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IPC-D-356B

Bare Substrate Electrical Test Data Format

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Developed by the IPC-D-356 Task Group (2-11c) of the Data Generation and Transfer Committee (2-10) of IPC

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Users of this standard are encouraged to participate in the development of future revisions.

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Acknowledgment

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Bare Substrate Electrical Test Data Format

1 SCOPE AND OBJECTIVE

This standard describes a data format for transmitting bare board electrical test information. The material contained herein is intended to convey requirements, guidelines, and examples necessary to provide the data structures and concepts for bare board electrical test information in digital form, including data suitable for computer aided repair. When used as a netlist input to test data processing, the receiver of IPC-D-356B data will determine test point assignments and positioning.

Being essentially a netlist test format, this standard has been crafted to represent interconnect substrate graphics and test in a balanced way. Although substantial support is given to convey the graphical image of conductor shapes, the standard is not “graphically correct.” It is not intended to serve as a means to produce artwork or other board fabrication tools, but rather serve as a useful aid in conducting electrical test, analysis and repair.

1.1 Format Compatibility Although the concepts detailed in this standard may be supplemented by descriptions defined in other companion IPC Standards, it is intended that this standard be suitable for use as a stand alone description of bare board test and repair data for an individual circuit or job. Refer to other standards in the family for other areas of applicability.

IPC-D-356B is not backward compatible to Revision A. The VER parameter allows this version to be distinguished from previous versions.

1.2 Goal of Revision B Despite the widespread acceptance of Revision A, it became clear over time that there were many places where IPC-D-356A format was subject to interpretation and ambiguity. The intent of Revision B is to remove ambiguities, improve graphics representation and reduce file size. Desired graphical improvements consist of better representation of pads and test areas, clear solder mask determination and support for contours or polygon conductor areas. Realization of these goals took into consideration the following requirements;

- Keep it simple, at least as simple as is possible.
- Minimize the difficulty in programming input or output translators.
- Make the file as humanly readable as possible.
- While attempting to improve the graphical capability of the standard, do not attempt to make it “graphically correct.”
- Support graphical data in commonly occurring forms to prevent the need for CAD or CAM systems from exploding

ing a compact representation of a graphical shape into a verbose statement of the same basic shape.

Every effort has been made to eliminate data redundancy and minimize file size. Extensive use of examples will hopefully make this version even more “user friendly” than the previous revision.

1.3 Changes Between Revision A and B

1.3.1 Test Area Revision B contains a paradigm shift in the definition of pads and what is a “testable pad area.” Revision A supported round or rectangular pad shapes that may or may not be covered with soldermask. Although this approach was useful for some time, the advent of unusually shaped pads, and SMD pads defined totally or partially by soldermask render this definition imprecise.

To address these problems, two significant changes were made. The traditional “pad” has been replaced with two new types of records, “test area” and “non-test area” records. A test area is literally an area on a pad (often the entire pad), that might be contacted during electrical test. By definition, it is entirely free from soldermask, although it may or may not be a mid-point. By supporting “test areas” in simple shapes, the definition of complex underlying “copper” can be left to other types of “graphics only” records such as trace segments, polygon copper areas or simple non-test areas of copper. This makes the interpretation of where the actual test point should be located within the test area much more straightforward for the receiver of IPC-D-356B data.

1.3.2 Complex Record Changes In addition to changes related to test areas, complex records have been redefined in a more general way to represent all inter-layer connections in nets. In IPC-D-356A, complex records were introduced to support “via in pad” constructions while blind vias and buried vias had their own op-code and syntax. Revision B combines all these records into one format that allows the definition of all the elements of a padstack. This definition is more in keeping with the notion that the receiver of a IPC-D-356B netlist should be responsible for assigning the particular test point location within a test area. If it is desired to avoid contacting an integral hole, or perhaps preferentially test a plated hole instead of the pad, the data is there to make that determination.

1.3.3 Polygon Copper Areas Revision A lacked a means to represent contours or polygon areas of copper. To improve the graphical representation of the board, and to minimize the explosion of contours in the netlist data

segments, a simple format for describing polygons has been added. Together with the definition of test areas, this approach was viewed by the CAM suppliers as the best means to handle complex pad constructions and avoid difficult format conversions.

1.3.4 Extended Line Length for Certain Records The first version of IPC-D-356 was created at the end of the era of computer punch cards and made use of an 80 column limit that was the standard of the day. While it is desirable to keep line length reasonable for human readability with common text editors, certain forms of data need not be limited by the 80-column rule. Revision B allows line length to be extended to 132 characters for polygons, line segments and board outline data.

1.3.5 New Shape Format With the introduction of new shapes for test areas and non-test areas, it made sense to redefine the format of these shapes for ease in writing translators and for human readability. Whereas before the format was fixed and column based, the new format uses a character key to define the shape, followed by the logical arguments for that shape. For example a rectangle is logically defined by its height and width, while a circle is defined by its diameter.

1.3.6 New End-Point Optimization Marking IPC-D-356A suffered in its support for various end-point optimization methods. In particular, the way that “conventional” and “end of copper” methods must be annotated for plated-through holes precluded notation of both methods in one file. (Conventional end-pointing is when only one side of a PTH end-point is tested.)

A new method of identifying end-points and mid-points has been introduced and a special method for marking an entire complex record as a mid-point or an end-point has been provided. By taking this approach, IPC-D-356B data contains sufficient data to interpret either an “end of copper” approach, or a “conventional end-pointing” approach.

1.3.7 New Form for Test Measurement Data IPC-D-356A contains a number of different formats for representing embedded and on-board components (resistors, capacitors and inductors), controlled impedance measurements and high voltage isolation testing. While recognizing that the embedded components are “features of the substrate,” and the other measurements are “test requirements for the substrate,” the actual data requirements for the two kinds of information are really quite similar. To achieve re-usability of code in input translators, the format for these types of records has been simplified and standardized using op-codes to distinguish between the record types.

1.4 Data Records and Their Organization IPC-D-356B job data is composed of a variety of different kinds of records. Those records must be organized in a specific way to make the job of writing IPC-D-356B readers and output generators more manageable. Specific sections of this document are devoted to describing the organization and intent behind the structure (Section 5). Parameter records inform the computer program how to interpret the records that follow in the job set. Comment records provide additional descriptive material for review by the user, but are not interpreted by the computer. Data records provide the detailed data that express the connectivity and attributes associated with test points for the circuit.

1.5 IPC-D-356B File Usage This standard is intended to transmit bare board test netlist and graphical information from CAM to electrical test data processing, from CAD design source to test, and/or from test to computer aided repair. Although it would be desirable for all IPC-D-356B files to be “full,” meaning they contain ALL the possible types of data supported in the standard, that is seldom, if ever, the case. CAM systems simply do not usually have the more CAD oriented signal name and Reference Designator/Pin information. CAD sources simply do not have the necessary end-point optimization or adjacency data. While one would hope the situation might change, it is important to point out the necessary and expected content of a IPC-D-356B file. See Appendix A for a description of the recommended content for IPC-D-356B files transmitting data from:

- CAD to test data processing
- CAM to test data processing
- Electrical test software to repair
- Electrical test software to ATE system

1.6 Interpretation “**Shall**,” the imperative 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.

2 APPLICABLE DOCUMENTS

The following documents form a part of this standard to the extent specified herein.

