FIRE HARDENING OF AN AIRCRAFT PASSENGER CABIN

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ABSTRACT

The implications of fires to that part of a passenger aircraft comprising the fuselage pressure shell are discussed, with particular reference to the passenger cabin and crew areas.

The history of materials utilisation is firstly reviewed, leading to an overview of the current materials scenario, with particular reference to the use of combustible materials.

The particular materials related regulations, covering aspects of fire hardening appertaining to baggage holds, passenger cabin furnishings, and seats, and the additional smoke and toxicity tests introduced by constructors, are discussed.

Potential developments to fire harden the fuselage shell to resist an external fire, and cabin furnishings improvements to provide increased fire hardening are exemplified. The interaction between the design aims of the constructors, passenger acceptance, the requirements of the airlines and fire safety are presented finally.

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1 INTRODUCTION

In civil aviation history, we have progressed through three materials ages, all in the time scale of less than a century. These ages may be defined sequentially as the wood age, the aluminium age, and the composites age. Each period recognised the dominance of a particular material, supported of course by the use of many other materials. The transition through the ages progressed with the new materials competing with, and in due course selectively superseding, those materials already in use. Thus their introduction was gradual, and the transition through the ages was progressive, without precise date boundaries.

Each age produced aircraft with their own distinctive character, reflecting the materials used, the design requirements and practices appertaining at the time, and the role of the aircraft as a passenger carrier. It was a significant feature of each age that the trends in materials usages applied similarly to both the airframe and cabin furnishings. Thus aircraft constructed mostly in wood contained furnishings mostly in wood. Aircraft constructed mostly in aluminium alloy contained large quantities of aluminium alloy within the cabin for components such as floors, bulkheads and galley units. With the advent of composites, initially of course on a selective basis for structural applications in civil aircraft, these were also introduced extensively within the cabin in place of metals as fibre reinforced composites, together with unreinforced thermoplastics.

Now, coincidentally with the advent of the composites age, a new problem has emerged. An unacceptable number of passengers have perished from aircraft fires, mostly when the aircraft were

2 REVIEW OF MATERIALS USAGE

A review is made of the materials usages over these three ages, in order to better understand and have the correct perspective on the current situation. In the wood age, this typically comprised the main structural material. However a number of other materials were of course used, including steel, aluminium, leather, and fabric based skin covering materials. Passenger aircraft were small by modern standards, and they were much simpler than today, with less ancillary equipment. They were perhaps more prone to structural or power plant problems, and accidents in general. In that period, any public awareness was probably limited to the feeling that flying did have an element of risk for the passenger. Aircraft fires as such were not thought of as a particular problem, certainly not in comparison for instance with those experienced by airships.

The aluminium age arrived with the progressive introduction of aluminium alloys in place of wood for aircraft structure. The use of aluminium alloy for fuselage skinning permitted the introduction of pressurised passenger cabins, and a new generation of aircraft passenger jet and turboprop aircraft was born.

As this age progressed, aluminium alloys were used increasingly for furnishing applications such as floors, bulkheads, galley units, doors, and overhead bins. Frequently sandwich construction was used, with aluminium alloy skins, and cores of either aluminium honeycomb, balsa wood, or PVC foam. Panels were decorated typically with fabric reinforced PVC, or melamine laminates. The use of timber was restricted mostly to trim pieces. The cabin sidewalls typically used PVC or polyester glasscloth laminates, sometimes with trim materials. The cockpit was largely fabricated from aluminium alloy, and most fluid containers and smaller components were typically of welded or fabricated aluminium alloy construction. The use of non-metallic composites and thermoplastics was relatively restricted. The fabrication methods suited the relatively low production quantities implicit in passenger aircraft manufacture, and generally there was little incentive to change materials or constructions. In summary, a typical passenger cabin representative of this age contained a high percentage of non-combustible metallic materials, and relatively smaller quantities of non-metallic materials such as composites, thermoplastics, wood, leather and fabrics, which could generally be defined as combustible materials. The seats, however, did frequently utilise polyurethane foam cushions which were highly combustible.

