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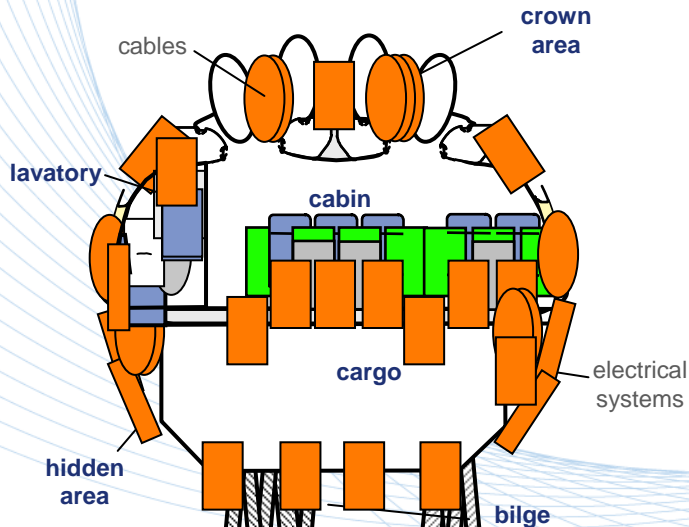
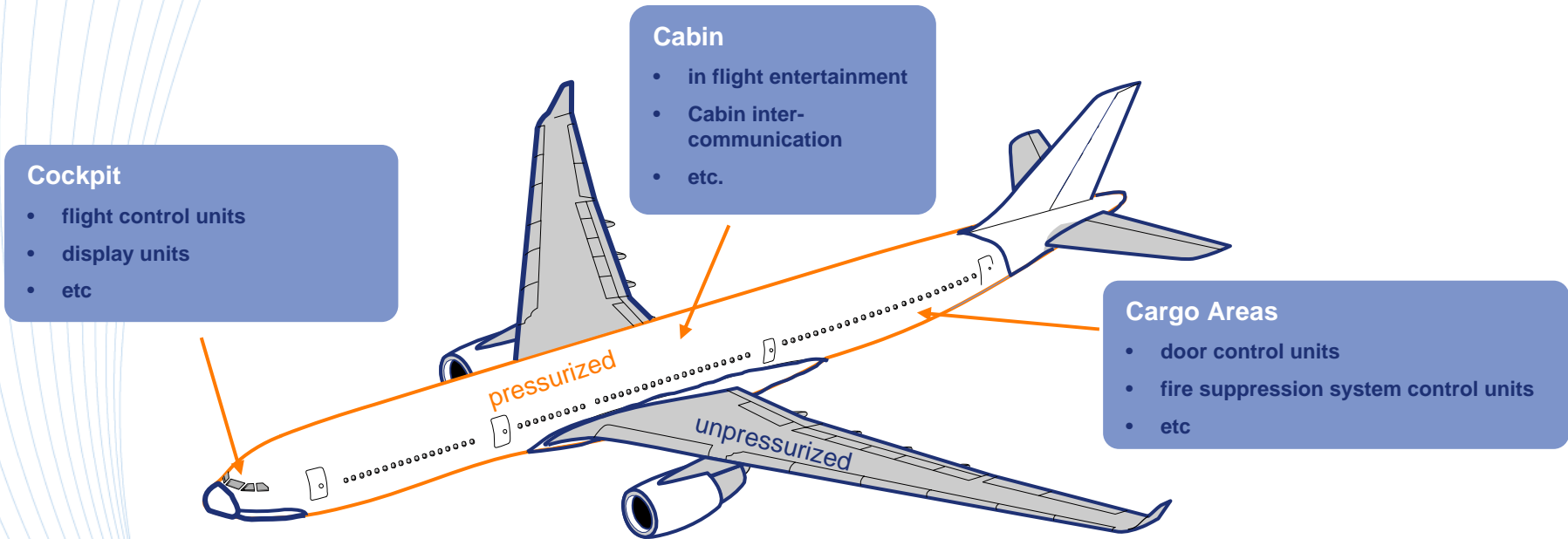
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Material & Processes
Interior & Fire Safety

Fire Safety Assessment of Electrical Devices under regard of Airworthiness Authorities Requirements

Atlantic City, 25th- 28th October 2010

General – Cabin & Cargo Electrical Installations



- ### Topics
- Raising number of electrical devices
 - Made from off-the-shelf products and components
 - Great variety in design and installation location
 - Devices are qualified according to DO160 using UL testing
 - Raw materials are often not available for test samples

