered electrical product technology, three dimensional piping, and engineering drawing applications, the use of the appropriate AP or subset (as described below) is required for implementation of this FIPS IGES.

An AP or subset provides a means to improve the fidelity of the product data exchanged. APs are developed by domain experts for the purpose of defining the processes, information flows, and functional requirements of an application. An AP defines the scope, context, information requirements, representation of the application information, and conformance requirements. Initial release of this FIPS for IGES publication includes two APs and one application subset.

- Layered Electrical Product (LEP) Application Protocol: The LEP AP is used for the transference of 2-D electrical and electro-mechanical product models. This AP is required for layered electrical products technology applications, including specification control drawings, circuitry, fabrication and final assembly of a layered product system.
- 3-D Piping Application Protocol: The 3-D Piping AP is used for the exchange of models from one piping modeling application to another. This AP is required for 3-D piping and related equipment models, including the fabrication and assembly of piping systems (e.g., pipe, pipe fittings, attached equipment, piping supports, and insulation).
- Engineering Drawing (Class II) Subset (MIL-D-28000A): The Class II subset is used for the exchange of the drawing model; including geometric and annotation entities, attributes such as color and line fonts, and organization information such as levels and subfigures. This subset is required for the exchange of engineering drawings and product data following MIL-T-31000 (General Specification for Technical Data Packages).

**10. Specifications.** This FIPS adopts ANSI/US PRO/IPO-100-1993 and the specified APs: Layered Electrical Product (LEP) Application Protocol; 3-D Piping Application Protocol; and Engineering Drawing (Class II) Subset (MIL-D-28000A). The ANSI/US PRO/IPO-100-1993 standard for IGES, defines the communications file structure and format (i.e., a file of entities), language format, and the representation of product definition data.

New entities and constructs are added with each revision and are upwardly compatible. Thus, a processor conforming to IGES Version 5.2 would be able to read and process an IGES Version 4.0 file, but the converse may not be true. The capabilities brought to the IGES user implementing the IGES Version 5.2 standard are:

- a new character set for the European Community;
- additional properties to the attribute table for Architecture/Engineering/Construction (AEC);
- the addition of a new form of the drawing entity; and
- the addition of a new class of entity use, termed construction information.

*Conformance Requirements.* Conformance is mandatory for this standard and is applicable to all Federal department and agency procurements. Conforming data files and processors must adhere to all the rules appropriate to specific features, such as entities, defined within ANSI/US PRO/IPO-100-1993 and when

applicable, one of the APs or subset identified in this standard. Vendors of processors claiming conformance to this standard shall complete documentation which accurately indicates the processor's support of, and mapping between, native and IGES entities.

A conforming preprocessor shall create conforming IGES data files which represent the native database which was input to the preprocessor. File content shall represent the native entities according to the vendor's completed documentation. Unsupported native entities shall be reported.

A conforming postprocessor shall be capable of reading any complying data file without halting or aborting, including data files containing unprocessable entities. All unprocessable entities shall be ignored. A conforming postprocessor shall translate conforming IGES data files into the native database form of a specific CAD/CAM system. It shall convert each supported entity into native constructs, which preserve the functionality and match the geometry, attributes, and relationships of the IGES entity in the file. The post-processor shall report on any IGES entities or features which have been discarded.

Any visual presentation of supported, displayable entities that is produced by the processor, shall represent a visual appearance equivalent to the examples appearing in ANSI/US PRO/IPO-100-1993 and, if applicable, the AP or subset. The visual appearance shall depict the functional intent of the database.

*Conformance Rules for Application Protocols and Subsets.* An application protocol or subset which claims conformance to this standard, must satisfy the following rule:

- An implementation conforming to an AP shall satisfy the conformance requirements specified in the AP as well as the conformance requirements in the ANSI/US PRO/IPO-100-1993 specification.

**11. Implementation.** The implementation of this standard involves four areas of consideration: effective date, acquisition, interpretation, and validation.

**11.1 Effective Date.** This publication is effective November 1, 1996. A transition period of twelve (12) months, beginning on the effective date, allows industry to produce IGES implementations and data files conforming to this standard. Agencies are encouraged to use this standard for solicitation proposals during the transition period. This standard is mandatory for use in all solicitation proposals for IGES data files and implementations (i.e., computer-aided design and manufacturing systems) acquired twelve (12) months after the effective date.

