Guidelines for Data Entry of the DPMO Database

Version 3

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1. Introduction

The National Electronics Manufacturing Initiative (NEMI), an industry-led consortium focused on strengthening the North American supply chain, has launched a project aimed at benchmarking DPMO (defects per million opportunities) rates for printed circuit board (PCB) assemblies. The project team plans to assemble DPMO data by package and technology type in an effort to help manufacturers benchmark their own relative quality performance.

The DPMO database was created to serve as a tool that records defects and opportunities for various package and technology types and calculates the DPMO values for placement, component, assembly, and termination categories. The DPMO is defined as the total number of defects divided by the total number of opportunities for a defect and multiply by 1 000 000.

2. Purpose

The following guidelines are intended to aid users in the correct input of data into the DPMO database.

3. Guide to Field Formats

The database records information regarding defects and opportunities of electronic assemblies in order to calculate the number of defect per million opportunities. The database is divided in four tables:

- Assembly Table
- Defect Table
- Opportunities Table
- Test Table

Each table collects information that identifies the nature of the assembly as well as the type and quantity of defects. A brief description of every field in the database is described below. It has to be noted that the maximum size of any database a single company submits to Georgia Tech should not exceed 200 megabytes.

3.1 Assembly Table

The Assembly Table contains general information about the electronic assemblies. This data is shared with the other tables and it helps to clearly identify the different board technology levels and the standards used in the board inspection when the dpmo is calculated. The fields within the Assembly Table are:

Company: This field corresponds to a non-descriptive ID that will be provided by Andrew Dugenske from Georgia Tech to every company in order to maintain the secrecy of the source of the information. Companies must request the ID from Andrew and populate their database with the ID.

Assembly: This field records the product assembly number. The companies must take precautions to "whitewash" their assembly numbers if the numbers are formatted such that the company name could be identified.

Technology: This field is to record the board technology level as defined by the Smart Group. There are 6 possible options for this field:

- *WAVE1* that corresponds to assemblies with only through hole components.
- *WAVE2*that corresponds to assemblies with through hole and surface mount passive components (resistor and capacitors).
- *WAVE3* that corresponds to assemblies with through hole, surface mount passive and surface mount active components down to 0.050" pitch.
- *REFLOW1* that corresponds to assemblies with surface mount passive and active components down to 0.050"pitch.
- *REFLOW2* that corresponds to assemblies with surface mount passive and active components down to 0.0025" pitch. This category may include through holes reflow components.
- *REFLOW3* that corresponds to assemblies with surface mount passive and active components less than 0.0025" pitch. This category includes BGAs and CSPs. It can also include through holes reflow components.

Standard: This field is to enter the inspection standard used to identify the defects. The field allows the following values:

- *IPC610CLASS1*
- *IPC610CLASS2*
- *IPC610CLASS3*
- *OTHER*

Batch: This field is used to indicate the batch in which a quantity of boards for a particular assembly was build. If multiple batches are tracked for a single assembly, a new row in the Assembly Table should be added for each batch, and the data in the other tables must correspond to each particular batch. If a data contributing company elects not to include batch information, the batch field must still receive a value that is consistent across all tables for the particular assembly.

Quarter: It records the calendar quarter during which the assemblies were built. The possible entries for this field are 1, 2, 3, and 4 which correspond to the first, second, third, and fourth quarter respectively.

Year: This is to record the year during which the assemblies were built. Assemblies built between 1980 and 2005 can be added to this database.

Total: This is used to indicate the number of boards for a particular assembly or batch that were evaluated for defects. The accuracy of this field is very important because it will multiply the number of opportunities per board in order to determine the total opportunity per package and technology types.

For example: Assume a batch of 100 boards is produced. 50 of those boards have been inspected, tested, and debugged such that defect data is only available for those 50. This field must then contain 50 (even if some of the 50 boards completed all tests with no defects). All defect data from the 50 boards must then be entered in the defect table.

