A POSSIBLE METHODOLOGY FOR THE MITIGATION OF FIRE HAZARDS FROM THE CONTAMINATION OF THERMAL ACOUSTIC INSULATION

Issue 2

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AMENDMENT RECORD

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EXECUTIVE SUMMARY

Following the investigation into the accident to the Swissair MD-11 on 2nd September 1998 caused by an in-flight fire, various recommendations were made by the TSB in their accident report A98H0003 intended to reduce the incidence of hidden materials ignition by small ignition sources. To this end Transport Canada have requested that a study be undertaken to develop a methodology intended to mitigate the risk of fire from contaminated Thermal Acoustic Insulation when subjected to an ignition source. The basis of such a methodology is discussed in this report; however, further development is needed under the auspices of the "International Aircraft Materials Fire Test Working Group".

Since it is not feasible to cover all eventualities in terms of thermal acoustic insulation contamination, the proposed methodology has been predicated on the basis of risk reduction. This process involves an assessment being made of each aircraft zone to ascertain the likelihood of there being hazardously contaminated insulation materials in combination with an ignition source. A Risk Matrix is proposed to assess the degree of hazard based on the flammability of contaminated Thermal Acoustic Insulation and the probability of there being an ignition source capable of initiating a fire. The primary means of hazard mitigation proposed is a scheduled cleaning program of Thermal Acoustic Insulation intended to reduce the risk of an in-flight fire to a satisfactorily low level.

Recommendations are made as to the manner in which such a methodology may be developed into a practical means of addressing the issue of fire hazards resulting from contaminated Thermal Acoustic Insulation. The primary recommendations are:

- *That the industry considers how the development of the methodology proposed in this document is best accommodated within the processes for deriving Airline Maintenance procedures (e.g. MSG3)*
- *Each element of the proposed process should be considered by a small task group within the "International Aircraft Materials Fire Test Working Group". The objective of the group would be to develop the process such that it becomes a practical means for mitigating any hazards that might exist on in service aircraft resulting from contaminated Thermal Acoustic Insulation.*
- *Consideration should be given to using the finalized process on a trials basis on a selected number of aircraft zones.*

1 INTRODUCTION

Following the investigation into the accident to the Swissair MD-11 on 2nd September 1998 where an in-flight fire led to a collision with water, various recommendations were made by the TSB in their accident report A98H0003 in order to reduce the incidence of hidden materials ignition by small ignition sources. To this end Transport Canada have requested that a study be undertaken to develop a methodology intended to mitigate the risk of fire from contaminated Thermal Acoustic Insulation when subjected to an ignition source. This report contains the basis of a proposed methodology for addressing the issue.

It is recognized that the aging of some materials used in Thermal Acoustic Insulation may also present a hazard. However, this aspect has not been addressed as part of this study and may need to be taken into account during the development phase of the risk reduction philosophy proposed in this report.

2 RISK REDUCTION PHILOSOPHY

Since it is not feasible to cover all eventualities in terms of thermal acoustic insulation contamination the process must be on the basis of risk reduction.

Analysis of past accidents has suggested that the rate of occurrence of hidden fires with a Thermal Acoustic Insulation involvement is of the order of:

$1x\ 10^{-8}$ per flight hour (Reference 1)

Since the ignition source is likely to be as a result of an electrical system failure it may be argued that it comes under the auspices of the Advisory Circular to 25.1309. The AC suggests that Catastrophic Failure Conditions should occur no more frequently than $1x\ 10^{-9}$ per flight hour.

On this basis an acceptable level of risk for the Thermal Acoustic Insulation would be to ensure that on average only

$1x\ 10^{-9} \div 1x\ 10^{-8} = 10\%$ were hazardously contaminated.

Thus, if it can be shown that the proportion of Thermal Acoustic Insulation on in-service aircraft, that present a fire hazard, as a result of contaminants, is less than 10%, then an acceptable level of safety would seem to have been achieved.

Whilst it is difficult to make a precise numerical assessment of the risk on any particular aircraft type, the 10% target provides a "yardstick" against which to assess the adequacy of any mitigation process. It also assists in determining whether certain contaminants that occur very infrequently need to be addressed or whether they can be considered as sufficiently unlikely to occur that they may be considered as an acceptably low level of risk.

3 MITIGATION STRATEGIES

It is suggested that, for the immediate future, the most cost effective mitigation for any fire hazard presented by contaminated Thermal Acoustic Insulation on in-service aircraft is likely to be the implementation of a cleaning program. As such, the proposed methodology is based on scheduled cleaning of Thermal Acoustic Insulation – the frequency of which being dependent on the severity of the assessed hazard presented by their contamination.