**11.2 Acquisition of IGES Implementations and Data Files.** Conformance to this standard should be considered whether the CAD/CAM systems are developed internally, acquired as part of a system procurement, acquired by separate procurement, used under a leasing agreement, or specified for use in contracts for programming services. Recommended terminology for procurement of FIPS IGES is contained in the U.S. General Services Administration publication *Federal ADP and Telecommunications Standards Index*, Chapter 5, Part 1.

**11.3 Interpretation of FIPS IGES.** Resolutions of questions regarding this standard will be provided by NIST. Procedures for interpretations are specified in FIPS PUB 29-3. All questions concerning the specifications and content should be addressed to:

Director  
Computer Systems Laboratory  
ATTN: FIPS IGES Interpretation  
Building 820, Room 562  
National Institute of Standards and Technology  
Gaithersburg, MD 20899-0001



**11.4 Validation of IGES Implementations.** Validation of IGES implementations is not mandatory at this time. Testing of an implementation's conformance to this FIPS IGES will be optional by the agency. Government agencies acquiring implementations in accordance with this standard may wish to require testing for conformance, interoperability, and performance. The tests to be administered and the testing organization are at the discretion of the agency Acquisition Authority.

## **12. Waivers.**

Under certain exceptional circumstances, the heads of Federal departments and agencies may approve waivers to Federal Information Processing Standards (FIPS). The head of such agency may redelegate such authority only to a senior official designated pursuant to section 3506(b) of Title 44, U.S. Code. Waivers shall be granted only when:

- a. Compliance with a standard would adversely affect the accomplishment of the mission of an operator of a Federal computer system, or
- b. Cause a major adverse financial impact on the operator which is not offset by Governmentwide savings.

Agency heads may act upon a written waiver request containing the information detailed above. Agency heads may also act without a written waiver request when they determine that conditions for meeting the standard cannot be met. Agency heads may approve waivers only by a written decision which explains the basis on which the agency head made the required finding(s). A copy of each such decision, with procurement sensitive or classified portions clearly identified, shall be sent to: National Institute of Standards and Technology; ATTN: FIPS Waiver Decisions, Building 820, Room 509; Gaithersburg, MD 20899.

In addition, notice of each waiver granted and each delegation of authority to approve waivers shall be sent promptly to the Committee on Government Reform and Oversight of the House of Representatives and the Committee on Governmental Affairs of the Senate and shall be published promptly in the *Federal Register*.

When the determination on a waiver applies to the procurement of equipment and/or services, a notice of the waiver determination must be published in the *Commerce Business Daily* as a part of the notice of solicitation for offers of an acquisition or, if the waiver determination is made after that notice is published, by amendment to such notice.

A copy of the waiver, any supporting documents, the document approving the waiver and any supporting and accompanying documents, with such deletions as the agency is authorized and decides to make under 5 U.S.C. Sec. 552(b), shall be part of the procurement documentation and retained by the agency.

**13. Where to Obtain Copies.** Copies of this publication are for sale by the National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161. (Sale of the included specifications document is by arrangement with the National Computer Graphics Association and the American National Standards Institute.) When ordering, refer to Federal Information Processing Standards Publication 177-1 (FIPSPUB177-1), and title. Payment may be made by check, money order, or NTIS deposit account.

## APPENDIX A

### The Family of Graphics Standards

The following computer graphics standards are now available to address the needs of government applications in creating, modifying, manipulating, and exchanging computer-generated pictures:

- FIPS PUB 120-1, Graphical Kernel System (GKS), which adopts ANSI X3.124-1985(R1991), X3.124.1-1985(R1991), X3.124.2-1988(1994), X3.124.3-1989, and ISO/IEC 8651-4:1991;
- FIPS PUB 153-1, Programmer's Hierarchical Interactive Graphics System (PHIGS), which adopts ANSI/ISO 9592.1,2,3:1989, 9592.1a,2a,3a,4:1992, 9593.1:1990, 9593.3-1990, 9593.4:1991, and 9593.1/AM1, 3/AM1, 4/AM1:1991;
- FIPS PUB 128-2, Computer Graphics Metafile (CGM), which adopts ANSI/ISO 8632:1992[1994], 8632:1992/Amd. 1:1994, 8632:1992/Amd. 2:1995, ATA Spec. 2100, Working Draft, Version 2.1, June 1994, and Model Profile contained in ISO 8632:1992/Amd. 1:1994;
- FIPS PUB 177-1, Initial Graphics Exchange Specification (IGES), which adopts ANSI/US PRO/IPO-100-1993, Version 5.2, Layered Electrical Product (LEP) Application Protocol, IPO-110-1994, 3-D Piping Application Protocol, and Engineering Drawing (Class II) Subset (MIL-D-28000A), Dec. 1992 Version.

