EFFECT OF ACCELERATED AGING CONDITIONS ON FLAMMABILITY TEST PERFORMANCE OF THERMAL/ACOUSTICAL INSULATION BLANKET MATERIALS

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Abstract - Thermal/acoustical insulation blankets are, in many cases, installed for the life of an aircraft which can be more than thirty years. Only those in accessible areas may be replaced. In service, these parts are subjected to sub-ambient temperatures as well as heat and humidity. This paper explores the effects of aging conditions including dry-heat above ambient temperature and freeze-thaw cycling exposure on the performance of materials used for thermal/acoustical insulation blankets in radiant panel flame spread tests.

Introduction

Aircraft thermal/acoustical insulation blankets are designed not only to provide the basic functions of thermal and acoustical insulation but also to meet stringent requirements on weight, moisture resistance, durability, flexibility, and cost. In addition, the regulatory authority in the United States of America, the Federal Aviation Administration (FAA), has now proposed stricter standards of flammability resistance for these products [1].

One of these standards involves testing in a radiant panel apparatus. It is intended to measure the propensity of insulation blankets to sustain and spread flames from a localized source as might occur in flight. The development of this method is described in reference [2].

Aircraft insulation blankets are typically constructed of insulation media such as fibrous mats and/or organic foams enclosed in coverings that provide moisture resistance and mechanical stability. In specialized applications, coated cloths may be used, but the primary cover material is a lightweight laminate consisting of a thin polymeric film with a scrim backing for tear stopping. Often, the laminate is designed for assembly by heat sealing. The common types currently in use are identified by the composition of the film component, that is, polyethylene terephthalate (PET), polyvinyl fluoride (PVF), metallized (aluminized) PVF (MPVF), and polyimide (PI). Regardless of how the perimeter is finished, adhesive tape is needed both to seal cutouts, slits, and other features and to repair damage. The common types of tape have a pressure sensitive adhesive deposited on a backing similar to the main covering film laminate.

The focus of this paper is on the four types of film laminates indicated above and the corresponding adhesive tapes in combination with fiberglass insulation.

In service, aircraft blankets are subjected to conditions ranging from sub-ambient temperatures in flight to occasional hot and humid climates on the ground. Previous work has indicated that continuous exposure to some of these conditions may affect the flammability properties of insulation blankets [3]. While the behavior of virgin materials in the radiant panel test has been well documented in reference [2] and elsewhere, no data on aged systems have been presented. Therefore, testing was conducted on both unaged samples and others that underwent accelerated aging regimes involving continuous dry heat exposure and freeze-thaw cycling, subject to the limitations of the available equipment.

Experimental

Materials and Specimen Preparation

Experimental specimens were fabricated using the following materials:

?? Commercially obtained fiberglass battings with 2.54 cm thickness and 6.7 kg/m^3 density. The fiberglass battings are mainly made of borosilicate glass fiber with phenol-formaldehyde resin binder and water-repellant chemical treatment. These battings are light, soft, and can be shaped flexibly during the blanket manufacturing process.

?? Bagging materials are PI, PET, PVF, and MPVF film laminates.

?? PI, PET, and MPVF tapes of 5 cm width were used to examine the flammability of the tape-film combination. These tapes consist of a pressure sensitive adhesive deposited on a backings of thread reinforced film laminates similar to the bagging materials. The films in the bagging material and the backing of the tape on each sample are of the same type.

Each specimen consists of 2 layers of fiberglass with dimension of 32 cm × 58 cm. The bagging material has three edges heat sealed and one edge open. Tape was applied to half-length on one side of each sample with 1.3 cm overlap except samples with PVF film cover. Figure 1 shows the configuration of a specimen with corresponding tape.

