Abstract

VIP aircrafts cabin interiors are refurbished according to specific needs of very demanding customers. In the mean time, international airworthiness authorities set high standard and inevitable certification procedures which do not provide the necessary freedom to fulfill such requests. This study points out four innovative ideas likely to lead to the drafting of approved new methods of compliance.

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1 Introduction

Air transport is fortunately subject to very high standards of safety promoted by the international authorities - EASA\(^1\) and FAA\(^2\) - but that amount of rules sometimes slows down secondary industrial activities like large aircrafts’ cabin interiors refurbishment. This venture consists in changing the finishes or decorative surfaces of compartment interiors by keeping the existing panels. There exists different types of cabin panels: floor panels, wall panels, window panels, class-dividers, furnishings, doors, overhead compartments... but they all are composite honeycomb ones. Refurbishment is more economical in comparison to complete cabin renewal -i.e. removing all existing parts and installing new ones- but it creates many certification issues. Since cabin fire is a main cause of fatality in aircraft accidents, the authorities are continuously implementing and monitoring fire safety rules which are to be strictly applied. Their responsibility include the type-certification of aircraft and components, which means every single new part as well as any major modification on one already in place must be approved. That concretely implies that every materials’ assembly - panel / glue / decorative layer(s) - introduced in an aircraft has to be fire tested according to EASA procedures. In the case of a refurbishment, thus there are two options so far:

- the references of all layers are available and the fire certificate of this exact assembly can be produced by testing either a spare panel or a newly manufactured panel;
- the existing panel must be sampled to fire test the new assembly.

The first option is only possible if the panel can be identified throughout the available documentation and yet the technical documentation is fairly not entirely provided by the original manufacturer or previous refurbisher. On the other hand, it can be impossible to sample the panel regarding its size, shape, uniqueness or structural issues. In the end, the actual legislation makes the refurbishment’s certification very hard and there is a need for innovative solutions which could lead to the drafting of new legislation. This is an even more important requisite for VIP aircrafts since the customers’ requirements are concerning rare materials whose references certification is exclusively kept by the previous refurbisher. In the VIP market, cabin interiors fitting companies are thus more likely to avoid these certification issues and offer their customer the re-completion method. Air France Industries\(^3\) Research & Development department decided to conduct a study to find a way to solve those issues. Our project comes within the scope of this research work, in parallel to the FAA Materials Fire Test Working group activities. While this think tank is more focusing on how to improve the materials fire resistance, we aim to set up innovative processes, demonstrate their reliability through test campaigns and submit them to the authorities for further application.

2 Design tools and guidelines

Our study must comply with the aeronautical legislation from which the relevant parts for us are CS25.853 and its appendix F. In addition to that, there are structural constraints by parts’ manufacturers.

2.1 CS25.853

The main guidelines are provided by the FAA through Federal Acquisition Regulations (FAR). Our project falls within the scope of part 25 - Airworthiness standards for transport category airplanes, subpart D - Design and Construction, section 25.853 - Fire Protection of Compartment interiors. The Certification Specification CS25.853 is the exact equivalent in the EASA legislation and is available as Appendix of this report. Those transcripts include a so-called Appendix F\(^4\) which prescribes

\(^1\) European Aviation Safety Agency  
\(^2\) American Federal Aviation Administration  
\(^3\) Further designated as AFI  
\(^4\) Also available as Appendix of this report.
the applicable test criteria. CS/FAR25.853 sets the following.

(a) Materials (including finishes or decorative surfaces applied to the materials) must meet the applicable test criteria prescribed in Part I of Appendix F.

Paragraph (c) refers to part II of appendix F which lists additional requirements for seat cushions which are out of our scope. The next relevant paragraph\(^5\) (d) draws up the applicability of Heat Release and Smoke Emission tests requirements (Parts IV and V of appendix F). In the frame of VIP refurbishment, the rare materials being used, especially the natural ones, do not pass these tests: wood, leather and other special synthetic materials release lots of smoke and heat. Parts IV and V have as objective to guarantee a complete evacuation of the plane within 90 seconds in case of a kerosene fire outside the aircraft penetrates the cabin. A partial exemption of these requirements is granted\(^6\) by the authorities in the scope of VIP refurbishments if it is proven the evacuation can be completed within 30 (FAA) or 45 seconds (EASA). This requirement is easy to meet considering the low number of passengers in a private large aircraft compared to commercial air carrier’s plane. Plus, VIP passengers are likely to be familiar with the cabin interiors which provide them the ability to escape it faster. In this way, this study will not intend to reach parts IV and V requirements and focus on part I certification issues.

