Special Aviation Fire and Explosion Reduction (SAFER) Advisory Committee

Office of Aviation Safety
Washington, D.C. 20591

Final Report
Volume II-B

June 26, 1978 through June 26, 1980

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The Special Aviation Fire and Explosion Reduction (SAFER) Advisory Committee and its technical supporting groups spent nearly 13 months from May 1979 through June 1980 examining the factors affecting the ability of the aircraft cabin occupants to survive in the post-crash fire environment and the range of solutions available.

Presentations were made to the SAFER Committee by Committee members, technical supporting groups, the FAA, citizens and private firms. The broadly-constituted body of information developed and presented to the Committee formed the basis for Committee Findings and Recommendations.

This volume contains the summary of the proceedings of the SAFER Committee, FAA responses to the recommendations, pertinent correspondence and information on crew protection and passenger evacuation.
VOLUME II-B

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June 26-27, 1979, Atlantic City, N.J.
June 28-29, 1979, Atlantic City, N.J.
Sept. 24-28, 1979, Mountain View, Calif.
Mar. 4-5, 1980, El Segundo, Calif.

FAA RESPONSES

Responses to "Short-Term" Recommendations
Responses to "Long-Term" Recommendations

CORRESPONDENCE


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ADDITIONAL DISCUSSIONS

Crew Protection and Passenger Evacuation
SUMMARY OF PROCEEDINGS

SAFER Advisory Committee Meeting of May 10-11, 1979
Washington, D.C.

A. Welcome address by Mr. Charles Foster, FAA's Associate Administrator for Aviation Standards, in which he outlined the events leading up to the formation of the SAFER Advisory Committee and set forth the tasks that the Committee was charged with, namely:

- By October 1, 1979, the Committee is to recommend to the Administrator specific regulatory action (within the Committee's scope) that can be taken on the basis of present-day technical knowledge and that could contribute significantly to safety.

- By June 26, 1980 (the termination date of the Committee) the Committee is to recommend to the Administrator ways to improve occupant survivability in the post-crash environment.

Mr. Foster also emphasized that the Committee was an independent body, in no way controlled by the FAA. To preserve this independence, FAA employees would not serve in the capacity of Committee Chairperson or Technical Group Leader. For this meeting only, Mr. Foster appointed Mr. J. O. Robinson, an FAA member of the Committee, as Temporary Chairperson.

B. Committee ground rules. The Temporary Chairperson announced several ground rules for the Committee's activities:

- All meetings will be open to the public, on a space available basis.

- A nonmember may make an oral statement at a meeting if he requests permission from the Executive Director not later than the day before that meeting. He may submit a written statement at any time.

- A member who is unable to attend (and who has no approved alternate) may designate another person to speak for him at that meeting. This person must be designated by letter to the Executive Director before the meeting.

- Each meeting of the Committee will be recorded by a court reporter. A verbatim transcript will be placed in the Committee's files.

- At the end of each Committee meeting, a draft summary of the Committee's proceedings will be discussed and revised as necessary by the Committee. A copy of that summary will be sent to each interested person.
C. Scope of the Committee. The Temporary Chairperson, on behalf of the FAA members, proposed the following scope for the Committee's activities:

- That the Committee confine itself to transport category airplanes.
- That, with respect to such airplanes, the Committee confine itself primarily to the post-crash fire issues discussed at the June 1977 public hearing on fire and explosion hazard reduction and at the November 1977 public hearing on compartment interior materials.
- That, when considering compartment interior materials issues, the Committee also consider the matter of carry-on materials (i.e., baggage, clothes, periodicals, etc.) and the fire-resistance of emergency evacuation slides.
- That other issues be considered only if they are comparably significant and directly related to the post-crash situation.

Several members suggested that the last element of the FAA proposal might lead the Committee into consideration of numerous issues (such as emergency evacuation criteria, crew training, etc.) concerning which the Committee has no expertise. It would be better, they believed, to spend the short time available on the basic issues, i.e., post-crash fire and compartment interior materials. Other members contended that the last element of FAA's proposal provided a needed flexibility in the deliberations of the Committee, that it should be free to consider other issues it believes comparably significant and directly related to the post-crash fire situation. After further discussion, it was the sense of the Committee that FAA's proposal be accepted, with the understanding that any "other issue" dealt with must not compromise accomplishment of the Committee's basic task.

D. Organization plan. The Temporary Chairperson, on behalf of the FAA members, proposed the following organization plan for the Committee:

1. That the 23 selected members/alternates be identified collectively as the "SAFER Advisory Committee," or simply the Committee.

2. That the Committee serve as the decision-making body which will ultimately determine what recommendations will be submitted to the Administrator.

3. That the Committee, at its first meeting, establish SAFER Technical Groups to provide technical expertise in at least the following general areas:
   - Post-crash fuel-fire hazard reduction.
   - Compartment interior materials (including the matter of carry-on materials and the fire resistance of emergency evacuation slides).
4. That, in general, the members of each SAFER Technical Group be drawn from the roster of applicants who responded to FAA's June 1978 notice inviting participation. FAA proposes the persons on the attached lists (Enclosures A & B) as members of the two SAFER Technical Groups identified above.

5. That a Group Leader be elected by the members of the Committee for each Technical Group established.

6. That the Committee's Executive Director, in collaboration with the appropriate SAFER Technical Group Leader, determine the time and place of each group meeting and notify all interested persons.

7. That the Committee, at each of its meetings, provide guidance and direction to each SAFER Technical Group and assign such specific tasks as it deems necessary.

8. That each SAFER Technical Group Leader attend each meeting of the Committee to report on the activities of his Group and to receive instructions from the Committee.