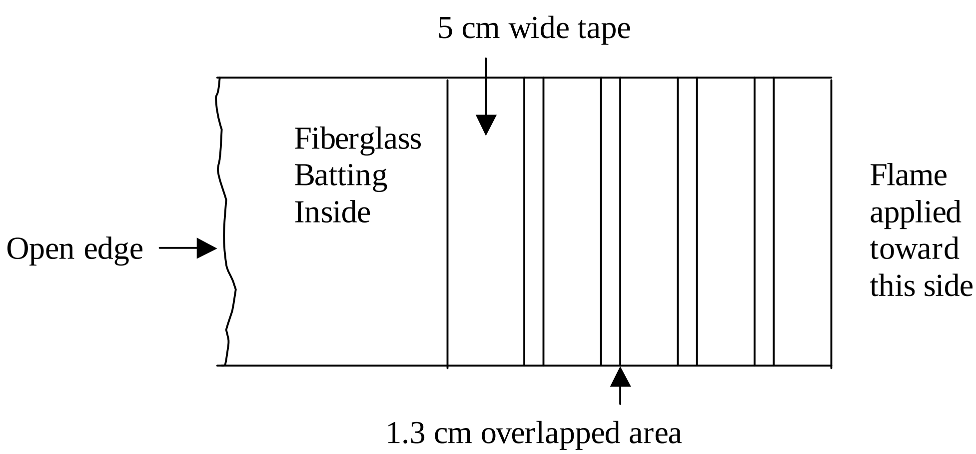


Figure 1. Configuration of a specimen (taped side).

Accelerated Aging Processes

Before testing, specimens were aged using two different processes:

(i) Dry Heat Aging (4 specimens): specimens were placed in a furnace operated at 52?C for 14 days.

(ii) Freeze-Thaw Cycling Aging (4 specimens): specimens were put in a humidity chamber and alternating freeze-thaw cycles of 2 hours at 38?C and 90 % relative humidity and 6 hours at -34?C were applied for 14 days.

4 specimens conditioned in ambient temperature and atmosphere were used for reference. The total experimental samples are 12 with 21 sides tested.

The aging processes are diagrammed in Figure 2.

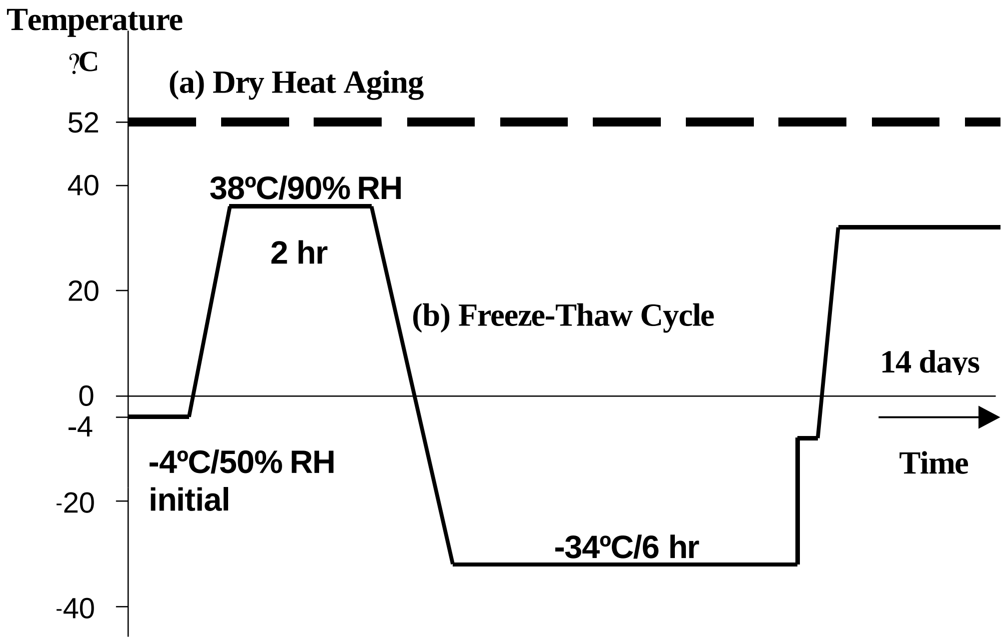


Figure 2. (a) Dry heat and (b) freeze-thaw processes for blanket aging before testing.

The identification of experimental specimens are shown in Table 1 below.