<table>
<thead>
<tr>
<th>Test</th>
<th>Applicability</th>
<th>Requirements (maximum values)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Flame time (s)</td>
</tr>
<tr>
<td>12s vertical</td>
<td>Floor covering, textiles, seat cushions, decorative and non-decorative coated fabrics...</td>
<td>15</td>
</tr>
<tr>
<td>60s vertical</td>
<td>Interior floor, ceiling and walls panels, partitions, galley structure, large cabinet walls, stowage compartments...</td>
<td>15</td>
</tr>
<tr>
<td>30s with 60° bank angle</td>
<td>Electrical system components</td>
<td>30</td>
</tr>
<tr>
<td>15s horizontal</td>
<td>Clear plastic windows and signs, seat belts, shoulder harnesses, baggage tiedown equipments, bins...</td>
<td>-</td>
</tr>
<tr>
<td>15s horizontal</td>
<td>Other parts</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 1: Summary of Test Criteria and Procedures for Showing Compliance with CS25.853

2.2 CS25 Appendix F - Part I

Part I aims to test the materials self-extinguishability by bunsen burning a minimum of three samples and measuring the average burn length, the average flame time after removal of the flame source and average flame time of drippings after falling down or the average burn rate. The test conditions and requirements are dependant on the type of material. Table 1 above briefly describes the different applicable tests, see Appendix 2 for more details. All these tests other than the 60s vertical one refer to single parts whose applicable fire test certificates are usually provided by

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\(^5\)Paragraphs b and e to h are irrelevant in our scope of study.

\(^6\)Confidential Certification Review Item between Air France and the EASA.
the manufacturer when installed and standing alone in the cabin. As a panel refurbisher, we do not need to test the new decorative layer itself, but the construction i.e. old panel + glue + new decorative layer, which corresponds to the 60s vertical test described below.

Thus, the certification methods to be defined in this study are innovative ways to get the 60s vertical test certificate of the refurbished panel.

2.3 Structural constraints

All rules regarding the complete or part modification of an assembly are provided by the manufacturer through so-called Structural Repair Manual (SRM) or Component Maintenance Manual (CMM). These documents explain in details how parts shall be repaired depending on the damage so the structural properties of the assembly are not spoiled and its certification remains valid. The solutions to be set through this study will thus have to come within the scope of these manuals.

3 Approach

The first inevitable step has been to closely read and analyze the legislation set by the EASA and the FAA as well as the inputs provided by the FAA Materials Fire Test Working group. These references are to set the main guidelines and design tools which are described in section 2. From this, a brainstorming originally revealed the following four ideas.

- similarity;
- commonality;
- core drilling;
- fire-blocking layer.

They must be considered as symbiotic inputs: while core drilling is a solution to identify an unknown panel, the concepts of similarity and commonality aim to minimize the number of certificates to be produced according to the documentation available. On another hand, fire-blocking layer acts as a refurbishment method that avoids fire testing. Depending on the information available about the existing panel, we are likely to use one or more of these four to get the refurbished panel certified. The next section will present in detail those concepts.

4 Innovative solutions

4.1 Similarity

The principle of similarity is to substantiate the certification of a panel with data from another one which has similar characteristics. FAA Policy Memorandum ANM-115-09-XXX, published so far as a draft version by the FAA Materials Fire Test Working group, is an important document to be considered for our study since it provides guidance on acceptable methods of compliance with the flammability requirements of FAR/CS Part 25 25.853(a) and (d).

It actually establishes the criteria of similarity which are either

[Part 1] acceptable

or those which are

Appendix 3 lists the most relevant criteria for us. In the frame of this project, we managed\(^8\) to get the EASA approval for considering all criteria as acceptable methods of compliance and the similarity principle applicable on further projects. Nevertheless, the prerequisite is to obtain the certification of the reference panel and to fulfill the criteria of similarity.

Let’s consider an aircraft’s refurbishment where the same laminate in two different colors has to be laid. If the original design data points out that the panels to be refurbished in color A and those in color B are exactly the same, there will be no need to sample both panels in order to substantiate the fire certification of both. Decreasing the number of fire certificates to be produced is the first interest of similarity. Furthermore, we can avoid sampling panels in the frame of each new project by referring to a fire certificate obtained in the frame of a previous project. In this purpose, a database shall be set up to gather all fire tests with a detailed description of the layers so we increase the chances of finding a corresponding reference panel for each refurbished one. For example, the fire certificate of a composite panel X with the glue Y and the synthetic leather Z in blue would be the reference for the refurbishment of a panel provided that the documentation clearly identifies the existing panel as being panel X and that we use the glue Y and a synthetic leather Z in any of its colors. This database is especially relevant for the so-called standard parts which are ceiling, dado\(^9\), windows and closure\(^10\) panels, overhead compartments and toilets blocks. In VIP aircraft interiors, those elements are situated in the sections in commercial airplane layout intended for accompanying people (bodyguards, journalists, private staff...). Standard parts are likely to be refurbished with the same finish of another color and the panel often comes from common manufacturers such as Airbus, Boeing, Sell and Dasel whose products are well known.

Thus, the similarity principle is an interesting method of the fire certification mainly for standard parts and more individually of VIP furnishing elements provided that the panel characteristics are given and a reference panel is identified.

