Thou Shalt Document

Electronic Documentation Requirements of the IPC-2610 series

Have you ever wondered how to get involved in IPC standards development? If so, I'm going to give you an opportunity to participate right here, right now! The IPC is currently in the process of updating IPC-D-325 Documentation Requirements into the new IPC-2610 series:

IPC-2611 Generic Requirements for Electronic Product Documentation
IPC-2612 Sectional Requirements for Electronic Diagramming Documentation
IPC-2613 Sectional Requirements for Assembly Documentation
IPC-2614 Sectional Requirements for Board Fabrication Documentation
IPC-2615 Printed Board Dimensions and Tolerances
IPC-2616 Sectional Requirements for Electrical and Mechanical Part Descriptions
IPC-2617 Sectional Requirements for Discrete Wiring Documentation
IPC-2618 Sectional Requirements for Bill of Material Documentation
IPC-2619 Sectional Requirements for Product Performance or Process Control

Four of these have been released into the world for comments, and we will begin this little experiment with two of them. Ready? Here we go...

The IPC wants us to pay attention to the word "**shall**" in all of its publications. This word is always highlighted in **bold** font, and each document contains a specific paragraph about how the word should be interpreted. Here it is:

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1.3 Interpretation
The word "shall", the emphatic form of the verb, is used
throughout this standard whenever a requirement is intended
to express a provision that is mandatory. Deviation from a
"shall" requirement may be considered if sufficient data is
supplied to justify the exception. The words "should" and
"may" are used whenever it is necessary to express non-
mandatory provisions. "Will" is used to express a declaration
of purpose. To assist the reader, the word "shall" is
presented in bold characters.
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I thought it would be interesting to scan through the new documents looking for the word "**shall**".
I chose the generic requirement (IPC-2611 Electronic Product Documentation) and one of the sectional requirements (IPC-2614 Fabrication Documentation) just to see what I would find.

These are in final draft form now and up for ballot, so very soon these will be official requirements that you **shall** use if you are going to build your documentation methods on the foundation that IPC provides. Here they are:

from IPC-2611 (applies to ALL electronic documentation)

In the event of any conflict in the development of new designs, the following order of precedence **shall** prevail:
1. The procurement contract.
2. An approved documentation package (w/deviation list, if applicable).
3. Company specific manufacturing standard
4. This standard.
5. Other applicable documents.

The grade of documentation and completeness mode **shall** be described in the contract. Grades and completeness may be A1, B1, C1, A2, B2, C2, A3, B3, or C3 see 3.2.1, 3.2.2, and 3.2.3. In the event that no grade is specified grade B2 **shall** be considered as the default.

In addition to the documentation grade, a data completeness mode and a function characteristic **shall** also be defined.

Any deviation from this standard in the documentation package **shall** have been recorded on the appropriate document as prescribed in the IPC-2610 series or a customer-approved deviations list.

In order to be able to accept intelligent data formatting the supply chain partners **shall** agree to the format used to describe the details of the documentation package. All information descriptions **shall** be provided in computer transferrable media on what the documentation package contains and how it may be interpreted. This should include date of generation, tool used and revision level, other manufacturing or ordering details.

The drawing sizes and format used to prepare the fabrication, assembly, schematic, etc. drawings **shall** be in accordance with ASME-Y14.1 & ASME-Y14.1M

When ANSI-Y14.1 is required, the standard drawing sizes A, B, C, or D **shall** be used

When continuation sheets of the drawing are used they **shall** be on standard sheet sizes, with a standard continuation sheet title block located in the lower right corner of each sheet

The projection requirements **shall** be 3rd angle

When ANSI-Y14.1M is required the standard drawing sizes identified in ISO 216 **shall** be used

When using the ISO 216 image formats the angle of projection **shall** be first angle in accordance with Figure 4-3

The title block **shall** contain the appropriate title of the document, the scale, the drawing number, the cage code number of the facility preparing the master drawing, if applicable, plus the appropriate approval block.