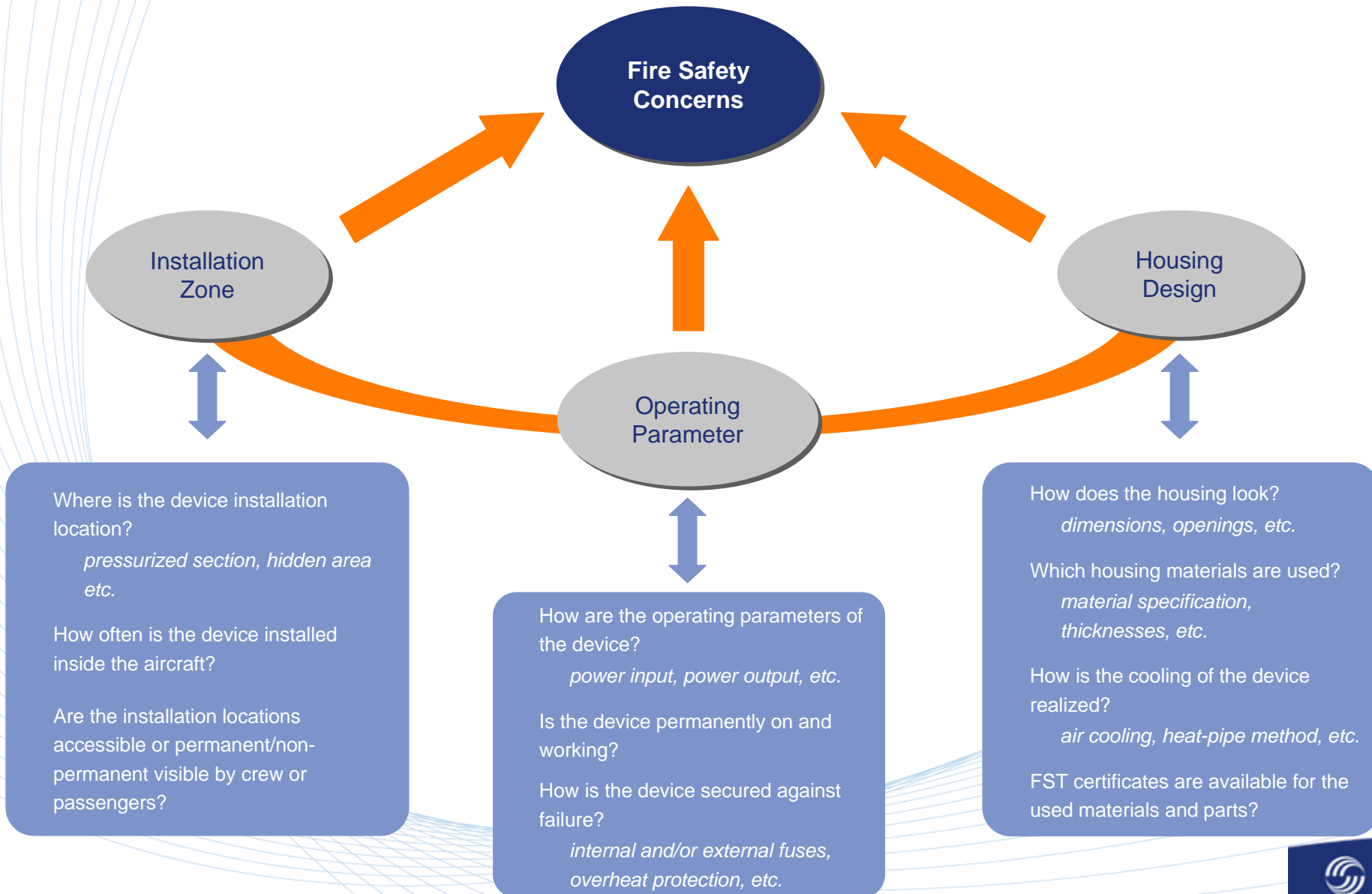
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General – Applicable Requirements Pressurized Area

Airworthiness Certification Requirement (baseline)	ABD0031 Issue G Airbus Fire Safety (AFIS) Requirement	Airbus Test Method*
Flammability		
CS/FAR 25.853(a) & App. F, Part I, §(a)(1)(i) to §(a)(1)(v) - Materials, Components	§1.2 - Materials, Components (General)	AITM2-0002
	§1.3 - Materials (Elastomeric)	AITM2-0003
CS/FAR 25.853(a) & App. F, Part I, §(a)(3) - Cable/Wires	§1.5 - Electrical and Non-Electrical Cable	AITM2-0005
	§1.6 - Heat Shrinkable Tubing	AITM2-0038
Smoke		
CS/FAR 25.869(a)(1) – Electrical Components CS/FAR 25.1713(a) – EWIS Components ↓ <i>CS/FAR 25.831(c) – Demands for System Malfunction Provisions</i>	§3.2 - Materials, Components	AITM2-0007
	§3.3 - Electrical Cables	AITM2-0008
	§3.4 - Data Transmission Cables (electrical & non-electrical)	AITM2-0008
Toxicity		
see smoke	§4 - Materials, Components, Cables	AITM3-0005

* The referred Airbus test methods are derived from the airworthiness authorities test methods specified in CS/FAR§25 and FAA Fire Testing Handbook DOT/FAA/AR-00/12.

Fire Safety Assessment Process – (I) Device Analysis



Fire Safety Assessment Process – (I) Fire Safety Categories

Recommended Criteria for			Fire Safety Accomplishment
Installation Zone	Operational Parameters	Housing	
Airworthiness Conformity *			
<ul style="list-style-type: none"> accessible and permanently visible by crew or passenger 	<ul style="list-style-type: none"> overheat protection external and internal electrical fuse low power consumption (<20W) separate manual switch off 	<ul style="list-style-type: none"> material compliant with flammability (airworthiness standard) cooling by air venting or heat pipe 	<ul style="list-style-type: none"> fire stops when fire source vanishes smoke & toxicity gases can be released
ABD0031 Conformity (Standard)			
<ul style="list-style-type: none"> accessible by crew or passengers during flight 	<ul style="list-style-type: none"> overheat protection external or internal electrical fuse moderate power consumption (<100W) 	<ul style="list-style-type: none"> material compliant with ABD0031 cooling by air venting or heat pipe 	<ul style="list-style-type: none"> fire stops when fire source vanishes, smoke & toxicity gases are harmless and not released in significant quantities
Flame Spread Safe (equivalent or enhanced)			
<ul style="list-style-type: none"> flight relevant systems nearby accessible by crew during flight (e.g. electronic compartments) secured by active fire safety means 	<ul style="list-style-type: none"> overheat protection external or internal electrical fuse shut down of forced venting 	<ul style="list-style-type: none"> nearly closed housing with small vent/decompression holes material compliant with ABD0031 cooling by air venting or heat pipe 	<ul style="list-style-type: none"> fire kept inside housing no fire risk for materials or parts in surrounding smoke & toxicity gases can escape housing
Fire Containment (equivalent or enhanced)			
<ul style="list-style-type: none"> flight relevant systems nearby inaccessible areas during flight (e.g. hidden area) no escaping smoke 	<ul style="list-style-type: none"> overheat protection external or internal electrical fuse 	<ul style="list-style-type: none"> completely closed material at least compliant with ABD0031 cooling only by heat pipe principle 	<ul style="list-style-type: none"> fire & smoke kept inside housing