2.1 IPC¹

IPC-T-50 Terms and Definitions for Interconnecting and Packaging Electronic Circuits

1. www.ipc.org

IPC-D-325A Documentation Requirements for Printed Boards

IPC-D-350 Printed Board Description in Digital Form

IPC-D-355 Printed Board Automated Assembly Description in Digital Form

IPC-9252 Guidelines and Requirements for Electrical Testing of Unpopulated Printed Boards

2.2 American National Standards Institute²

ANSI X3.12 Subroutine Record Format Standardization

2.3 International Electrotechnical Commission (IEC) International Standards Organization (ISO)³

IEC 60194 Terms and Definitions for Printed Circuits

IEC 1182-1 Printed Boards - Electronic Data Description and Transfer. Part 1 - Printed Board Description in Digital Form

ISO 646 Information Exchange

3 TERMS AND DEFINITIONS

Unless otherwise specified herein, terms and definitions **shall** be in accordance with IPC-T-50, IEC 60194, ANSI X3.12 and the definitions in the following paragraphs.

3.1 Field A data element (a unit of information) which defines a characteristic of the feature(s) being described.

3.2 Record An ordered set of fields (data elements) of ASCII characters. In the context of IPC-D-356, there are four types of records: Comment Records, Data Records, General Records and Parameter Records. The term “Copper” or “Copper Area” records are used to describe the more generic “conductors” that are patterned on or within an interconnect substrate.

3.2.1 Comment Record A record that provides, or refers to, an additional descriptive set.

3.2.2 Data Record(s) A type of record or group of records that describe the size, location and shape of a feature, as well as instructions for use of previously defined data.

3.2.2.1 Point Record A type of Data Record describes a feature that is located at a single position or discrete positions. Point records may include test areas, non-test areas or via connections between layers. Point records may also

include some non-test features such as fiducials and tooling holes.

3.2.2.2 Complex Record Complex records are the method used in IPC-D-356B to describe a combination of surface features and integral hole(s) or via(s). They are a contiguous group of point records that typically contain one record representing the pad (or test area) on the primary side, a record representing the conducting hole or holes through the substrate, and a third (or more) record representing the pad (or test area) on the secondary side.

3.2.2.3 Line Records A type of Data Record that describes a sequence of linear segments and/or circular arcs.

3.2.2.4 Polygon Records A non-testpoint record to describe an irregular shape of conductor on a layer. For simplicity, conductors are often referred to as “copper areas” in this document.

3.2.2.5 Measurement Records Measurement records are used to describe controlled impedance measurements and high voltage isolation measurements between signals in the board or in the panel. Measurement records also describe embedded and on-board components actually included in or on the board.

3.2.3 End of Job Record A record which terminates processing sequence for the job data file.

3.2.4 Parameter Records A record that defines the interpretation or processing of the subsequent Data Records. Parameter records are modal.

3.3 Physical Layer A printed wiring board (or other layered product) layer or artwork image representing a complete conductive layer.

3.4 Job Data A group of records which represent the data needed to perform electrical test on an individual circuit or part number.

3.5 Feature The make, shape, or appearance of characteristics of a printed board or artwork (e.g., lands, conductors, holes, cutouts, dielectric separation, legend, etc.). Features are described by records.

3.6 Datum Reference The theoretically exact point that is the origin from which the location of geometric characteristics of features are established.

2. www.ansi.org

3. www.iec.ch

3.7 Modal Form The technique whereby a data description or other command is given only once at the beginning of a related set of data and is in effect until otherwise instructed.

3.8 Operation Codes Operation codes (op-codes) are used in columns 1-3 of data records to indicate the type of data represented in that line. They serve as an indicator to the program (or human) reading the line on how the line should be processed. Linked records are expressed with a continuation op-code, the first character of which is always "0." A complete list of op-codes is provided in Appendix B, and the individual op-codes defined within a section are listed at the beginning of each section.

3.9 End-Point Optimization Net end-points are commonly assigned as tested nodes on a substrate. Net mid-points (those with conductor connection to at least two other distinct end-points) are often not assigned as tested nodes in common test strategies. Various methods of end-point optimization calculation and definition have evolved that provide different levels of test coverage. While this standard does not seek to endorse one particular method over another, it must support the clear expression of all the popular methods. See Appendix D for an overview of end-point optimization methods in this standard.

While end-point optimization information is optional in data records, it is strongly recommended that the data is either always or never included within a file.

3.10 Adjacency Adjacency is a list of nets (by signal name) that could possibly be shorted based on their proximity to one another.

4 GENERAL REQUIREMENTS

Individual circuits may be represented by use of this standard, in either a single image configuration or a stepped or multi-up configuration. This standard does not support multiple circuits or part numbers within a single file of Job Data.

4.1 Data Hierarchy Printed boards and/or artwork **shall** be described in data formats appropriate for their use. IPC-D-356B does not support all the possible graphical features and artwork images in a printed wiring board. Other standards or data formats should be used for conveying design and fabrication data.

Job Data is composed of parameter records, comment records, and data records, which describe related circuit or printed board manufacturing data.

Parameter records inform the computer program how to interpret the records that follow in the job set. Comment records provide additional descriptive material for review

by the user, but are not interpreted by the computer. Data records provide the detailed data that express the connectivity and attributes associated with test points for the circuit.

Typical examples of information supplied by data records are listed below:

- Signal ID
- Component ID
- Feature Dimensions and Location
- Physical Layer
- Hole Size
- Type of Hole
- Electrical Node Identification
- Type of Hole
- Test Point Location
- Conductor Segment Data
- Net Adjacency Data
- Resistance and Capacitance Test Data
- Test Channel Assignment
- Blind and Buried Via Data
- Component and Measurement Data

4.2 Basic Record Types The following are the basic record types and structures discussed in this document:

- General Records (Section 5)
- Parameter Records (Section 6)
- Comment Records (Section 7)
- Electrical Test Area Record Structures (Section 8)
- Specified Test Point Location (Section 9)
- Graphical Support of the Board Image (Section 10)
- Adjacency Data (Section 11)
- Electrical Test Measurement Data (Section 12)
- Special and non-Test Features (Section 13)
- Stepped Images using the Image Parameter (Section 14)

In addition, the sequencing of different types of data within a file is described in Section 5.

4.3 Compatibility With the introduction of the Version Parameter, it was decided that Revision B need not be backward compatible with IPC-D-356 or IPC-D-356 Revision A.

4.4 Fixed and Field Delimited Formats Two methods of formatting data are commonly used in representing data. One is a fixed column format, the other is a field delimited format. In the fixed column format, information is specified for each column in the record. In the field-delimited format, data is left-justified, may be variable in length, and is separated by a described delimiter.

IPC-D-356B employs fixed column format, and several forms of data where the record starts as fixed format for a specified number of columns, and then transitions to field delimited to the end of the record. The delimited portion of the record is used for optional fields and for fields whose width is dependent on the type of object being described. This “mixed” structure was selected because it reduces the number of different types of reader functions, reduces file size and allows use of op-codes and common data forms to initiate a record. Table 4-1 below lists the various forms of IPC-D-356B data and whether they are fixed, field delimited, or start as fixed and end in field delimited.