On continuation sheets without revision blocks, the title block **shall** contain provisions for recording the revision

Signatures **shall** have a minimum of 3 signatures; who drew the document, who it was for and who checked the document

Titles and subtitles for hard copy or electronic documentation **shall** always be shown in uppercase letters. The names of items used as titles for drawings **shall** be brief, descriptive, and of uniform definition. Titles **shall** consist of a basic noun or noun phrase and **shall** include sufficient modifiers to differentiate like items in the same major assembly

The date format **shall** be the year (XXXX), month (XX) and day(XX). (i.e., 20040821, 20051122). The following characters **shall not** be used \ / : * ? " < > @ ~ |

The drawing revision description block **shall** identify the specific changes made. It is not acceptable to just reference to the Engineering Change Proposal (ECP) or other engineering document that initiated the change

Data file approval **shall** be contained within the data file.

When a drawing or electronic document is created using multiple sheets, the first sheet of the drawing **shall** contain the revision status block

When multiple files are used in order to define the data used in the documentation package they **shall** be identified in a clear and unambiguous manner in order to facilitate data searches and configuration management.

The number assigned to a document (hard copy or electronic) or data file ID may consist of any alphanumeric including a dot, dash or underscore punctuation. Any letters that become part of the number **shall** be in upper case

Every part, drawing, data file **shall** have a unique identifier that is part of an overall system The identifier assignment **shall** be managed through a consistent set of rules that can provide objective evidence that the system is robust and free of ambiguities

The use of an alias (unique company identification or part number) representing internal IDs is a successful way of managing a variety of situations through the use of a consistent system intended to avoid confusion or to simplify information access. A method **shall** be established in order to validate that the alias is a legal ID assignment, and that a truth table concept is available in order to insure the cross reference to the other forms of identification can be ascertained easily

In the event that a particular part, drawing or data file is not available that fully meets the form, fit and function requirements of the end product, a documented substitution may be authorized by the user. Since the substitute is not completely identical a new alternate **shall** be used in order to have the substitute be part of the system

The first production change for any released document or data file **shall** be Revision "A", with subsequent and sequential letters being used for additional revisions; i.e., Revision "B", Revision "C", etc

Whenever the drawing, or computer transferrable media, requires a revision, the description **shall** identify whether the revision impacts form, fit, function

The first engineering change, considered the first production change, **shall** be assigned the letter "A". Subsequent changes **shall** follow in sequence: "B", "C", "D", etc. Uppercase letters **shall** be used in alphabetical sequence. The letters "I", "O", "Q", "S", "X", and "Z" **shall** be omitted. When revisions are numerous enough to exhaust the alphabet, the revision following "Y" **shall** be "AA", and the next "AB", then "AC", etc. Should "AA" to "AY" be exhausted, the next sequence **shall** be "BA", "BB", etc.

The contract for the manufacturing supplier **shall** reference the documentation package, any applicable external standards or specifications, and the interpretation of the requirements related to the manufacturing of the end product

The contract **shall** define the order of precedence when multiple date standards are referenced

The contract **shall** define all deliverables from the manufacturer including requested time lines and quantity as well as any allowable yield oriented product being delivered in the set

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from IPC-2614 Board Fabrication Documentation

Classification of printed board documentation **shall** meet the requirements of IPC-2611, and **shall** be defined by Grade and completeness mode.

A specific grade **shall** consist of a letter to define the differences between hard copy and electronic data. In addition a second classification, consisting of a number, is required that defines the completeness mode of the documentation procurement package.

The output from the design process **shall** be consistent for the products being documented from the design process or the CAD system.

Conductor layer identification starting with the primary side, the next conductive layer **shall** be Layer 2. (For assemblies with components on both sides the most complex or densely populated side **shall** be Layer 1.)