This does not, of course, obviate the possibility of onerous cleaning tasks being avoided by changes in design which are shown to be cost beneficial. Furthermore aircraft maintainers may elect to replace contaminated Thermal Acoustic Insulation in instances where this is considered preferable to an extensive cleaning task. It is also likely that aircraft maintainers will attempt to reduce the contamination risk by means of corrective maintenance e.g. by reducing hydraulic system leaks.

4 RISK ASSESSMENT

N.B. It should be noted that the process described in this report is intended to illustrate the proposed concept. Further development will be required prior to it being considered to be a workable process. In particular the categories and groupings are given as examples.

Thermal Acoustic Insulation materials, their installation characteristics, and the nature of any contamination will vary with aircraft and with their location on an aircraft. Hence any risk assessment must be carried out for each zone[1] of the aircraft.

Any fire hazard associated with contaminated Thermal Acoustic Insulation will be dependent on the following:

- The likelihood of contamination and its resultant effect on the flammability of Thermal Acoustic Insulation
- The likelihood of there being an ignition source sufficient to ignite the contaminated Thermal Acoustic Insulation

4.1 CONTAMINATION EFFECTS ON FLAMMABILITY & FLAMMABILITY GROUPING

The degree of hazard presented by contaminated Thermal Acoustic Insulation will be dependent on the likelihood of its being contaminated and the degree to which the contamination affects the flammability of the insulation material.

Firstly it is necessary to determine the likely flammability characteristics of the insulation material when subjected to the more likely contaminants experienced on in-service aircraft. It will then be necessary to consider each zone of the aircraft to determine how likely it is that the contaminant will be present. It is suggested that the following process is adopted to make these determinations:

4.1.1 Testing the most frequent contaminants that are to be found on in-service aircraft

Much work has already been carried out on determining the contaminants found on Thermal Acoustic Insulation on in-service aircraft and full advantage should be taken of these data although it may be found that further samples may be required. The determination as to whether the most frequent contaminants have been identified should be made on the basis of engineering judgment. However, guidance on whether sufficient samples have been obtained may be based on the objective of achieving less than 10% of Thermal

[1] Aircraft zones are defined in ATA iSpec 2200 (formerly ATA 100)

Acoustic Insulation, on in-service aircraft, presenting a fire hazard as a result of contaminants.

The test samples may be taken from in-service aircraft materials with known contaminants however better control of specimens may be achieved by the use of new materials contaminated with previously identified substances. Test samples are likely to be needed for each contaminant/Thermal Acoustic Insulation combination.

The test method to be utilized should be determined by the industry. However, the method employed should provide a reliable means of quantifying the relative flammability of the test samples.

4.1.2 Flammability Grouping

Based on their level of flammability each Thermal Acoustic Liner/contaminant combination should be placed into one of four groups. The definitions of these groups require development; however, the following illustrates the intent of the grouping:

1. Group 1 – Very little change in the flammability of the contaminated Thermal Acoustic Insulation beyond that of the uncontaminated material. (This Group includes instances where the contamination results in a reduction in the flammability of the insulation material.)

2. Group 2 – TBD

3. Group 3– TBD

4. Group 4 – Extensive increase in the flammability of the contaminated Thermal Acoustic Insulation beyond that of the uncontaminated material.

4.2 ZONAL ANALYSIS

Each zone of the aircraft will need to be addressed to assess

- The degree of hazard presented by contaminated Thermal Acoustic Insulation. This will be dependent on the likelihood of the insulation material being hazardously contaminated and
- The probability of fire initiation occurring as a result of system failures.

The proposed process is summarized in Section 4.3, Figure 2.

4.2.1 The degree of hazard presented by contaminated Thermal Acoustic Insulation

Each zone of the aircraft will need to be assessed to determine the contaminants that are likely to be present. This should be supported by experience of the zone under consideration on in-service aircraft. The factors that should be taken into consideration when making this assessment should include:

- the equipment located in the zone
- the maintenance activity within the zone
- etc,

Based on both the likelihood of contaminants being present and their flammability grouping, each zone of the aircraft should be categorized into a suggested four categories of increasing hazard. The definitions of these categories require development however the following illustrates the intended range of the categorization:

1. Category A – Only Group 1 Thermal Acoustic Insulation/ contaminant combinations possible in this zone

2. Category B – This zone is likely to contain only Group 2 Thermal Acoustic Insulation/ contaminant combinations

3. Category C – This zone is likely to contain only Group 3 Thermal Acoustic Insulation/ contaminant combinations

4. Category D – This zone is likely to contain:

    i. Group 4 Thermal Acoustic Insulation/ contaminant combinations or
    ii. Two or more group 3 Thermal Acoustic Insulation/ contaminant combinations.