Table 1. Identification of 21 tested sides of 12 specimens.

Reference Samples	Dry Heat Aged Samples	Freeze-Thaw Aged Samples	Cover Material
R1A	DH1A	FT1A	PI, no tape side
R1B	DH1B	FT1B	PI, tape side
R2A	DH2A	FT2A	MPVF, no tape side
R2B	DH2B	FT2B	MPVF, tape side
R3	DH3	FT3	PVF, no tape both sides
R4A	DH4A	FT4A	PET, no tape side
R4B	DH4B	FT4B	PET, tape side

Radiant Panel Testing

The radiant panel testing apparatus as shown in Figure 3 below was used to investigate the flame spread characteristics of the specimens. This test has been proposed for the certification of flammability of materials used in the fabrication of aircraft thermal/acoustical insulation blankets [1]. Details of the apparatus configuration, calibration process, and testing procedure were also described in the reference 1.

Figure 3. A radiant panel testing apparatus using electric heating elements.

III. Results and Discussion

Test results are described in Table 2. Principal factors for the determination of the flammability performance of specimens are the flame-spread length and after-flame time. The flame-spread length is defined as the distance from the flame impingement spot to the farthest evidence of fire burning after the removal of the burner. The after-flame time is the duration of the flame on the sample after the removal of the burner.

Figures 4a and 4b are pictures of the reference and dry-heat aged PI specimens. The sides with no tape showed no burning, melting, or shrinkage after the burner was removed, indicating the high resistance to flame-propagation of the PI bagging material. For the taped side of the PI reference specimen, about 10 seconds after the burner was turned on, the tape peeled off unevenly, forming a wavy surface with openings for penetration of the flame to the adhesive layer. After removal of the pilot flame, the sample continued burning for about 30 s. The adhesive appeared to be sustaining the combustion, not the polyimide film in the bagging material or the tape backing. No afterburning was observed for aged PI samples. In all cases, the specimens were not deformed upon being heated and burned.

All MPVF specimens did not burn after the burner was lifted. The bagging material melted away and slightly shrank in the width direction. Figures 5a and 5b show the reference and dry-heat aged MPVF samples. For taped sides, the melting length is shorter and the width shrinkage is more obvious.

Table 2. Radiant panel test results for samples covered with PI, MPVF, PVF, PET film.

Sample	Materials	Aging Process	Flame Spread Length (cm)	After-Flame Time (s)	Film Melt Away (cm)	Notes
R1A	PI, no-tape side	Reference	0	0	0	
DH1A	PI, no-tape side	Dry-Heat	0	0	0	
FT1A	PI, no tape side	Freeze-Thaw	0	0	0	
R1B	PI, tape side	Reference	0	30	0	Adhesive burning
DH1B	PI, tape side	Dry-Heat	0	0	0	
FT1B	PI, tape side	Freeze-Thaw	1.3	0	0	
R2A	MPVF, no-tape side	Reference	0	0	23	
DH2A	MPVF, no-tape side	Dry-Heat	0	0	23	
FT2A	MPVF, no tape side	Freeze-Thaw	0	0	23	
R2B	MPVF, tape side	Reference	0	0	10	
DH2B	MPVF, tape side	Dry-Heat	0	0	5.1	
FT2B	MPVF, tape side	Freeze-Thaw	0	0	5.1	
R3	PVF, no tape	Reference	0	0	30.5	Cover shrinks across width
DH3	PVF, no tape	Dry-Heat	0	0	33	
FT3	PVF, no tape	Freeze-Thaw	0	0	33	
R4A	PET, no-tape side	Reference	0	0	33	
DH4A	PET, no-tape side	Dry-Heat	0	0	30.5	
FT4A	PET, no tape side	Freeze-Thaw	0	0	30.5	
R4B	PET, tape side	Reference	0	0	35.5	
DH4B	PET, tape side	Dry-Heat	0	2	30.5	
FT4B	PET, tape side	Freeze-Thaw	0	0	30.5	