A member suggested that the term "fuel-fire" in the third item of the proposal would exclude consideration of other flammable fluids in the post-crash environment. The Committee agreed that the word "fuel" should be eliminated from the title of that Technical Group. Several members suggested that the proposed Technical Groups did not provide adequate expertise in certain technical areas and should be expanded accordingly. There was no objection from the Committee, and the Temporary Chairpersons asked that each person wishing to join a Technical Group write to the Executive Director, identifying that Group and explaining why his services would be needed.

A member suggested that a mechanism be provided to furnish a summary of R & D programs (both in industry and in government) now underway, to assist the Technical Groups. The AIA (for industry), NASA (for U. S. government), and FAA (for international R & D) agreed to accept this assignment.

E. Work plan. The Temporary Chairperson proposed the following general work plan for the Committee and its Technical Groups:

1. Review and update the service record, to gain insight into what our current safety problems actually are. The situation may have changed since the 1977 public hearings.

2. Assess the adequacy of pertinent FARs, and propose rulemaking actions (changes or additions to current rules) which are within the state-of-the-art and are adequately supported. The Committee should, by October 1, 1979, determine whether the state-of-the-art would allow the early adoption of upgraded standards within its areas of concern.
3. **Assess pertinent FAA-funded and FAA-conducted R & D programs** (both those completed and those currently underway) in terms of their potential contribution to safety. On the basis of this assessment, determine --

- With respect to completed programs, whether the R & D findings warrant rulemaking action or the publication of guidance material;
- With respect to programs underway, whether they should be continued to completion, redirected along potentially more fruitful lines, or aborted altogether; and
- The need for new R & D programs.

4. **Assess other pertinent government and industry R & D programs** (both those completed and those underway) to determine --

- With respect to completed programs, whether R & D findings warrant rulemaking or other action by FAA; and
- With respect to programs underway, whether they warrant FAA support.

5. **By October 1, 1979, submit a preliminary report** containing the Committee's recommendations for early adoption of new or revised standards within its area of concern.

6. **By June 26, 1980, prepare a final report** describing the work of the Committee, outlining its findings and conclusions, and setting forth its recommendations to the Administrator for specific action.

Concerning the 5th item of the proposed work plan, several members raised the question whether the Committee had the alternative of concluding (after study) that there was no justification for early adoption of new or revised standards. The Temporary Chairperson stated that the FAA had no preconceived ideas as to what the Committee ought to recommend for any item in the proposed work plan.

**F. Current status of R & D efforts and available funding.** Oral presentations on this subject were made by the following persons:

- Charles W. McGuire - DOT - Office of Environment & Safety
- Douglas E. Busby, M.D. - FAA - Office of Aviation Medicine
- John H. Enders - National Aeronautics & Space Administration
- Clayton Huggett - National Bureau of Standards
G. Election of the permanent Chairperson of the Committee. The following members were nominated as the permanent Chairperson, subject to approval by the Administrator:

- Lowell R. Perkins (who declined)
- James O. Robinson (who declined)
- S. Harry Robertson (who declined)
- John H. Enders (elected)

H. Election of the Technical Group Leaders. The following persons were nominated by the members:

- For the SAFER Technical Group on Post-Crash Fire Hazard Reduction:
  - Mr. B. P. Botteri and Mr. E. G. Versaw. Mr. Botteri declined and Mr. Versaw was elected.
- For the SAFER Technical Group on Compartment Interior Materials:
  - Mr. M. E. Wilfert and Mr. Sanford Davis. When the initial vote ended in a tie, a member suggested another vote on the basis that the winning nominee would serve as Group Leader and the other nominee would serve as Deputy Group Leader. The Committee agreed. Mr. Wilfert was elected as Group Leader. Mr. Davis will serve as Deputy Group Leader.

I. Oral Statements. The Temporary Chairperson recognized two nonmembers who made oral statements as follows:

- Edward Graham, of the Airline Safety Equipment Co., on aircraft compartmentation.
- Robert Mitchell, of LISI America, on ISOPHENOL - a rigid foam with a base of phenolic resins.

J. First Technical Group Meetings. The Executive Director, after consulting with the newly elected SAFER Technical Group Leaders (E. G. Versaw and M. E. Wilfert), announced a tentative agreement to convene a back-to-back meeting of both Technical Groups at FAA's NAFEC facility during the week of June 25, 1979. A formal announcement will be prepared by the Executive Director, published in the Federal Register, and distributed to all interested persons.

K. Members, Alternates, and Authorized Substitutes who participated in the meeting:

- E. L. Thomas, member
- J. P. Reese, member
- B. V. Hewes, member
- C. F. Hitchcock, member
- S. J. Green, member
• G. N. Goodman, member
• C. Huggett, member
• J. H. Enders, member
• J. R. Perkins, member
• J. M. Del Balzo, member
• J. D. Robinson, member and Temporary Chairperson
• D. L. Busby, member
• C. W. McCollar, member
• S. H. Roberson, member
• J. E. Scott, member
• T. L. Geoghegan, member
• A. R. Nevin, member
• B. Webster, authorized substitute for E. L. Hutton
• E. E. Hatterson, authorized substitute for M. Coane
• D. M. Neil and S. Bennett, authorized substitutes for
  J. Slater
• T. F. Cole, authorized substitute for J. B. Busby
• T. Gates, authorized substitute for J. M. Del Balzo
• K. W. Charker, alternate for R. W. Hewes

I. Nonmember attendance. Other than members, alternates, and authorized substitutes, there were 5 nonmembers in attendance at the meeting. Of these, nine were FBI employees.

M. Agenda. Time and place for next meeting of the SAFER Advisory Committee. After some general discussion, it was agreed that action on this topic would be deferred until theTechnical Groups meet later in June. Mr. Enders, who has attended some of the meetings, will, at that time in consultation with the Executive Director, determine the agenda, time, and place of the next SAFER Advisory Committee meeting, probably in late summer.