The historical evidence does support the opinion that in this era passenger cabin fires were not a serious problem, in comparison to other service incidents and accidents. Aircraft were generally smaller, and had lower seat densities. This factor combined with the materials selection practices, probably resulted in the combustible materials being of insufficient quantity and so distributed that they did not comprise a critical mass in the combustion process, nor generate sufficient inflammable gases to cause flashover. Thus when a fire did start, it did not escalate in the manner experienced in more recent fire situations.

The composites age had a false dawn with the use of radome constructions typically in glass fibre with a polyester matrix resin. The main advance came with the introduction of composite materials both for secondary structural components, and for constructions within the cabin. The commitment by constructors to the use of composites and thermoplastics in interiors has, in recent years, been progressive and extensive; the main driver for their introduction being weight saving. Nowadays virtually all interior panelling both in monolithic and sandwich forms, air conditioning ducting, and miscellaneous moulded items are constructed in composites. Thermoplastics are used in unreinforced sheet forms for many cabin furnishing applications, and fibre reinforced variants are used for mouldings such as passenger service units and grills. The passenger seat fittings, and in some cases the seat frames, are increasingly using composites and thermoplastics.

When composite items were first introduced they were fabricated using mostly polyester or epoxy resins systems with a glass fibre reinforcement, and PVC was still used for unreinforced moulded sheet applications. More recently, in order to meet new design and airworthiness requirements, various material changes have been introduced, and the whole cabin furnishings materials scenario has received close scrutiny by the materials suppliers, the aircraft constructors, and the airworthiness authorities. Typical changes for improved flame, smoke and toxicity (FST) performance and improved heat release characteristics, have been the use of phenolic resin systems in place of epoxies and polyesters for the matrix system of fibre reinforced composites; the use of polycarbonate in place of PVC for non-reinforced thermoplastic applications; and more recently the use of polyethersulphone and polyetherimide non-reinforced thermoplastics in place of polycarbonate where regulations on heat release necessitated a change. The use of thermoplastic resin systems such as polyetheretherketone, polyphenylene sulphide, and polyetherimide as the matrix systems for both long fibre and short fibre reinforced composite laminates and mouldings is becoming more evident; the main driver again being their improved FST performance.

3 FIRE HARDENING

This document is concerned primarily with the subject of fire hardening; it is therefore appropriate that this be defined.

Fire hardening is the creation of a material or structure with the ability to withstand the effects of radiant heat or a direct flame source. This may be quantified by two main parameters:

i) resistance to combustion, and consequent heat release, smoke and toxic gas emission characteristics over a measured time period.

ii) its resistance to degradation in terms of physical and mechanical properties, and resistance to total disintegration or melting.

The combustion characteristics are typified by a number of features:

i) The speed with which the material is heated to a temperature at which combustion byproducts such as smoke, toxic gases and volatiles are emitted, when it is subjected to radiant heat or a direct flame source.

ii) The time to ignition when exposed to the above heat source.

iii) The ability of the material to support combustion on its own in various modes, ie vertical, inclined or horizontal, when the heat source is removed.

iv) The quantity and nature of the toxic gases emitted by the material during combustion under its continued exposure to the heat source.

v) The quantity and nature of any inflammable gases emitted during this process.

vi) The quantity of smoke emitted during this process.

vii) The quantity of heat emitted by the material and its relationship with the time to complete the combustion process.

The degradation characteristics are typified by features such as:

i) The distortion, and subsequent sagging, leading to the collapse and melting of the material (a feature of unreinforced thermoplastics).

ii) The progressive strength reduction leading to the complete loss of mechanical properties, except possibly for the bursting strength (a feature of fibre reinforced thermosets and thermoplastics).

iii) The ability to act as a fire barrier during and after the combustion process (a feature of certain fibre reinforcements).

The creation of an effective fire hardened structure will require that some or all of the constituent materials be fire hardened. This will depend upon the nature of the structure and the disposition of the various materials within the structure.

4 REVIEW OF COMBUSTIBLE MATERIALS

In order to understand better the significance of materials selection on combustion performance, a comparison has been made between an aircraft constructed in the year 1960 in the aluminium age, and one constructed in 1989, in the composites age, using materials appropriate to each era.