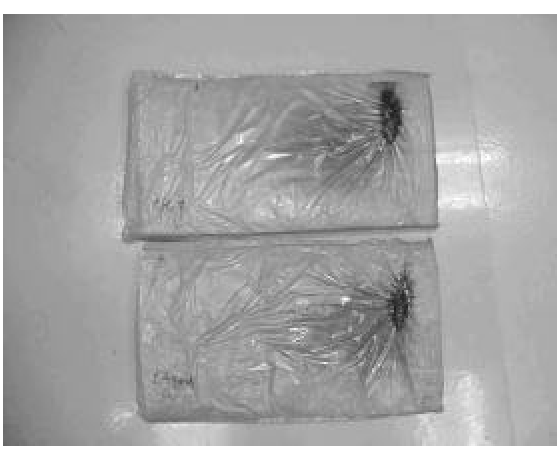


Figure 4a. No-tape side of PI samples. (above: R1A, below: DH1A)

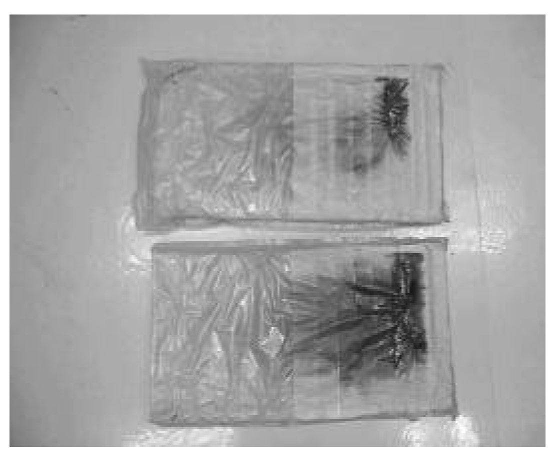


Figure 4b. Taped side of PI samples. (above: DH1B, below:R1B)

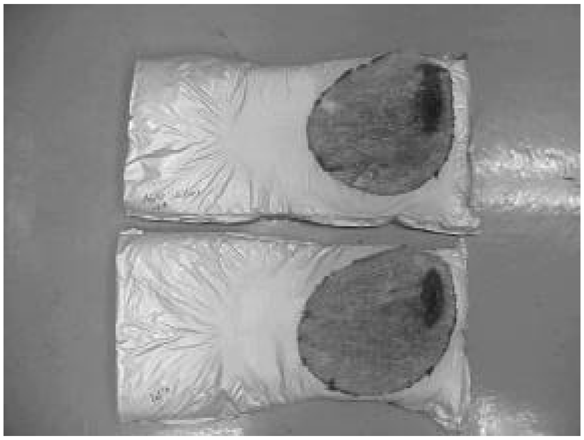
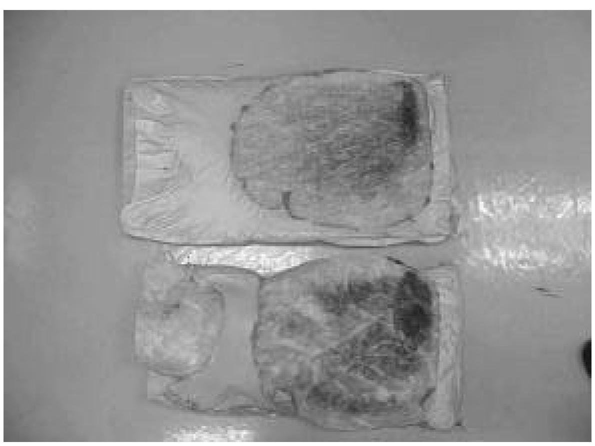


Figure 5a. No-tape side of MPVF samples. (above: DH2A, below: R2A)

Figure 5b. Taped side of MPVF samples. (above: DH2B, below: R2B)

All PVF samples did not burn after the removal of the pilot flame. For the reference sample, the cover rapidly melted away and shrank in the width direction. The sample was deformed due to this shrinkage. The shrinkage across the width was not observed for the dry-heat aged samples. Figures 6a and 6b show both sides of the reference and dry-heat aged PVF specimens after testing.