Prepared By: [Signature] 14/19
Irving Fazin, Executive Director

Approved By: [Signature] 14/19
James D. Robinson, Temporary Chairperson
### Selected Membership for SAFER Technical Group on Post-Crash Fire Hazard Reduction

<table>
<thead>
<tr>
<th>Name</th>
<th>Affiliation</th>
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<tbody>
<tr>
<td>Thomas G. Horeff</td>
<td>FAA, AFS-140</td>
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<td>Robert Salmon</td>
<td>FAA-NAFEC: ANA-420</td>
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<tr>
<td>Alt. - Thor Eklund</td>
<td>FAA</td>
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<tr>
<td>Richard A. Kirsch</td>
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<td>Benito P. Botteri</td>
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<td>Joseph T. Leonard</td>
<td>Naval Research Lab.</td>
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<td>Charles M. Pedriani</td>
<td>USARTL, Port Eustis</td>
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<td>Alt. - Richard E. Bywaters</td>
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<tr>
<td>Solomon Weiss</td>
<td>NASA; Lewis Research Center</td>
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<tr>
<td>Lyle A. Wright</td>
<td>Douglas Aircraft Co. (AIA)</td>
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<td>Don C. Nordstrom</td>
<td>Lockheed-California Co. (AIA)</td>
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<td>Edward G. Versaw</td>
<td>Gates Learjet Corp. (AIA)</td>
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<td>Tom W. Reichenberger</td>
<td>Trans World Airlines (ATA)</td>
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<td>N. R. Parmet</td>
<td>Piper Aircraft Corp. (GAMA)</td>
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<td>Elliot Nichols</td>
<td>Flight Engineers Int'l. Assoc.</td>
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<td>Alt. - A. Weiser</td>
<td>Uniroyal. Inc.</td>
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<td>Donald F. Thielke</td>
<td>Fenwal. Inc.</td>
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<td>J. D. Galloway</td>
<td>Walter Kidde and Co.</td>
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<td>George J. Grabowski</td>
<td>Parker Hannifin Corp.</td>
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<td>Lester Hebenstreit</td>
<td>A/Research Mfg. Co. of Calif.</td>
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<td>Cleve C. Kimmel</td>
<td>System Safety Associates</td>
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<td>Alt. - At Lothrigel</td>
<td>Goodyear Aerospace Corp.</td>
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<tr>
<td>Scott A. Hanatt</td>
<td>Firestone Coated Fabrics Co.</td>
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<td>Ira J. Rimson</td>
<td>NTSB</td>
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<td>H. D. Smith</td>
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<td>E. Philip Webb</td>
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<td>Gerrit J. Walnout*</td>
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<td>Alt. - Matthew M. McCormick*</td>
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* Observer only


**Selected Membership for SAEER Technical Group on Compartment Interior Materials**

<table>
<thead>
<tr>
<th>Name</th>
<th>Affiliation</th>
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<tbody>
<tr>
<td>Robert Allen</td>
<td>FAA - AFS-12</td>
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<td>Henri Brautigam</td>
<td>Ac. Al - 126</td>
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<td>Charles A. Crane</td>
<td>SAA - AAC-41</td>
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<td>Bartholomew Kirsch</td>
<td>FAA - KD-520</td>
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<td>Constantine Saitos</td>
<td>FAA - MAPF-2</td>
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<tr>
<td>R. Sera</td>
<td>Boeing Commercial Airplane Co. (AIA)</td>
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<td>J. C. Fargo</td>
<td>Lockheed-California Co. (AIA)</td>
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<tr>
<td>M. E. Wilford</td>
<td>Douglas Aircraft Co. (AIA)</td>
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<tr>
<td>John J. Simon</td>
<td>Gates Learjet Corp. (AIA)</td>
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<tr>
<td>Robert Magatung</td>
<td>Cessna Aircraft Co. (GAMA)</td>
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<tr>
<td>Artur D. Belman</td>
<td>The Wool Bureau Inc.</td>
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<td>William E. Long</td>
<td>Man-Made Fiber Producers Assoc.</td>
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<td>George S. Weak</td>
<td>General Tire and Rubber Co.</td>
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<tr>
<td>A. C. McAlinden</td>
<td>Celanese Fibers Marketing Co.</td>
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<td>Dale R. Onderk</td>
<td>John Schneider and Associates</td>
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<td>C. D. Lay</td>
<td>Delta Air Lines (ATA)</td>
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<tr>
<td>Bernard Brocker</td>
<td>NASA - Johnson Space Center</td>
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<td>J. K. A. Roper</td>
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<td>D. W. Sheike</td>
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* Observer only
SUMMARY OF PROCEEDINGS

SAFER Technical Group on Compartment Interior Materials
Meeting of June 26-27, at NAFEC

A. The Group was welcomed by Mr. Joseph Del Balzo, Acting Director of the National Aviation Facilities Experimental Center (NAFEC). Mr. John H. Enders, Chairman of the basic SAFER Advisory Committee, followed with an outline of the events leading up to formation of the SAFER Technical Group on Compartment Interior Materials. The Executive Director then introduced Mr. Martin E. Wilfert and Mr. Sanford Davis, the elected Group Leader and Deputy Group Leader, respectively, for this Group. For the remainder of the meeting (which was tape recorded), Mr. Wilfert presided.

B. Ground rules. The Group Leader announced several ground rules for the Group's activities, as follows

1. This meeting, and all subsequent meetings of the Group will be open to the public on a space-available basis.

2. A nonmember may make an oral statement before the Group if he asks permission from the Executive Director not later than a day before the meeting, and is recognized by the Group Leader. A nonmember may make a written statement to the Group (via the Executive Director) at anytime.

3. All members will have an equal say on what the Group will recommend to the basic SAFER Advisory Committee.

4. Sub-groups will be formed to study particular issues. Each will consist of members, and other interested persons, selected by the assigned sub-group chairman.

C. Scope and objectives. The Group Leader introduced a proposed "Scope of Activities" (Enclosure I) containing suggested initial and long-term objectives. After some discussion, the Group accepted the proposal with a number of minor changes (shown as inked revisions on Enclosure I).