It should be noted that a nominal weight reduction of 15% has been assumed, being directly attributable to the replacement of metals by composites and thermoplastics.

Firstly, the weight of combustible materials within the pressure cabin, but including the windows, was ascertained for an aircraft of around 70 seats, for both cases. This was then related to the total weight of materials within the pressure cabin envelope.

Whereas in 1960 the weight of combustible materials was a nominal 710 kg, it had risen by the year 1989 to 1310 kg, which represented an 84 percent weight increase. The percentage of combustible materials related to the total weight of furnishings had increased over this period from 32 to 69 percent. These changes in materials usages are summarised in the following table.

YEAR	1960	1989
TOTAL WEIGHT OF FITTINGS AND EQUIPMENT, INCLUDING CABIN WINDOWS (KG)	2230	1900
REDUCTION IN TOTAL WEIGHT		15%
WEIGHT OF NON-COMBUSTIBLE MATERIALS (KG)	1520	590
PERCENTAGE OF TOTAL WEIGHT	68%	31%
WEIGHT OF COMBUSTIBLE MATERIALS (KG)	710	1310
PERCENTAGE OF TOTAL WEIGHT	32%	69%
INCREASE IN WEIGHT OF COMBUSTIBLE MATERIALS (KG) FROM 1960 TO 1989	-	600
PERCENTAGE INCREASE		84%

5 REVIEW OF RULE MAKING

With respect to fire hardening of materials and constructions, the rules already introduced by the authorities may be summarised into the following categories.

- i) Baggage holds
- ii) Seat cushions
- iii) Toilet and galley waste containers and surrounds
- iv) Flammability of materials
- v) Heat release of cabin furnishing constructions

In addition to the airworthiness authorities rules, some aircraft constructors have instituted their own aircraft type specification requirements. These are aimed at complementing and strengthening the control exercised in materials selection for cabin interiors.

Typically these include:

- i) Smoke Emission Tests
- ii) Toxic Gas Emission Tests

It should be noted that the authorities plan to introduce smoke emission testing as a mandatory regulation in 1990.

The implementation of these rules serves to control various aspects of the combustion performance of materials and constructions within the fuselage pressure shell. Each regulation defines a number of specific requirements. These are briefly discussed, and observations made on the implications of their implementation on materials selection.

When creating constructions that meet these regulations, the designer must avoid becoming blinkered by over-concentrating on FST performance. He must maintain a perspective, and ensure that the component is properly engineered, typically in respect of its strength, stiffness, resistance to impact, and durability.

Baggage Holds

The materials selection process for baggage holds is primarily driven by the requirement to provide a containment of a fire starting within the hold. However should the fire reach the walls of the baggage hold, then degradation of the wall material could occur with the consequent emission of smoke and toxic gases from the outer surfaces of the walls.

Should the baggage hold be positioned beneath the floor, then any possible threat from this source may be minimal. However, should the hold be above the cabin floor, then a fire within the hold could cause smoke and toxic gases to be emitted from the outer surfaces which may be more likely to invade the passenger cabin. It is therefore advisable at the development stage to carry out additional screening tests on proposed materials and constructions to monitor smoke and toxic gas emissions to ensure that these are not excessive; and if necessary to modify the wall construction or to change the selected materials to achieve an acceptable product.

Seat Cushions

The primary purpose of the regulation concerning passenger cabin seats is to minimise the combustion of the cushion material when it is exposed to a flame source.

The basic problem with regard to materials selection is that the current generation of polyurethane foams, which possess excellent characteristics as cushion materials combined with good durability, normally have a totally unacceptable combustion performance. Conversely, foams with a good combustion performance provide poor durability and comfort.

Certain foams suppliers have carried out extensive research into suitable alternative materials, and to date the evidence suggests that a layered construction using two different foams may provide a solution. Meanwhile a common current practice is to cover the cushion with a fire blocking layer comprising a high temperature resistant fabric.

It is considered important to ensure that, in addition to meeting the regulations, the combustion byproducts meet acceptable standards in terms of smoke and toxic gas emissions; and development work on these matters is ongoing.

Flammability of Materials

This, the longest standing of the regulations, is a rule of many parts. The basic tests, utilising a bunsen burner flame applied to the specimen, are well understood.

