Destructive Physical Analysis (DPA) Program Methodology
DPA: Introduction

- Destructive Physical Analysis (DPA) is a comprehensive quality assessment for workmanship on Printed Circuit Board Assemblies (PCBAs).

- The Best Known Method for determining quality of boards, components, design, and assembly processes. Sample size is typically one assembly.

- Performed using non-destructive and destructive inspections: external visual, X-ray, and cross-sectioning.

- Workmanship conditions are determined as Target, Acceptable, Process Indicator, or Defect based on IPC-A-610E for the applicable product class (Class II typical for data center products).
DPA: Introduction

• Plated Through Hole (PTH) locations are typically included to determine internal board fabrication conditions as Target, Acceptable, or Non-Conforming based on IPC-A-600H.

• Ionic Cleanliness testing can be added to determine if assembly process residues are benign. This includes Critical Cleanliness Control (C3) spot testing for local areas and Full Bag Extraction for cleanliness of the entire assembly.

• Rinse fluid from these tests can be subjected to Ion Chromatography (IC) to identify and quantify the ionic species extracted. These test are used for compliance with IPC-A-610E clause 10.6.
DPA: Techniques – External Visual & X-ray Inspection

• External visual inspection utilizes a stereo-zoom microscope and a small hand-held mirror to inspect solder fillets, pin alignment, BGA solder balls (outer rows), contamination, reference designator markings, etc.

• X-ray allows non-destructive internal inspection for voids, pin alignment, press-fit connections, solder fill, PTH plating issues, etc.

• Any locations showing questionable workmanship from external visual or X-ray, such as hole-fill, fillet height, solder cracks, etc. should be verified by cross-sectioning.
DPA: Techniques – Cross-sectioning

• Cross-sectioning is a destructive technique that physically slices into the features of a component or board that are targeted for inspection.

• The extracted components are encapsulated in epoxy to protect the features while they are ground and polished to show details of their internal structure.

• This method is often used to confirm workmanship for fillet height, hole-fill, press-fit pins, solder cracks, wetting issues, solder balls, PTH plating quality, delamination, etc.

• Representative devices typically includes Connectors, BGAs, Capacitors, PLCCs and any device showing questionable workmanship from the other inspections.
DPA Report-Product: XYZ

Example Only

• Client: ABC Systems
• Contact: John D.
• Prepared by: Roger Jay
• Report Date: 10-01-13
• Report #: 1013-001
• Samples Submitted: One XYZ Assembly
Product: XYZ – Introduction:

• This report summarizes the results for the Destructive Physical Analysis (DPA) for Product: XYZ.

• The Printed Circuit Board Assembly (PCBA) was evaluated to Class II specification for IPC-A-610E and IPC-A-600H.

• The evaluation consisted of external visual, X-ray, and cross section inspections.

• Examples of C3 and Ion Chromatography (IC) results for board cleanliness are included.
Product XYZ: IPC Defects and Observation  Summary:

IPC Class II defects observed:

• C1 capacitor showing fractured solder, which is a defect per IPC-A-610E clause 5.2.9. (cross-section-slide 30).

• Q2 through-pin Transistor showing hole-fill <75%, which is a defect per IPC-A-610E, clause 7.3.5.1 (visual-slide 17, cross-section-slide 31).

• Power Relay showing end overhang, which is a defect per IPC-A-610E, clause 8.3.1. (cross-section-slide 35).

• Via hole showing complete Inner Layer Separation, which is a defect per IPC-A-600H clause 3.3.14. (cross-section-slide 37).

Customer Process Indicators observed (example):

• C6 capacitor pin protrusion is approximately 88mils, which is acceptable (Class1,2) and a defect (Class 3) per IPC-A-610E, clause 7.3.3 (visual-slide 18, cross-section-slide 34).
Product: XYZ
- Assembly
Product: XYZ – Component locations

Primary:

Components are mapped out by reference designator for identification during inspections (example). Components selected for cross-sectioning are shown in Red.
Product: XYZ – Component locations

secondary:

Solder source side is inspected for fillets and pad coverage on through-pin devices, lead protrusion, exposed base metal, and solder joint quality for chip components or larger devices, if present.
Product: XYZ
PCB/PCBA Identification Markings:

All Serial Numbers, Date Codes, and other applicable Identification Markings for Board and Assembly are photographed and shown here.
Product: XYZ
– Board Cleanliness
C3 collects rinse fluid from specific locations and checks for leakage current over time. The threshold is set to contamination levels that are compliant with IPC-A-610E clause 10.6.3. The Clean results are acceptable for all three product classes. The Dirty results are defects for all three product classes.
Product: XYZ – Ion Chromatography (IC) Results