### 4.2 Commonality

As for similarity, the alternative substantiation method commonality aims to decrease the number of samplings and fire tests by identifying groups of panels that have identical design. The difference is in the definition of the “identical”. While similarity requires the exact knowledge of the different layers so to prove the criteria of similarity is the only difference, commonality only requires the assurance that panels are the same regarding fire behavior, not matter whether they actually are. For instance, this principle allows us to consider that a two-windows and a one-window window panel are the “same” even if they do not have the same part number. Thus, the idea is to sample and fire test one panel to substantiate the certification of all panels of this commonality group. The point is to agree with the authority about the definition of a group. AFI managed to set the criteria but they must unfortunately be kept confidential for patent rights issues.

For example, let’s consider a piece of furniture with 10 doors. If the documentation points out that the 10 doors are the same but does not give the characteristics of the panel, similarity is not applicable but commonality applies: instead of sampling and burn the 10 doors, we will sample one of the door, remove the old finish, lay the new one and burn the assembly. If it passes the §25.853 requirements, then all 9 remaining doors are certified in their new layout. The sampled panel is also fire certified but given the size of the samples (three times 76x305mm i.e. ca.7dm\(^2\) - see Appendix 2) it is no longer valid, because of structural constraints and must be either repaired or replaced as explained in section 2.3. Most of the time, CMMs and SRMs do not cover such samplings and a replacement is inevitable. Thus,

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\(^{8}\)For patent rights issues, the arguments cannot be detailed in this report.

\(^{9}\)Vertical panel between the floor and the window panel.

\(^{10}\)Curved panel between the window panel and the ceiling.
there are two possibilities: either the panel is a standard part which can be purchased as spare parts based on its reference or we need to redesign it against the following procedure:

- If the panel is part of a structural assembly, we replace it with an available different panel complying with §25.853 requirements and we check the structural resistance of the furniture by finite-elements methods.
- If the panel is not part of a structural assembly, we measure its size, thickness and weight and manufacture an equivalent panel having these three characteristics and complying with §25.853 requirements.

We see here that this retro-engineering is an applicable limit of commonality. Nevertheless, as it is a complementary to similarity, we can significantly group all panels to be refurbished and in this way decrease the number of samplings and tests needed or even avoid them if we can find a corresponding panel in such a “fire tests database”.

4.3 Core drilling

The idea of core drilling is to identify an unknown composite panel by analyzing a sample of it, ideally a 1-inch squared piece so SRMs and CMMs can cover the reparation procedure. This process is a solution to an eventual lack of design data leading to the impossibility of applying similarity and/or commonality. Thus, core drilling is eventually a preliminary procedure to one or both these principles. Discussions with labs lead to the list of parameters needed to determine reliably the different layers of a composite panel. For the plies, these parameters are required: resin type, fabric type, number of layers of fabric, fabric weave and style, resin content; as for the honeycomb core: material type, cell shape, cell size and density. To validate this method, we aimed to complete the following steps:

- Test campaign to ensure the feasibility;
- Results analysis;
- AFI Compliance Verification Engineers’ (CVE) validation;
- Test campaign to demonstrate the reliability;
- Results analysis;
- CVEs validation;
- Authority’s validation.

AFI agreed with a laboratory on the following procedure for the composite panel determination.

1. Sample preparation: cutting, washing, core/skins separation, removal of the top painted layer;
2. Resin identification through infrared spectroscopy;
3. Skin and core resin chemical analysis through pyrolysis, gas chromatography and mass spectrometry;
4. Fabric identification (thermal degradation if glass fabric, chemical treatment if carbon fabric);
5. Resin content determination through comparative weighing;
6. Fabric weight weighing;
7. Fabric fiber weave and style and core cell size and shape determination through scanning electron microscope (SEM) analysis;
8. Core density measurement.

In the scope of this project, the first test campaign has been performed: the results and analysis are presented in section 5.1. Thanks to the product sheets of the tested panels, we can compare the theoretical values with the measured one and check if the panel’s reference is correct. Thus, we can conclude on the reliability of the lab’s measurements and its ability to identify the panel correctly.

4.4 Fire-blocking layer

This method consists in laying down a flame retardant layer between the panel and the decorative layer, as shown on the following figure:

We intend to demonstrate that this material has a significant positive impact on the fire resistance of the decorated panel. As a first
step, samples of the most used materials will be tested according to the 60s vertical Bunsen burner test (F1) with and without the flame retardant layer in order to get an idea of the qualitative and quantitative fire resisting effect using this material in assemblies. If the results are convincing, the reliability of this method is to be enhanced with a larger market representative sampling. We aim to prove that the addition of the flame retardant layer will ensure that the refurbishment with a new trim and finish fulfills all CS25.853 requirements, considering what the previous one was. At the end, we plan on adopting the same approach as for core drilling:

- Test campaign to ensure the feasibility;
- Results analysis;
- AFI CVEs’ validation;
- Test campaign to demonstrate the reliability;
- Results analysis;
- CVEs validation;
- Authority’s validation.