Table 4-1 Record Form

Record Type	Form
Parameters	Fixed
Basic Test Area, Non-test Area	Fixed
Complex Records	Fixed
Specified Test Point Location	Fixed
Conductor Segment Data	Fixed then Field
Board/Panel Outline Data	Fixed then Field
Polygon Data	Fixed then Field
Net Adjacency Data	Fixed then Field
Test Measurement Data	Fixed

4.5 Data Set Descriptions The data **shall** explicitly describe absolute (not incremental) values, and the contour and location of each individual feature, or a composite feature of the electronic interconnection product. The location of each of the individual elements of a composite element **shall** be defined with reference to the composite datum using data records. Individual features **shall** be defined as either lands, holes, line segments, annotation, or individual elements of a complex/composite feature. A feature **shall not** be defined more than once at a specific location.

4.6 Data Sorting Data **shall** be organized in sections and in a specific sequence. Within a section, records **shall** be grouped by net name or number to make input and output converters more efficient. 5.1 describes the organization and marking of sections within the Job Data file. Data for a net need not be sorted by XY location.

4.7 Data Orientation All data **shall** describe the physical properties of an electronic interconnection product with respect to the side of the printed board assembly that contains the components (primary side). For those printed boards that have components on more than one side, either external side may be designated as the primary side; however, the orientation **shall** match the external view of the finished PWB from the primary side.

Physical layers may be conductive or non-conductive as required to satisfy the physical or electrical properties of the interconnection product. Physical layers **shall** be num-

bered consecutively starting from the primary side as layer one (1) (see IPC-D-325). The convention for physical layer definition (numbering of layers) is given in Table 4-2.

Table 4-2 Physical Layer Definitions

Layer Number	Definition
01	First conductive layer, primary side
02 through N	Second conductive layer through Nth conductive layer.

When coordinates are used to describe physical information, the origin (0,0) **shall** be the same for all layers of interconnection description within a file, and **shall** follow the standard Cartesian coordinate reference system. Positive and negative coordinate values are permitted. Rotations are always positive and counter-clockwise.

All feature and location records **shall** be defined at 1:1 scale.

4.8 Line Termination Every line record **shall** be terminated in a line feed with an optional carriage return.

4.9 Transfer Media and Data Formats Data transfer **shall** be mutually agreed to by sender and receiver. The allowable character set for non-comment records **shall** be referred to as the standard ISO code, and **shall** be restricted to the ISO 7-bit coded character set for information interchange (ISO 646) from “space” (decimal value 32) through “tilde” (decimal value 126) and the following characters: “null” (decimal value 0), carriage return (decimal value 13), and “line feed” (decimal value 10). Characters defined in ISO 646 for currency, number code, and national code **shall** be per Table 4-3 (identical to ANSI/ASCII, Table 5-1).

Table 4-3 Special Character Definitions

Character	Definition	Decimal Value
\	national code	92
#	number	35
\$	currency	36

Comment records, and TITLE, NUM, and REV parameter records can include characters from any native language character set. See Section 6 for requirements of comment records, and 5.2 for parameter CODE, which specifies the character set for these records.

5 ORGANIZATION OF THE IPC-D-356B FILE

IPC-D-356B Job Data files are to be organized in a specific sequence which represent logical groupings of data to simplify the task of importing or exporting test data. Not all record structures are required since some data providers and receivers do not require or are not in a position to provide all the possible data sections, but the data present must follow this sequencing.



Documents

Document Sharing Hub

5.1 Organization of the Job Data File The job data file **shall** be organized into sections. Sequencing and content of the sections **shall** conform to the following:

1. Header

The header **shall** contain parameters related to the entire data set. The header **shall** start with the JOB parameter followed by VER, SOURCE, CODE, TITLE, NUM, REV, SECONDARY_SIDE_LAYER, UNITS, GRID_UNITS, BOARD_THICKNESS, and ADJACENCY in this order unless a particular parameter is permitted to be omitted. See each parameter definition for omission requirements. Comments **shall not** precede the CODE parameter.

2. IMAGE PRIMARY

This section contains all the data associated with the Primary image as well as the test channel assignments for additional images and/or the test channel assignment for multiple tests of the same image. Sequencing of this subsection **shall** be as follows:

- The start of the section **shall** be indicated by the parameter P IMAGE PRIMARY.
- Parameter NNAME section for long net names found in the netlist for the panel, sorted by net. See 6.10 and 8.2.1.
- Primary image non-plated tooling holes.
- Netlist section including the test areas (Section 8) and non-test copper areas for the primary image, grouped by net, together with test channel assignment (Section 9) for the primary **and** any additional images **and** any additional tests.
- Primary image net conductor segment data, grouped by net, see 10.1. If the parameter REMOVED_CONDUCTORS is used for a net, it **shall** immediately precede the graphical data of the net.
- Primary image polygon data, grouped by net, see 10.2. If the parameter REMOVED_CONDUCTORS is used for a net, it **shall** immediately precede the graphical data of the net.
- Primary image board outline data as described in 10.3.
- Primary image adjacency data, sorted by net, see Section 11.
- Electrical test measurement data for the primary image as described in Section 12. Measurements defined in the primary image are performed at the corresponding location on all images.
- Primary image non-test records for fiducials, targets and test status marking such as described in Section 13.

3. IMAGE 2

This section **shall** contain the offset data which should be applied to the primary image data to arrive at the ori-

entation for image 2 as described in Section 14. The start of the section **shall** be indicated by the parameter “P IMAGE 2.”

4. IMAGE NNNN

This section **shall** contain the offset data which should be applied to the primary image data to arrive at the orientation for image NNNN as described in Section 14. The start of the section **shall** be indicated by the parameter “P IMAGE NNNN.”

5. IMAGE PANEL

This section **shall** contain:

- NNAME section for long net names, sorted by net. See 8.2.1.
- Panel non-plated tooling holes.
- Netlist section including test areas (Section 8) and non-test copper areas for the panel netlist, grouped by net, together with test channel assignment (Section 9).
- Panel image net conductor segment data, grouped by net, see Section 10. If the parameter REMOVED_CONDUCTORS is used for a net, it **shall** immediately precede the graphical data of the net.
- Panel polygon data, grouped by net, see 10.2. If the parameter REMOVED_CONDUCTORS is used for a net, it **shall** immediately precede the graphical data of the net.
- Panel outline data as described in 10.3.
- Panel Adjacency data, sorted by net, see Section 11.
- Electrical test measurement data for the panel as described in Section 12.
- Panel non-test records for fiducials, targets and test status marking such as described in Section 13.

6. End Of File Marker

The Operation code 999 is used to mark the end of the Job Data file.

6 PARAMETER RECORDS AND JOB DATA FILE ORGANIZATION

A “P” and two spaces in columns 1-3 indicate a parameter record, and **shall** be followed by one of the following parameter record designations:

JOB, CODE, UNITS, TITLE, NUM, REV, VER, IMAGE, REMOVED_CONDUCTORS, NNAME, TEST, SECONDARY_SIDE_LAYER, GRID_UNITS, SOURCE, ADJACENCY and BOARD_THICKNESS.

6.1 through 6.11 describe the syntax and use of these parameters respectively.