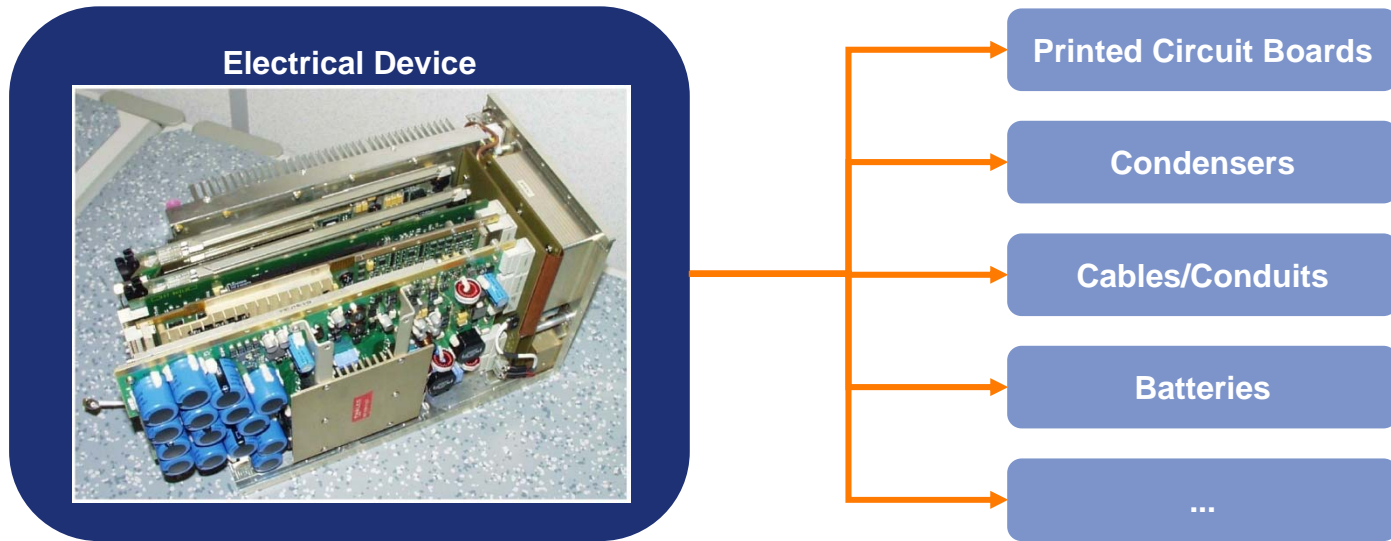
* Use of a devices inside Airbus commercial aircrafts that is certified only against airworthiness standards has to be allowed by exception permission from the responsible aircraft chief engineering department.

Fire Safety Assessment Process – (II) Test Selection

Fire Safety Level	Testing Methods (pp11 – 17)		
	Flammability	Smoke & Toxicity	Equivalent or Enhanced Safety Test
Airworthiness Conformity	all materials & parts*: (1a), (1b), (3) & (4)	--	--
ABD0031 Conformity	all materials & parts*: (1a), (1b), (3) & (4)	all materials & parts*: (2), (3)	--
Flame Spread Safe	only housing & critical parts: (1a), (3) & (4)	only housing & critical parts: (2), (3)	Flame Propagation Test (5)
Fire Containment	only housing: (1a)	only housing (2)	Fire Containment Test (6)

* Component parts inside a device can be regarded as „small parts“ that have not to fulfill flammability, smoke and toxicity requirements under certain circumstances. The way of handling is described in ABD0031, Issue G, chapter 2.2.5.1

Fire Safety Assessment Process – (III) Test Performance: Critical Electrical Parts Selection



Selection Criteria:

- made from non-metallic materials or contain flammable substances (e.g. thermoplastics, printed circuit boards, electrolyte containing condensers etc.)
- are larger in dimensions
- come in a larger quantity
- are placed at or nearby critical zones in the electrical device, (e.g. power supply, air venting holes)
- can contribute to flame propagation (e.g. cables, heat shrinkable tubing)
- carry larger amounts of energy (e.g. Li-Ion batteries)

Fire Safety Assessment Process – (III) Testing for Enhanced or Equivalent Fire Safety Demands