**Fire test plan** Only two types of panels are used on aircrafts which are likely to be refurbished: wooden and honeycomb panels. Thus, we will be provided a 5mm thick panel of each type, which is the thinnest available according to our experience and the principle of similarity applies for panel thickness (see Appendix 3 - Reference number 2). The first sampling focuses on four common trims and finishes: synthetic leather, fabric, laminate and paint. For each type, we will be provided one representative reference. As for the adhesive, a standard AFI aeronautical glue will be used.

The flame retardant material chosen in this flammability test is called a mica paper. Mica is a mineral which can withstand temperature in excess of 1000°C, it is flame-retardant, non-flammable, does not give off fumes and conducts very little heat. Mica paper consists in a continuous layer of mica flakes squeezed between fiberglass and silicon. This paper is currently in use in the aeronautical industry for the fuselage insulation thanks to its high burn-through resistance.

All combinations of 2 panels and 4 trims & finishes will be manufactured and tested with and without the fire retardant layer, which makes 16 different samples, each of them being manufactured in four pieces according to the minimum of three required in §25.853, Appendix F, part I, paragraph (4) (see Appendix 2) and since our fire testing laboratory asks for one extra piece.

The samples manufacturing process is as follows, see Appendix 4 for photographs:

1. Cutting of all materials in 320x320cm pieces;
2. Application of glue on the wooden and composite panels;
3. For the samples with mica paper:
   a. Laying of the mica;
   b. Application of glue;
4. Laying of the decorative layer or painting.

The samples have been sent to a FAA certified laboratory which will proceed to the 60s vertical bunsen burner tests according to the test procedure described in §25.853, Appendix F, part I, paragraph (b) (see Appendix 2). The results and the analysis are presented in section 5.2.

5 Results and analysis

This section will detail the results of both test campaigns core drilling and fire-blocking layer. The analysis shall conclude the feasibility of these methods.

5.1 Core drilling test campaign of feasibility

In order to ensure the feasibility of core drilling for the identification of a composite panel, we have been provided samples of three different panels referring to three different international specifications: Jameco (Japan), Airbus (Europe) and Boeing (USA). Those three samples have been sent to the lab for determination of all characteristics according to the procedure described in subsection 4.3 as well as identification of the panel’s reference. The exact numerical results cannot be presented in this report.
because of patent rights issues on the materials specifications. Nevertheless, table 2 summarizes the differences between the measured valued and the theoretical parameters for the skin’s analysis\textsuperscript{11}. This comparison highlights the following points of analysis.

- The determination of the parameters weight and resin content is very reliable for one-skin composite panels.
- For the multiple skins panel - sample 1, these values are inaccurate because of the difficult differentiation between the two plies. The resin type is even false for sample 1 because of residual glue traces.
- The fabric’s weave and style are determined accurately.
- Sample 1 comes from the japanese manufacturer. Since the laboratory does not have its panels’ specifications, it has not been able to link it.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sample 1</th>
<th>Sample 2</th>
<th>Sample 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Skin 1</td>
<td>Skin 2</td>
<td>Skin 1</td>
</tr>
<tr>
<td>Resin type</td>
<td>wrong</td>
<td>wrong</td>
<td>right</td>
</tr>
<tr>
<td>Fiber type</td>
<td>right</td>
<td>right</td>
<td>right</td>
</tr>
<tr>
<td>Fabric weight (relative deviation)</td>
<td>8% (4% max.)</td>
<td>4% (10% max.)</td>
<td>0.6% (5% max.)</td>
</tr>
<tr>
<td>Fabric weave &amp; style</td>
<td>right</td>
<td>right</td>
<td>right</td>
</tr>
<tr>
<td>Resin content (relative deviation)</td>
<td>28% (6% max.)</td>
<td>18% (6% max.)</td>
<td>4% (6% max.)</td>
</tr>
<tr>
<td>Panel reference</td>
<td>not determined</td>
<td>not determined</td>
<td>correct</td>
</tr>
</tbody>
</table>

Table 2: Comparison of the core drilling test campaign’s results with materials specifications.

AFI is still expecting some inputs concerning the minimum sample’s size required to perform all these tests and the core analysis results. Already, the procedure is to be upgraded in order to avoid the uncertainties and to make this method more reliable.

5.2 Fire-blocking layer test campaign of feasibility

As we saw earlier, the 60s vertical test includes the measure of the burn length, the extinguishing time after flame removal and the extinguishing time of the drippings. Since no drippings were observed for all burnt samples, there is no value for the extinguishing time of the drippings. On the other hand, figures 1 and 2 in Appendix 4 present the average values for the two other parameters.

One can see that the wooden assemblies do not pass the test since the extinguishing time reaches 24 to 73 seconds whereas §25.853 limit is 15 seconds (see again table 1). On the contrary, the burn length complies with the requirements. As for the composite based samples, they easily pass the 60s vertical test as both parameters do not even reach half the limit. One of the reason is that ply-wood contains a lot of glue which served to fix the different wooden plies. In the future, we have to be very careful with such old panels to be refurbished.

