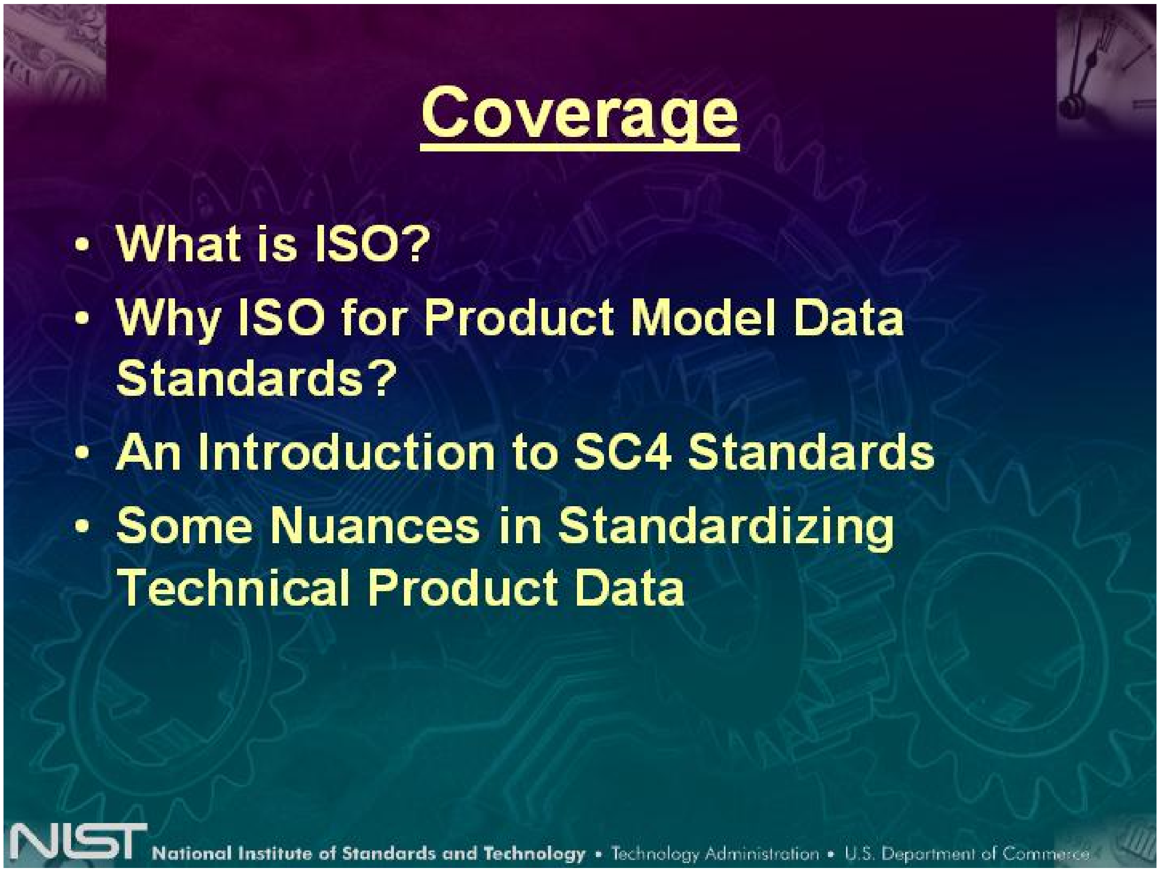

Developing exchange standards for technical product data started historically as multiple, and isolated, national efforts in the 1970s and early 80s. The industrial domain leading the way in the 70s was primarily the transportation sector (automotive and aerospace). As manufacturers of such large "products" began to outsource and depend more heavily on a large complex supply chain infrastructure, it became more inefficient to exchange product data. Enter: a way to develop a standardized exchange method for product data in an internationally recognized forum --- ISO, the International Organization for Standardization.




This talk will introduce ISO, introduce the product data exchange standards, provide rationale for why ISO was the perfect organization for standardizing product data exchange, and some of the nuances faced specifically by the ISO Subcommittee responsible for these standards.


International standardization began in the electrotechnical field: the International Electrotechnical Commission (IEC) was established in 1906. Pioneering work in other fields was carried out by the International Federation of the National Standardizing Associations (ISA), which was set up in 1926. The emphasis within ISA was laid heavily on mechanical engineering. ISA's activities came to an end in 1942.

In 1946, delegates from 25 countries met in London and decided to create a new international organization, of which the object would be "to facilitate the international coordination and unification of industrial standards". The new organization, ISO, officially began operations on 23 February 1947.

What ISO's name means: Because "International Organization for Standardization" would have different abbreviations in different languages ("IOS" in English, "OIN" in French for *Organisation internationale de normalisation*), it was decided at the outset to use a word derived from the Greek isos, meaning "equal." Therefore, whatever the country, whatever the language, the short form of the organization's name is always ISO. ISO has a Central Secretariat in Geneva, Switzerland, that coordinates the whole ISO standards development and publication system.

Every participating ISO member institution has the right to take part in developing any standard which it judges to be important to its country's economy. National delegations represent all the economic stakeholders concerned - suppliers, users, government regulators and other interest groups, such as consumers. The United States member is the American National Standards Institute.

Today ISO is a network of 150 national members, one representative per country.


**Equal footing**
Every participating ISO member institute (full members) has the right to take part in the development of any standard which it judges to be important to its country's economy. No matter what the size or strength of that economy, each participating member in ISO has one vote. ISO's activities are thus carried out in a democratic framework where each country is on an equal footing to influence the direction of ISO's work at the strategic level, as well as the technical content of its individual standards.

**Voluntary**
ISO standards are voluntary. As a non-governmental organization, ISO has no legal authority to enforce their implementation. A certain percentage of ISO standards - mainly those concerned with health, safety or the environment - has been adopted in some countries as part of their regulatory framework, or is referred to in legislation for which it serves as the technical basis. Such adoptions are sovereign decisions by the regulatory authorities or governments of the countries concerned; ISO itself does not regulate or legislate. However, although ISO standards are voluntary, they may become a market

requirement, as has happened in the case of ISO 9000 quality management systems, or of dimensions of freight containers and bank cards.

**Market-driven**
ISO develops only those standards for which there is a market requirement. The work is carried out by experts from the industrial, technical and business sectors which have asked for the standards, and which subsequently put them to use. These experts may be joined by others with relevant knowledge, such as representatives of government agencies, consumer organizations, academia, and testing laboratories.

**Consensus**
Although ISO standards are voluntary, the fact that they are developed in response to market demand, and are based on consensus among the interested parties, ensures widespread applicability of the standards.
Consensus, like technology, evolves and ISO takes account both of evolving technology and of evolving interests by requiring a review of its standards at least every five years to decide whether they should be maintained, updated, or withdrawn. In this way, ISO standards retain their position as the state of the art, as agreed by an international cross-section of experts in the field.

**Worldwide**
ISO standards are technical agreements which provide the framework for compatible technology worldwide.

Participating in developing standards in the ISO community can be fun, exhilarating, and rewarding. While most representatives participating are part of a national member body, anyone can come to, and participate in, the development of the ISO standards. Everyone who participates is there with their own agenda... whether hoping for a particular technical solution, just wanting a standard to resolve interoperability issues, or having a software product implementing the standard for commercial use. So as a participant, it is good to come with, or fine tune your skills as a negotiator, remain agile in your thinking, and be prepared to be a team player to reconcile conflicts as a win-win for everyone. If you are part of a national body team of experts, it is also critical that you are aware of the national opinions prior to arriving for an international standards development meeting.