3.2 Defect Table

The Defect Table contains information of the defects by package type that were found after a specified inspection operation, as well as information of the manufacturing process used to assemble these boards. This table shares three fields (Company, Assembly, and Batch) with the Assembly Table that need to be input for each defect. The fields within the Defect Table are:

Company: Refer to the Assembly Table (3.1)

Assembly: Refer to the Assembly Table (3.1)

Serial: This field records the serial number of the assembly that has defects. As the assembly number in the Assembly Table, the companies should use a non-descriptive number if their actual serial numbers are formatted in such a way that the company name could be identified.

Batch: Refer to the Assembly Table (3.1)

Test Operation: This field corresponds to the inspection operation performed to identify the defects. The possible categories for this field are:

- *APISIDE1:* Automated paste inspection on side 1.
- *APISIDE2:* Automated paste inspection on side 2.
- *AOISIDE1:* Automated optical inspection on side 1.
- *AOISIDE2:* Automated optical inspection on side 2.
- *MVISIDE1:* Manual vision inspection on side 1.
- *MVISIDE2:* Manual vision inspection on side 2.
- *AXI:* Automated x-ray inspection.
- *ICT:* In-circuit test (including MDA and Flying Probe test.
- *FUNC:* Functional test (including ESS, Burn in, and any System tests).

Defect: This field describes the type of defects found in the assembly. There is one row entry for each defect. The defects are divided in 4 categories namely component, termination, placement, and assembly. The definition of each

category is defined as per IPC 7912 and IPC 9261. The component defect applies to components that do not match the component specifications or do not match the acceptability requirements per the inspection standard used for the assembly in question as identified in the Standard field of the Assembly Table. The printed circuit board is considered to be one component. Only one defect can be counted per component. The termination defect applies to any joint terminations that do not match the requirements established by the standards. The joint termination is defined as “any hole, land, or other surface at which the component may be electrically terminated” [IPC 7912]. Only one defect can be counted per termination. The placement defect applies to a presence or positioning defect of any component on the printed circuit board during the manufacturing process. Only one defect can be counted per placement. The assembly defect category pertains to defects that affect entire assembly. Only one assembly defect can be counted per assembly.

22 possible options can be entered in this field. The descriptions of each defect as well as its corresponding category are:

Defect	Description	Category
PASTEINSUFFICIENT	Insufficient amount of solder paste is printed	Assembly
PASTESMEARING	The solder paste squeeze out from the soldered pads	Assembly
PASTEBRIDGING	Printed paste that connects two or more not intended connectors creating an open	Assembly
PASTESCOOPING	The squeegee scoops out the paste deposit	Assembly
OTHERPASTEDEFECT	Other paste defects	Assembly
SOLDERTERMINATIONBRIDGESHORT	Two or more solder joints are connected creating an open	Termination
SOLDERTERMINATIONOPEN	Open joint	Termination
SOLDERINSUFFICIENT	Insufficient amount of solder	Termination
SOLDERTERMINATIONSHAPE	Improper collapse or improper fillet	Termination
SOLDERBALL	Tiny spheres of solder located usually around a solder joint	Termination
OTHERTERMINATIONDEFECT	Other solder joint defects	Termination
COMPONENTWRONG	A wrong component is placed	Placement
COMPONENTORIENTATION	A component with a wrong orientation is placed	Placement
COMPONENTMISSING	The component is missing	Placement
COMPONENTPLACEMENT	The component is misplaced	Placement
COMPONENTLEADBENTORMISSING	The lead(s) of the component is bent or missing	Component
COMPONENTELECTRICALLYDEFECTIVE	The component is electrically	Component
COMPONENTDAMAGED	The component is damaged	Component

MECHANICALASSEMBLYDEFECT	The component is mechanically defective	Component
BAREBOARDDEFECT	The Printed Circuit Board is defective	Component
OTHERCOMPONENTDEFECT	Other component defects	Component
OTHERDEFECT	Other defects	Assembly

Location: This is an optional field that records the location reference of the defect on the assembly.

Side: This field corresponds to the side where the defect was found. Two values can be entered: 1 or 2. Use 1 for defects that occur on the side of the board where parts were first placed (first side run across the line), and use 2 for defects that occur on the other side of the board.