4.2.2 Probability of Fire Initiation

Studies have shown that the most likely ignition source within areas containing Thermal Acoustic Insulation is electrical/electronic equipment and wiring. The probability of there being an electrical ignition source is likely to be predominantly dependent on:

i. The amount and nature of electrical/electronic equipment and wiring within the zone

ii. The probability of the electrical/electronic equipment or wiring failing in such a way that it results in overheating or arcing

iii. The proximity of electrical/electronic equipment and wiring to contaminated Thermal Acoustic Insulation

Each zone will require to be assessed individually to make a subjective judgment of the likelihood of there being electrical failures that could result in an ignition source. It is proposed that each zone be categorized into one of five categories of increasing magnitude of likelihood of there being an ignition source. The definitions of these categories require development however the following illustrates the intended range of the categorization:

1. Category 1 – No electrical/electronic equipment or wiring in the zone

2. Category 2 – Electrical wiring only in the zone

3. Category 3 – Electrical/electronic equipment and wiring in the zone

4. Category 4 – Extensive electrical/electronic equipment in the zone – (e.g. cable looms, static plate heaters, etc) some of which are in close proximity to Thermal Acoustic Insulation. This category is likely to include the cockpit and E & E Bays.

It is suggested that these categories are developed based on the increasing likelihood of there being an ignition source using criteria including those proposed in i to iii above.

4.2.3 Risk Matrix

Having determined for each zone the categories relating to both “degree of hazard presented by contaminated Thermal Acoustic Insulation” and “probability of fire initiation” a risk matrix process may be utilized as illustrated in Figure 1.

		Probability of Fire Initiation			
		1	2	3	4
Degree of Hazard presented by Contaminated Thermal Acoustic Insulation	A	No Cleaning Required	No Cleaning Required	TBD	TBD
	B	No Cleaning Required	TBD	TBD	TBD
	C	TBD	TBD	TBD	Most Frequent Cleaning Required
	D	TBD	TBD	Most Frequent Cleaning Required	Most Frequent Cleaning Required

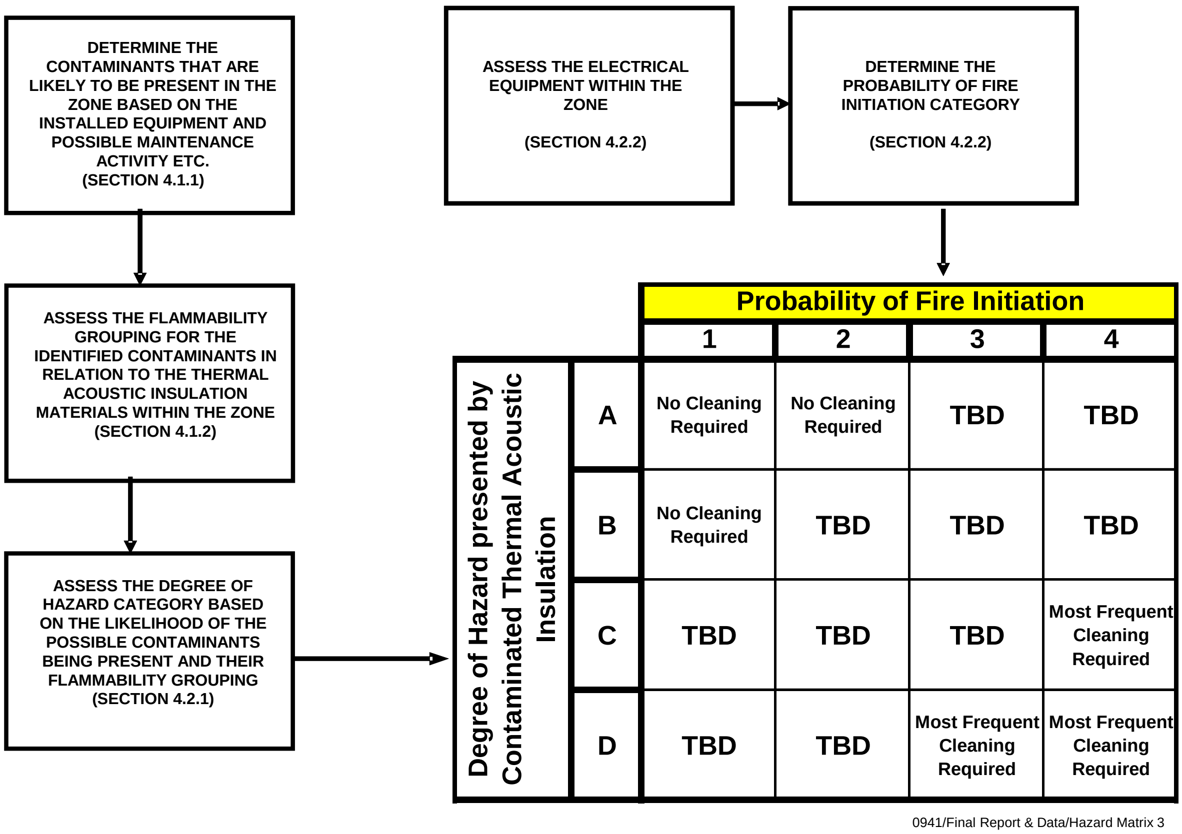
0941/Final Report & Data/Hazard Matrix 3