**Stage 1: Proposal stage**
The first step in the development of an International Standard is to confirm that a particular International Standard is needed. A new work item proposal (NP) is submitted for vote by the members of the relevant TC/SC to determine the inclusion of the work item in the program of work. The proposal is accepted if a majority of the P-members of the TC/SC votes in favor and at least five P-members declare their commitment to participate actively in the project. At this stage a project leader responsible for the work item is normally appointed.

**Stage 2: Preparatory stage**
Usually, a working group of experts, the chairman (convener) of which is the project leader, is set up by the TC/SC for the preparation of a working draft. Successive working

drafts may be considered until the working group is satisfied that it has developed the best technical solution to the problem being addressed. At this stage, the draft is forwarded to the working group's parent committee for the consensus-building phase.

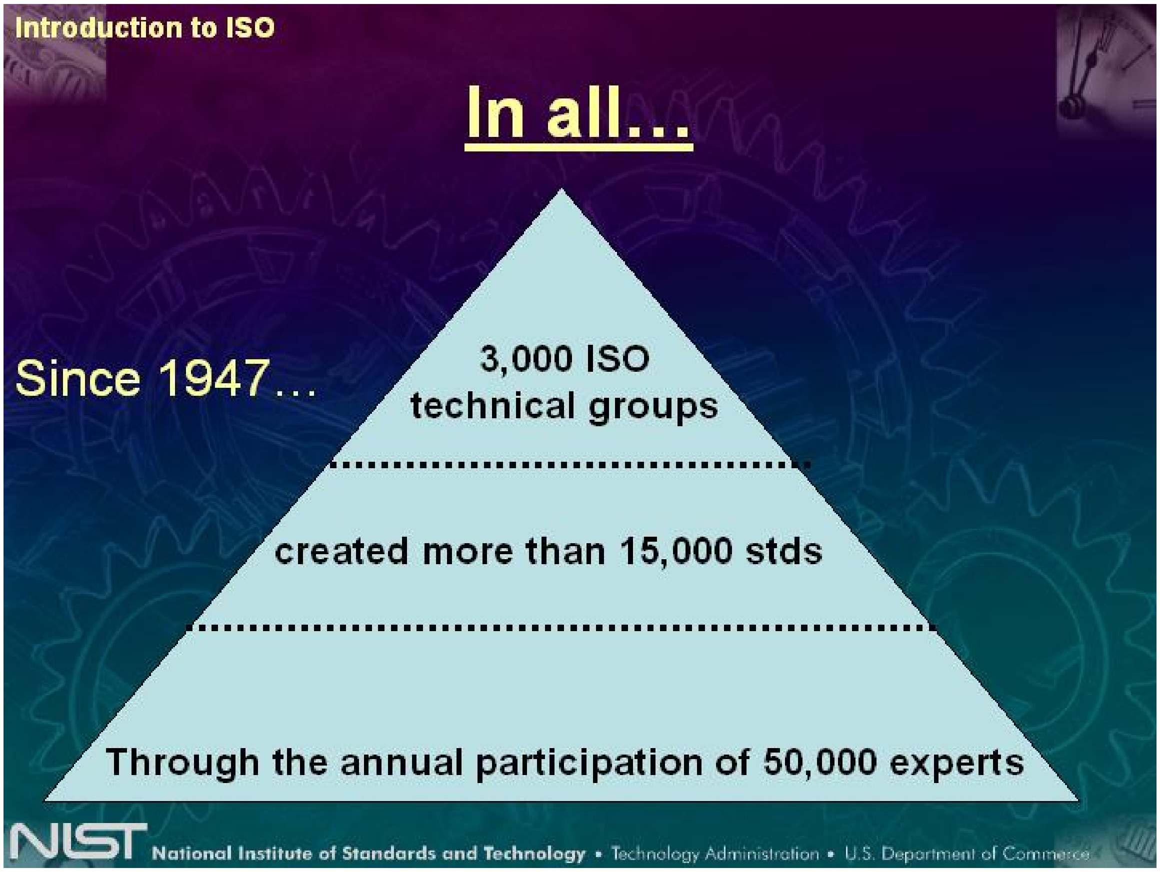
**Stage 3: Committee stage**
As soon as a first Committee Draft (CD) is available, it is registered by the ISO Central Secretariat. It is distributed for comments and, if required, voting, by the P-members of the TC/SC. Successive committee drafts may be considered until consensus is reached on the technical content. Once consensus has been attained, the text is finalized for submission as a draft International Standard (DIS).

**Stage 4: Enquiry stage**
The Draft International Standard (DIS) is circulated to all ISO member bodies by the ISO Central Secretariat for voting and comment within a period of five months. It is approved for submission as a Final Draft International Standard (FDIS) if a two-thirds majority of the P-members of the TC/SC are in favor and not more than one-quarter of the total number of votes cast are negative. If the approval criteria are not met, the text is returned to the originating TC/SC for further study and a revised document will again be circulated for voting and comment as a draft International Standard.

**Stage 5: Approval stage**
The Final Draft International Standard (FDIS) is circulated to all ISO member bodies by the ISO Central Secretariat for a final Yes/No vote within a period of two months. If technical comments are received during this period, they are no longer considered at this stage, but registered for consideration during a future revision of the International Standard. The text is approved as an International Standard if a two-thirds majority of the P-members of the TC/SC are in favor and not more than one-quarter of the total number of votes cast are negative. If these approval criteria are not met, the standard is referred back to the originating TC/SC for reconsideration in the light of the technical reasons submitted in support of the negative votes received.

**Stage 6: Publication stage**
Once a Final Draft International Standard has been approved, only minor editorial changes, if and where necessary, are introduced into the final text. The final text is sent to the ISO Central Secretariat which publishes the International Standard.

Review of International Standards (Confirmation, Revision, Withdrawal)
All International Standards are reviewed at least once every five years by the responsible TCs/SCs. A majority of the P-members of the TC/SC decides whether an International Standard should be confirmed, revised, or withdrawn.