\textsuperscript{11}Results of the core’s analysis not yet available.
Let’s now look at the influence of the mica paper thanks to the following table 3 which displays the relative standard deviation between the values with and without the flame retardant. It is obvious that this effect is completely hazardous when looking at the values only: they do not point out any tendency to extinguish better the flame and neither to reduce the burn length.

The photographs of the burnt samples are available in Appendix 6. They are a visual confirmation of the average values, which are calculated from the measured values of each of the three samples of each type. Nevertheless, we can observe by looking closer at the following figure that the mica paper partly remains: while the silicon burnt away, the fiber and the mica flakes are carbonized but not consumed. This confirms the very good fire resistance of mica and eventually its ability to retard the flame propagation for a burn-through test but it did not help it for our vertical burn tests. The idea of the mica being such a good fire insulator that it could isolate the panel and the decorative layer to limit burning is invalid.

As a conclusion of this method, we can say that mica in a paper application is not dependable solution as fire-blocking layer. Further studies have to be performed to find another way of revealing mica’s excellent fire properties in that purpose.

6 Conclusions

This project highlighted four innovative solutions for the fire certification of VIP cabin interiors refurbishments. On one hand, similarity and communality are principles that are now approved by authorities. Their relevance is on a case to case basis as it is dependant on the consistency of the documentation. The more information available on the existing panels, the more we can gather them into groups and therefore the less certification data is required. On the other hand, when regarding unknown panels, core drilling is a solution that can become more and more reliable and there are possibilities of finding a material that can have the expected flame-resistant properties. Thus, this study has to be carried out to solve those issues. Before applying a method, it is worth considering the economic issues. For example, the more parts there are in a commonality group, the more interesting this method becomes, provided we have all necessary design data. In some cases, such as the refurbishment of a unique piece of furniture, it is also crucial to compare the price of replacing it with a new one to how much the core drilling analysis of the different parts will cost. At the end, it is impossible to draw up a standard decision matrix.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Description</th>
<th>Influence of mica paper</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Extinguishing time (%)</td>
</tr>
<tr>
<td>B1</td>
<td>Wood-Paint</td>
<td>-34</td>
</tr>
<tr>
<td>B2</td>
<td>Wood-Synthetic leather</td>
<td>+20</td>
</tr>
<tr>
<td>B3</td>
<td>Wood-Fabric</td>
<td>+14</td>
</tr>
<tr>
<td>B4</td>
<td>Wood-Laminate</td>
<td>-43</td>
</tr>
<tr>
<td>C1</td>
<td>Composite-Paint</td>
<td>-16</td>
</tr>
<tr>
<td>C2</td>
<td>Composite-Synthetic leather</td>
<td>0</td>
</tr>
<tr>
<td>C3</td>
<td>Composite-Fabric</td>
<td>+35</td>
</tr>
<tr>
<td>C4</td>
<td>Composite-Laminate</td>
<td>-19</td>
</tr>
</tbody>
</table>

Table 3: Relative standard deviation of measured burn length and extinguishing time
since certification issues are so different from one refurbishment project to another. Neverthe- 
less, this six-months study pointed out some interesting tools for the fire certification of VIP 
cabin interiors refurbishment and is a good start for further developments.

7 Acknowledgments

I would like to express my gratitude to my industrial supervisor, Jean-Paul Gresset, de- 
sign manager at Air France Industries, for his complete confidence and guidance as well as his patience all along this project. I wish to acknowledge design engineers Sylvain Lecointe and Johan Grenier for their expertise and precious help and Jean-Jacques Michel, Executive Vice-President Engineering Aircraft Modifications, for the genuine interest he took in my project. I would also like to thank Fabrice Leszczyk and Antoine Deledalle for their sincere moral support and friendship during these six months as well as all my other colleagues whose kindness and knowledge made this experience within Air France very pleasant and enriching.

I must also acknowledge my academic supervisor, PhD Per Wennhage (KTH), for his guidance and availability and Pr. Simon Davies (Ecole Centrale) for his motivation and support during my double-degree program.

I would also like to thank my family, friends and girlfriend without whose fidelity and patience I would not have successfully completed those seven exciting years of studies from Toulouse to Stockholm via Lille, Hamburg, Paris and Kourou.
Appendices

Appendix 1: EASA Certification Specifications for Large Aeroplanes
CS-25/Amdt 10 - Section 25.853 Compartment interiors

For each compartment occupied by the crew or passengers, the following apply:

(a) Materials (including finishes or decorative surfaces applied to the materials) must meet the applicable test criteria prescribed in Part I of Appendix F or other approved equivalent methods, regardless of the passenger capacity of the aeroplane.

(b) Reserved

(c) In addition to meeting the requirements of sub-paragraph (a) of this paragraph, seat cushions, except those on flight crewmember seats, must meet the test requirements of part II of appendix F, or other equivalent methods, regardless of the passenger capacity of the aeroplane.