D. Review and update of the pertinent service record. H. Branting presented several charts (Enclosure II) providing data on impact-survivable aircraft fire accidents (air carrier) during 1965-1974. During that period there were 31 such accidents world-wide with 153 fatalities, of which 594 were believed to have been caused by fire. E. Bara questioned whether these 594 (estimated) deaths by fire had been verified, since impact could have been the cause of death. H. Branting indicated that the estimates were made by the NTSB, based on post-mortem examinations. E. Bara then asked whether any of the "fire" deaths could be attributed to interior materials rather than to the post-crash fuel fire itself. C. Sarkos estimated that about one-third of the fire fatalities during the 1965-1974 interval were attributable to interior
materials, based on his engineering analysis of the available data, including toxicologic information. He also suggested that the Group ought not confine itself to accident statistics but should also consider the future potential for fire accidents. Other members disagreed with this view, contending that future design (and even prospective research programs) must be based on concrete evidence derived from actual service experience.

After some additional discussion, the Group agreed (in response to a proposal by E. Bara) to set up a sub-group to study the accident record to determine how many fire-related deaths were, in fact, attributable to interior materials, and how many of the total deaths in survivable accidents were, in fact, fire related. The Group Leader assigned S. Davis as Chairman of that sub-group and authorized him to solicit the services of others (members or nonmembers) to assist in the work (see Enclosure VII).

E. Assessment of the adequacy of pertinent Federal Aviation Regulations (FAR's).

1. Cabin materials fire safety; key issues. H. Branting suggested that the key regulatory issues involving cabin interior materials were as follows:

- In the post-crash fire environment, how much of the hazard, or threat to survival, can be attributed to burning cabin interior materials and how much to burning spilled fuel?

- If burning cabin interior materials present a significant threat, what is the relative significance (to fire safety) of materials properties such as flammability, smoke emission, and toxic gas emission? This involves a trade-off since a material's resistance to burning is often gained at the expense of increased smoke and toxic gas emission.

On the matter of trade-off, a member pointed out that in many cases a material's flammability characteristics can be improved without increasing smoke or toxic gas emission.

J. Parker suggested a ranking of the hazards associated with a post-crash materials fire (assuming that the fuel fire has penetrated the cabin) in the following order: flash fire; smoke and toxic gas emissions; effect on evacuation capability; long-term physical effects on occupants.

2. Current airworthiness rules covering compartment interior materials. H. Branting introduced this item, noting that the current rules applicable to passenger and crew compartments are contained in FAR 25.853 (Enclosure III). These rules specify simple bunsen burner tests for flammability, varying in severity with the manner in which the material is used in the cabin. FAR 25 also contains similar test standards for materials used in cargo and baggage compartments and for electrical wiring.
Discussion by the Group led to the conclusion that current FAR's dealt primarily with the in-flight fire condition, since material properties relating to the post-crash fire condition (flash-fire potential, smoke/toxic emissions, lachrymal effects, etc.) and to the probability of escaping are not specified. It was the sense of the Group that its activities should include an evaluation of the need to specify material properties for the post-crash fire condition.

3. Fire protection of emergency evacuation slides. H. Branting raised the question whether there is a need to improve the fire resistance of emergency evacuation slides (deployed and inflated) when exposed to post-crash fuel fire, either by convection or by radiation. A member noted that current FAR standards do specify a flammability test for such slides, but that this test does not assure safe slide performance in the post-crash fire condition. It was agreed that the Group would look into the need for additional standards.

4. Flammability of passenger carry-on articles. H. Branting suggested that the Group assess the significance, as potential fuel sources in a post-crash fire, of passenger carry-on articles such as clothing, baggage and reading material, and determine whether fire-safety standards should cover these materials. He noted that certain carrier-furnished articles, such as blankets, pillows and head-rest covers, should also be considered from this standpoint. E. Bara suggested further that baggage in the cargo compartment should also be considered in this context. C. W. McGuire proposed including materials being shipped. The Group agreed that each of these potential fuel sources warranted study. As a related item, H. Branting distributed a briefing memorandum (Enclosure IV) dealing with proposed flammability standards for flight attendant uniforms.

5. Effects on in-service deterioration of the fire resistance characteristics of materials. H. Branting noted that there had been instances of materials which failed to meet their applicable flammability standards after some time in service, apparently because of aging and deterioration. He suggested that the Group investigate this problem and develop appropriate standards and practices suitable for industry-wide application. D. Onderak observed that there were practical difficulties in retesting materials, since detailed records would have to be kept on the actual exposure to wear, laundering, refurbishing, etc., to ensure that the test is meaningful. J. Parker questioned whether retesting the current flammability standard would be meaningful with respect to the hazards of concern to the Group; namely, flash-fire potential and smoke/toxic-gas emissions. A. Delman suggested that materials could be tested to determine whether laundering (or dry-cleaning) degraded their flammability characteristics. Two members, representing aircraft manufacturers, stated that their company's materials specifications included provisions for testing after laundering and dry-cleaning.
J. Parker pointed out that there were widely-used cabin interior materials other than fabrics or carpets that could age to the extent that their performance in a post-crash fire would be degraded. Such aging could be caused by exposure to altitude and temperature. It was the sense of the Group that there was a need to look into these matters.

F. Review of current R & D programs.
Presentations were made on this subject by the following members:

1. C. Sarkos: "FAA-NAFEC R & D Programs on Cabin Fire Safety."
3. E. Bara: "Industry IRAD and CRAD Programs."

There ensued at this point a discussion on whether there were any short-term solutions to the cabin interior materials problem. E. Bara contended that there was at present no practical way of predicting, by laboratory tests, the safety performance of an interior materials configuration in the full-scale post-crash fire environment, and that the Group was not likely to devise one by October 1. J. Parker agreed, but suggested that there were materials within the state of the art today, which, on the basis of laboratory tests alone, have been shown to be capable of significant hazard reduction. He referred specifically to new materials that have lower flash-fire potential, and to a window material with greater resistance to fire penetration. M. Salkind, referring to an earlier statement by another member concerning the improved fire-safety record shown by wide-body transport airplanes, suggested that the materials standards responsible for that improvement might be recommended by the Group as a short-term action.