Data **shall** be organized in a specific sequence. The parameter IMAGE (5.8) and individual operation codes are used as a modal mark to indicate the start of distinct sections in the file. 5.11 describes the organizations of sections within the file.



6.1 Parameter JOB (See Figure 6-1) The designation “JOB” in columns 4-6, preceded by a “P” in column 1, **shall** indicate the beginning of a job set. Columns 8 through 72 **shall** refer to the common identifying name or number to be used for identification of the job. See Figure 6-1. These parameter records at the start of the Job Data file constitute the header of the Job Data file.

0000000001111111112222222223333333333 123456789012345678901234567890123456789
P JOB SYNTHESIZER/ANALYZER

Figure 6-1 Parameter JOB

The JOB parameter **shall** be in fixed format and **shall** be the first record in the data.

6.1.1 Data Management Each JOB parameter record **shall** be followed by CODE (when needed) UNITS, TITLE, NUM, REV, and VER parameter records. These records are mandatory to identify the characteristics of the job, and to indicate revision level of the total file.

6.1.2 End-of-Job The characters “999” in columns 1-3 **shall** indicate the end of job. This record **shall** be the last record in the data.

6.2 Parameter CODE (See Figure 6-2) The designation “CODE” in columns 4-7, preceded by a “P” in column 1, **shall** indicate a switch to a native language character set for comment records and TITLE, NUM, and REV parameter records. If a parameter CODE record is not present, the standard ISO code **shall** be assumed. Refer to Appendix E.

0000000001111111112222222223333333333 123456789012345678901234567890123456789
P CODE 16

Figure 6-2 Parameter CODE

A 2-digit code specified in columns 9-10 of the parameter CODE record **shall** identify the native language character set in accordance with Appendix E.

6.3 Parameter UNITS (See Figure 6-3) Listed in Table 6-1, the designation “UNITS” in columns 4-8, preceded by a “P” and two spaces in columns 1-3, **shall** indicate units of measurement. The code “MM” in columns 10-11 **shall** indicate that linear dimensions are millimeters. The code “MIL” in columns 10-12 **shall** indicate linear dimensions are mils (0.001 inches). Column 14 **shall** indicate the negative exponent of the power of 10 that the dimension must be multiplied by to determine its value. For example, MM in 10-11 and 1 in column 14 means that lengths are 0.1MMs, a 2 in column 14 means 0.01MMs, etc.

The designation “RAD” in columns 16-18 **shall** indicate that angles will be expressed in radians. The designation

Table 6-1 Codes for “UNITS”

Code	Explanation
MM	Lengths are expressed in millimeters.
MIL	Lengths are expressed in mils.
RAD	Angles are expressed in radians.
DEG	Angles are expressed in degrees.

“DEG” in columns 16-18 **shall** indicate that angles will be expressed in degrees.

0000000001111111112222222223333333333 123456789012345678901234567890123456789
C For UNITS SI in IPC-D-356A (0.001mm and C angles in hundredths of a radian), the C UNITS are: P UNITS MM 3 RAD 2 C C For UNITS CUST 0 in IPC-D-356A (0.1 C mil and angles in whole degrees), the C UNITS are: P UNITS MIL 1 DEG 0 C C For UNITS in 0.001 mm and degrees: P UNITS MM 3 DEG 0 C C For UNITS in 0.01 mm and degrees: P UNITS MM 2 DEG 0

Figure 6-3 Parameter UNITS

Column 21 **shall** indicate the number of digits after the decimal in expressing the angle. For example, RAD in 16-18 and 2 in column 20 means that angles are 0.01 radians, a 3 in column 20 means 0.001 radians, etc.

There **shall** be only one UNITS parameter in a Job Data file.

6.4 Parameter TITLE (See Figure 6-4) The designation “TITLE” in columns 4-8, preceded by a “P” in column 1, **shall** indicate the title of data defined in a job (artwork title, schematic title, etc.). Columns 10-72 **shall** be used to contain the exact title, which **shall** also be used in the title block of the appropriate drawing(s). Titles requiring more than one line of text **shall** use separate TITLE records for each line of text (see Figure 5-3). Permissible characters for columns 10-72 **shall** be in accordance with the requirements for comment records (see Section 6), and the CODE parameter.

0000000001111111112222222223333333333 123456789012345678901234567890123456789
P TITLE IPC 35X SAMPLE

Figure 6-4 Parameter TITLE

6.5 Parameter NUM (See Figure 6-5) The designation “NUM” in columns 4-6, preceded by a “P” and two spaces in columns 1-3, **shall** indicate the part number for data defined in a job (artwork number, schematic number, etc.). Columns 8-72 **shall** be used to contain the left-justified number (fixed format) that is

block(s) of the appropriate drawing(s). Permissible characters for columns 8-72 **shall** be in accordance with the requirements for comment records (see Section 6) and the CODE parameter.

000000000111111111222222222333333333 123456789012345678901234567890123456789
P NUM IPC-B-25-35X

Figure 6-5 Parameter NUM

6.6 Parameter REV (See Figure 6-6) The designation “REV” in columns 4-6, preceded by a “P” and two spaces in columns 1-3, **shall** indicate the revision identifier for data defined in the job data (artwork revision, schematic revision, netlist revision, etc.). Columns 8-72 **shall** be used to contain the revision identifier, left-justified (fixed format).

000000000111111111222222222333333333 123456789012345678901234567890123456789
P REV A

Figure 6-6 Parameter REV

Permissible characters for columns 8-72 **shall** be in accordance with the requirements for comment records (see Section 6) and the CODE parameter.

The REV parameter record **shall** be changed each time changes are made to any record within the file. Since letters may be used to indicate revision level, once the single-letter alphabet is depleted, a double-letter alphabet (e.g., “AA,” “BB,” “CC,” etc.) may be used.

6.7 Parameter VER (See Figure 6-7) The designation “VER” in columns 4-6, preceded by a “P” in column 1, **shall** indicate the version of IPC-D-356 that the job data file conforms to. For version IPC-D-356B, characters 8 through 17 **shall** be filled as shown in Figure 6-7.

000000000111111111222222222333333333 123456789012345678901234567890123456789
P VER IPC-D-356B

Figure 6-7 Parameter VER

6.8 Parameter IMAGE The designation “IMAGE” in columns 4-8 preceded by a “P” and two spaces in columns 1-3, **shall** indicate the start of a data section within the file. Following a space in column 9, the keywords PRIMARY, PANEL or an integer for an image number are the allowed arguments for this parameter.

P IMAGE PRIMARY

Data that may be stepped across and down the panel

P IMAGE 2

Offset data for the second image

P IMAGE 3

Offset data for the third image

P IMAGE N

Offset data for the Nth image

P IMAGE PANEL

Test coupons, strip lines, registration and scoring data for the panel.

6.8.1 “P IMAGE PRIMARY” Indicates the start of the primary board data records; note that “PRIMARY” occupies columns 10 through 16. See Figure 6-8. This section **shall** contain the primary image netlist information as well as tester channel assignment for all images (stepped boards) within a tested panel. See Sections 5 and 14 for further description.