(d) Except as provided in sub-paragraph (e) of this paragraph, the following interior components of aeroplanes with passenger capacities of 20 or more must also meet the test requirements of parts IV and V of appendix F, or other approved equivalent method, in addition to the flammability requirements prescribed in sub-paragraph (a) of this paragraph:

(1) Interior and wall panels, other than lighting lenses and windows;

(2) Partitions, other than transparent panels needed to enhance cabin safety;

(3) Galley structure, including exposed surfaces of stowed carts and standard containers and the cavity walls that are exposed when a full complement of such carts or containers is not carried; and

(4) Large cabinets and cabin stowage compartments, other than underseat stowage compartments for stowing small items such as magazines and maps.

(e) The interiors of compartments, such as pilot compartments, galleys, lavatories, crew rest quarters, cabinets and stowage compartments, need not meet the standards of sub-paragraph (d) of this paragraph, provided the interiors of such compartments are isolated from the main passenger cabin by doors or equivalent means that would normally be closed during an emergency landing condition.

(f) Smoking is not to be allowed in lavatories. If smoking is to be allowed in any other compartment occupied by the crew or passengers, an adequate number of self-contained, removable ashtrays must be provided for all seated occupants.

(g) Regardless of whether smoking is allowed in any other part of the aeroplane, lavatories must have self-contained removable ashtrays located conspicuously both inside and outside each lavatory. One ashtray located outside a lavatory door may serve more than one lavatory door if the ashtray can be seen readily from the cabin side of each lavatory door served.

(h) Each receptacle used for the disposal of flammable waste material must be fully enclosed, constructed of at least fire resistant materials, and must contain fires likely to occur in it under normal use. The ability of the receptacle to contain those fires under all probable conditions of wear, misalignment, and ventilation expected in service must be demonstrated by test.
Appendix 2: CS25 - Appendix F - Part I - Test Criteria and Procedures for Showing Compliance with CS25.853, 25.853 or 25.869

(a) Material test criteria

(1) Interior compartments occupied by crew or passengers.

   (i) Interior ceiling panels, interior wall panels, partitions, galley structure, large cabinet walls, structural flooring, and materials used in the construction of stowage compartments (other than underseat stowage compartments and compartments for stowing small items such as magazines and maps) must be self-extinguishing when tested vertically in accordance with the applicable portions of Part I of this Appendix. The average burn length may not exceed 15 cm (6 inches) and the average flame time after removal of the flame source may not exceed 15 seconds. Drippings from the test specimen may not continue to flame for more than an average of 3 seconds after falling.

   (ii) Floor covering, textiles (including draperies and upholstery), seat cushions, padding, decorative and nondecorative coated fabrics, leather, trays and galley furnishings, electrical conduit, air ducting, joint and edge covering, liners of Class B and E cargo or baggage compartments, floor panels of Class B, C, E or F cargo or baggage compartments, cargo covers and transparencies, moulded and thermoformed parts, air ducting joints, and trim strips (decorative and chafing), that are constructed of materials not covered in sub-paragraph (iv) below, must be self-extinguishing when tested vertically in accordance with the applicable portions of Part I of this Appendix or other approved equivalent means. The average burn length may not exceed 20 cm (8 inches), and the average flame time after removal of the flame source may not exceed 15 seconds. Drippings from the test specimen may not continue to flame for more than an average of 5 seconds after falling.

   (iii) Clear plastic windows and signs, parts constructed in whole or in part of elastomeric materials, edge lighted instrument assemblies consisting of two or more instruments in a common housing, seat belts, shoulder harnesses, and cargo and baggage tiedown equipment, including containers, bins, pallets, etc, used in passenger or crew compartments, may not have an average burn rate greater than 64 mm (2·5 inches) per minute when tested horizontally in accordance with the applicable portions of this Appendix.

   (iv) Except for small parts (such as knobs, handles, fasteners, clips, grommets, rubber strips, pulleys, and small electrical parts) that would not contribute significantly to the propagation of a fire and for electrical wire and cable insulation, materials in items not specified in paragraphs (a)(1)(i), (ii), (iii), or (iv) of Part I of this Appendix may not have a burn rate greater than 102 mm/min (40 inches per minute) when tested horizontally in accordance with the applicable portions of this Appendix.

(2) […] (irrelevant)

(3) Electrical system components. Insulation on electrical wire or cable installed in any area of the fuselage must be selfextinguishing when subjected to the 60 degree test specified in Part I of this Appendix. The average burn length may not exceed 76 mm (3 inches), and the average flame time after removal of the flame source may not exceed 30 seconds. Drippings from the test specimen may not continue to flame for more than an average of 3 seconds after falling.