Terms used on the Fabrication data set **shall** conform to this standard and IPC-T-50

A Printed Board requiring a change **shall** be updated by raising the revisions of the following:
   a) the fabrication drawing, including revisions of all cognizant pattern description;
   b) the "bare board marking revision"; solder paste stencil pattern;
   c) metal core pattern; laminated heatsinks, etc.
   d) An update to a fabrication data set is permissible, provided the following criteria is met: the change **shall** not affect form(shape), fit (dimensional size) and function (electrical characteristics).
   e) The assembly drawing (if the drawing duplicates information on the PWB drawing – e.g., artwork views)"

Whenever a printed board requires a change which does affect the form, fit, or function, the board **shall** be assigned a new part number and treated as a new design. The revision in this situation **shall** be treated the same as an initial release; therefore, the fabrication data set, pattern description and board revisions are assigned a dash (—) revision.

When the revisions do not affect form fit or function, the changed board **shall** be assigned the next revision identification, consistent with the revision system.

All CAD system output data **shall** meet the requirements of IPC-2580 series format and/or other industry acceptable standard formats as agreed to between trading partners. This requirement

shall be part of the grade and completeness descriptions documented in the contractual agreements.

The fabrication drawing as a part of the data set **shall** be prepared in accordance with the requirements of this specification. Typical fabrication drawing documentation requirements are shown in Table 3-2.

The data pattern **shall** contain as a minimum, the following information:
A. Board part number and revision.
B. Layer number
C. For composite printed boards, a complete set of quality conformance coupons is required for the top board, the bottom board and the composite board.
D. Three fiducials (or registration targets) **shall** be located on grid and on each layer of data pattern. Each additional layer or data pattern **shall** have fiducials located at the same points which, **shall** register with each other, layer to layer.
E. Marking or silkscreen data patterns (when required) **shall** have a minimum of two alignment fiducials to coincide with the center-line of features located on the board surface to be marked.
F. Component pedestal data patterns (when required for no-lead parts) **shall** have a minimum of two fiducials to coincide with the center line of features located on the board surface.
G. Special tooling data patterns: During the formal design review and prior to layout, special tooling requirements which can be generated during design should be considered.

When a production master is not provided as part of the data set, the fabricator **shall** have responsibility for creating the production master from the data pattern master, the accuracy of which **shall** meet the requirements of the fabrication data set

When production masters are supplied as a supplement to the engineering fabrication data set, they **shall** be supplied as readily usable 1:1 precision masters including all manufacturing allowances

When conformance test circuitry is required in order to validate the production quality the test coupon images **shall** be included in the single image production master.

The method of excising individual boards **shall** be included in the assembly pallet description.

Automated systems, such as CAD equipment, computer aided engineering (CAE) equipment, computer aided manufacturing (CAM) equipment, test equipment, photoplotters, automated assembly equipment (auto insertion and/or pick and place equipment), automated optical inspection (AOI) equipment, **shall** be capable of communicating with each other.

Generation of master patterns and measurement techniques **shall** be in accordance with the requirements of IPC-D-310. The appropriate pattern tolerances and processing allowances **shall** be incorporated into the production master

Titles for printed boards **shall** consist of a noun phrase used to define the product type followed by an adjective that provides the specific use or function of the product type

The noun phrases **shall** be followed by an approved separation character or format. The preferred separation character is a dash. Naming for files may use underscores as a name separator or have the capital letter of each word be the delimiter. e.g., PrintedBoardSynthesiser

In the electronic format files can be intermixed in order to ease the processing capability

by the manufacturer, however the first file **shall** identify the mixing and matching of different electronic formats.

Content formats are directly computer processable and require observance of the standard protocol and **shall** not be mixed with other format except to permit a reference to an external URL. In this instance the proper link **shall** be supplied and assurance provided that the link remains active through the life of the data file.

The number assigned to a format for an individual product **shall** be unique

A contract number **shall** be part of the fabrication information and should be maintained in a separate location in order to avoid changing many data items when the contract changes. When a contract number appears in multiple format locations it **shall** be consistent without ambiguity.

A distribution list should be developed for all fabrication data set recipients. The list **shall** be related to the contract, mode or usage of the data set, and be updated periodically

A revision control system **shall** be established for all formats that become part of the fabrication data set. The system **shall** include a method to define the original release of the data as well as changes made when the product is in full production

Revision letters used to define different characteristics of the fabrication data **shall** be made up of single letters of the alphabet without use of the letters I, O, Q, S, X, Z as defined in IPC-2611. If revision requirements go beyond the 20 available characters a double letter **shall** be used starting with revision AA.