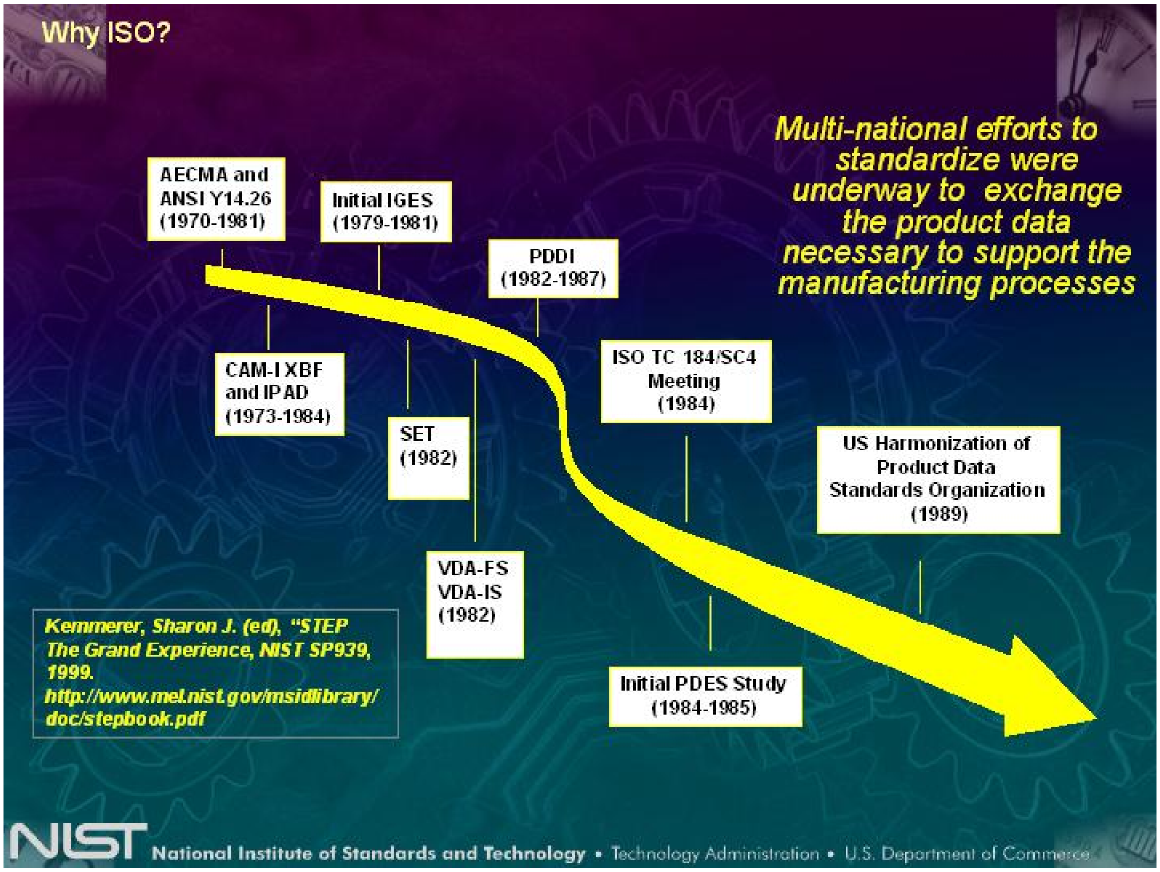



Developing technical consensus on this international scale is a major operation. In all, there are some 3,000 ISO technical groups (technical committees, subcommittees, working groups etc.) in which some 50,000 experts participate annually to develop ISO standards.  More than 15,000 standards have been created since ISO's inception in 1947.


In the midst of all these thousands of experts, and thousands of standards, and thousands of technical groups; ISO is the primary international standards development organization for developing information technology standards specific to the exchange of product & process data.


As mentioned in the introduction, developing exchange standards for technical product data started historically as multiple, and isolated, national efforts in the 1970s and early-to-mid 80s. The industrial domain leading the way in the 70s was primarily the transportation sector (automotive and aerospace).

As manufacturers of such large "products" began to outsource and depend more heavily on a large complex supply chain infrastructure, it became more inefficient to exchange the necessary information about the product. ISO provided a level playing field on which to bring all these national efforts, and to attempt to build a single international standardized exchange product data standard.




AECMA: In 1977, the European aerospace industry recognized a major problem in exchanging shape representation on collaborative projects. The European Association of Aerospace Industries (AECMA) developed a common exchange format that allowed the collaborating companies to exchange simple surface geometry. The format was used on a few occasions, but the advent of more complex surface types, integrated into vendor systems, caused it to fall into disuse. Even so, there was good work done by AECMA. The United Kingdom contributed the AECMA Report of the Geometry Data Exchange Study Group to the ISO effort for building an international product model data standard.

The Integrated Programs for Aerospace-Vehicle Design (IPAD) project funded by NASA, had a geometry focus and is credited with being the first to make use of information modeling for systems integration.

The Computer-Aided Manufacturing - International (CAM-I) organization, through its Geometric Modeling Project begun in the early 1970s, contributed significantly to the formal description of Boundary Representation (B-REP) data. The result of the CAM-I funded work, which was a mathematical representation of standard geometry and topology, was considered ahead of its time and clearly captured more information than the typical CAD systems of the day could interpret. It was submitted to ANSI committee Y14.26 [Digital Representation for Communication of Product Definition Data] for standardization as a data exchange mechanism. The CAM-I specification did not contain an exchange mechanism, but a foundational description of the data that could be exchanged.

IGES: In 1979, events took place that catalyzed the CAD vendor and user community to create the first national standard for CAD data exchange in the United States.
**I** - Interim (to suggest that it would not replace ANSI's work)
**G**- Graphics (not geometry, to acknowledge that academics may come up with superior mathematical descriptions)
**E**- Exchange (to suggest that it would *not* dictate how vendors must implement their internal databases)
**S**- Specification (not to be as imposing as a standard)

The French Standard d'Echange et de Transfert (SET) project started at Aerospatiale in 1983. Aerospatiale needed a common database capability across its different CAD systems. They did a formal test of IGES and found it did not work. To be a little more precise, they tested the first beta IGES implementations from two vendors which, according to documentation, had implemented only points, lines, arcs, and text notes. (A major amount of information on an engineering drawing would of course be lost even if these few entities had been implemented completely and correctly!) From this test, Aerospatiale concluded that it was the *IGES specification* that did not work. The result was a French effort to write a specification, standardize it, implement it, test it, and support its use in production. Designed to address the difficulties using IGES, the primary industrial drivers of SET were automotive and aerospace industries. The standard represents the results of the requirement to exchange data between different CAD/CAM systems, and from the need to archive these data. Version 1.1 of SET was put on the international table to contribute toward the international product model standard.

VDA-FS, VDA-IS
The Germans standardized Flachenschnittstelle des Verbandes der deutschen Automobilindustrie (VDA-FS) addressed the exchange of free form surfaces and free form curves needed by the automotive industry. VDA-FS was based on IGES but offered a competing exchange file format to that of IGES. The VDA was created in 1982 to increase the efficiency of the design process and usefulness of CAD/CAM systems. The Germans brought VDA-FS to the international table to contribute toward the international product model data standardization effort.