000000000111111111222222222333333333 123456789012345678901234567890123456789
P IMAGE PRIMARY

Figure 6-8 Image Primary

6.8.2 “P IMAGE NNNN” Indicates the start of the offset data which should be applied to the primary image data to arrive at the orientation for images 2 through NNNN. Up to 9999 images are allowed and the field should be filled as an integer starting in column 10. See Figure 6-9.

000000000111111111222222222333333333 123456789012345678901234567890123456789
P IMAGE NNNN

Figure 6-9 Image NNNN

See Section 14 for a detailed description of the board offset data format. Images other than PRIMARY must follow the full representation of the PRIMARY data and must be in a continuous and sequential series (i.e. the Parameter and offset data for image 3 **shall** follow the parameter and offset data for image 2). See Section 5 for file organization requirements.

6.8.3 “P IMAGE PANEL” P IMAGE PANEL indicates the start of panel data records as opposed to primary or stepped image data records. Panel data may include test and non-test records. For example, panel data may include coupon data to be tested such as strip lines, registration monitors and scoring completion patterns together with any associated conductor segment data. Panel data may also include non-test data for the panel such as board outline data, non-plated tooling holes or fiducials.

000000000111111111222222222333333333 123456789012345678901234567890123456789
P IMAGE PANEL

Figure 6-10 Image Panel

6.9 Parameter REMOVED_CONDUCTORS The designation “REMOVED_CONDUCTORS” in columns 4-21, preceded by a “P” and two spaces in column 1-3, **shall** indicate the nets for which graphical data (conductor segment data or polygon data) has been omitted in the interest of reduced file size. See Figure 6-11 for a description of syntax.

```
0000000001111111112222222223333333333
123456789012345678901234567890123456789
P  REMOVED_CONDUCTORS NETNAMENETNAME
```

Figure 6-11 Removed Conductors

Columns 23-36 **shall** contain the 14 character net name for which conductors have been omitted.

The REMOVED_CONDUCTORS parameter **shall** immediately precede the net conductor segment data or net polygon data to which it applies. If all the polygons or conductor segment data is omitted for a particular net, the REMOVED_CONDUCTORS parameter may stand alone.

This parameter is intended to alert receivers of IPC-D-356B data that the graphical records provided are incomplete for a particular net. Keeping in mind that graphical data is itself optional in IPC-D-356B, the REMOVED_CONDUCTORS parameter **shall** be omitted if all graphical data is omitted.

6.10 Parameter NNAME The designation “NNAME” preceded by a “P” and two spaces in columns 1-3 indicates an identifier or alias for a long net or signal name which would not otherwise fit into the 14 character space allotted in data records. Columns 9-17 contain the signal name identifier or alias, while columns 19-72 are reserved for the user name assigned in the source data. A single NNAME substitution **shall** be used for each long user net name to aid in a user’s ability to read the data. Both the substitute name and the user name **shall** be left justified, the printable ASCII character set may be used. See 8.2.1 for additional information on the use of parameter NNAME. See Figure 6-12 for a description of syntax.

```
0000000001111111112222222223333333333
123456789012345678901234567890123456789
P  NNAME123456789 INTERRUPT_SIG_234_LO
```

Figure 6-12 Parameter NNAME

6.11 Parameter TEST Since the primary side always represents physical layer one, the orientation of the board relative to the test system should be declared if 099 records are employed. (099s are defined in Section 9.) P TEST did not exist in IPC-D-356A which led to confusion when the primary side of the board was assigned to the secondary side of the tester. In IPC-D-356B, 099 records specify the tester side that each individual record is tested on. P TEST is an optional designation in the header to represent the side of the tester for 099 records for a particular test.

The designation “TEST” preceded by a “P” and two spaces in columns 1-3 defines the position of test for 099 records. Column 9 **shall** indicate the type of test records for this definition. Table 6-2 contains a list of all the supported test assignments for use in 099 test records. Starting in column 11 is the word “PRIMARY” followed by “UP,” “DOWN,” “FRONT” or “BACK” to indicate the position

Table 6-2 Test Record Types

Code	Test Record Type
X	Grid
C	Channel
B	Block and Pin
P	Prober
S	Shorting block
R	Row and Column

of L01 during test. See Figure 6-13. If multiple tests are included in the file, columns 28-29 **shall** contain the test number as described in 9.12.

```
0000000001111111112222222223333333333
123456789012345678901234567890123456789
P  TEST X PRIMARY DOWN
P  TEST P PRIMARY UP
C  or for vertically oriented testers
P  TEST P PRIMARY FRONT
```

Figure 6-13 Parameter TEST

6.12 Parameter SECONDARY_SIDE_LAYER Trace segment data and polygon data are defined as existing on different physical layers of the substrate. It is useful to the reader of an IPC-D-356B file to know upon reading the header, what is the last layer of the substrate.

The designation “SECONDARY_SIDE_LAYER” in columns 4-23, preceded by a “P” and two spaces in columns 1-3, **shall** indicate the last physical layer (conductor layer) in the substrate. Columns 25-26 **shall** indicate the last layer number. See Figure 6-14 for a description of syntax.

```
0000000001111111112222222223333333333
123456789012345678901234567890123456789
P  SECONDARY_SIDE_LAYER NN
```

Figure 6-14 SECONDARY_SIDE_LAYER

6.13 Parameter GRID_UNITS Since a majority of grid testers are based on 0.1 inch grid spacing (or fractions thereof), a parameter is provided to allow specific declaration of the units of grid channel assignment if different from the parameter UNITS. This parameter is required when there is a difference between the units of grid assignment and the remainder of the IPC-D-356B file.

The designation “GRID_UNITS” in columns 4-13, preceded by a “P” in column 1 and two spaces, **shall** indicate the units for grid coordinates if different from the parameter UNITS. Column 14 **shall** contain a space. Columns 15-26 **shall** be the same syntax as 10-21 in the UNITS record. See Figure 6-15 for a description of syntax.

Column 27 **shall** remain blank. If the GRID_UNITS parameter applies to a specific test number (see 9.12) then column 28 **shall** contain a “T” and column 29 **shall** contain the test number.



```
0000000001111111112222222223333333333
123456789012345678901234567890123456789
P GRID_UNITS MIL 1 DEG 0
```

Figure 6-15 Parameter GRID_UNITS

6.14 Parameter SOURCE It is extremely useful to know the source of the IPC-D-356B file in case there are questions about the content. Parameter SOURCE defines a way to describe the name of the software application that produced the file, the revision number of that software, and the date that the file was created. SOURCE is a required parameter unless the IPC-D-356B file was hand generated.

The designation “SOURCE” in columns 4-9, preceded by a “P” in column 1 and two spaces, **shall** indicate the source and date of production of the IPC-D-356B file. Following a space in column 10, the name of the producing software application, the applicable revision of that application, and then the date of file creation **shall** be listed using columns 11 through 80 as required. Spaces **shall** be used to separate the three pieces of information, and spaces are allowed in multiple word designation of the application name or revision. Dates **shall** be expressed as DDMMYY where DD is the day of the month, MM is the numeric representation of the month of the year, and YY is the last two digits of the calendar year. See Figure 6-16 below for an example of a file produced on May 21, 2001.

```
00000000011111111122222222233333333344
12345678901234567890123456789012345678901
P SOURCE CAD INSIGHT EASYCAM 3.6C 210501
```

Figure 6-16 Parameter SOURCE

6.15 Parameter ADJACENCY It is useful to be told by the producer of the IPC-D-356B file how the net adjacency list was determined. This parameter describes the method used to calculate adjacency, the number of axes that the calculation involved, and the separation distance that was used. Before describing the syntax for this parameter, a brief explanation is warranted.