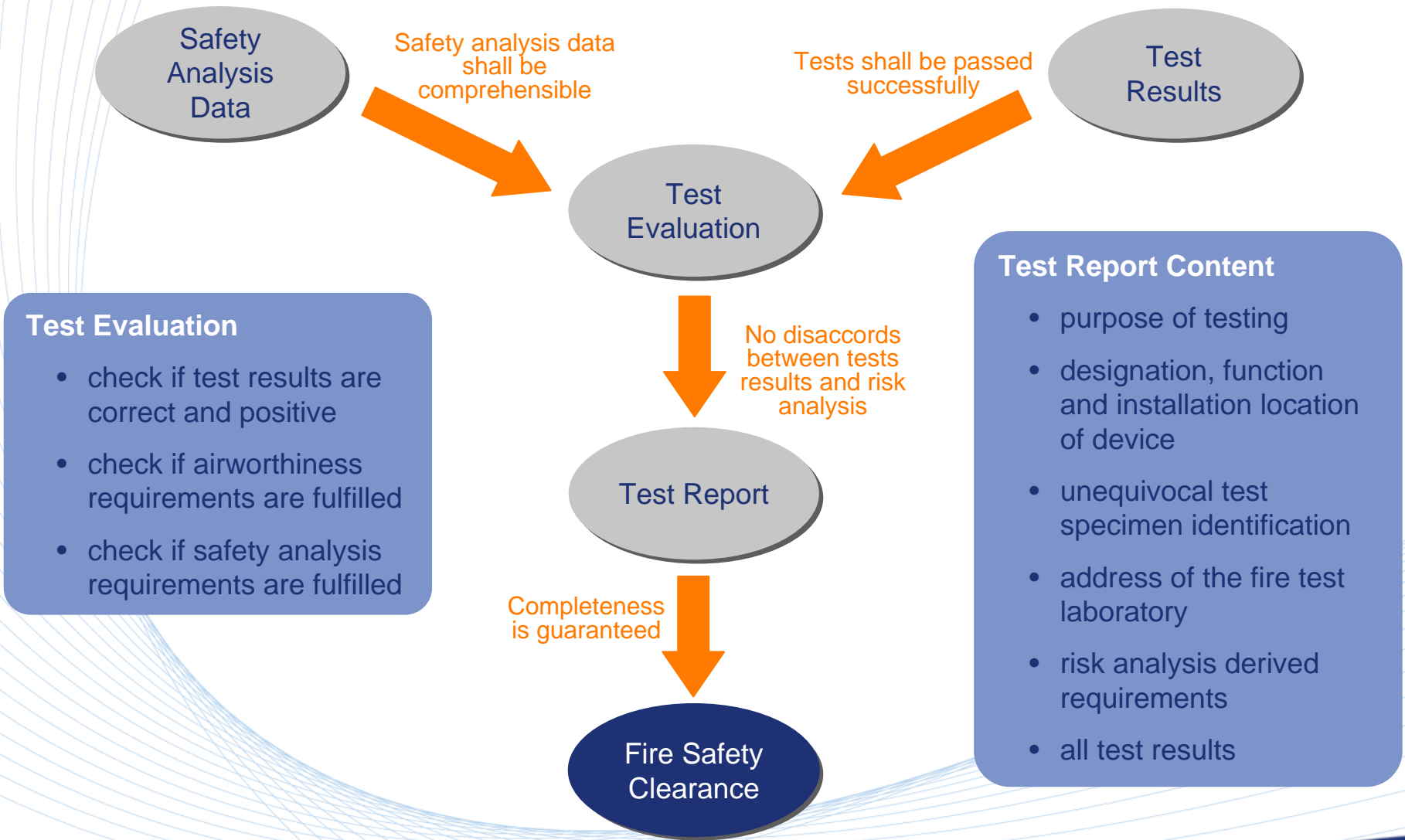
Critical Assessment Factors:

- hidden areas
- closeness to flight relevant systems or critical aircraft components
- critical operating parameters (e.g. high power consumption)
- Non- satisfactory fire safety compliances for used materials & parts

Enhanced Fire Safety Demands:

- fire shall stay inside housing
- smoke shall not be distributed inside aircraft
- possible malfunctions of switch-off routines shall be compensated
- relevant systems shall not be inflicted by incident
- missing fire certificates shall be compensated

Fire Safety Assessment Process – (IV) Test Evaluation

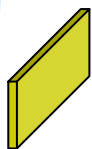


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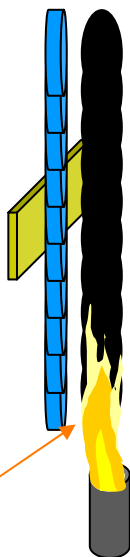
Test Methods – (1a) Flammability Testing Materials & Parts

Test Details

Materials & Boards without Components



Board with Components



flame applied to edge of tested component

Testing in accordance to AITM2.0002B (12s vertical Bunsen burner testing)

limits: burn length < 152mm
after flame time < 15s
after flame time drips < 3s

Sample Layouts

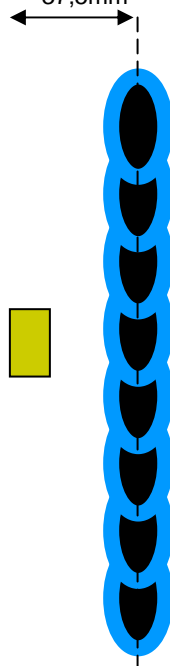
Materials & Printed Circuit Boards

with protective coating as used in device

Condensers*

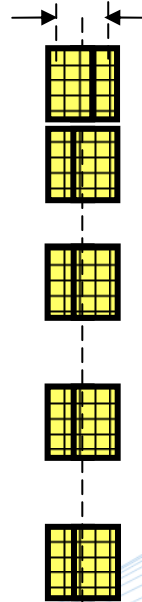
37,5mm

300mm



Connectors*

min 10mm



75mm

75mm

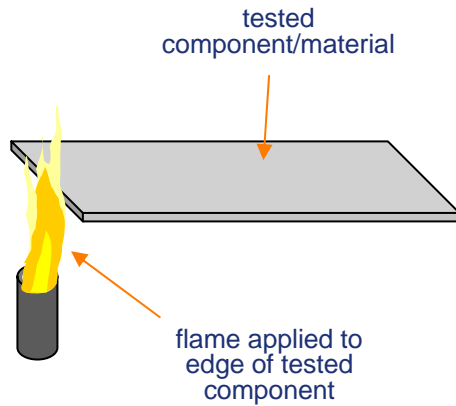
75mm

* Condensers and Connectors have to be mounted in such a way that the complete row is filled