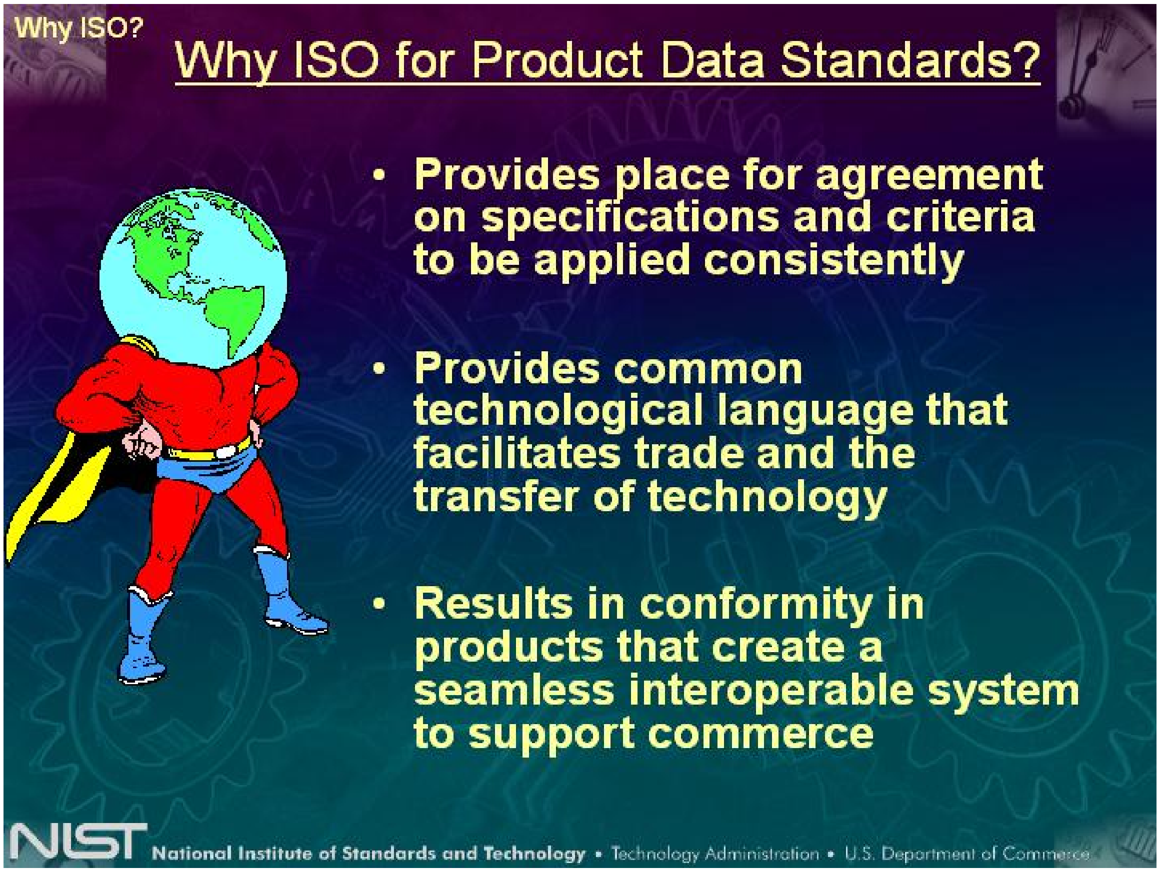
The German automotive industry, through VDA-IS (IS-IGES Subset), defined subsets of annotation entities that were relevant for various applications in automobile manufacturing. These subsets were created so that compliance could be tested. The particular data exchange requirements met by these subsets included: drawing information, two- and three-dimensional geometry, and analytic and free-form surfaces.

The U.S. Air Force built upon the ANSI/X3/SPARC methodology by developing formal methods for information modeling, as a part of its Integrated Computer Aided Manufacturing (ICAM) program. The Air Force ICAM program made a significant contribution to the evolution of product data exchange standards, through its Product Definition Data Interface (PDDI) contract with McDonnell Aircraft Company. The purpose of PDDI was to develop a replacement for *blueprints* as a communication mechanism between engineering and manufacturing. It sought to replace all information found on a blueprint (more commonly known as an engineering drawing today). PDDI developed a set of information models, a modeling language which contributed to EXPRESS, a product model data exchange file format that separated the data being exchanged from its definition, and a mechanism for applications to share data.

PDES: By 1984, many of these efforts had produced enough results to be compared, and an international community was preparing to form a committee in hopes of creating a common solution to CAD data exchange. In May of 1984, a late night meeting of the IGES Organization Edit Committee was held. The outcome: the first Product Data Exchange Specification (PDES) report issued in July of 1984, followed by a second report in November of 1984. These reports laid the groundwork for the PDES Initiation Effort, which, similar to PDDI, was considered a theoretical exercise at building a standard based on a broader automation goal and the discipline of information modeling.

In November 1989, NIST accepted the leadership of the Harmonization effort, which was later formalized as the Harmonization of Product Data Standards (HPS) organization under the Industrial Automation Planning Panel (IAPP) of the American National Standards Institute (ANSI). The HPS established three councils, to which NIST continued to serve as the Secretariat: Business Needs and Planning, Standards Development and Coordination, and Tools and Technology.

> "There was tremendous excitement about embarking on new territory; engineers were liberated by their employers to delve into research and development. Passions ran high. Vendors learned early that by opening up their systems to the public they could more readily catch a market, not lose it. Late-night conversations in smoke-filled rooms played a critical role in the birth of these early standards, as did personal trust among the participants. Once feasibility was shown through STEP predecessors, the tremendous need within industry for a formally-standardized CAD exchange capability drove the world to develop STEP. No one in 1984 could have comprehended the magnitude and longevity of the events about to unfold." Kemmerer, Sharon J. (ed), *STEP: The Grand Experience*, NIST Special Publication 939, (1999).




Provides place for agreement on specifications and criteria to be applied consistently in the classification:

- •of materials
- •in the manufacture and supply of products
- •in testing and analysis
- •in terminology
- •in the provision of services

•Provides common technological language that facilitates trade and the transfer of technology. This is achieved through:

- •consensus agreements
- •between national delegations
- •representing all the economic stakeholders concerned - suppliers, users, government regulators, consumers.

Results in, and enables, conforming products or services that allow industry-wide standardization for a seamless interoperable system to support commerce.

A "language" to communicate among systems to exchange product data information around the world.

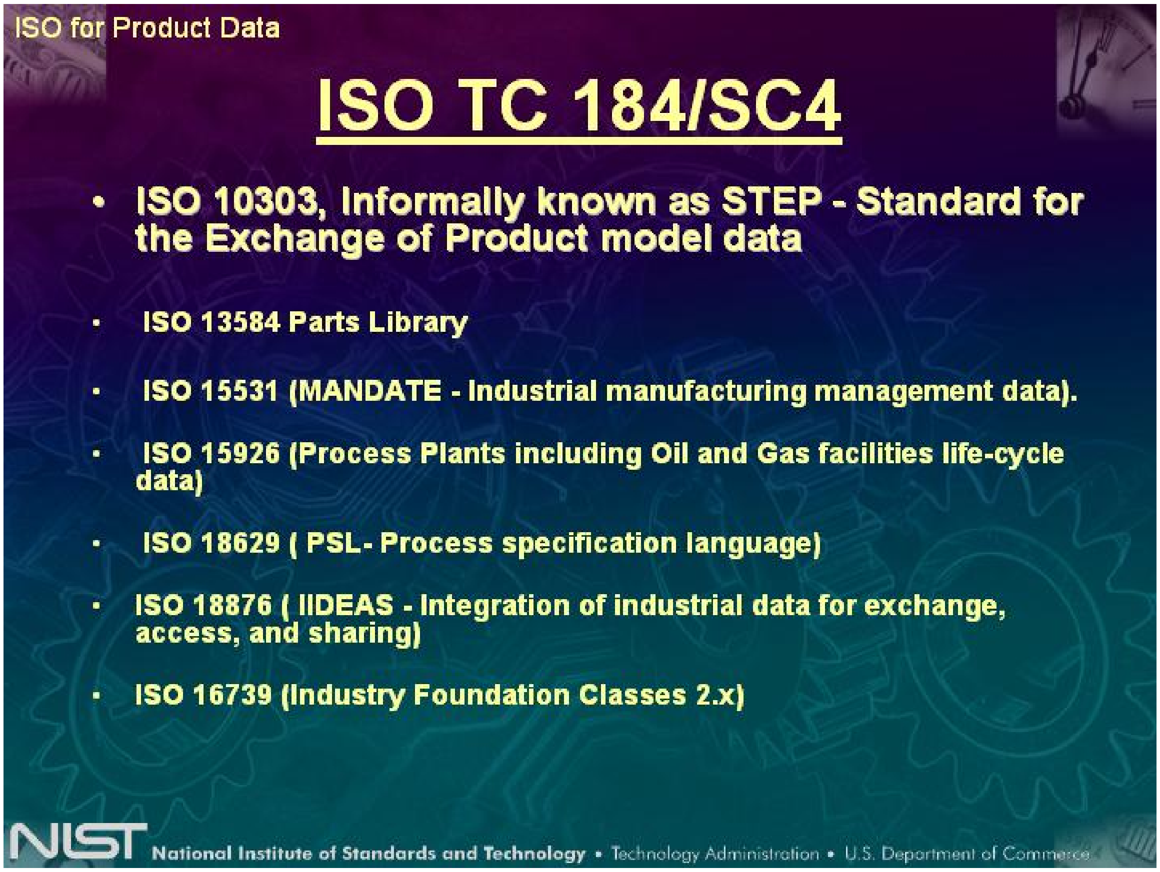
ISO provided a forum to create the proverbial "Pot of Gold" for standardizing the exchange of product data internationally.