Adjacency is a list of nets (by signal name) that could possibly be shorted based on their proximity to one another. While typically adjacency is calculated based on a minimum separation distance in X Y space on each layer, a Z axis adjacency may also be calculated (between layers) for very thin and non-reinforced dielectrics. Other forms of adjacency can be referred to as the “absolute distance” or the “shielded” method of adjacency.

In the absolute distance method, if two nets exist within the “separation distance” of each other (minimum gap between graphical features), they are considered adjacent. Refer to the adjacency that exists between nets A, B, C and D in Figure 6-17. Using the “absolute” method, A to B, A to C and A to D would all be listed as adjacencies to net A if the separation distance were large enough. Using the “shielded” method, adjacency A to B exists, but A to C and

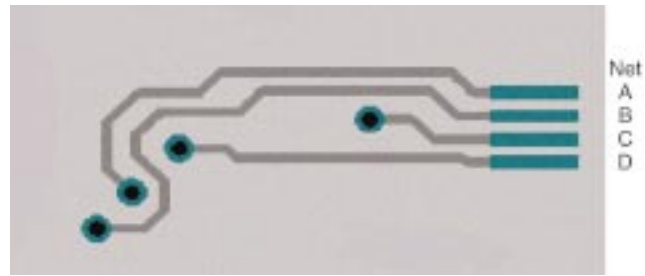


Figure 6-17 Absolute and Shielded Adjacency

A to D are shielded and would not be listed. (B to C and other non-shielded adjacencies would be listed however.)

6.15.1 Parameter ADJACENCY Syntax The designation “ADJACENCY” in columns 4-12 preceded by a “P” and two spaces in columns 1-3, **shall** indicate the adjacency calculation method and separation distance (see Figure 6-18). Column 13 **shall** contain a space. Columns 14-17 **shall** contain the separation (gap) distance parameter in UNITS. Zero suppression is disallowed. Column 18 **shall** contain a space. Column 19 **shall** contain a “Z” if the adjacency calculation accounted for interlayer (Z axis) adjacencies between neighboring layers; it **shall** contain an A if the calculation for interlayer (Z axis) is for all layers otherwise, it **shall** be left blank. Column 20 **shall** be left blank. Columns 21-28 **shall** contain the keyword “ABSOLUTE” if the adjacency calculation method was absolute, or **shall** contain the keyword “SHIELDED” if the calculation method was shielded.

```
00000000011111111122222222233333333344
12345678901234567890123456789012345678901
P ADJACENCY 0250 ABSOLUTE
```

Figure 6-18 Parameter ADJACENCY

6.16 Parameter BOARD_THICKNESS Board thickness information is useful for a variety of different test methodologies and is an optional entry in an IPC-D-356B file.

The designation “BOARD_THICKNESS” in columns 4-18, preceded by a “P” and two spaces in columns 1-3, **shall** indicate the nominal thickness of the board expressed in UNITS. Columns 20-25 **shall** contain the thickness without zero suppression. See Figure 6-19 for a description of syntax.

```
0000000001111111112222222223333333333
123456789012345678901234567890123456789
P BOARD_THICKNESS NNNNNN
```

Figure 6-19 Parameter BOARD_THICKNESS

7 COMMENT RECORDS AND ALLOWED CHARACTERS

The letter “C” in column 1 followed by one space **shall** indicate a comment record. Columns 3 through 80 are used for descriptive material. Comment Records support the design data by referencing pertinent descriptive information, specifications and documents.

7.1 Allowable Character Set The allowable character set for comment records includes the allowable character set for non-comment records (see Appendix D), and, in addition, comment records can include characters from any native language set identified by the CODE parameter (see Appendix D). The rules for allowable characters in comment records also apply to TITLE, NUM, and REV parameter records, and the comment columns of JOB (columns 10-72) records.

Native language comments are permitted only for comment records, and are not available for data, complex, or other parameter records (other than the TITLE, NUM, and REV parameters). The use of native language character sets **shall** be preceded by the appropriate CODE parameter (5.2). If a parameter CODE record is not present, the standard ISO code **shall** be assumed.

7.2 Comment Records Utilizing 2-Byte Characters Comment records that intermix 1- and 2-byte characters require control characters to indicate the change of character definition. The Japanese Kanji is an example of a language that utilizes 2-byte characters. (See Appendix E.) Two sets of control characters have been designated to signify the change between 1- and 2-byte characters. To switch from 1- to 2-byte characters, the set “ESC, \$, B” **shall** be used. To switch from 2- to 1-byte characters, the set “ESC, (, J” **shall** be used.

8 ELECTRICAL TEST RECORD STRUCTURE

IPC-D-356B contains two clear classes of records, those copper areas (or other conductor metallurgy) that are test areas, and those copper areas that are non-test areas. This section describes the requirements for these types of records, and how they are to be used together to describe inter-layer connections in substrates.

A test area is literally an area on a pad, (often the entire pad) that might be contacted during electrical test. By definition, it is entirely free from soldermask, although it may or may not be a mid-point. A non-test area is a simple copper area that is not to be contacted during test.

Electrical test has evolved to the point that specific information about holes and pads are required to accomplish test. IPC-D-356B uses the complex record format to express each of the elements that make up an inter-layer connection in a substrate. Complex records are made up of test area and non-test area elements.

8.1 Operation Code Definition (Columns 1-3) Columns 1-3 are reserved and **must** contain either a 3-digit numerical operation code for a test data record, a “P” and two spaces to introduce a parameter record, or a “C” and one space to begin a comment.

8.1.1 Allowed Operation Codes Simple test areas (those without a hole or via of any type) **shall** be represented using op-code 327. Allowed shapes for these records are round, rectangular (including square), rounded rectangular, donut and bullet. Test areas may be designated as mid-points or end-points. Potential test areas, those mid-points which are otherwise accessible and might be contacted during diagnostic and other test or repair operations, **shall** be represented with a 327 record with appropriate mid-point flags.

Simple copper areas that are NOT potential test areas **shall** be represented with op-code 333. Such copper areas may be covered with soldermask, but for the purposes of test, it must be assumed that contact cannot be made to these copper shapes. Allowed shapes are the same as for the 327 records. Non-test areas **shall not** be used to describe component pad attachment locations or loaded board test points that would otherwise be considered test areas, even if such areas are logical mid-points. See Figure 8-1 for an illustrative example of these two op-codes.

Table 8-1 contains the op-codes defined in this section. See Appendix B for a complete list of op-codes used in IPC-D-356B.

Table 8-1 Operation Codes for Simple Areas

Op. Code	Op-Codes Defined in 8.1-8.9	Ref.
327	Simple test area at a point.	8.1.1
333	Simple non-test area at a point.	8.1.1

In some cases it may be desirable to represent a test area (327) as a subset of a larger 333 copper area. The areas may overlap as shown below.