(b) Test Procedures

(1) Conditioning. Specimens must be conditioned to $21 \pm 11 \pm 3^\circ C$ ($70 \pm 5^\circ F$) and at 50%±5% relative humidity until moisture equilibrium is reached or for 24 hours. Each specimen must remain in the conditioning environment until it is subjected to the flame.
(2) Specimen configuration. Except for small parts and electrical wire and cable insulation, materials must be tested either as a section cut from a fabricated part as installed in the aeroplane or as a specimen simulating a cut section, such as a specimen cut from a flat sheet of the material or a model of the fabricated part. The specimen may be cut from any location in a fabricated part; however, fabricated units, such as sandwich panels, may not be separated for test. Except as noted below, the specimen thickness must be no thicker than the minimum thickness to be qualified for use in the aeroplane. Fabricated units, such as sandwich panels, may not be separated for test. Except as noted below, the specimen thickness must be no thicker than the minimum thickness to be qualified for use in the aeroplane. Test specimens of thick foam parts, such as seat cushions, must be 13 mm (1/2-inch) in thickness. Test specimens of materials that must meet the requirements of subparagraph (a)(1)(v) of Part I of this Appendix must be no more than 3.2 mm (1/8-inch) in thickness. Electrical wire and cable specimens must be the same size as used in the aeroplane. In the case of fabrics, both the warp and fill direction of the weave must be tested to determine the most critical flammability condition. Specimens must be mounted in a metal frame so that the two long edges and the upper edge are held securely during the vertical test prescribed in sub-paragraph (4) of this paragraph and the two long edges and the edge away from the flame are held securely during the horizontal test prescribed in sub-paragraph (5) of this paragraph. The exposed area of the specimen must be at least 50 mm (2 inches) wide and 31 cm (12 inches) long, unless the actual size used in the aeroplane is smaller. The edge to which the burner flame is applied must not consist of the finished or protected edge of the specimen but must be representative of the actual cross-section of the material or part as installed in the aeroplane. The specimen must be mounted in a metal frame so that all four edges are held securely and the exposed area of the specimen is at least 20 cm by 20 cm (8 inches by 8 inches) during the 45° test prescribed in sub-paragraph (6) of this paragraph.

(3) Apparatus. Except as provided in sub-paragraph (7) of this paragraph, tests must be conducted in a draught-free cabinet in accordance with Federal Test Method Standard 191 Model 5903 (revised Method 5902) for the vertical test, or Method 5906 for horizontal test (available from the General Services Administration, Business Service Centre, Region 3, Seventh & D Streets SW., Washington, DC 20407). Specimens, which are too large for the cabinet, must be tested in similar draught-free conditions.

(4) Vertical test. A minimum of three specimens must be tested and results averaged. For fabrics, the direction of weave corresponding to the most critical flammability conditions must be parallel to the longest dimension. Each specimen must be supported vertically. The specimen must be exposed to a Bunsen or Tirrill burner with a nominal 9.5 mm (3/8-inch) I.D. tube adjusted to give a flame of 38 mm (1 1/8 inches) in height. The minimum flame temperature measured by a calibrated thermocouple pyrometer in the centre of the flame must be 843°C (1550°F). The lower edge of the specimen must be 19 mm (3/4-inch) above the top edge of the burner. The flame must be applied to the centre line of the lower edge of the specimen. For materials covered by sub-paragraph (a)(1)(i) of Part I of this Appendix, the flame must be applied for 60 seconds and then removed. For materials covered by sub-paragraph (a)(1)(ii) of Part I of this Appendix, the flame must be applied for 12 seconds and then removed. Flame time, burn length, and flaming time of drippings, if any, may be recorded. The burn length determined in accordance with subparagraph (7) of this paragraph must be measured to the nearest 2.5 mm (tenth of an inch).

(5) Horizontal test. A minimum of three specimens must be tested and the results averaged. Each specimen must be supported horizontally. The exposed surface, when installed in the aircraft, must be face down for the test. The specimen must be exposed to a Bunsen or Tirrill burner with a nominal 95 mm (3-inch) I.D. tube adjusted to give a flame of 38 mm (1 1/2 inches) in height. The minimum flame temperature measured by a calibrated thermocouple pyrometer in the centre of the flame must be 843°C (1550°F). The specimen must be
be positioned so that the edge being tested is centred 19 mm (3/4-inch) above the top of the burner. The flame must be applied for 15 seconds and then removed. A minimum of 25 cm (10 inches) of specimen must be used for timing purposes, approximately 38 mm (1 1/2 inches) must burn before the burning front reaches the timing zone, and the average burn rate must be recorded.

(6) Forty-five degree test. A minimum of three specimens must be tested and the results averaged. The specimens must be supported at an angle of 45° to a horizontal surface. The exposed surface when installed in the aircraft must be face down for the test. The specimens must be exposed to a Bunsen or Tirrill burner with a nominal 3/8-inch (9.5 mm) I.D. tube adjusted to give a flame of 38 mm (1 1/2 inches) in height. The minimum flame temperature measured by a calibrated thermocouple pyrometer in the centre of the flame must be 843°C (1550°F). Suitable precautions must be taken to avoid draughts. The flame must be applied for 30 seconds with one-third contacting the material at the centre of the specimen and then removed. Flame time, glow time, and whether the flame penetrates (passes through) the specimen must be recorded.