So, where is the product data standardization activity hosted within the ISO organization? Under the Industrial Automation Systems and Integration Technical Committee 184, within Subcommittee 4 for Industrial data.

The scope of SC4 includes all the industrial data related to discrete products including, but not limited to:

- •geometric design and tolerance data
- •material and functional specifications
- •product differentiation and configuration
- •process design data
- •production data (including cost)
- •product support and logistics
- •life cycle data
- •quality data
- •disposal planning data

It includes organizational data such as the relationship between enterprises or the relationship between components of a single enterprise for the purposes of supplier identification. It includes personnel data to the extent of identification of approvals. Specifically excluded are business planning data such as profit projections, cash flow; and any other personnel data or organizational data.




SC4 currently has 20 P-members working on seven ISO standards: Australia, Austria, Brazil, Bulgaria, China, Czech Republic, France, Germany, Italy, Japan, Korea, Netherlands, Norway, Portugal, Russia, Spain, Sweden, Switzerland, United Kingdom, United States

**10303**: (formally titled: Product Data Representation and Exchange), is informally best known as the **St**andard for the **E**xchange of **P**roduct Model Data (STEP). It's an ISO standard used for exchanging data between different CAD/CAM and Product Data Management (PDM) systems. It represents a viable alternative to the current chaos of multiple, fragmented standards and proprietary data formats, and is a proven way to ensure fast, reliable data exchange between partners and suppliers using different systems. STEP supports engineering, manufacturing, electrical/electronics, architecture and construction life cycle information (e.g., design, engineering, manufacturing and maintenance). Industry sectors using STEP in production or in pilot tests around the world include aerospace, automotive, shipbuilding, electronics, architecture and the process industries. STEP is a collection of inter-related documents which form a multi-part standard:

•Description methods provide the specifications of the languages that are used for creating the standards (Parts 1-19)

•Implementation methods support the development of software implementations of the standards (Parts 20-29)

•Conformance testing methodology and framework specify how an implementation of ISO 10303 should be tested for conformance to the Standard (Parts 30 -39)
•Integrated generic resources as a group, provide a single information model for a manufactured product (Parts 40-49)
•Integrated application resources specializations of the Integrated Generic Resources for some general engineering requirements (Parts 100 - 199)
•Application protocols specify the requirements for data for a specific engineering application in a standardized representation derived from the Integrated Generic Resources (Parts 200 - 299)
•Abstract test suites describe the tests to be used to determine if an implementation conforms to the related Application Protocol (Parts 300 - 399)
•Application interpreted constructs sections of data models that describe concepts that are common to more than one Application Protocol (Parts 500 - 599)
•Application Modules small information models that are intended to be reusable in the development of future Application Protocols (Parts 1000 - )

**13584**: ISO 13584 is a series of International Standards for the computer-sensible representation and exchange of part library data. The objective is to provide a mechanism capable of transferring parts library data, independent of any application which is using a parts library data system. The nature of this description makes it suitable not only for the exchange of files containing parts, but also as a basis for implementing and sharing databases of parts library data.

Each International Standard in the ISO 13584 series is published as a separate part. These parts are grouped into one of the following series:
- conceptual descriptions (reserved part numbers are 10 to 19),
- logical resources (20 to 29), implementation resources (30 to 39),
- description methodology (40 to 49),
- conformance testing (50 to 59), view exchange protocol (101 to 199) and standardized content (500 to 599).

The numbers are for unambiguous reference to the documents.

**15531**: The MANDATE (ISO 15531)The ISO 15531, Industrial automation systems and integration- manufacturing management data exchange (MANDATE) includes the representation of data relating to the management of the production process and the exchange and sharing of management data within or between companies.
Three main categories of data relating to the management of manufacturing can be identified as the information related to:
•external exchanges, e.g., with suppliers
•the management of the resources used during the manufacturing processes
•the management of the manufacturing flows within the plant and among the process stages.

ISO 15531 does not standardize the model of the manufacturing process. The aim of the standard is to provide standardized data models for the three types of data, above, which are usually complex, strongly time-dependent and with close relationships among them.

The objective is to facilitate the integration between numerous industrial applications by means of a common, standardized tool able to represent these three sets of data that are shared and exchanged during the whole production life cycle and are in the core of the manufacturing process.

ISO 15531 is a collection of inter-related documents which form a multi-part standard:
•Overview and fundamental principles (Part 1)
•Production data for external exchanges (Parts 21-23)
•Manufacturing resources usage management data (Parts 31-33); and
•Manufacturing flow management data (Parts 41-45)

**15926**: Integration of life-cycle data for oil and gas production facilities (Oil & Gas). This initiative includes standardization of the data associated with the engineering construction and operation of oil and gas production facilities.

The scope of activities to be supported by this standard includes:
•conceptual process design
•conceptual engineering design
•detailed process design
•detailed engineering design
•fabrication and construction; and
•operations and maintenance

The Oil and Gas Parts standard is a multipart standard with the following parts:
•Part 1: Overview and fundamental principles
•Part 2: Data model
•Part 3: Methodology for the creation of reference data libraries
•Part 4: Reference data
•Part 5: Precedures for registration and maintenance of reference data.
•Part 6: Scope and representation for additional reference data.
•Part 7: Templates (Developers Area).