At times a temporary revision of a product is required in order to select the best possible solution to a variety of conditions either fabrication, assembly or any condition where further evaluation might be necessary. In this instance a dash **shall** be used behind the original revision letter followed by a unique number for any variation being explored. The first number used **shall** be 1 followed by sequential numbering. The affectivity (number of units to be produced) **shall** be identified as part of the fabrication data set.

Configuration control **shall** be maintained between and among all elements of the fabrication data set.

The fabrication data set **shall** describe the final configuration of the printed board in sufficient detail to ensure fabrication of the end product board. In addition to the configuration details, information **shall** also be supplied as to the performance requirements expected of the printed board throughout its life cycle.

All notes **shall** be numbered sequentially, starting with number 1. (1, 2, 3, 4 etc.) In order to categorize similar notes sub-letters may be added to the number such as 1A, 1B, 1C, or they A, B, and C may be indented under note 1 in an outline format. Those notes which are referenced elsewhere on the fabrication drawing **shall** be enclosed in a square or flag. The corresponding reference number(s) delineated elsewhere on the drawing **shall** also be enclosed in a square or flag. Those notes that are elsewhere in the fabrication set **shall** be enclosed in a diamond. The first item behind a note in a diamond **shall** be the note location such as a URL or document number.

The placement of notes on the fabrication data set **shall** be on the first file or image and located in the upper left-hand corner starting with Note 1

In the event that no design or board performance requirements are noted, the manufacturer **shall** assume that Class 2 Level B is intended.

The fabrication construction **shall** be described using a cross sectional view, or table indicating the construction and stackup of the board

The fabrication construction in mode 2 and mode 3 completeness formats **shall** include:
   a) The core thicknesses and tolerances; prepreg and tolerances; constraining core and construction, (when required) including thickness and tolerance;
   b) Individual layer locations; solder mask information (top and bottom, when required);
   c) silk screen information (top and bottom, when required);
   d) primary and secondary (top and bottom) identification plus an overall dimension including tolerance.
   e) Power plane layers **shall** be identified by their voltage; i.e., +5V, +15V, 15V RTN, etc. Split plane layers **shall** be identified with the voltages separated by an underscore or slash delimiter; i.e., +12V_-5V_GND.

The layout or board design **shall** be viewed from the primary side of the board

Unless otherwise specified, conductor layers **shall** be numbered consecutively, starting with the primary (component) side as layer 1

The accuracy and scale of any data set, design layout or check plot **shall** show sufficient detail to eliminate inaccuracies in interpretation during the pattern generation process.

The location of blind and/or buried vias **shall** be identified for each layer pair and should be illustrated on the drawing or electronic Image. When controlled depth drilling is used to create blind vias (usually filled with conductive or non-conductive material), the drill depth from top or bottom **shall** be included in the separate drill list data

When creating documentation illustrating constraining core printed boards the following parameters **shall** be considered:
   a) Substrate drawings or data, illustrating constraining core construction, **shall** use the same coordinate zero feature location as the printed board(s).
   b) clearance holes required for the top-to bottom plated through-hole interconnects
   c) profile dimensioning
   d) thickness(es)
   e) materials used, processing requirements
   f) coupon clearance holes
The coupon **shall** be designed in accordance with IPC-2221

The Fabrication Data Set **shall** have a chart titled ''Hole Schedule''.

Each unique hole diameter **shall** be assigned a separate hole schedule symbol or code letter (optional) for reference. The hole schedule **shall** also correspond with the plotted ''Drill Pattern'' illustrating all drill locations.

Every hole **shall** be identified (by symbol) and **shall** contain the following information in the hole schedule:
   a) Diameter,
   b) Tolerance range,
   c) Maximum hole considered when developing circumscribing land (Optional)

d) Plating requirements, (plated or nonplated).
e) Additional information used to identify tooling holes,
f) Tented holes or filled holes

The drill pattern **shall** be included as part of the Fabrication Data Set for mode 2 and 3.