G. Discussion of the need to redirect or modify existing R & D programs.
The Group Leader noted that the Group could not properly evaluate existing R & D programs without consulting with the various organizations (including the materials industry) that were engaged in these programs. Since this consultation would require more time than available at this meeting, he proposed establishment of an "R & D Review Sub-Group," chaired by M. Salkind, to look into this item and to report back to the Group at its next meeting. The Group agreed (see Enclosure VII).

H. Discussion of whether the state of the art would warrant short-term rule making, or other action within the Group's area of concern.
C. Sarkos proposed that the Group consider for this purpose an "interim standard" (Enclosure V) developed recently by FAA technical people.
A. Delman cautioned that ASTM test procedures were subject to change. It
used, the date should be specified. He also questioned whether the modified NBS chamber test had adequate reproducibility, whether tests using animals (for determining toxic emission effects) were practical for routine use, and whether the combustion chamber tube method might provide misleading data with respect to the emission of NOx from materials that have no nitrogen in their molecular structure. J. Parker expressed concern that the proposed interim standard might eliminate good commercially-available materials. G. Nelson considered that a set of interim standards for early adoption could be developed by the group based on the Bunsen burner vertical test, the ASTM E-162 radiant cone test, and the NBS smoke chamber test at 2 1/2 watts. He believed, however, that other elements of C. Sarkos's proposal were still experimental.

H. Branting continued with a proposal (Enclosure VI) concerning the applicability of the interim standards proposed by C. Sarkos. Several members contended that it would be inappropriate to consider questions of applicability until the proposed interim standard (as well as other proposals) was evaluated and that there was not enough time left before October 1 to consider both the interim standard and its applicability. G. Nelson suggested that the Group take advantage of nonaviation experience with standard materials tests, since their use has significantly improved the fire safety of interiors. The Group instead proposed that the interim standard issue be reviewed in depth by a "Short-Time Action Sub-Group" co-chaired by H. P. Bara and H. Schneiders, and supported by the members designated in Enclosure VII. The co-chairman could solicit the services of other members, and also nonmembers, at their discretion. The Group Leader charged the sub-group with two major tasks:

1. Advise as to what can be done in the short-term (subject to the October 1 deadline); and

2. Establish a draft list of long-term objectives aimed at increasing survivability in the post-crash fire environment.

I. Members, Alternates, and Authorized Substitutes who participated in the meeting:

- E. Bara, member
- H. P. Branting, member
- C. R. Crane, member
- S. Davis, Deputy Group Leader
- A. D. Delman, member
- J. J. Fargo, member
- R. G. E. Furlonger, observer
- J. R. Gibson, member
- R. A. Kirsch, member
W. C. Long, member  
R. Madding, member  
J. May, member  
K. C. McAllister, member  
C. W. McGuire, member  
G. Nelson, member  
D. Onderak, member  
J. A. Parker, member  
J. D. Ray, member  
C. Sarkos, member  
M. Salkind, member  
H. C. Schjelderup, member  
J. D. Simon, member  
D. R. Spicer, member  
G. Wear, member  
M. E. Wiltert, Group Leader  
A. T. Matey, authorized substitute for B. R. Aubin  
M. M. McCormick, observer, alternate for G. J. Walker

1. Nonmember attendance. Other than members, alternates or authorized substitutes, there were 37 persons in attendance at the meeting. Of these, five were U.S. government employees.

E. Agenda, time, and place for the next meeting of the SAFER technical group on compartment interior materials. After consultation with J. Ender, M. Wiltert, and L. Versaw, the Executive Director announced that separate meetings of this technical group, the technical group on post-crash fire hazard reduction, and the basic SAFER advisory committee were tentatively scheduled for the last full week of September 1979, at NASA's Ames Research Center in Palo Alto, California. The agenda for this group would include:


2. Final draft of long-term objectives, to be submitted for endorsement by the basic SAFER advisory committee.


Prepared by:  
Inria Fagin  7/10/79  
Executive Director, SAFER Advisory Committee

7 Enclosures
RESTRICTED TO TRANSPORT AIRCRAFT

RESTRICTED TO POST-CRASH FIRE SCENARIO

INCLUDE ACTIVITIES PERTAINING TO:

- **HUMAN TOLERANCES**
  - Fire
  - Irritants/Intoxicants
  - Smoke
  - Toxicity

- **CABIN INTERIOR CONSTRUCTION MATERIALS**
  - Transparencies
  - Thermofoming Plastics
  - Fabrics
  - Cushions
  - Decorative Plastics
  - Floor Coverings

- **MATERIALS EVALUATION AND ACCEPTANCE TESTING**
  - Lab Test/Analytical
  - Full Scale Test

- **CABIN INTERIOR CONSTRUCTION SYSTEMS**
  - Containment
  - Compartmentalization
  - Hardening

- **IGNITION AND HEAT SOURCES**
  - Potentials of Materials for Producing a Flash Fire

- **PROTECTION SYSTEMS**
  - Fire Detection
  - Extinguishment
  - Personal

- **PASSENGER CARRY-ON MATERIALS**

- **IMPROVED HEAT RESISTANCE OF**

- **EVACUATION SLIDES**

- **TRASH MANAGEMENT SYSTEMS**

- **ANALYTICAL STUDIES RELATED TO A FULL-SCALE FIRE SCENARIO**
SAFER MATERIALS TECHNICAL GROUP

INITIAL OBJECTIVES

(PROPOSED)

EVALUATE PERTINENT FARS

EVALUATE PERTINENT R&D PROGRAMS

- FAA Funded
- FAA Conducted
- Other Government and Industry

SUBMIT PRELIMINARY FINDINGS BY OCTOBER 1, 1979 INCLUDING:

- Recommendations as to short-term rule making or other action.
- Any initial recommendations to redirect, modify and/or fund existing/new R&D programs.