Historically, the requirement to meet this test meant that, for some materials, manufacturers may have modified the polymer or included additives to improve its flammability performance and self-extinguishing characteristics.

This test provides a very useful and necessary screening of materials. It is still true that the rate of combustion, measured by burn length, and the self-extinguishing characteristics, both of the material and of any drippings, provide a good basic monitor of a material's combustion performance. However, experience has shown that there are shortcomings to this test when done in isolation. A better overall measure of the combustion performance of a material may be achieved by also monitoring other parameters such as smoke and toxic gas emission, and heat release performance; and this is discussed later.

Heat Release Performance

The purpose of this test, which is applicable to panelling within the passenger cabin, is to control the quantity of heat emitted by a panel during the combustion process. The sample panel is subjected to a radiant heat source and pilot flames, and the total and peak heat release are monitored over defined time periods.

The implementation of the rule is in two planned stages. The first stage became mandatory in 1988, and the second stage, which has more stringent acceptance requirements, will be introduced in 1990. This rule recognises that improvements in materials technology do take time to bring to fruition. The timings of its introduction must serve to accelerate the pace of new materials development; and the material suppliers and the panel constructors are making considerable efforts to create viable products to meet this new regulation.

Again, like other rules, the measurement of heat release should not be considered in isolation, because this may be counterproductive. The manufacturers must be cautious when formulating new products, and screening them in terms of their heat release performance, to ensure that a suitable balance of combustion performance parameters is again maintained. The manufacturers of the panel assemblies must also maintain a good liaison with the suppliers of all the constituent materials, because each one may contribute to the overall heat release performance of the assembly, which must itself meet the regulation.

Smoke Emission and Toxic Gas Emission

Smoke emission testing will first become an airworthiness authorities regulation in 1990, when it will be applicable to the same panel categories as the heat release test. It is already a British Aerospace self-imposed requirement, and it was first introduced on selected aircraft a number of years ago.

Toxic gas emission testing has also been made a British Aerospace requirement for new aircraft. The authorities have not announced any plans to make toxicity testing a mandatory requirement, although they do fully support the initiatives taken by constructors to enforce toxicity standards for furnishing materials.

The test methods used at BAe to measure both smoke and toxic gas emissions utilise typically the National Bureau of Standards (NBS) smoke chamber. The test panel is subjected to a radiant heat source, and measurements are taken at two predetermined time intervals. A problem experienced with smoke and toxic gas testing concerns the power of the radiant heat source. Test work has shown that levels of emissions can very significantly dependent on the radiant heat level, and judgements have differed on this matter.

Toxic gas emission testing may be carried out by taking gas samples from the NBS chamber. Typically, in the most common practical method, a preselected number of toxic gases are detected using reagent tubes, which will define the levels of these gases in a sample. An argument against this method is that a preselected standard list of gases to be monitored is specified. This presupposes the types of toxic gases emitted by all polymers. The cabin furnishings utilise materials comprising many fundamentally different polymers, which will generate a range of different byproducts during the combustion process. Thus non-specified toxic gases would escape the net thrown by the preselected reagents, and their presence would remain undetected. However the major toxicants would be normally detected, using the standard range of reagents.

This situation could be improved by carrying out a complete gas analysis using a mass spectrometer, or by using ion chromatography or high performance liquid chromatography. We would then be faced by a different problem; having knowledge of all the combustion byproducts would mean fixing an acceptance level for them all, then the whole task would perhaps become too complex. Another consideration is that this equipment is quite expensive, and many manufacturers do not currently possess it.

In summary, it is considered that both smoke and toxicity testing do have a primary part to play in the overall understanding of the FST performance of a material, and do provide an important complementary function in conjunction with the tests previously discussed, in support of the aim to produce safer aircraft interiors.

Résumé

A problem experienced in attempting to meet a specific rule can be that the designer will focus all his efforts to meet the rule. This will be done in conjunction with suppliers who will develop materials with performance characteristics to meet his requirements. However, in creating his design, he may become too restrictive in his thinking; and successfully meet the mandatory regulations without giving due regard to all aspects of the FST performance of the constituent materials, and the engineering performance of the component.