**18629**: The Process Specification Language (PSL) standardization initiative includes the semantics for describing the fundamental concepts of manufacturing processes. PSL defines a neutral representation for manufacturing processes. Process data is used throughout the life cycle of a product, from early indications of manufacturing process flagged during design, through process planning, validation, production scheduling and control. In addition, the notion of process also underlies the entire manufacturing cycle, coordinating the workflow within engineering and shop floor manufacturing.
PSL is being standardized within Joint Working Group 8 of Subcommittee 4 (Industrial data) and Subcommittee 5 (Manufacturing integration) of Technical committee ISO TC 184 (Industrial automation systems and integration).
PSL is a multi-part standard that currently includes:
•Part 1: Overview and Basic Principles
•Part 11: Process Specification Language: PSL-Core.
•Part 12 : PSL Outercore

•Part 13 : Time and ordering
•Part 14 : Resources
•Part 15 : Activity performance
•Part 21 : External mapping to EXPRESS
•Part 22 : External mapping to XML
•Part 23 : External mapping to UML
•Part 41 : Activity
•Part 42 : Time and State
•Part 43 : Ordering
•Part 44 : Resources role
•Part 45 : Kinds of resource sets
•Part 46 : Processor activities
•Part 47 : Process intent
•Part 2xx series: Translator implementation guidelines

**18876**: The IIDEAS (ISO 18876) Integration of Industrial Data for Exchange, Access and Sharing initiative covers Integration of industrial data to support the reconciliation and cooperative use of industrial data from multiple sources.
The IIDEAS initiative is a multi-part standard development effort that currently includes:
•Part 1: Architecture overview and description
•Part 2: Mapping and integration methodology

ISO 18876 establishes an architecture, a methodology, and other specifications for the integration of industrial data for exchange, access, and sharing. The objective is to provide the following capabilities:
•integrating data from different sources, different models, perhaps written in different modeling languages
•sharing data among applications through systems integration architectures
•resolving conflict between models developed with different objectives
•translating data between different encodings and models between different modeling languagesThe components that support these capabilities include:
•integration models
•methods for creating, extending, and updating integration models
•methods for mapping between an integration model and an application model that falls within its scope
•encoding and decoding of data and models with different formats, such as ISO 8876 (SGML), XML, ISO 10303-11 (EXPRESS), ISO 10303-21
•methods for integrating data sets from different sources and different models including identification mechanisms
•appropriate modeling and mapping languages.


All the SC4 standards each have a series of parts on which, when assembled together, form an integrated whole standard for implementation. STEP initially used a layered architecture to integrate the various standard parts into application protocols for a standardized implementation specific to a particular domain. More recently, the ISO 10303 standardization effort has moved to a modular architecture to expedite future standardized industrial domain specifications. ISO 18629, the Process Specification Language is a new breed of standard for product data exchange, and is based on first order logic.

ISO TC 184/SC4 created its own little microcosm of ISO by including a quality function in their standardization process and by creating an oversight Policy and Planning Committee.

SC4 quality policy
It is SC4's policy to develop standards to a high and consistent level of quality, and to achieve quality by executing the appropriate procedures within projects. Quality of SC4 standards is measured by accurate satisfaction of industry requirements, implementation and deployment of standards in commercial software systems, and approval of standards through the ISO process without the need for rework or reballoting.

This policy is supported by a quality system that is described in the SC4 Quality Manual. The SC4 quality system is an implementation of ISO 9001 appropriate to the needs and capabilities of a voluntary standards organization. The quality system consists of procedures, guidelines, and work instructions that augment and clarify the ISO/IEC Directives, provides information that directs and guides the work of SC4 projects, and defines metrics for the assessment of quality of SC4 standards. Project teams are responsible for the quality of their deliverables.

The Policy and Planning Committee (PPC) is independent of the normal ISO technical committee structures. The PPC was established by SC4 to become the single advisory group to assist the SC4 Chairman, Committee, Conveners and Project Leaders:
•To facilitate the smooth running of the organization, including a leading role in conflict resolution between WGs, monitoring progress in critical issues and ensuring effective communication across the organization.
•To monitor the effectiveness of the organization and to make recommendations to the SC4 chairman on improvements to the organization and its processes and procedures as defined in the SC4 Organization Handbook, for which the PPC was responsible to draft.

The PPC not only provides advice in response to formally submitted requests but also operates meetings to address specific issues. The PPC members act as "Ombudsmen," providing a focus for issues relating to the organization, process and procedure of SC4. PPC members shall endeavor to resolve such issues by communicating with those involved, referring the issue to SC4 only when settlement is not possible.

The report, “Economic Impact Assessment of the International Standard for the Exchange of Product Model Data (STEP) in Transportation Equipment Industries” offers great examples of the benefits from implementing international standards.  The objective of this economic study was to conduct an economic impact assessment of STEP’s use by transportation equipment industries, namely the automotive, aerospace, shipbuilding, and specialty tool and die industries. Both the full potential and current realized benefits are quantified.

Data collected from industry surveys and case studies were used to estimate the potential benefits of existing STEP capabilities. We estimate that STEP has the potential of save $928 million (2001$) per year by reducing interoperability problems in the automotive, aerospace, and shipbuilding industries. Currently approximately 17 percent ($156 million) of the potential benefits of STEP quantified within the scope of this study are being realized. Benefits and costs were projected through 2010 assuming a 75 percent penetration rate for STEP in 2010. STEP development costs include expenditures by government agencies, software vendors, and industry users, and were estimated to be approximately $17 million per year in the late 1990s.

Benefits accrue to end users through increased interoperability of computer-aided design, engineering, and manufacturing and product data management systems (collectively referred to as CAx in this study) used in the product design supply chain. These benefits can be generally categorized as:

•decreased avoidance costs
•decreased mitigation costs
•decreased delay costs (RTI, 1999)

The primary economic benefits are realized by end users of these systems in the automotive, aerospace, and shipbuilding industries. However, for these benefits to be realized by end users, resources must be invested to make STEP functionality available. These resource investments include:

•government sector involvement in the standards development process and demonstration of STEP.
•software developers’ costs associated with the standards development and demonstration (referred to as R&D).
•expenditures to integrate STEP functionality into commercial products.
•end users’ costs associated with the standards development, demonstration, and implementation of STEP.

Benefits and costs actually occur as flows over time. The costs of standards development, infrastructure tools, and software development are shown occurring early in the life-cycle of STEP functionality. Once commercial products were available with STEP functionality, aggregate manufacturers’ benefits increased as adoption occurred until the CAx markets are saturated.  “Steady state” benefits continue to accrue until the STEP functionality incorporated with the software becomes obsolete.[1]

[1] Economic Impact Assessment of the International Standard for the Exchange of Product Model Data (STEP) in Transportation Equipment Industries, Gallaher, M.,

O'Conner, A., Phelps, T., Research Triangle Institute, December 2002., http://www.nist.gov/director/prog-ofc/report02-5.pdf .

***Why is STEP Important?***
STEP allows companies to effectively exchange information with their worldwide partners, customers and suppliers, as well as internally. In order to remain competitive in the global marketplace, companies will have to ensure this exchange is consistent, accurate and timely.

Unlike other data transfer standards, STEP is computer sensible. It supports design reuse, data retention, and provides access to data across a product's entire life cycle. Product development strategies, such as concurrent engineering, enterprise integration, electronic commerce and quality function deployment, will significantly benefit from the use of STEP -- allowing them to have a broad impact within enterprises.

By removing the barriers that prevent maximum flexibility in design, manufacture, and support, STEP will enable manufacturers to achieve new, higher levels of quality and productivity while reducing costs and time-to-market.


These references provided most of the text contained in this document and are great resources for additional information, should you be interested.