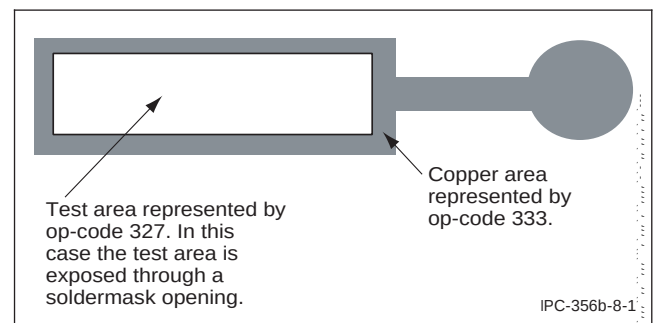


Figure 8-1 Test Area and Non-Test Area Illustration

An 099 continuation record (see Section 9) may follow a 327 record, however they **shall not** follow 333 records. See the examples in Appendix C.

8.2 Signal Name Identifier (Columns 4-20)

8.2.1 Columns 4-17 Columns 4-17 **shall** contain a unique alphanumeric identifier for each network (electrically continuous path). “N/C” **shall** be entered in columns 4-6 for all single point networks if unique identifiers are

not assigned to each single point. These columns **shall** be left blank for features not associated with a net, for example non-plated tooling holes. A space character is not allowed within the signal name identifier character string. Since signal names are character strings, they **shall** be left justified, even if the signal name is represented as a number.

8.2.1.1 Long Signal Names Signal name identifiers longer than 14 characters **shall** employ the parameter NNAME as described in 6.10 to create a shorter alias for the original net name.

8.2.1.2 NNAME Substitutions NNAME substitutions **shall** be made in the P IMAGE PRIMARY section for substitutions of primary image net names. NNAME substitutions **shall** be made in the P PANEL section for substitutions of panel net names.

8.2.2 Complex Record End-Point Designator (Columns 18-20) For simple test areas and non-test areas at a point (op-codes 327 and 333 respectively) Columns 18-20 **shall** be left blank. For complex record sets, Columns 18-19 **shall** be filled as described in 8.11.3.1 and column 20 **shall** be left blank.

8.3 Component Name Identifier (Columns 21-31) The requirements in the following paragraphs are not binding for CAD or CAM systems that cannot output component identifier information.

8.3.1 Reference Designator (Columns 21-26) Columns 21-26 should contain the alphanumeric reference designator assigned to the component attachment pad or feature on the substrate. Typically, test point assignment is not determined by the reference designator record. The reference designator field **shall** be left justified.

8.3.2 Column 27 If a reference designator is included, column 27 **shall** contain a dash to separate the reference designator from the pin identifier. If a reference designator is not included, the dash **shall** be omitted.

8.3.3 Pin Number (Columns 28-31) If a reference designator is included, columns 28-31 **shall** contain the pin identifier of the record. Since some pin numbers involve alpha as well as numeric characters, the pin number field **shall** be left justified.

8.3.4 Mid-Point and End-Point Flag (Column 32) For test areas, column 32 may contain an “M” to signify that a point is in the middle of a network; an “E” to signify an end-point of a network or may be left blank to indicate that end-point optimization analysis was not performed. Usage

of this field is optional. For non-test areas, column 32 **shall** be left blank.

8.4 Columns 33-38 For simple test areas (op-code 327) and simple non-test areas (op-code 333), columns 33-37 **shall** be left blank. See 8.11 for the use of these columns for holes.

8.5 Feature Side and Layer Designation (Columns 39-41) Column 39 **shall** contain an “L” for a layer number, which is used to specify the layer on which that feature resides. A “01” in columns 40-41 **shall** specify access from the primary (see 4.7 and Table 4-2) side of the substrate. A number greater than “01” corresponding to the physical layer **shall** be specified according to Table 4-2 to indicate access to an inner layer or the secondary side of the printed board.

In complex record sets, interlayer connections expressed with op-code 013 or 413 **shall** have columns 39-41 left blank since the side definition is meaningless and the “from” and “to” layers are defined in columns 33-38 as defined in 8.11.3.2.

8.6 Feature Location Field (Columns 42-57) Columns 42-57 **shall** contain the (X, Y) location of the test area or non-test area. The (X, Y) location is defined as the center of the bounding rectangle of the feature. Column 42 **shall** contain an “X” to specify the x-coordinate of the location. Column 43 **shall** contain “+,” “-,” or a blank to specify the sign (a blank **shall** be interpreted as a “+”). Columns 44-49 **shall** contain six digits representing the x-location. Column 50 **shall** contain a “Y” to specify the y-coordinate of the location. Column 51 **shall** contain a “+,” “-,” or a blank (meaning “+”), and columns 52-57 **shall** contain the 6-digit y-location.

The smallest value of the data **shall** be 0.001 mm [0.0001 in]. There **shall** be no decimal points, and leading zeros **shall not** be omitted.

8.7 Feature Shape and Size Definition (Columns 58 and beyond) Test areas and copper non-test areas may be represented in a number of different standard shapes including circles, rectangles, rounded rectangles, bullets and donuts. Squares may be represented as rectangles whose height and width are equal. Non-test area copper shapes may also be expressed in the form of polygons or by use of trace segments but test areas **shall** be limited to the five specific standard feature shapes.

Because the parameters needed to describe the allowed shapes differ with each shape, the format beyond column 58 is different for each shape. The column 58 shape designator should be used as a key for reading subsequent columns in the record. The arguments required for describing the supported shapes are summarized in Table 8.

Table 8-2 Allowed Shapes for Test and Non-Test Areas

Column 58 Designator	Shape	Arguments beyond Column 58
C	Circle	Diameter, Soldermask Edge
R	Rectangle	Width, Height, Rotation, Soldermask Edges
O	Rounded Rectangle	Width, Height, Radius, Rotation, Soldermask Edges
B	Bullet	Width, Height, Rotation, Soldermask Edges
D	Donut	Inner Diameter, Outer Diameter, Soldermask Edge

There **shall** be no zero suppression when expressing feature shape dimensions. The value of the smallest digit **shall** be 0.001 mm [0.0001 in]. There **shall** be no use of the decimal point. See Figure 8-2 for a description of syntax of these various shapes.

8.7.1 Syntax for Circle To designate a circular shape, column 58 **shall** contain a “C,” followed in columns 59 by the character “D” for diameter and four digits with the value of the diameter of the circle in “Units.”

Columns 64-65 may contain the soldermask edge definition described in 8.9. Columns 66-72 may contain test area attribute information described in 8.10.

8.7.2 Syntax for Rectangle To designate a rectangular shape, column 58 **shall** contain an “R,” followed in columns 59-63 with the character “W” followed by four digits to describe the width (horizontal) of the rectangle. Column 64-68 **shall** contain the character “H” followed by four digits to describe the height (vertical) of the rectangle. Columns 69-72 may contain the rotation of the feature as described in 8.8. Columns 73-77 may contain the soldermask edge definition described in 8.9. Columns 78-84 may contain test area attribute information described in 8.10.

To describe a square, both the width and the height **shall** contain the same value.