The manufacture of most composite or plastic materials involves the blending of polymers, and it is well understood that additives designed say to improve the resistance to combustion may cause the smoke or toxic gas emission characteristics to be changed, possibly adversely. Thus the concept that each material should be tested to screen for all aspects of its FST performance, in order that an overall performance rating, sometimes referred to as a Combined Hazard Index, could be established, has received consideration. Ideally this could be refined by giving weightings to the individual tests dependent on their importance, so that the material could be optimised, within of course the limits of the polymers being blended. In practice, there would be considerable problems in weighting the separate tests, defining suitable design acceptance values and ascertaining their meaning. In consequence this approach is generally not favoured.

6 DESIGN IMPROVEMENT PROPOSALS

The aircraft industry recognises, by studies of accidents involving fires, that initiatives must be continued to obtain improvements in fire hardening of the aircraft passenger cabin. The material suppliers and the constructors both have a reasonable understanding of the materials being used, and they are collaborating to drive materials development along the road of continuous improvement in fire hardening of materials and constructions within the cabin.

The constructors must continue to take the initiative, as some have done by introducing their own smoke and toxicity testing requirements. This will call for imaginative design and materials selection proposals. A considerable research and development effort and expenditure will be required to achieve these new standards, and it must be recognised that the time scales to realise the more significant improvements may be protracted. There will be the inevitable conflict between requirements for fire hardening and other engineering matters, and the need for compromises must be recognised in the achievement of progress.

It is important to recognise that, as a general principle, materials and constructions are selected and designed to meet specification requirements, and the primary driver for any change is the introduction of a new requirement. This may be initiated either by an amendment to the aircraft type specification, or by an airworthiness authorities regulation. For instance, should fire penetration resistance of the pressure shell be made an additional requirement, then this would initiate development work leading to the selection of new materials and constructions to meet the new requirement.

7 FIRE HARDENING OF THE PASSENGER CABIN

7.1 Overview

The fuselage pressure shell structure of a passenger aircraft is not currently subjected to any specific airworthiness authority regulations with regard to fire hardening. There is evidence that, in certain fire situations, the ability of the fuselage shell to act as a fire barrier for a definitive time period would provide a significant contribution to fire safety in certain external fire situations. There is also evidence that further improvements, in terms of fire hardening of the constituent materials within the cockpit and the passenger cabin, would also make a major contribution.

This exercise comprises the selection of certain structural and furnishings components, and discussion of potential materials changes and design modifications which should provide improved fire hardening. The research and development work necessary to provide the technical support for any change is exemplified where relevant. The introduction of any proposal would obviously require a study of all the engineering and economic aspects, both for aircraft in current production, and for future aircraft design studies.

In order to assist the exercise and for discussion purposes, the passenger cabin has been divided arbitrarily into a number of categories. These shall be defined as: the external pressure shell, the cabin secondary envelope, the cabin furnishings, and the ancillary equipment.

The external pressure shell shall comprise the outer skin of the fuselage, between the front and rear pressure bulkheads, and the windows, doors and pressure seals in this shell.

The cabin secondary envelope shall comprise the thermal insulation materials, cabin sidewalls, floors, ceiling panels, window shades, and door linings.

The cabin furnishings comprise all the fixtures and fittings within the cabin, including the seating, galley units and overhead baggage bins. They do of course include some of the constituents of the secondary envelope.

The ancillary items include the passenger service units, air conditioning ducting, instrumentation housings, wiring, and other components not visible within the cabin.

7.2 External Pressure Shell Improvements

The fuselage external pressure shell structure comprises typically an aluminium alloy skin, bonded or fastened to frames and stringers. It contains windows typically manufactured in glass for the cockpit transparencies, and acrylic for the passenger cabin windows. The primary weaknesses in this structure in an external fire situation are the acrylic windows which would melt and burn, the structural and furnishings adhesives which would degrade, the paint finishes and sealants which would burn, and in extreme cases the skin which would melt.

This typical situation offers scope for improvement by materials changes and design modifications, but these would involve compromises and problems. These matters are briefly discussed in order that the nature and magnitude of the development work required may be appreciated.