The drill pattern (viewed from the primary side) **shall** include quality conformance coupons as agreed to between user and supplier

The methods for dimensioning the profile (board outline) **shall** be in accordance with IPC-2615. The methods for depicting feature size, position and location, form and associated tolerances. Tolerances **shall** be in accordance with IPC-2615.

The board thickness **shall** be dimensioned in an end view or depicted in the board construction crosssectional view.

Board thickness **shall** be specified on the Fabrication Data Set and, unless otherwise specified, **shall** include metallic deposition. In critical areas, such as connector contact areas, the thickness tolerances may be more stringent and **shall** be detailed with specific size conditions (MMC and LMC), and should, wherever possible, be limited only to those areas where needed.

When printed board features fall off grid, they **shall** be individually dimensioned and toleranced on the Fabrication Data Set.

Grid systems **shall** be located with respect to a minimum of two datum points.

The grid increment **shall** be specified on the Fabrication Data Set

The fabrication data set **shall** include the relationships and acceptable tolerances between all datum features as established in accordance with IPC-2615. A minimum of two holes located on grid **shall** be dimensioned and toleranced with respect to a datum reference frame.

The values of printed board dimensions and tolerances **shall** be in accordance with IPC-2615. The dimensioning and tolerancing convention used on the fabrication data set **shall** be in accordance with IPC-2615.

Datum features **shall** be specified on the fabrication data set by means of datum symbols per IPC-2615; implied datums **shall** not be used. Datum features **shall** be functional features of the printed board, and should relate to mating parts such as mounting holes, connectors, or component leads or terminations. All datum features should be located on grid or establish the grid criterion, and they **shall** be located within the printed board profile.

Unplated through hole patterns, especially tooling and mounting holes (board mounting holes, interface connector mounting holes, board top plate/mounting bracket mounting holes, etc.) are generally drilled in separate drilling operations as one of the last fabrication operations. They **shall** be explicitly dimensioned and toleranced, even if they occur on grid.

A minimum of two holes on grid **shall** be dimensioned and toleranced with respect to a datum reference frame in order to locate the grid.

When specified on the fabrication data set, boards and assemblies **shall** be marked by appropriate inks, labels, etched characters, or other permanent methods

If a conductive marking ink is used, it **shall** be permanent and appropriately isolated by spacing or coating from the balance of the circuitry

Markings **shall** be of sufficient size, clarity, and location to allow legibility during processing, inspection, storage, installation, and field repair

The fabrication drawing **shall** specifically indicate the location for the date code, fabricator's I.D. and UL marking, user's cage code, ESD symbol and all other required traceability markings

ESD, military or Underwriters Laboratories requirements may include special marking considerations which **shall** become a part of the master drawing

A note on the fabrication data set **shall** specify the acceptable bow and twist requirements

Coupons or their technical equivalent **shall** be used to determine the quality of the final product; user and supplier agreement for alternate methods **shall** be required

When process control coupons are used in lieu of quality conformance coupons, they **shall** be depicted on the Fabrication Data Set or Contract

Target patterns (fiducial targets or marks) **shall** be provided on all surface mount images

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Whew! That's a lot of **shall**s....

The prospect of wading through an entire series of new documents is intimidating to most people, so maybe this abbreviated list is an easier approach for some of you. If you are involved in circuit board design and are familiar with fabrication drawings, you will know which of these can be implemented without too much trouble, and which of them might be difficult or unneccessary.

If you have a short comment on any of these, I can collect them at pcbjack@gmail.com and submit them as a group to the committee by March 25th. Editorial comments are easy, but for Technical comments you should know enough about the subject to suggest an alternative.

If any of these statements are worthy of open discussion,
the best forum is probably the Designer's Council listserver.
join by sending "subscribe DesignerCouncil (yourname)" in
the body of an email (no subject required) to listserv@ipc.org

If you are interested in the subject of electronic documentation, help us out!
Download the entire document and official comment forms at
http://members.ipc.org/committee/drafts/2-40_d_261XPSB.zip