Package: It describes the types of components that can be found in the assemblies. Every package type must be categorized as one of the following:

Package Type	Package Description
BGA	Ball Grid Array. Standard pitch is 1mm (or 0.039") and above. Includes plastic, ceramic, eutectic, high-melt.
BGAFP	BGA - Fine Pitch. Anything less than standard BGA pitch (1mm or 0.039") may require special handling. Includes CSPs
BGACONN	BGA Connector. It includes any BGA connector regardless of pitch
CGA	Column Grid Array, similar to BGA except terminations are small columns of solder
CGAFP	Column Grid Array - Fine Pitch. Anything less than standard BGA pitch (1mm or 0.039") may require special handling.
FLIPCHIPARRAY	Flip Chip Array - a chip on board technology that has bumps attached to the silicon die, is flipped, and mounted directly to a printed wiring board.
PGA	Pin Grid Array
GW16MIL	16 mil Gull Wing QFP, SOIC, SOP, SSOP, TSOP, TSSOP and hardware (sockets, switches), also includes 12 mil gull wing
GW20MIL	20 mil Gull Wing QFP, SOIC, SOP, SSOP, TSOP, TSSOP and hardware (sockets, switches)
GW25MIL	25 mil Gull Wing QFP, SOIC, SOP, SSOP, TSOP, TSSOP and hardware (sockets, switches)
GWGT25MIL	Gull Wing greater than 25 mill gull wing components and hardware (sockets, switches), SOT - Small Outline Transitors, SOD, DPAKs
GWCONN	Gull Wing Connectors, regardless of pitch, (does not include Mictor or Straddle Mount)
JLEAD	J Leads. It Includes SOJ - Small Outline J-leads, PLCC - Plastic Leaded Chip Carriers, sockets
LABEL	Labels
LANDGRIDARRAY	Land Grid Array
LCC	Leadless Chip Carrier, also LCCC- Leadless Ceramic Chip Carrier, both have solderable castellations for terminations
MECHASSEM	Mechanical Assembly. It includes bearing, chassis, faceplates, fan guard, fuse holder, handle, heatsink, plastic part, RF shields,
MECHFASTENER	Mechanical Fasteners. It includes bolt, clip, kit, nut, pin, rivet, screw, spacer, spring, standoff, washer

MICTORCONN	Mictor Connector has both SMT and PTH pins
STRADDLEMOUNTCONN	Straddle Mount Connector. Edge connector with SMT leads on both sides of the board, Includes Straddle Mount Mictors
MULTICHIPMODULE	Multichip Module (Consider 1 component)
OPTIC	Fiber Optic cables and components
SMTMISC	Surface Mount Technology Miscellaneous. A SMT component that falls into no other category (EMI shields, ground planes, inductors, MELF components, non-leaded)
PRESSFIT	Press Fit connectors and components that are hand plugged, includes ICs hand placed into chip carriers
PTHCOMP	Pin Through Hole Components, SIP, DIP, radial and axial mount components, jumpers,
PTHCONN	Pin Through Hole Connectors, sockets - above 50 mil
PTHCONNFP	Pin Through Hole Connectors Fine Pitch Array, connectors, sockets - 50 mil and below
PWB	Printed Wiring (or PCB-Circuit) Board, includes gold fingers, buried capacitors/resistors
SMTPASSIVENETWORKS	Surface Mount Passive Networks. It includes resistor networks, capacitor networks, RPACK, (only if device has solderable castellations, if leaded falls into corresponding category (PTH COMP, GW, etc)
0201	0201 chip components
0402	0402 chip components
0603	0603 chip components
0805	0805 chip components
GT0805	Greater than 0805 chip components (excluding Tantalum)
TANT	Tantalum capacitors
WIREADDSCUTS	Wire Additions and/or Trace Cuts due to design modifications

Quantity: This records the number of defects per defect type found in the assembly.

Operation: This field records the manufacturing process used to assemble the different component types.