The aluminium alloy external skinning is vulnerable to an external fire, and could loose strength and be subsequently burnt through in extreme circumstances. An intumescent paint, which expands and foams under the application of heat, applied to the external skin surfaces could delay the heating and consequent penetration of the shell for an acceptable period of time. The use of such a paint would require research and development into various commercially available materials, to assess matters such as:

efficiency as a fire barrier
quality of surface finish
effect of paint on drag
adhesion to substrate
environmental ageing
suitability for overpainting and paint stripping
corrosion protection
inspection for cracks or corrosion
weight and cost

The acrylic cabin windows are very vulnerable to an external fire, and they would ultimately melt and burn. The interior protective window pane could also melt and burn. The use of alternative materials is technically feasible, and candidate materials for assessment would include glass, glass/thermoplastic hybrid laminates, and alternative thermoplastics. The development work would involve matters such as:

efficiency as a fire barrier
flame smoke and toxicity performance
optical performance and appearance
aerodynamic profile
static and fatigue testing
environmental ageing
scratch resistance/cleaning
weight and cost

The pressure seals may not be particularly effective in the case of an external fire. The effect of the loss of door and window seals by burning on fire penetration into the cabin would need to be assessed first, in order that the potential benefits from seal improvements could be determined, and the cost effectiveness of any material or design changes defined.

Design changes to the build standard could also contribute to improved fire hardening. For instance the fitment of an insulative interfay between the skin and frames would delay the heatup of the interior and its consequential effects. Design proposals would require evaluation and development testing.

In the longer term, the use of an alternative to an aluminium alloy skin, such as a fibre reinforced composite, or a hybrid composite/metallic laminated construction may be proved to exhibit an improved fire penetration resistance. However, this route would demand a high research and development effort, which firstly would be required to establish the viability of these materials in terms of the benefits achievable in structural efficiency.

7.3 Cabin Secondary Envelope Improvements

Within the fuselage shell are what may be described as secondary envelope materials and constructions. These have their individual primary functions, such as to provide thermal and acoustic insulation, to provide the cabin sidewalls, window shades, flooring, ceiling panels, partitioning and baggage storage.

Many of these materials have a dual role to play in respect of fire hardening. In addition to their potential contribution in providing an external fire barrier, should the external skin shell be penetrated, they also have an important role as furnishing materials in respect of their FST performances in the event of a fire initiating within the cabin or behind the furnishings.

Currently it is uncommon for materials to be selected and constructions to be designed as fire barriers in addition to their normal role; although they would be selected to meet the flame, smoke and toxicity requirements relevant to the aircraft. Typical weaknesses in respect of fire penetration can be for instance that the insulation bagging would melt and burn, the insulation would disintegrate, and thermoplastic items such as window shades, sidewalls, and other moulded panels would melt and burn.

Let us consider potential improvements that could be considered to meet an external fire situation. Take first the insulation bags; these are currently designed primarily to provide thermal and acoustic insulation, and to be resistant to water ingress. Should fire penetration resistance be made an additional requirement, then the research and development work might proceed along the following lines. A bagging material, such as a PVF film containing an integral reinforcement such as a woven fabric utilising a fire resistant fibre, possibly a ceramic, would be a candidate material for evaluation. Consideration would be given to creating a continuous fire resistant membrane by stitching the bags together, and attaching the bags to frames or to an insulative interfay between the frames and external skin. The use of fire hardened foams would be evaluated for both thermal and acoustic performance.

The cabin windows are typically fitted with sliding shades. These could provide a valuable contribution as a fire barrier should they be constructed in a fire resistant material. This might be based on the sidewall panel technology developments discussed below.