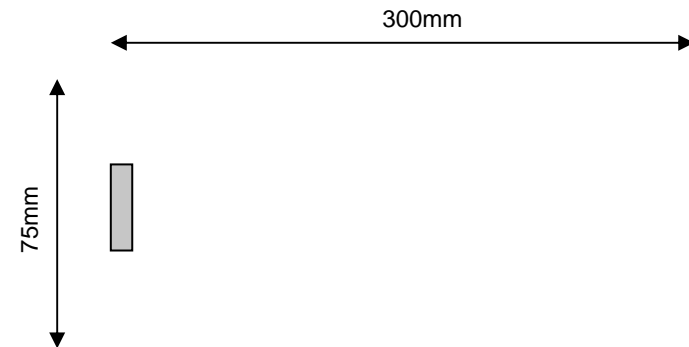
Test Methods – (1b) Flammability Testing Materials & Parts

Test Details

Elastomerics, Signs



Generic test sample prepared for the test



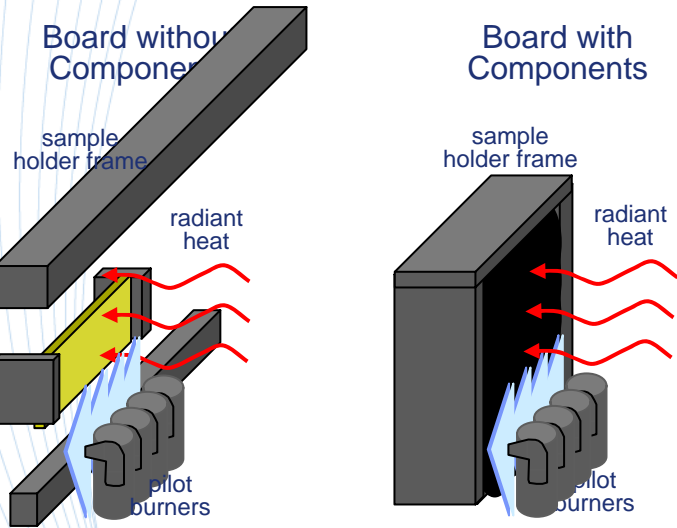
Testing in accordance to AITM2.0003
(15s horizontal Bunsen burner testing)

limits: burn rate < 64mm/min

- sample shall be tested in same thickness as used in device but not thicker as 3mm

Test Methods – (2) Smoke & Toxicity Testing Electrical Parts

Test Details



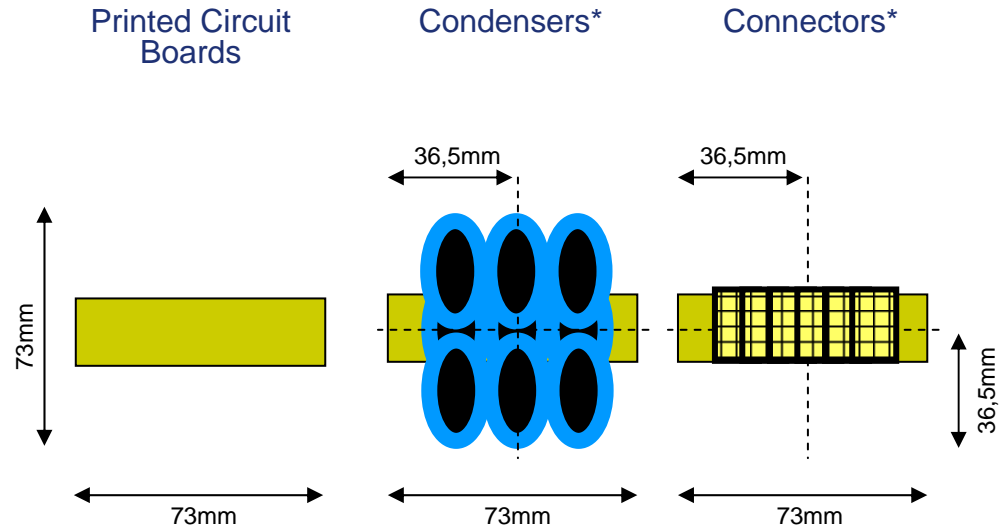
tested part should be at level of pilot burner flame application

Testing in accordance with AITM2.0007 (smoke density) and AITM3.0005 (toxicity) in flaming & non-flaming mode

limits: smoke density $D_m < 200$

HF: 100 ppm, HCl: 150 ppm,
HCN: 150 ppm, SO₂: 100 ppm,
NO/NO_x: 100 ppm, CO: 1000 ppm