**Projects in ISO TC 184/SC4 as of June 2005:**

| | |
|---|---|
| ISO/DIS 10303-14 | Industrial automation systems and integration -- Product data representation and exchange -- Part 14: Description methods: The EXPRESS-X language reference manual |
| ISO/CD TS 10303-25 | Industrial automation systems and integration -- Product data representation and exchange -- Part 25: EXPRESS to OMG XMI binding |
| ISO/CD TS 10303-28 | Industrial automation systems and integration -- Product data representation and exchange -- Part 28: Implementation methods: XML representations of EXPRESS schemas and data |
| ISO/DIS 10303-41 | Industrial automation systems and integration -- Product data representation and exchange -- Part 41: Integrated generic resource: Fundamentals of product description and support |
| ISO/PRF 10303-51 | Industrial automation systems and integration -- Product data representation and exchange -- Part 51: Integrated generic resource: Mathematical representation |
| ISO/CD 10303-52 | Industrial automation systems and integration -- Part 52: Integrated generic resource: Mesh-based topology |
| ISO/CD 10303-53 | Industrial automation systems and integration -- Part 53: Integrated generic resource: Numerical analysis |
| ISO/PRF 10303-54 | Industrial automation systems and integration -- Product data representation and exchange -- Part 54: Integrated generic resource: Classification and set theory |
| ISO 10303-56 | Industrial automation systems and integration -- Product data representation and exchange -- Part 56: Integrated generic resource: State |
| ISO/DIS 10303-107 | Industrial automation systems and integration -- Industrial data -- Part 107: Integrated application resource -- Finite element analysis definition relationships |
| ISO/CD 10303-110 | Industrial automation systems and integration -- Product data representation and exchange -- Part 110: Integrated application resource: Mesh based computational fluid dynamics |
| ISO/CD 10303-111 | Industrial automation systems and integration -- Product data representation and exchange -- Part 111: Integrated application resource : Construction history features |
| ISO/CD 10303-112 | Industrial automation systems and integration -- Product data representation and exchange -- Part 112: Integrated application resource: 2d standard modeling commands for the procedural parametric exchange |
| ISO/CD TS 10303-203 | Industrial automation systems and integration -- Product data representation and exchange -- Part 203: Application protocol: Configuration controlled 3D design of mechanical parts and assemblies |
| ISO/CD 10303-219 | Industrial automation system -- Product data |

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| | representation and exchange -- Part 219: Dimensional inspection information exchange |
| ISO/CD 10303-221 | Industrial automation system -- Product data representation and exchange -- Part 221: Application protocol: Functional data and their schematic representation for process plants |
| ISO/NP 10303-224 | Industrial automation systems and integration -- Product data representation and exchange -- Part 224: Application protocol: Mechanical product definition for process planning using machining features |
| ISO/PRF 10303-227 | Industrial automation systems and integration -- Product data representation and exchange -- Part 227: Application protocol: Plant spatial configuration |
| ISO/AWI 10303-233 | Industrial automation systems and integration -- Part 233: Systems engineering data representation |
| ISO/DIS 10303-236 | Industrial automation systems and integration -- Product data representation and exchange -- Part 236: Application protocol: Furniture catalogue and interior design |
| ISO/WD 10303-237 | Application Protocol -- Part 237: Fluid dynamics |
| ISO/DIS 10303-238 | Industrial automation systems and integration -- Product data representation and exchange -- Part 238: Application Protocol: Application interpreted model for computerized numeric controllers |
| ISO/DIS 10303-239 | Industrial automation systems and integration -- Product data representation and exchange -- Part 239: Application protocol: Product life cycle support |
| ISO/PRF 10303-240 | Industrial automation systems and integration -- Product data representation and exchange -- Part 240: Application protocol: Process plans for machined products |
| ISO/CD TS 10303-403 | Industrial automation systems and integration -- Product data representation and exchange -- Part 403: Application module: AP203 Configuration controlled 3D design of mechanical parts and assemblies |
| ISO/CD TS 10303-421 | Industrial automation systems and integration -- Product data representation and exchange -- Part 421: Application module: Functional data and schematic representation |
| ISO/TS 10303-439 | Industrial automation systems and integration -- Product data representation and exchange -- Part 439: Application module: AP239 product life cycle support |
| ISO/CD 10303-522 | Industrial automation systems and integration -- Product data representation and exchange -- Part 522: Application interpreted construct: Machining features |
| ISO/CD TS 10303-1050 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1050: Application module: Dimension tolerance |
| ISO/CD TS 10303-1051 | Industrial automation systems and integration -- Product |

data representation and exchange -- Part 1051: Application module: Geometric tolerance

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| ISO/CD TS 10303-1052 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1052: Application module: Default tolerance |
| ISO/CD TS 10303-1063 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1063: Application module: Product occurrence |
| ISO/CD TS 10303-1071 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1071: Application module: Class of activity |
| ISO/CD TS 10303-1074 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1074: Application module: Property condition |
| ISO/CD TS 10303-1077 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1077: Application module: Class of product |
| ISO/CD TS 10303-1080 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1080: Application module: Property space |
| ISO/CD TS 10303-1085 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1085: Application module: Property identification |
| ISO/CD TS 10303-1091 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1091: Application module: Maths space |
| ISO/CD TS 10303-1092 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1092: Application module: Maths value |
| ISO/CD TS 10303-1099 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1099: Application module: Independent property definition |
| ISO/CD TS 10303-1101 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1101: Application module: Product property feature definition |
| ISO/CD TS 10303-1102 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1102: Application module: Assembly feature definition |
| ISO/CD TS 10303-1103 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1103: Application module: Product class |
| ISO/CD TS 10303-1104 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1104: Application module: Specified product |
| ISO/CD TS 10303-1108 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1108: Application module: Specification based configuration |
| ISO/CD TS 10303-1109 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1109: |

Application module: Alternative solution

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| ISO/CD TS 10303-1110 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1110: Application module: Surface conditions |
| ISO/CD TS 10303-1111 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1111: Application module: Classification with attributes |
| ISO/CD TS 10303-1112 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1112: Application module: Specification control |
| ISO/CD TS 10303-1115 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1115: Application module: Part collection |
| ISO/CD TS 10303-1116 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1116: Application module: Pdm material aspects |
| ISO/CD TS 10303-1129 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1129: Application module: External properties |
| ISO/CD TS 10303-1130 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1130: Application module: Derived shape element |
| ISO/CD TS 10303-1131 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1131: Application module: Construction geometry |
| ISO/PRF TS 10303-1143 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1143: Application module: Building component |
| ISO/PRF TS 10303-1144 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1144: Application module: Building item |
| ISO/CD TS 10303-1145 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1145: Application module: Building structure |
| ISO/CD TS 10303-1146 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1146: Application module: Location in building |
| ISO/CD TS 10303-1147 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1147: Application module: Manufacturing configuration effectivity |
| ISO/CD TS 10303-1151 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1151: Application module: Functional data |
| ISO/CD TS 10303-1156 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1156: Application module: Product structure and classification |
| ISO/CD TS 10303-1157 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1157: |

Application module: Class of product structure

ISO/CD TS 10303-1158 Industrial automation systems and integration -- Product data representation and exchange -- Part 1158: Application module: Class of composition of product

ISO/CD TS 10303-1159 Industrial automation systems and integration -- Product data representation and exchange -- Part 1159: Application module: Class of connection of product