(7) Sixty-degree test. A minimum of three specimens of each wire specification (make and size) must be tested. The specimen of wire or cable (including insulation) must be placed at an angle of 60° with the horizontal in the cabinet specified in sub-paragraph (3) of this paragraph with the cabinet door open during the test, or must be placed within a chamber approximately 61 cm (2 feet) high by 31 cm by 31 cm (1 foot by 1 foot), open at the top and at one vertical side (front), and which allows sufficient flow of air for complete combustion, but which is free from draughts. The specimen must be parallel to and approximately 15 cm (6 inches) from the front of the chamber. The lower end of the specimen must be held rigidly clamped. The upper end of the specimen must pass over a pulley or rod and must have an appropriate weight attached to it so that the specimen is held tautly throughout the flammability test. The test specimen span between lower clamp and upper pulley or rod must be 61 cm (24 inches) and must be marked 20 cm (8 inches) from the lower end to indicate the central point for flame application. A flame from a Bunsen or Tirrill burner must be applied for 30 seconds at the test mark. The burner must be mounted underneath the test mark on the specimen, perpendicular to the specimen and at an angle of 30° to the vertical plane of the specimen. The burner must have a nominal bore of 9.5 mm (3/8-inch) and be adjusted to provide a 76 mm (3-inch) high flame with an inner cone approximately one-third of the flame height. The minimum temperature of the hottest portion of the flame, as measured with a calibrated thermocouple pyrometer, may not be less than 954°C (1750°F). The burner must be positioned so that the hottest portion of the flame is applied to the test mark on the wire. Flame time, burn length, and flaming time of drippings, if any, must be recorded. The burn length determined in accordance with subparagraph (8) of this paragraph must be measured to the nearest 0.5 mm (tenth of an inch). Breaking of the wire specimens is not considered a failure.

(8) Burn length. Burn length is the distance from the original edge to the farthest evidence of damage to the test specimen due to flame impingement, including areas of partial or complete consumption, charring, or embrittlement, but not including areas sooted, stained, warped, or discoloured, nor areas where material has shrunk or melted away from the heat source.
Appendix 3: Most relevant methods of compliance for FAR/CS §25.853 proposed in FAA draft policy memo ANM-115-09-XXX

<table>
<thead>
<tr>
<th>Part</th>
<th>Ref. Nb.</th>
<th>Feature/Construction</th>
<th>Similarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part 1</td>
<td>2</td>
<td>Thickness ranges</td>
<td>Data from testing a thinner construction substantiates a thicker construction made of the same materials.</td>
</tr>
<tr>
<td>Part 1</td>
<td>13</td>
<td>Texture</td>
<td>Data from testing one texture of a decorative type substantiates a panel with the same decorative type with a different texture.</td>
</tr>
<tr>
<td>Part 1</td>
<td>16</td>
<td>Aluminum/Steel/Titanium</td>
<td>Unless they contain magnesium or magnesium alloys, unfinished metal parts do not require testing. Finished metal parts do not require testing provided: standard* paint/finishes are used and the parts do not contain magnesium or magnesium alloys.</td>
</tr>
<tr>
<td>Part 2</td>
<td>3</td>
<td>Core, density</td>
<td>Data from testing a lower density honeycomb core substantiates a higher density honeycomb core[...].</td>
</tr>
<tr>
<td>Part 2</td>
<td>4</td>
<td>Core, cell size</td>
<td>Data from testing ANY core cell size/shape substantiates other core cell size/shapes of the same material[...].</td>
</tr>
<tr>
<td>Part 2</td>
<td>5</td>
<td>Paint/ink systems</td>
<td>Test of one color substantiates other colors of the same paint/ink system and the unpainted panel.</td>
</tr>
<tr>
<td>Part 2</td>
<td>15</td>
<td>Synthetic leather/suede</td>
<td>Data from testing one synthetic leather/suede material sample will substantiate other colors of the same material.</td>
</tr>
</tbody>
</table>

* Standard paint/finishes are defined as inorganic finishes, epoxy primers and topcoats, urethane topcoats, and corrosion inhibiting dry films.

Appendix 4: Photographs of the samples manufacturing process relative to the FBL preliminary campaign

(a) Cutting of large pieces (b) Preparation of the assemblies
(c) Application of the glue on the panels

(d) Drying after application of the glue on all layers

(e) Laying of the laminate

(f) Drying of the painted panels

(g) Cutting of the samples

(h) Packing and expedition
Appendix 5: Results of the FBL preliminary test campaign

Figure 1: Average values of the measured burn length

Figure 2: Average values of the measured extinguishing time
Appendix 6: Photographs of the burnt samples relative to the FBL preliminary campaign

The two samples to the left are without mica paper, while the two to the right do have it.

*Composite based assemblies*

(a) Composite-Laminate  (b) Composite-Fabric

(c) Composite-Paint  (d) Composite-Synthetic leather
Wooden assemblies

(e) Wood-Laminate
(f) Wood-Fabric
(g) Wood-Paint
(h) Wood-Synthetic leather