- MECHANICALASSEMBLY: Mechanically Assembled
- SMTMACHINEPLACEDREFLOWSOLDERED: For surface mount components, the manufacturing process uses a placement machine and a reflow process.
- SMTMACHINEPLACEDWAVESOLDERED: For surface mount components, the manufacturing process uses a placement machine and a wave soldering process.
- SMTHANDPLACEDREFLOWSOLDERED: For surface mount components, the manufacturing process uses hand placement and a reflow process

- SMTHANDPLACEDWAVESOLDERED: For surface mount components, the manufacturing process uses hand placement and a wave soldering process
- SMTHANDPLACEDHANDSOLDERED: For surface mount components, the manufacturing process uses hand placement and a hand soldering process
- PTHMACHINEPLACEDREFLOWSOLDERED: For through hole components, the manufacturing process uses a placement machine and a reflow process
- PTHMACHINEPLACEDWAVESOLDERED: For through hole components, the manufacturing process uses a placement machine and a wave process
- PTHMACHINEPLACEDHANDSOLDERED: For through hole components, the manufacturing process uses a placement machine and a hand soldering process
- PTHHANDPLACEDREFLOWSOLDERED: For through hole components, the manufacturing process uses a hang placement and a reflow process
- PTHHANDPLACEDWAVESOLDERED: For through hole components, the manufacturing process uses a hand placement machine and a wave soldering process
- PTHHANDPLACEDHANDSOLDERED: For through hole components, the manufacturing process uses a hand placement and a hand soldering process
- PRESSFIT: Pressfit
- NA: Not Applicable. NA can be used for PWB defects.

3.3 Opportunity Table

The Opportunity Table contains information on the total amount of opportunities per each assembly and package type. There is an entry for each package type on an assembly per manufacturing operation and board side. Each row entry will indicate the number of assembly, placement, termination, and component opportunities per package type. . The fields within the Opportunity Table are:

Company: Refer to the Assembly Table (3.1)

Assembly: Refer to the Assembly Table (3.1)

Package: Refer to the Defect Table (3.2)

Side: This field corresponds to the side of the board where the defect opportunity exists. Three values can be entered: FIRST, SECOND, or NA. Use FIRST for opportunities on the side of the board where parts were first placed (first side run across the line), use SECOND for opportunities on the other side of the board, and use NA (Not Applicable) for defects that occur in the PWB.

AssemblyOps: It is the count of assembly opportunities per line entry in the table (package type per manufacturing process and board side) as defined by IPC 9061. In most cases this field will be 0 as each assembly only has one assembly opportunity. For the sake of database consistency, it's recommended that the one assembly opportunity be assigned to the PWB package type.

For example:

Package	Side	Assembly Ops	Placement Ops	Termination Ops	Component Ops	Operation
0805	FIRST	0	15	30	15	SMTMACHINEPLACED REFLOWSOLDERED
GT0805	FIRST	0	3	6	3	SMTMACHINEPLACED REFLOWSOLDERED
GW20MIL	FIRST	0	20	1200	20	SMTMACHINEPLACED REFLOWSOLDERED
GW25MIL	FIRST	0	30	1300	30	SMTMACHINEPLACED REFLOWSOLDERED
GWGT25 MIL	FIRST	0	40	1400	40	SMTMACHINEPLACED REFLOWSOLDERED
PWB	NA	1	0	0	1	NA
0603	SECOND	0	200	400	200	SMTMACHINEPLACED REFLOWSOLDERED
0805	SECOND	0	3	6	3	SMTMACHINEPLACED REFLOWSOLDERED

PlacementOps: It is the count of placement opportunities per line entry in the table (package type per manufacturing process and board side) as defined by IPC 7912. In most cases this field will be 1. For the PWB package type this field will be 0 as there is no placement opportunity for the PWB.

TerminationOps: It is the count of termination opportunities per line entry in the table (package type per manufacturing process and board side) as defined by IPC 7912.

ComponentOps: It is the count of component opportunities per line entry in the table (package type per manufacturing process and board side) as defined by IPC 7912. In all cases this field will be 1.

Operation: Refer to the Defect Table (3.2)

3.4 Test Table

The test table describes the types of tests that are performed per assembly and the approximate level of test coverage. The fields within the Test Table are:

Company: Refer to the Assembly Table (3.1)

Assembly: Refer to the Assembly Table (3.1)

Test Operation: Refer to the Defect Table (3.2)

Coverage: This field records the level of coverage that the company used in its inspection process. Three values can be entered to this field:

- High: >80% of devices tested/inspected
- Medium: Between 20% and 80% of devices tested/inspected
- Low: <20% of devices tested/inspected