Specimens made with MPVF and PVF bagging material and aged by a freeze-thaw process both show almost no shrinkage on both sides.



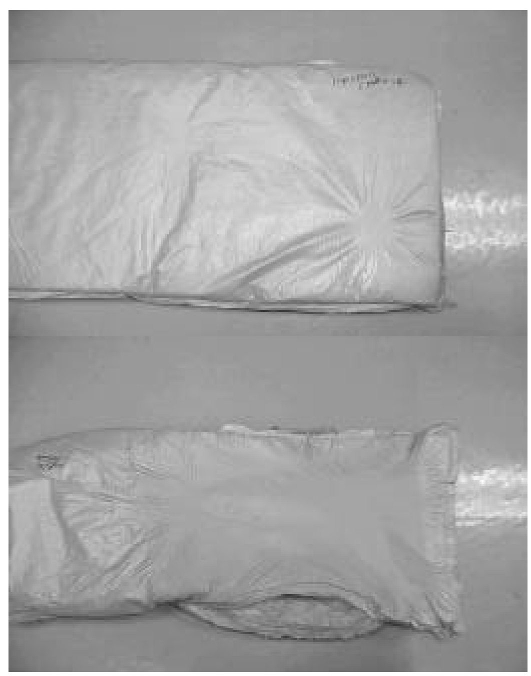


Figure 6a. Tested side of MPVF samples. (above: DH3, below: R3)

Figure 6b. Untested side of MPVF samples. (above: DH3, below: R3)

Figure 7a shows the side without tape of the reference (below) and dry-heat aged (above) samples with PET bagging material. Flame did not spread on either after burner removal. Cover film materials melted away when the pilot flame approached the tested samples. For taped sides as seen in Figure 7b, the burned, or dark, areas were larger, but no afterflaming was observed.

Figure 7a. No-tape side of PET samples. (above: DH4A, below: R4A)

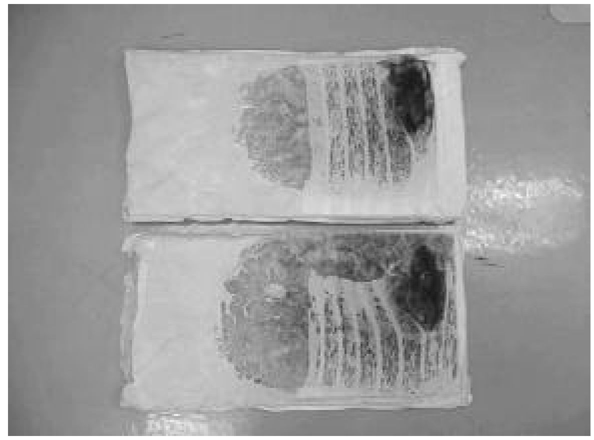


Figure 7b. Taped side of PET samples. (above: DH4B, below: R4B)

IV. Conclusion

The effects of accelerated aging conditions on flammability test performance of thermal/acoustical insulation blanket materials were examined. The testing apparatus was an electric radiant panel chamber connected to a computerized data acquisition system. Blanket aging regimes included dry-heat and freeze-thaw cycling processes. Aging conditions were selected to model the types of environmental exposure seen by in-service blankets on aircraft. Experimental results indicated that:

(i) Tape adhesive did not burn on PI samples aged by both processes and the blanket shape is conserved upon being heated.

(ii) When being heated, shrinkage and melting away effects are less for dry-heat aged MPVF and PVF samples. For freeze-thaw aged specimens, the film shrinkage is negligible.

(iii) The burn-length is a little shorter for aged PET specimens and the specimens are not deformed in the heating and burning process. Thermal effects of an aging process on specimens with PET film cover are not obvious.

Acknowledgement

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References

1. U.S. Federal Register, Sept. 20, 2000, Notice of Proposed Rulemaking (NPRM), Docket No. FAA-2000-7909, "Improved Flammability Standards for Thermal/Acoustic Insulation Materials Used in Transport Category Airplanes; Proposed Rule."
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