Sample Layouts

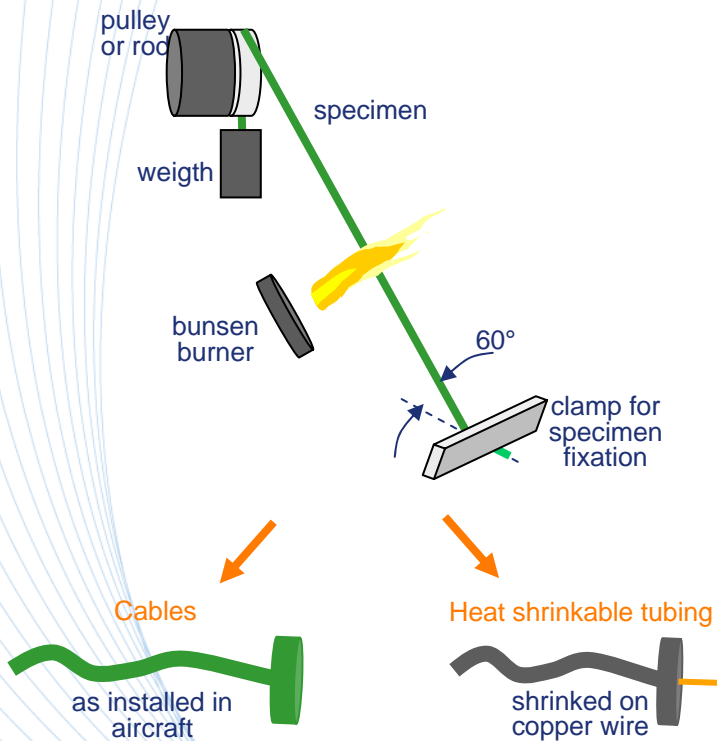


* Condensers and Connectors have to be mounted in such a way that they cover a surface area of app. 63mm x 63mm with no gaps in between

At each edge 5mm have to be left free

Test Methods – (3) Flammability, Smoke & Toxicity for Cables

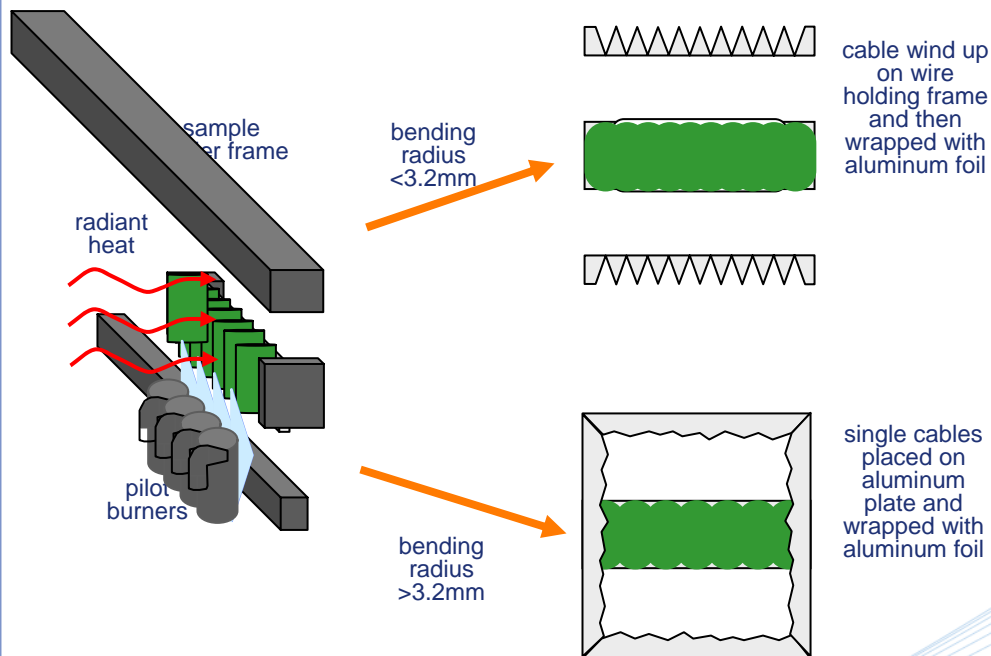
Flammability



Testing in accordance with AITM2.0005 (cables) or AITM2.0038 (heat shrinkable tubing)

limits: burn length < 76mm
 after flame time < 30s
 after flame time drips < 3s

Smoke & Toxicity



Testing in accordance with AITM2.0008A/B and AITM 3.0005

limits: smoke density $D_m < 20$ within 16min
 or $D_m < 200$ within 4min

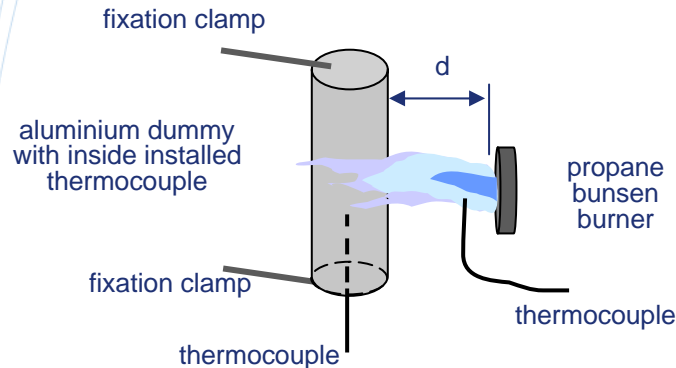
HF: 100 ppm, HCl: 150 ppm, HCN: 150 ppm,
 SO₂: 100 ppm, NO/NO_x: 100 ppm, CO: 1000 ppm

Test Methods – (4) Battery Testing

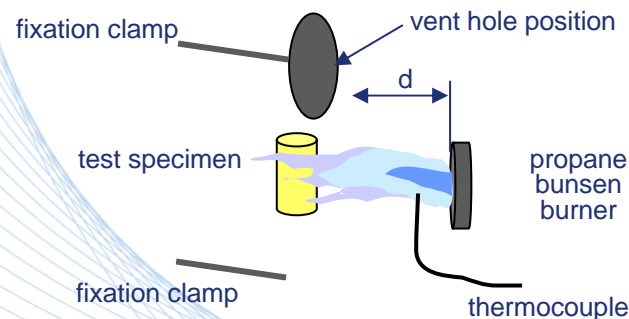
Test Set-Up

Test Details

1st Step: Distance Estimation (3min exposure)



2nd Step: Sample Testing (10min exposure)



Testing is done utilizing the test procedure described in British Standard BS 2G 239 (1992). The used burner shall be compliant with CS/FAR 25.853.