OBTAIN MAIN COMMITTEE ENDORSEMENT OF LONG-TERM OBJECTIVES

OBTAIN MAIN COMMITTEE GUIDANCE FOR OVERALL APPROACH
ESTABLISH HUMAN TOLERANCES AND PROTECTIVE MEASURES

- Fire
- Irritants/Intoxicants
- Smoke
- Toxicity

IMPROVED CABIN MATERIALS

- Transparencies
- Thermoforming Plastics
- Fabrics
- Cushions
- Decorative Plastics
- Floor Coverings

- Improved Cabin Interior Construction Systems

DEVELOP SIMPLE RELIABLE MATERIALS EVALUATION AND ACCEPTANCE TESTS

IMPROVED FIRE DETECTION AND SUPPRESSION SYSTEMS WITHIN THE CABIN AND CARGO COMPARTMENTS

IMPROVED FIRE CONTAINMENT SYSTEMS

EVALUATE TRASH MANAGEMENT SYSTEMS

IMPROVED EVACUATION SYSTEMS

INVESTIGATION OF MEANS FOR SMOKE CONTROL

SUBMIT RECOMMENDATIONS ON LONG-TERM OBJECTIVES TO THE SAFER ADVISORY COMMITTEE BY JUNE 26, 1980.
TOTAL SURVIVABLE/FATAL AIRCRAFT FIRE ACCIDENTS

U. S. AIR CARRIERS WORLD-WIDE, 1964-1978

<table>
<thead>
<tr>
<th>NO.</th>
<th>FUEL RELEASE MODE</th>
<th>TOTAL</th>
<th>DUE TO FIRE</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>WING SEPARATION</td>
<td>805</td>
<td>290*</td>
</tr>
<tr>
<td>10</td>
<td>TANK DAMAGE</td>
<td>601</td>
<td>210*</td>
</tr>
<tr>
<td>1</td>
<td>ENGINE COMPONENT DAMAGE</td>
<td>48</td>
<td>48</td>
</tr>
<tr>
<td>1</td>
<td>FUEL FIRE DAMAGE</td>
<td>43</td>
<td>43</td>
</tr>
<tr>
<td>1</td>
<td>UNKNOWN</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>31</td>
<td></td>
<td>1500</td>
<td>594*</td>
</tr>
</tbody>
</table>

*ESTIMATED 594 FATALITIES DUE TO FIRE REPRESENT 40% OF THE TOTAL FATALITIES IN THESE 31 FATAL FIRE ACCIDENTS.
# Impact Survivable/Fatal Aircraft Fire Accidents

**U. S. Air Carriers World-Wide, 1977-1978**

<table>
<thead>
<tr>
<th>DATE</th>
<th>AIRCRAFT</th>
<th>LOCATION</th>
<th>FUEL RELEASE</th>
<th>TLRB</th>
<th>TOTAL</th>
<th>FIRE</th>
<th>IMPACT</th>
<th>UNKNOWN</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/27/77</td>
<td>B-747</td>
<td>TENERIFE</td>
<td>TANK DAMAGE</td>
<td>396</td>
<td>335</td>
<td>118</td>
<td>60</td>
<td>157</td>
</tr>
<tr>
<td>4/4/77</td>
<td>DC-9</td>
<td>NEW HOPE, GA</td>
<td>WING SEP.</td>
<td>85</td>
<td>62</td>
<td>20</td>
<td>42</td>
<td>0</td>
</tr>
<tr>
<td>7/6/77</td>
<td>L-188C</td>
<td>ST. LOUIS, MO</td>
<td>UNKNOWN</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3/1/78</td>
<td>DC-10</td>
<td>LOS ANGELES, CA</td>
<td>TANK DAMAGE</td>
<td>200</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

|       |          |                |              | 684  | 402   | 143  | 102    | 157     |
TOTAL SURVIVABLE/FATAL AIRCRAFT FIRE ACCIDENTS

U. S. AIR CARRIERS WORLD-WIDE, 1964 - 1976

<table>
<thead>
<tr>
<th>NO.</th>
<th>FUEL RELEASE MODE</th>
<th>FATALITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>TOTAL</td>
</tr>
<tr>
<td>17 (3)</td>
<td>WING SEPARATION</td>
<td>743</td>
</tr>
<tr>
<td>8 (2)</td>
<td>TANK DAMAGE</td>
<td>264</td>
</tr>
<tr>
<td>1 (1)</td>
<td>ENGINE COMPONENT DAMAGE</td>
<td>48</td>
</tr>
<tr>
<td>1</td>
<td>FUEL LINE DAMAGE</td>
<td>43</td>
</tr>
<tr>
<td>27 (6)</td>
<td></td>
<td>1098</td>
</tr>
</tbody>
</table>

Estimated 450 fatalities due to fire represent about 39% of the fatalities in the total 32 survivable/fatal accidents.
§ 25.853 Compartment interiors.

Materials (including finishes or decorative surfaces applied to the materials used in each compartment occupied by the crew or passengers) must meet the following test criteria as applicable:

(a) Interior ceiling, walls, and partitions.
(b) Large cabinet walls, structural flooring, and materials used in the construction of storage compartments other than underseat storage compartments are compartments for storing small items such as magazines and maps must be self-extinguishing when tested according to the applicable portions of this test method and the approved equivalent methods. The average burn length may not exceed 6 inches and the average time to extinguish any portion 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 failing.