These standards fall into two categories: Application Programmer's Interface (API) standards, and Interoperability standards. The goal of API standards is to enhance the portability of graphics programs (and programmers) between installations and environments. The goal of Interoperability standards is to enable graphics data to be exchanged successfully between graphics systems and devices.

Figure 1 is a very simple reference model of a computer graphics operating environment. The model emphasizes that a graphics application program interacts with physical devices and human operators via a computer graphics environment. Figure 1 also shows that the application may receive information from an external database.

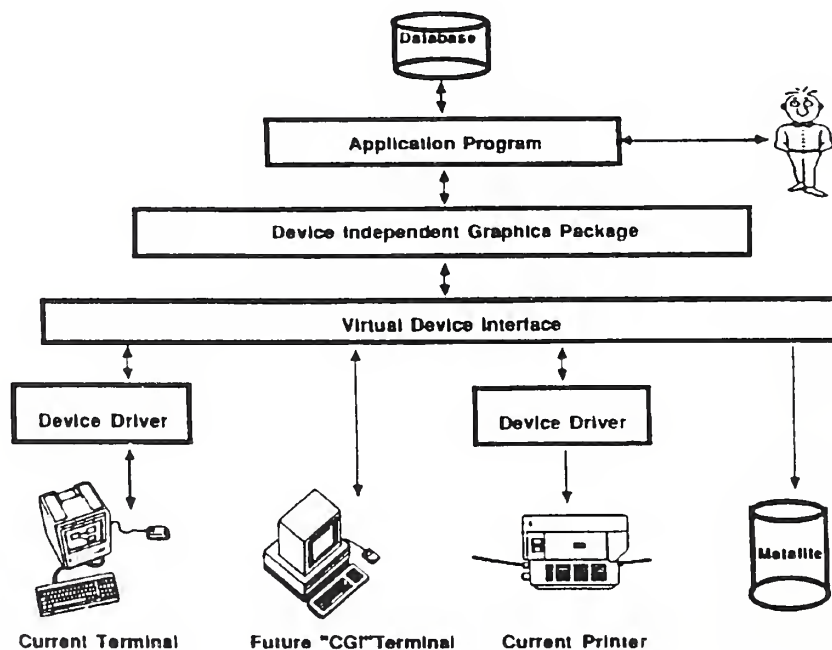


Figure 1. *Computer Graphics Reference Model.*

The output of the graphics program, as shown in Figure 1, is directed to a virtual graphics device (i.e., Virtual Device Interface or VDI) rather than directly to a physical device. A Device Drive provides an interface, implemented in either hardware or software, for translating virtual device commands to commands understood by a particular physical device. By substituting one device drive for another, an application can run on a different physical device. This device independence is a central concept of this graphics reference model.

In Figure 1, the API standards reside in the box labelled the Device Independent Graphics Package. Interoperability standards are related to the boxes in Figure 1 labelled Metafile, Database and Virtual Device Interface. Figure 2 depicts the various graphics standards associated with the general model shown in Figure 1. These are discussed below.