Test Procedure:

- aluminum dummy shall be up-heated above 200°C within 3 minutes by the burner
- flame temperature shall be measured
- distance between cell and burner is estimated
- replacement of dummy by test sample
- flame exposure of test sample for 10 minutes
- observation of behavior
- test is stopped
- damage on test specimen is documented and analyzed

Test conditions:

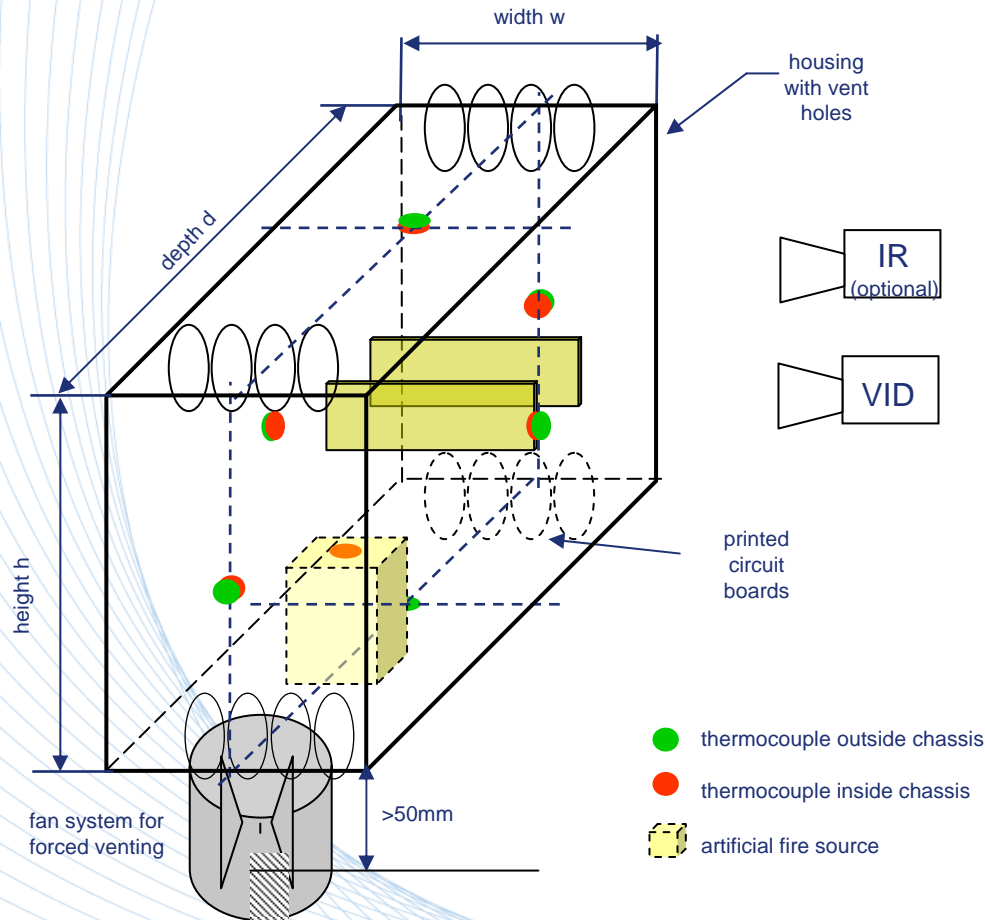
- room temperature of $20 \pm 2^\circ\text{C}$
- test specimens shall be discharged below 75% of nominal capacity

Pass/fail criteria:

- all cases of the cell shall be intact
- no solid components shall be ejected
- hermetically sealed cells should only vent through the designated vent area
- non-hermetically sealed cells shall vent only at the seal area

Test Methods – (5) Flame Spread Test Procedure

Test Set-Up



Test Details

Test Procedure:

- artificial fire source placed inside housing
- application of accelerant
- closing of housing
- starting of data acquisition and of video recording
- Activation of fan system (if necessary)
- ignition of the fire source
- test stop when fire source thermocouple shows again ambient temperatures
- opening of housing
- photo documentation of damage

Test conditions:

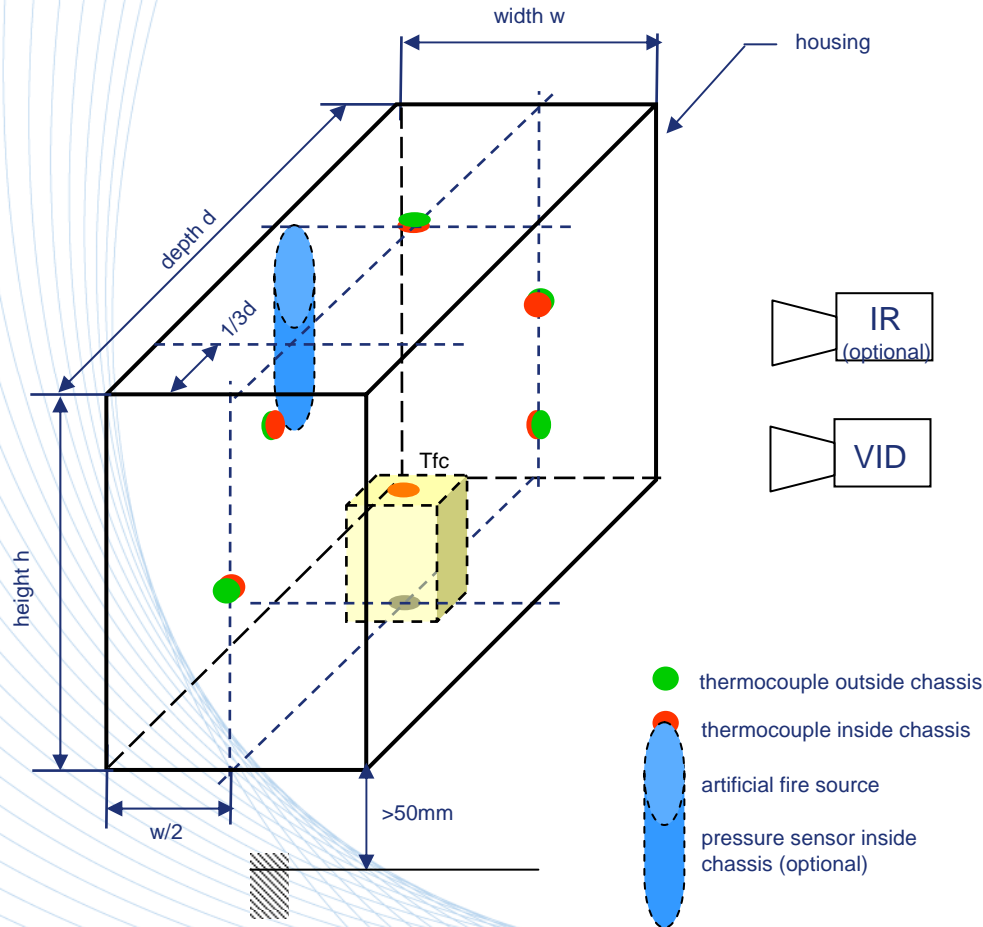
- room temperature of $20 \pm 2^\circ\text{C}$
- relatively humidity of app. 50%.

Pass/fail criteria:

- no fire penetration of the housing,
- outside temperature of the housing has to be below 180°C ,
- no significant flame propagation inside the housing

Test Methods –(6) Fire Containment Test Procedure

Test Set-Up



Test Details

Test Procedure:

- artificial fire source placed inside housing
- application of accelerant
- closing of housing
- starting of data acquisition and of video recording
- ignition of the fire source
- test stop when fire source thermocouple shows again ambient temperatures
- opening of housing
- photo documentation of damage

Test conditions:

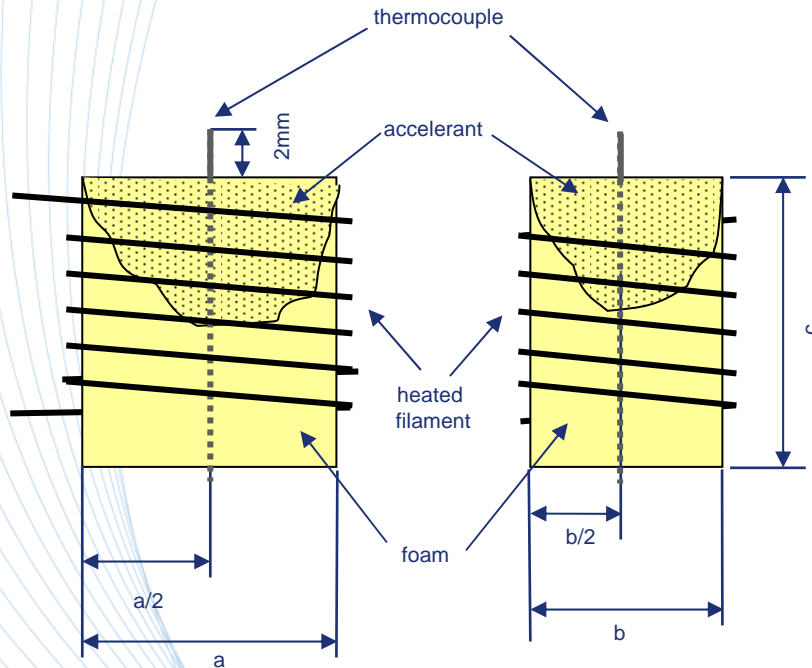
- room temperature of $20 \pm 2^\circ\text{C}$
- relatively humidity of app. 50%.

Pass/fail criteria:

- no fire penetration of the housing,
- outside temperature of the housing has to be below 180°C ,
- no smoke outside the housing visible

Test Methods – Artificial Fire Source Layout

Set-Up



Fire Source Layout Criteria

- type of test (fire containment or flame spread)
- detected critical fire load in device
- worst case assumption that these components are not flame retardant
- position inside housing
- accessibility at fire source position
- capability of igniting other components
- fire shall burn for an overall time of 200...300s

Fire Source Components

- polyurethane foam without flame retardants (density $\sim 30\text{kg/m}^3$)
- accelerant: heptane
- ignition source, e.g. heated filament
- thermocouple for fire source temperature measurement

Summary

Airworthiness flammability requirements (CS/FAR §25)

Airbus fire safety requirements

Fire safety assessment & compliance testing procedure

Establishment of standardized way of compliance showing

Complete coverage of all airworthiness and Airbus requirements

Preparation of „easy-to-use“ test methods

Comparability of results

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