FAA Flammability Certification of Electrical and Electronic Components

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Boeing Goals

• Comply with Regulatory Requirements
• Continuously Improve Safety of Flight
• Utilize Supplementary Internal and Industry Standards
• Improve procurement cost of equipment
  – Utilize industry data
  – Use engineering skills and experience
  – Work together with our suppliers
  – Eliminate unnecessary and non-value added processes and testing
Typical Elements of Electronic Equipment

- Electric Wire
- Printed Wiring Boards (PWBs)
- Cathode Ray Tubes
- Liquid Crystal Displays
- Transformers
- Switches
- Small Components (Diodes, Resistors, etc.)
Typical Electronic Equipment in a Jet Transport

- Cooling holes
- Circuit cards
Typical Printed Wiring Assembly
History of Electronic Equipment Usage in Commercial Transport Airplanes

- In the early years, electronic equipment consisted primarily of simple avionics in the flight deck and E/E bay
- Later, additional electronic units and sensors were added all over the airplane
- In recent years, there has been a great expansion of in-flight passenger entertainment systems, up to Internet access on seat-powered laptop computers
Electronic Equipment Design Criteria

- Military specifications used to control the fire properties of electronic equipment.
- Many of these military specifications have been recently canceled.
  - Example older requirement - *Printed Wiring Board material shall be epoxy/glass (Type GF) or other material with equivalent or better temperature, arc, and flame resistance, in accordance with MIL-P-13949.*
FAA Flammability Requirements

- FAA regulations were changed in 1967, and new flammability requirements and test methods were added
  - New standards for side-walls, ceilings, etc.
- Small parts did not have to be tested
  - Except for small parts (such as small electrical parts) that would not contribute significantly to the propagation of a fire…
- Electronic components were viewed as “small parts”
FAA Flammability Requirements (cont)

• In the 1960’s, there were only a few electronic components in the EE bay and flight deck.
  – Only materials compliant to the Military Standards (self-extinguishing) were used
• Today significantly more electrical/electronic components are used
• Military production standards have been canceled and replaced by industry production standards
FAA Flammability Requirements (cont)

- Aerospace industry standards require either
  - IPC 4101 flammability test be done on laminates making up a PWB before board is assembled or
  - UL 94 V0 test on the finished PWB
  - No industry requirement for 12-sec vertical

- FAA clarified that regulatory testing of electronic components requires
  - FAR tests - 12-sec vertical Bunsen burner test (e.g., printed wiring boards, PWBs)
  - or approved alternatives
FAA Flammability Requirements (cont)

• Aerospace PWBs built to industry standards always pass FAA test with high margin
• FAA receptive to “equivalent safety finding” to approve PWBs meeting industry standards without requiring FAR 12-sec vertical test
• FAR 21, § 21.21(b)(1)
  – …. any airworthiness provisions not complied with are compensated for by factors that provide an equivalent level of safety …
Equivalent Safety Finding

• Plan for establishing equivalent safety finding
  – Analysis of IPC, UL, and FAR test procedures
  – Analysis of the sample testing by suppliers
    (i.e. the on-going process control)
  – Test a representative sample of IPC and UL compliant
    PWB materials using the FAR 12-sec vertical test
    • Bare printed wiring board laminates
    • Complete multilayer printed wiring boards
    • Printed wiring assemblies with conformal coat
FAA Flammability Requirements (cont)

- When an “equivalent safety finding” is granted, PWBs will be FAA-approved by process control.
- Showing compliance by process control is a significant need for electronics.
  - Electronics are in constant redesign.
    - Testing by part number is inefficient and extremely expensive in the long run.
  - Continuous process control provides better assurance.
    - As opposed the current one time test.
  - Most electronics redesign does not change materials.
    - Re-layout of PWBs and microcircuits.
    - Software updates.
Reasons for Electronic Redesign

- **Airline requests for increased functionality**
  - More features and options
  - In-flight entertainment

- **Product improvements**
  - Updates, problem resolution, production improvements

- **Component obsolescence**
  - Cancellation of the military specifications
  - Commercial components have a shorter production life due to high volume users
PWBs are the Most Frequently Changed Item

<table>
<thead>
<tr>
<th>Typical Materials</th>
<th>Redesign Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small electrical components:</td>
<td>Frequent change but small are parts</td>
</tr>
<tr>
<td>Microcircuits, resistors, capacitors, switches, etc.</td>
<td></td>
</tr>
<tr>
<td>Flexi-cables, small wire cables</td>
<td>Seldom change</td>
</tr>
<tr>
<td>Displays</td>
<td>Seldom change</td>
</tr>
<tr>
<td>Gaskets</td>
<td>Seldom change</td>
</tr>
<tr>
<td>Connectors</td>
<td>Seldom change</td>
</tr>
<tr>
<td>Sheet metal, screws, etc.</td>
<td>No impact on the flammability analysis</td>
</tr>
<tr>
<td>Printed wiring boards</td>
<td>Frequent change</td>
</tr>
</tbody>
</table>
Process Control Methods

- Boeing is incorporating process control methods for design and manufacturing
  - DO-178 (Example of Software process control)
  - DO-254 (Example of hardware process control)
  - ISO-9000 (Example of quality by process control)
  - AS-9000 (Example of quality by process control)
- Process control provides
  - Improved quality, reliability, and performance
  - Lower costs
  - Shorter design cycle times
Use of Industry Standards

Design for a PWB

PWB Laminates registered & tested per IPC 4101 or UL 94-V0?

NO

Is PWB registered & tested per UL 94-V0?

NO

Conformal coating registered & tested UL 94 V0?

NO

FAR 25 Flame Test

NO

Flammability Assured

YES

Flame Test Report

YES

BOM* Analysis Documented

* BOM = Bill Of Materials
Conclusions

- The FAA requires data for flammability certification of electronics before E/E components can be delivered on airplanes.
- Currently, all affected parts must be tested to 12-sec vertical for flammability certification.
- Suppliers of E/E equipment need to put a priority on acquiring acceptable data far upstream of delivery.
Conclusions (cont.)

• An alternative method for flammability certification is urgently needed

• Boeing is working with the FAA to establish an equivalent safety finding to enable certification by process control using existing industry standard test processes instead of testing each PWB