8.7.3 Syntax for Rounded Rectangle To designate a rounded rectangular shape, column 58 **shall** contain an “O,” followed in columns 59-63 with the character “W” followed by four digits to describe the width of the rounded rectangle. Column 64-68 **shall** contain the character “H” followed by four digits to describe the height of the rounded rectangle. Column 69-72 **shall** contain the character “R” followed by four digits to describe the radius of the corner rounding of the rounded rectangle. The radius **shall not** exceed one half the smaller of the height or the width. Columns 73-77 may contain the rotation as described in 8.8. Columns 78-82 may contain the soldermask edge definition described in 8.9. Columns 83-89 may contain test area attribute information described in 8.10.

8.7.4 Syntax for Bullet To designate a bullet shape, column 58 **shall** contain a “B,” followed in columns 59-63 with the character “W” followed by four digits to describe the width of the bounding rectangle of the bullet. Column 64-68 **shall** contain the character “H” followed by four digits to describe the height of the bullet.

Columns 69-72 may contain the rotation as described in 8.8. Columns 73-77 may contain the soldermask edge definition described in 8.9. Columns 78-84 may contain test area attribute information described in 8.10.

Bullets are defined as shown below in Figure 8-3. The semi-circular section is always to the right; the rotation field is used to describe other orientations.

8.7.5 Syntax for Donut To designate a donut shape, column 58 **shall** contain a “D,” followed in columns 59-63 with the character “O” followed by four digits to describe

00000000011111111122222222233333333333334444444445555555556666666667777777778			
12345678901234567890123456789012345678901234567890123456789012345678901234567890			
C	Round test area of diameter 0200, edges defined by soldermask:		
327VCC	U127	-13	E L01X+009750Y+062880CD0200EA
C	C Square test area rotated 45 degrees with soldermask defined edges:		
327GROUND	U13	-14	M L01X+017250Y+072583RW0300H0300R045ELBRT
C	C Rectangular test area with soldermask defined edges on bottom and top:		
327DAT15_MOD_HI	R125	-1	E L01X+031250Y+082922RW0400H0300 E-B-T
C	C Rounded rectangular test area rotated 45 degrees with copper defined edges:		
327STAR_6831	C44	-2	E L01X+026250Y+0829810W0400H0300R0050R045E----
C	C Bullet test area rotated 180 degrees:		
327INT_505_7606	U45	-33	E L01X+041280Y+089900BW0400H0200R180E----
C	C Donut shaped non-test area:		
333DI_LASER_16302	IND	-	L01X+016322Y+374995D00800I0340E-

Figure 8-2 Test Area and Non-Test Area Examples

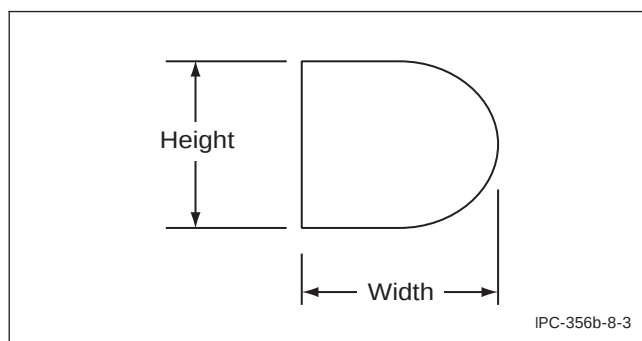


Figure 8-3 Bullet

the outer diameter of the donut. Column 64-68 **shall** contain the character “I” followed by four digits to describe the inner diameter of the donut. Columns 69-70 may contain the soldermask edge definition described in 8.9 which describes only the outer edge definition. Columns 71-77 may contain test area attribute information described in 8.10.

8.8 Rotation of Standard Shapes Rotation of standard shapes **shall** be described with the character “R” followed by 3 digits describing a counter clockwise rotation of the feature. The units of the digits **shall** be as described in the parameter “UNITS.” Rotation **shall** occur about the center of the bounding rectangle of the feature.

If there is no rotation, all four of the designated columns **shall** be left blank.

8.9 Soldermask Defined Edges Some test methodologies require information about test areas beyond the location and size. A test area that is defined by soldermask may have a registration shift relative to a test area defined by a patterned conductor. Consequently, an optional method is described here to represent which edges of a 327 (or 027 continuation in a complex record, see 8.11) test area are defined by soldermask. This information is optional, but it is relevant for the electrical test of tiny structures where soldermask openings can be comparable in magnitude with the registration shift.

8.9.1 If Soldermask Defined Edges are Not Calculated If soldermask edge definition is not calculated or known, each of the four designated columns **shall** be left blank. Soldermask edge definitions are represented before pad rotations.

8.9.2 How to Define Soldermask Defined Edges of Test Areas In the first of the designated columns, an “E” **shall** indicate the start of soldermask edge definition information.

The following four columns **shall** contain edge definition information as described here, otherwise they all **shall** be left blank.

Only test area edges where soldermask opening **overlaps** with copper area are considered. Edges, where soldermask is “in-line” with copper are ignored.

Each of four allotted columns represents one test area edge, see Figure 8-4. For rectangular pads, the edges are considered **before** any rotations. The whole test area edge along one side is marked as soldermask defined if any part of the edge on that side is soldermask defined.

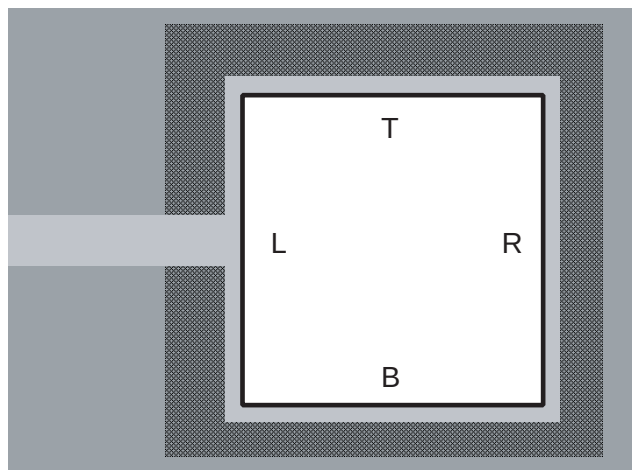


Figure 8-4 Soldermask Defined Edges

When defining soldermask edges, each of four assigned columns **shall** contain a character from the Table 8-3 to specify a soldermask defined pad edge or “-” to specify a copper defined pad edge. See Figure 8-5 for an example.

**Table 8-3 Soldermask Edge Designation
(For Rectangles, Rounded Rectangles and Bullets)**

Column	Edge	Character
First assigned	Left	“L”
Second Assigned	Bottom	“B”
Third Assigned	Right	“R”
Fourth Assigned	Top	“T”

Circles and donuts defined by soldermask are not easily segmented into “sides,” so they **shall** be annotated as being either totally defined by soldermask, or not at all. A circle totally or partially defined by soldermask **shall** be designated with the character “A” in the first assigned column to indicate “all sides.” A circle not at all defined with soldermask **shall** have a “-” in the first assigned column.

8.10 Test Area Attributes Some test methodologies require information about test areas beyond the location, size and method of edge definition. For example, a test area that has trace segments entering or exiting from a particular side may make it unsuitable for use as an alignment fiducial. Similarly, some test areas may have a particular sensitivity to pad damage and may require special or limited methods of contact. These attributes are supported as optional data in IPC-D-356B using 7 columns as described below.



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