Figure 1 Risk Matrix

From the developed Risk Matrix each zone of the aircraft may be allocated a frequency of cleaning with the zones exhibiting the greatest risk being cleaned the most frequently.

4.3 Summary of Proposed Process

The Zonal Analysis process described in Section 4.2 is shown diagrammatically in Figure 2.



Degree of Hazard presented by Contaminated Thermal Acoustic Insulation	Probability of Fire Initiation: 1	2	3	4
A	No Cleaning Required	No Cleaning Required	TBD	TBD
B	No Cleaning Required	TBD	TBD	TBD
C	TBD	TBD	TBD	Most Frequent Cleaning Required
D	TBD	TBD	Most Frequent Cleaning Required	Most Frequent Cleaning Required

Figure 2 Summary of Proposed Process

5 OTHER ISSUES

The proposed methodology for addressing the mitigation of hazards that may be presented by contaminated Thermal Acoustic Insulation on in-service aircraft is based on an assessment of each aircraft zone which are likely to result in servicing and maintenance requirements on the aircraft. This process is normally carried out as part of the Maintenance Review Board process on an aircraft utilizing the MSG3 Zonal Analysis process. This process already accommodates risks from electrical ignition sources as illustrated by the following extract from "ATA MSG-3 Operator/Manufacturer Scheduled Maintenance Development" (Reference 2):

2-5. Zonal Analysis Procedure

"Identify zones that both contain electrical wiring and have potential for combustible material being present. For those zones, perform an enhanced zonal analysis that permits the identification of stand-alone inspections and tasks that minimize contamination by combustible materials. Rating tables addressing the potential effects of fire on adjacent wiring and systems, the size of the zone and the density of installed equipment may be used to determine the inspection level."

"This Zonal Analysis Procedure permits appropriate attention to be given to electrical wiring installations. Thus, as well as determining zonal inspections, the logic provides a means to identify applicable and effective tasks to minimize contamination and to address significant wiring installation discrepancies that may not be reliably detected through zonal inspection. These dedicated tasks may subsequently be included in the Systems and Powerplant tasks."

It is therefore recommended that the industry considers how the development of the methodology proposed in this document is best accommodated within the processes for deriving Airline Maintenance procedures.

6 SUMMARY OF RECOMMENDATIONS

1. It is recommended that the industry considers how the development of the methodology proposed in this document is best accommodated within the processes for deriving Airline Maintenance procedures (e.g. MSG3)

2. Each element of the proposed process should be considered by a small task group within the "International Aircraft Materials Fire Test Working Group". The objective of the group would be to develop the process such that it becomes a practical means for mitigating any hazards that might exist on in service aircraft resulting from contaminated Thermal Acoustic Insulation.

3. Consideration should be given to using the finalized process on a trials basis on a selected number of aircraft zones.

7 REFERENCES

1. "A Benefit Analysis for Enhanced Protection from Fires in Hidden Areas on Transport Aircraft" CAA PAPER 2002/01 FAA Reference DOT/FAA/AR-02/50 – UK Civil Aviation Authority
2. "ATA MSG-3 Operator/Manufacturer Scheduled Maintenance Development" – Air Transport Association