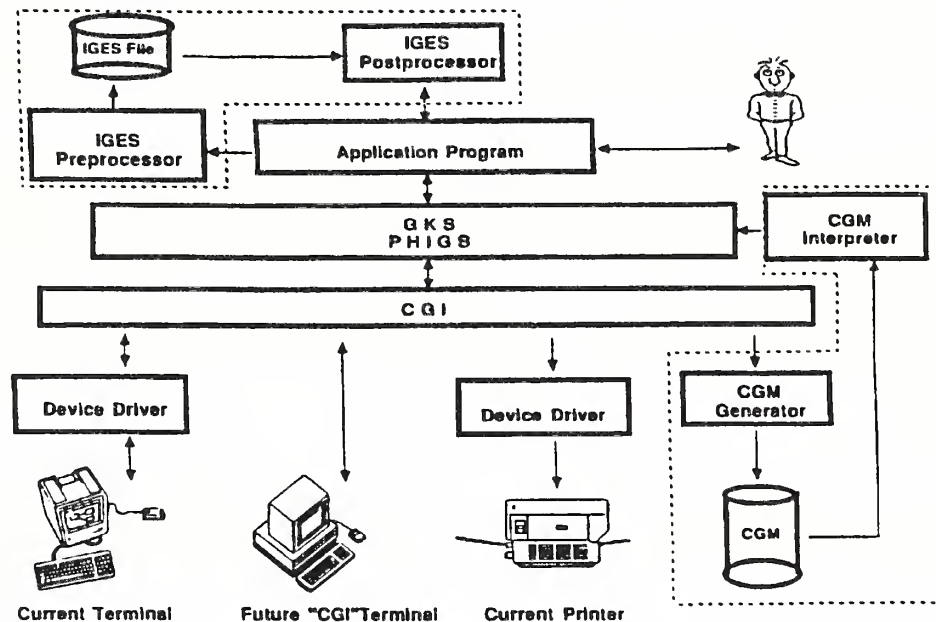


Figure 2. Standards in the Computer Graphics Reference Model.

### Application Programmer's Interface (API) Standards

Standards at the API promote program and programmer portability. A standard at this level specifies a set of operations on a variety of graphics objects. An API standard provides for the portability of applications across a wide range of computer hardware, operating systems, programming languages, and graphics devices. A program written to an API standard at one facility in one environment should be easily transferable to another facility in a different environment. Facility dependencies should be the major area requiring modification.

The specific functions supported by a particular API standard provide certain capabilities. The application programmer, by identifying the capabilities needed, determines the API better suited for the application. As shown in Figure 2, there are currently two graphics API standards, GKS and PHIGS.

GKS provides a functional description of a two-dimensional (2D) graphics interface. It provides the basic graphics support required by a wide variety of applications requiring the production of computer-generated pictures. A procedural language binding of a functional standard specifies the exact name for each operation, its parameter sequence, and the data types for the parameters. FORTRAN, Pascal, Ada and C language bindings are parts of GKS.

GKS is suitable for use in graphics programming applications that employ a broad spectrum of graphics, from simple passive graphics output (where pictures are produced solely by output functions without interaction with an operator) to interactive applications; and which control a whole range of graphics devices, including but not limited to vector and raster devices, microfilm recorders, storage tube displays, refresh displays, and color displays.

PHIGS provides for the definition, display, modification, and manipulation of 2D and 3D graphical data. It provides functionality to support storage of graphics and application data in a hierarchical form. Information may be inserted, changed, and deleted from the hierarchical data storage with the functions provided by PHIGS. Language binding specifications for PHIGS include FORTRAN, C and Ada.

PHIGS is specifically designed to meet the performance requirements of such demanding applications as Computer Aided Design/Computer Aided Engineering/Computer Aided Manufacturing, command and control, molecular modeling, simulation and process control.

Capabilities in PHIGS but not in GKS include: the centralized hierarchical data storage; the dynamic and responsive nature of interactions; the addition of a modeling capability; and support for color models other than Red-Green-Blue (RGB).

### **Interoperability Standards**

Graphics Interoperability standards allow graphical data to be interchanged between graphics devices. As shown in Figure 2, there are three graphics interoperability standards, CGM (future), CGI, and IGES.

CGM is used for the storage and transfer of picture description information. It enables pictures to be recorded for long term storage, and to be exchanged between graphics devices, systems, and installations. As indicated in Figure 2, the storage mechanism for CGM is in the form of a neutral file format called metafile. The software which creates the metafile is known as a CGM Generator. The software which reads and displays a CGM metafile is known as an interpreter.

CGM specifies a semantic interface that describes 2D graphical entities using primitives (like polyline, text, and ellipse) and attributes (like color, line width, interior style, and fonts). CGM is compatible with the specification of 2D elements in GKS. A data encoding specifies the exact sequence of bits used to represent each operation and its parameters. CGM contains three types of data stream encodings (binary, character, and clear text) to provide the implementor choices depending on the particular application.

IGES provides a method for representing and storing geometric, topological, and nongeometric product definition data that is independent of any one system. Where CGM transfers graphical pictures, IGES transfers a graphical database which can be processed to represent a picture. Thus IGES represents more than just purely graphical data. As Figure 2 indicates, the storage mechanism for IGES is in the form of a neutral file format that must be translated by a Preprocessor and Postprocessor for conversion between systems. IGES permits the compatible exchange of product definition data used by various computer aided design/computer aided manufacturing (CAD/CAM) systems.

The future CGI standard is designed to specify the exchange of information at the Virtual Device Interface. It will provide an interface between the device independent and device dependent parts of a graphics system. Since CGI contains information at a virtual level, it can be used to create a CGM. A CGM can also be output on a CGI device in a straightforward manner.



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