ISO/CD TS 10303-1160 Industrial automation systems and integration -- Product data representation and exchange -- Part 1160: Application module: Class of containment of product

ISO/CD TS 10303-1161 Industrial automation systems and integration -- Product data representation and exchange -- Part 1161: Application module: Class of involvement of product in connection

ISO/CD TS 10303-1162 Industrial automation systems and integration -- Product data representation and exchange -- Part 1162: Application module: Class of product library

ISO/CD TS 10303-1163 Industrial automation systems and integration -- Product data representation and exchange -- Part 1163: Application module: Individual product structure

ISO/CD TS 10303-1165 Industrial automation systems and integration -- Product data representation and exchange -- Part 1165: Application module: Involvement of individual product in connection

ISO/CD TS 10303-1166 Industrial automation systems and integration -- Product data representation and exchange -- Part 1166: Application module: Composition of individual product

ISO/CD TS 10303-1167 Industrial automation systems and integration -- Product data representation and exchange -- Part 1167: Application module: Connection of individual product

ISO/CD TS 10303-1168 Industrial automation systems and integration -- Product data representation and exchange -- Part 1168: Application module: Containment of individual product

ISO/CD TS 10303-1169 Industrial automation systems and integration -- Product data representation and exchange -- Part 1169: Application module: Activity structure and classification

ISO/CD TS 10303-1170 Industrial automation systems and integration -- Product data representation and exchange -- Part 1170: Application module: Class of activity structure

ISO/CD TS 10303-1171 Industrial automation systems and integration -- Product data representation and exchange -- Part 1171: Application module: Class of composition of activity

ISO/CD TS 10303-1172 Industrial automation systems and integration -- Product data representation and exchange -- Part 1172: Application module: Class of connection of activity

ISO/CD TS 10303-1173 Industrial automation systems and integration -- Product data representation and exchange -- Part 1173: Application module: Class of involvement in activity

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| ISO/CD TS 10303-1174 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1174: Application module: Class of activity library |
| ISO/CD TS 10303-1175 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1175: Application module: Individual activity structure |
| ISO/CD TS 10303-1176 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1176: Application module: Individual activity |
| ISO/CD TS 10303-1177 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1177: Application module: Composition of individual activity |
| ISO/CD TS 10303-1178 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1178: Application module: Connection of individual activity |
| ISO/CD TS 10303-1179 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1179: Application module: Individual involvement in activity |
| ISO/CD TS 10303-1188 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1188: Application module: Class of person |
| ISO/CD TS 10303-1198 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1198: Application module: Property and property assignment |
| ISO/CD TS 10303-1199 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1199: Application module: Possession of property |
| ISO/CD TS 10303-1203 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1203: Application module: Schematic and symbolization |
| ISO/CD TS 10303-1204 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1204: Application module: Schematic drawing |
| ISO/CD TS 10303-1205 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1205: Application module: Schematic element |
| ISO/CD TS 10303-1206 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1206: Application module: Draughting annotation |
| ISO/CD TS 10303-1207 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1207: Application module: Drawing structure and administration |
| ISO/CD TS 10303-1208 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1208: Application module: Schematic element library |
| ISO/CD TS 10303-1209 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1209: Application module: Symbolization by schematic element |

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| ISO/CD TS 10303-1211 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1211: Application module: Cardinality of relationship |
| ISO/CD TS 10303-1212 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1212: Application module: Classification |
| ISO/CD TS 10303-1213 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1213: Application module: Reference data library |
| ISO/TS 10303-1287 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1287: Application module: AP239 activity recording |
| ISO/TS 10303-1292 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1292: Application module: Ap239 product definition information |
| ISO/TS 10303-1293 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1293: Application module: Ap239 part definition information |
| ISO/TS 10303-1304 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1304: Application module: AP239 product status recording |
| ISO/TS 10303-1306 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1306: Application module: Ap239 task specification resourced |
| ISO/TS 10303-1307 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1307: Application module: Ap239 work definition |
| ISO/CD TS 10303-1341 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1341: Application module: Generic expression |
| ISO/CD TS 10303-1342 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1342: Application module: Expression |
| ISO/CD TS 10303-1343 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1343: Application module: Product placement |
| ISO/CD TS 10303-1344 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1344: Application module: Numerical interface |
| ISO/CD TS 10303-1345 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1345: Application module: Item definition structure |
| ISO/CD TS 10303-1346 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1346: Application module: Numeric function |
| ISO/CD TS 10303-1347 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1347: Application module: Wireframe 2d |

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| ISO/CD TS 10303-1349 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1349: Application module: Incomplete data reference mechanism |
| ISO/CD TS 10303-1350 | Industrial automation systems and integration -- Product data representation and exchange -- Part 1350: Application module: Inertia characteristics |
| ISO 13584-102 | Industrial automation systems and integration -- Parts library -- Part 102: View exchange protocol by ISO 10303 conforming specification |
| ISO/DIS 13584-501 | Industrial automation systems and integration -- Parts library -- Part 501: Reference dictionary for measuring instruments -- Registration procedure |
| ISO/DIS 13584-511 | Industrial automation systems and integration -- Parts library -- Part 511: Mechanical systems and components for general use -- Reference dictionary for fasteners |
| ISO/PRF 15531-32 | Industrial automation systems and integration -- Industrial manufacturing management data: Resources usage management -- Part 32: Conceptual model for resources usage management data |
| ISO/PRF 15531-42 | Industrial automation systems and integration -- Industrial manufacturing management data -- Part 42: Time Model |
| ISO/DIS 15531-43 | Industrial automation systems and integration -- Industrial manufacturing management data -- Part 43: Manufacturing flow management data: Data model for flow monitoring and manufacturing data exchange |
| ISO/CD TS 15926-4 | Industrial automation systems and integration -- Integration of life-cycle data for process plants including oil and gas production facilities -- Part 4: Initial reference data |
| ISO/PRF PAS 16739 | IFC 2 . x Platform specification |
| ISO/PRF 18629-11 | Industrial automation systems and integration -- Process specification language -- Part 11: PSL core |
| ISO/PRF 18629-12 | Industrial automation systems and integration -- Process specification language -- Part 12: Outer core |
| ISO/DIS 18629-13 | Industrial automation systems and integration -- Process specification language -- Part 13: Duration and ordering theories |
| ISO/DIS 18629-14 | Industrial automation systems and integration -- Process specification language -- Part 14: Resource theories |
| ISO/DIS 18629-41 | Industrial automation systems and integration -- Process specification language -- Part 41: Activity extensions |
| ISO/DIS 18629-42 | Industrial automation systems and integration -- Process specification language -- Part 42: Definitional extension: Temporal and state extension |
| ISO/DIS 18629-43 | Industrial automation systems and integration -- Process specification language -- Part 43: Activity ordering and |

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| ISO/DIS 18629-44 | Industrial automation systems and integration -- Process specification language -- Part 44: Definitional extension: resource extensions |
| ISO/CD PAS 20542 | Industrial automation systems and integration -- Systems engineering data representation |
| ISO/NP PAS 22720 | Procedures for Transposing Externally Developed Specifications into ISO Deliverables |
| ISO/NP TS 22745 | Industrial automation systems and integration -- Open technical dictionary |