(b-1) Floor covering textiles including draperies and upholstery; seat cushions; padding; decorative and non-decorative coated fabrics, leather, and other felts, furnishings, electrical, conduit, and insulating, and acoustical insulation and linings, covering, air ducting, and other essential cargo compartment fire protection blankets, cargo covers, and other cushions, molded and tubing parts, ducting joints, and joining devices (decorative and cladding) that are constructed of materials that cover blanket increases 

(b-2) of this section, must be self-extinguishing when tested according to the applicable portions of this test or other approved equivalent methods. The average burn length may not exceed 8 inches and the average time to extinguish any portion 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 failing.

(b-3) Motion picture film, sound film, and safety film meet the Surface Burning Rate test requirements of Federal Aviation Regulations for Safety Standards of the United States of America Standards. 2510 12180 13030 14060. If the film travels through ducts, the ducts must meet the requirements of paragraph (a) of this section.

(b-4) Aircraft windows and signs painted in a part of the interior of the cabin must be resistant to the application of two or more consecutive tests in accordance with the applicable portions of this test or other approved equivalent methods. The average burn length may not exceed 6 inches and the average time to extinguish any portion 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 failing.

(b-5) Each end panel, paper, or cloth must be a resistant and non-combustible material containing the following:

- Each panel must have at least one hand hold or other means of gripping each panel must be located in the panel itself.

- There shall be at least one hand hold or other means of gripping each panel must be located in the panel itself.
Appendix 1

(6) Vertical test in compliance with D5855 (6) and (b). A minimum of three specimens must be tested to obtain the results accepted for fabric by the direction of weave corresponding to the most critical flammability conditions that may be encountered in the normal use of the fabric. The specimen must be cut across the warp and weft and will not contain an open seam or break. The specimen must be cut from any part of the fabric that is sewn to another part of the fabric. The fabric must be in a state of tension as it is tested. The specimen must be cut from the same part of the fabric as the test fabric. The specimen must be in the same condition as the test fabric. The specimen must be tested in the same manner as the test fabric. The specimen must be in the same condition as the test fabric. The specimen must be in the same condition as the test fabric. The specimen must be in the same condition as the test fabric. The specimen must be in the same condition as the test fabric. The specimen must be in the same condition as the test fabric. The specimen must be in the same condition as the test fabric.

(6) Horizontal test in compliance with D5855 (6) and (b). A minimum of three specimens must be tested to obtain the results accepted for fabric by the direction of weave corresponding to the most critical flammability conditions that may be encountered in the normal use of the fabric. The specimen must be cut across the warp and weft and will not contain an open seam or break. The specimen must be cut from any part of the fabric that is sewn to another part of the fabric. The fabric must be in a state of tension as it is tested. The specimen must be cut from the same part of the fabric as the test fabric. The specimen must be in the same condition as the test fabric. The specimen must be tested in the same manner as the test fabric. The specimen must be in the same condition as the test fabric. The specimen must be in the same condition as the test fabric. The specimen must be in the same condition as the test fabric. The specimen must be in the same condition as the test fabric. The specimen must be in the same condition as the test fabric. The specimen must be in the same condition as the test fabric. The specimen must be in the same condition as the test fabric.

(6) Final test in compliance with D5855 (6) and (b). A minimum of three specimens must be tested to obtain the results accepted for fabric by the direction of weave corresponding to the most critical flammability conditions that may be encountered in the normal use of the fabric. The specimen must be cut across the warp and weft and will not contain an open seam or break. The specimen must be cut from any part of the fabric that is sewn to another part of the fabric. The fabric must be in a state of tension as it is tested. The specimen must be cut from the same part of the fabric as the test fabric. The specimen must be tested in the same manner as the test fabric. The specimen must be in the same condition as the test fabric. The specimen must be in the same condition as the test fabric. The specimen must be in the same condition as the test fabric. The specimen must be in the same condition as the test fabric. The specimen must be in the same condition as the test fabric. The specimen must be in the same condition as the test fabric. The specimen must be in the same condition as the test fabric. The specimen must be in the same condition as the test fabric.
SAFER Technical Group on Compartment Interior Materials
Meeting on June 9, 1979 at FAA

SUBJECT: Flammability Standards for Flight Attendant Uniforms

Early in 1974, the Association of Flight Attendants (AFA) petitioned the FAA to improve the safety of uniforms worn by its members. AFA's petition made reference to burn tests on typical uniforms conducted by the Gillette Research Institute. The tests indicated that some uniforms (particularly cotton-polyester types) burned vigorously even when they were ignited. Ignition was achieved by means of a paper napkin pinned to the uniform - an accepted test procedure at the National Bureau of Standards (NBS) and other government agencies studying the threat.

Responding to AFA's petition, FAA entered into a inter-agency agreement with NBS for development of an appropriate flammability standard. The terms of reference required NBS to:

1. Evaluate the flammability of a group of typical flight attendant uniforms (both male and female) by igniting each garment and allowing it to burn for 90 seconds, the prescribed evacuation interval. These tests were performed using a temperature-instrumented manikin, and the data interpreted in terms of second-degree burns.

2. Identify advanced fabrics (such as Nomex, flame-retarded polyester, and flame-retarded cotton) that could be substituted for current fabrics.

3. Manufacture uniform components such as shirts, blouses, and blouses) and conduct manikin tests to demonstrate that flammability improvement was possible.

4. Prepare proposed flammability standard based on the self-extinguishing characteristics of the prototype standard for Children's Sleepwear, which had been developed in 1972. Since flight attendants may be exposed to more effective heat sources in cabin fire, it was necessary that the proposed standard include heat resistance test.

To support this development effort, the FAA issued an Advanced Notice of Proposed Rule Making (Notice 75-1), dated January 1975, which solicited comment on the durability, color possibilities, and technical limitations of materials that had been treated for fire retardation. In addition, comment was solicited on the possibility of treating...
summer-weight fabrics for fire retardation.