<table>
<thead>
<tr>
<th>Foresite ID#</th>
<th>Sample Description</th>
<th>Cl^-</th>
<th>NO_2^-</th>
<th>Br^-</th>
<th>NO_3^-</th>
<th>PO_4^{2-}</th>
<th>SO_4^{2-}</th>
<th>WOA</th>
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<tbody>
<tr>
<td>1751-96-16</td>
<td>DPA 622</td>
<td>1.36</td>
<td>0</td>
<td>0.41</td>
<td>0.24</td>
<td>0</td>
<td>0.70</td>
<td>43.90</td>
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<table>
<thead>
<tr>
<th>Ion</th>
<th>Target Micrograms/Sq. Inch</th>
<th>Limit Micrograms/Sq. Inch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorides</td>
<td>2.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Bromides</td>
<td>7.0</td>
<td>12.0</td>
</tr>
<tr>
<td>Sulfate</td>
<td>1.5</td>
<td>3.0</td>
</tr>
<tr>
<td>Nitrates</td>
<td>1.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Ion Chromatography (IC) identifies and gives concentrations for ionic species found in the rinse fluid. This example shows levels that are acceptable per IPC-A-610E clause. 10.6.3 for all three product classes.
Product: XYZ
– External Visual Inspection
Q2 Through-Pin transistor showing primary and secondary-side fillets. One pin shows incomplete hole-fill per IPC-A-610E, clause 7.3.5. Acceptability to be determined by cross-sectioning.

All three pins show target fillets at the solder-source side per IPC-A-610E, clause 7.3.5 for all three classes of product.
C6 Through-Pin capacitor showing excessive pin protrusion per IPC-A-610E, clause 7.3.3. Acceptability to be determined by cross-sectioning.
Product: XYZ – Optical Inspection

Resistor pins showing target hole-fill per IPC-A-610E, clause 7.3.5 for all three classes of product.
Product: XYZ – Optical Inspection

SMT connector showing acceptable alignment and heel fillets per IPC-A-610E, clause 8.3.5 for all three classes of product.
BGA solder joints showing acceptable solder ball size, shape, and spacing per IPC-A-610E, clause 8.3.12 for all three classes of product.
Product: XYZ
– X-ray Inspection
Press-Fit connector showing no damaged pins, which is acceptable per IPC-A-610E, clause 9.10 for all three classes of product.
Product: XYZ – X-ray Inspection

C6 through-pin capacitor showing incomplete hole-fill per IPC-A-610E, clause 7.3.5.1 on both pins. Confirmation to be made by cross-sectioning.
Product: XYZ – X-ray Inspection

BGA solder joints showing acceptable alignment and ball shape per IPC-A-610E, clause 8.3.12 for collapsing balls for all three classes of product.

Note: chip components on secondary side of board can give the appearance of solder bridging between balls.
Product: XYZ – X-ray Inspection

Irregular shaped BGA solder joint, which is a process indicator per IPC-A-610E, clause 8.3.12.3 for collapsing balls for class 2 & 3 products.
Product: XYZ – X-ray Inspection

BGA solder joints showing voids <25%, which is acceptable per IPC-A-610E, clause 8.3.12.4 for collapsing balls for all three classes of product.
Product: XYZ
– Cross-section Inspection
Product: XYZ – Cross-section Inspection

BGA solder joints showing acceptable size, shape, and spacing per IPC-A-610E, clause 8.3.12 for collapsing balls for all three classes of product.
BGA solder joints showing acceptable size and shape per IPC-A-610E, clause 8.3.12 for collapsing balls for all three classes of product.

Voids show <25%, which is acceptable per IPC-A-610E, clause 8.3.12.4. Note 2 from Table 8-12 allows for alternate acceptance criteria for voids, such as cross-sectioning, provided prior testing or analysis has been performed.
Surface Mount Capacitor showing fractured solder (heel fillet crack), which is a defect per IPC-A-610E, clause 5.2.9 for all three classes of product.
Transistor Through-Pin showing hole-fill approximately 58%, which is a defect (class 2, 3) per IPC-A-610E, clause 7.3.5.1.
C6 capacitor pin shows hole fill approximately 36%, which is a defect (class 2,3) per IPC-A-610E, clause 7.3.5.1.
C6 capacitor pin protrusion is approximately 88mils, which is acceptable (class 1,2) and a defect (class 3) per IPC-A-610E, clause 7.3.3.
Power Relay showing end overhang, which is a defect per IPC-A-610E, clause 8.3.1 for all three classes of product.
Press-Fit connector pin showing good electrical contact and no damage to annular rings, which is acceptable per IPC-A-610E, clause 4.3.2, for all three classes of product.
Vertical cross-section views showing complete Inner Layer Separation, which is non-conforming per IPC-A-600H clause. 3.3.14, for all three classes of product.
Internal Annular Ring measurements showing acceptable condition per IPC-A-600H, clause. 3.3.1 for all three classes of product.
Product: XYZ – Cross-section Inspection:

Plated Through Hole (PTH) showing plating thickness measurements taken in accordance with IPC-A-600H, clause 3.3. The minimum average copper plating thickness based on this method should be specified in the customer drawing.