The sidewall and dado panels could provide an important role as a secondary fire barrier. To achieve this function they would need to stay retained in place, remain in one piece, and not be punctured by a flame or radiant heat source. It these concepts were accepted as a requirement, then the use of unreinforced thermoplastic sheeting would be effectively eliminated for these items. The panel construction most likely to meet the above requirement would need to incorporate a fibre reinforcement, such as a short fibre mat, or a woven fabric. A reasonable burn through resistance may be achieved by the use of S glass, carbon, or ceramic fibre fabrics. The selection of suitable matrix resins to be used in conjunction with the fibre reinforcement offers considerable scope for research and devlopment. Thermosetting resin systems such as the modified phenolics and bismaleimides are candidate materials; as are the thermoplastic resins such as PEI, PES, PPS and PEEK. The panel construction, in both monolithic form and thin sandwich forms would be assessed, and the final selection would obviously be influenced by its overall performance, in addition to is performance as a fire barrier.

The technology used for the sidewalls should have some applicability to other sandwich panel constructions, such as the overhead bins, bulkheads and floor panels. The attachment of all the items discussed above needs to receive consideration, because it would be essential, for the preservation of a secondary fire barrier, that the various constructions were retained in place. Thus all attachment devices, both visible and within sandwich panelling, would need to be fire hardened to achieve this aim, and the use of all adhesives and adhesive tapes would need to be critically reviewed.

7.4 Furnishing Materials Improvements

The cabin furnishings shall be deemed to include all the constructions, fittings and furnishing materials, such as galleys, overhead bins, bulkheads and doors, seating, carpeting and furnishing fabrics.

A primary requirement for these items, and for the secondary envelope furnishing constructions discussed earlier, is that they shall have a good performance in respect of flammability, heat release, smoke and toxicity. This subject is already receiving close attention by the constructors, and extensive research and development work has already been carried out, and is ongoing. Improvements in FST performance can be expected from two main sources; firstly by product improvement driven by the material suppliers, and secondly by design policy on material selection, construction methods, and furnishing decor.

Thermosetting matrix resins for fibre reinforced composites, in particular the phenolics and bismaleimides, are undergoing continuous development, and some further improvements in both mechanical and FST performance may be expected.

An increased use of thermoplastic matrix resins for fibre reinforced composites may be expected both for short fibre injection mouldings, and long fibre laminating applications. These realise a good FST performance combined with production benefits for some applications such as injection mouldings. The decorative films are being urgently developed by the suppliers and some further FST improvements may be expected. Development work is continuing on secondary adhesives for purposes such as the attachment of decorative films, carpets and dado panels.

8 IMPROVEMENTS BY POLICY CHANGES

The proposals discussed are aimed at realising improved fire hardening. However it is probable that radical improvements in performance will only be achieved by radical changes in design policy. The implementation of certain changes may require initiatives from the airworthiness authorities.

In general, improvements may be placed in two categories, namely:

i) materials and constructional changes which are not visible and would mostly not affect the passenger

ii) furnishings and cosmetic changes which are visible, do affect the aesthetics of the cabin, and may affect passenger comfort

Whereas the first category would not require passenger acceptance, the implementation of the latter category would do so, and would require their education to achieve this.

In the first category, there is considerable scope for design development work on constructions to withstand an external fire. Within the cabin it is possible that any significant further improvements in FST performance may require the replacement of polymeric materials by metals.

Within the second category, perhaps the greatest opportunity for improvement involves minimising the luxury furnishings. The use and selection the carpets, furnishing fabrics, and indeed the decorative films should be reviewed in this context. Further design changes which affect the passenger may also be considered, such as the fitment of smaller overhead stowage compartments, and the removal or reduction of cloakrooms.

Finally, airlines specification requirements can influence fire safety. The design of aircraft interiors is influenced by operator requirements, and they in turn are guided by market research on the preferences of the travelling public. The problem is that this sequence of events can lead to more luxury, but it may be counterproductive to standards of fire safety.

The time may have come for a reassessment of this apparent contradition of aims. The travelling public already accept the inconvenience of personal and baggage searches. They conform to the various in-flight restrictions on smoking, the use of seat belts, and the various safety and emergency procedures. Perhaps they may accept some loss of personal comfort, and the new concepts in decor and aesthetics, once it is understood that these represent the new standards of fire safety provided by a fire hardened pressure cabin.

Acknowledgement

I wish to thank British Aerospace (Commercial Aircraft) Ltd for giving me permission to present this paper, and for the assistance of my colleagues in its preparation. The comments and opinions expressed are entirely my own and do not necessarily represent the policies of the company.