The standard proposed by NBS is described in Appendix C of FAA Report FAA-RD-75-176,* dated August 1976. This standard (rationalized as a result of follow-on NBS tests performed on numerous additional fabrics), and the comments received in response to Notice 75-13, will form the technical basis for a Notice of Proposed Rule Making (NPRM) that is being developed by FAA for release late in 1979. As presently conceived, the NPRM would cover the uniforms worn by all crewmembers.

DEPARTMENT OF TRANSPORTATION
Federal Aviation Administration

Flammable Substance Advance Notice of Proposed Rule Making

The Federal Aviation Administration (FAA) is considering the need to amend Part 121 of the Federal Aviation Regulations (FARs) and the Aeronautics Act of 1926 to require the clothing worn by flight attendants to be flame-retardant. The FAA is requesting comments on the following issues:

1. Would the materials that are treated for fire retardation be used only for flight attendants or for other purposes also?
2. Would the materials that are treated for fire retardation be used only for flight attendants or for other purposes also?
3. Would the materials that are treated for fire retardation be used only for flight attendants or for other purposes also?
4. Would the materials that are treated for fire retardation be used only for flight attendants or for other purposes also?
5. Would the materials that are treated for fire retardation be used only for flight attendants or for other purposes also?
6. Would the materials that are treated for fire retardation be used only for flight attendants or for other purposes also?
7. Would the materials that are treated for fire retardation be used only for flight attendants or for other purposes also?
8. Would the materials that are treated for fire retardation be used only for flight attendants or for other purposes also?
9. Would the materials that are treated for fire retardation be used only for flight attendants or for other purposes also?
10. Would the materials that are treated for fire retardation be used only for flight attendants or for other purposes also?

Comments are welcome on these areas of interest as well as any additional areas regarding the safety aspects relating to the use of materials for flight attendants with respect to the hazards created by extreme heat and fire.


James M. Vrolyt
Active Director
Flight Standards Service.
FAA Proposed Interim Standard for Cabin Materials

Background

An ad-hoc committee was recently convened, composed of FAA individuals involved and familiar with fire testing and research, to discuss whether an interim fire standard for aircraft cabin materials was feasible and, if so, the structure of such a standard. Based on the state-of-the-art, it was agreed that an interim standard may be feasible within the near future, but that additional work, perhaps over the next 12 months, was needed to develop and verify the standard. The committee concentrated its efforts primarily on reaching some sort of consensus on test methodology that could be proposed at the initial session of the SAFER Technical Group on Compartment Interior Materials, scheduled for June 26-27, 1979, at NAFEC.

Proposed Test Methodology

The committee felt that the most practical interim standard would be composed of individual tests for flammability, smoke, and toxicity. Although considered, it was felt that present modeling technology and knowledge of human tolerance limits would not permit the derivation of weighing factors for each of these "hazards." Instead, the committee selected separate test methods for each "hazard" that were standardized or sufficiently developed. These are shown on the attached table for utilization under two possible strategies, which are presented later for consideration. Both strategies incorporate the same test methods; however, the test conditions are different. An important feature of the proposal is that smoke and toxicity are measured under pyrolytic or nonflaming conditions. For most aircraft materials, research experience to date indicates that the thermal mode that yields the most-toxic and smokiest products is the hottest environment possible that does not cause spontaneous flaming ignition. Fortunately, correlation of small-scale nonflaming pyrolysis tests with full-scale results is both theoretically defensible and appears to be experimentally demonstrated.

Flammability

Two standardized test methods are proposed: the vertical Bunsen burner test (FAR 25.853) and the radiant panel test (ASTM E-162). The former is the basis for existing FAA standards and would be retained in order to continue to minimize the likelihood of an in-flight fire from a small ignition source. In order to evaluate materials in the intense postcrash cabin fire environment, a more severe exposure condition is required. A suitable test for this purpose is the radiant panel test, which measures both flame spread rate and heat evolution.
Smoke

It is proposed that smoke emission be measured with the widely-used NBS smoke chamber. This test method has been standardized by NFPA at a radiant heat exposure level of 2.5 w/cm², which was selected primarily for evaluating building materials. Fire resistant cabin materials require evaluation under more intense heat levels, which are attainable with any one of a number of special heaters, in order to characterize their smoke emissions in a postcrash cabin fire.

Toxicity

A relatively reliable, simple, and accurate procedure for evaluating the toxicity of an aircraft material due to thermal decomposition is the CAMI combustion tube test method. Toxicity is determined by the time-to-incapacitation of the albino rat inside a motor-driven, rotating cage. The combustion tube furnace should be charged with a weight of the sample material that will produce a load of 50 mg. of sample per liter of total enclosed atmospheric volume. It is proposed that the toxicity be converted to a numerical value (global toxicity) that represents the relative toxic hazard of that weight of each material required in the end-use configuration.

Proposed Test Conditions

Two-Zone Strategy

The two-zone strategy recognizes the significant stratification of heat throughout the cabin from an external fuel fire. The ceiling is heated primarily by convection and radiation from the hot smoke layer moving down the cabin with additional radiative heating near the initial fire source, and the hot smoke layer in turn radiates heat to the lower zone of the cabin. Every full-scale fire test and aircraft cabin fire accident has vividly demonstrated that the upper zone cabin materials are exposed to a much higher heat flux than the materials in the lower zone. Therefore, it is proposed that smoke and toxicity be measured, under nonflaming conditions, at 2.5 w/cm² in the lower zone and at 5.0 w/cm² in the upper zone. These test conditions are approximated representative heat flux levels within each zone, and may have to be adjusted when additional data and information becomes available. With regard to flammability, the current Bunsen burner test (FAR 25.853) will be retained for lower zone materials in order to maintain control over in-flight fires. However, for
materials located in the upper zone, where the exposure conditions are much more severe and extensive, the radiant panel test for flammability is needed to exercise some control over flame spread rate and heat evolution.

Worst Test Condition Strategy

The worst test condition strategy recognizes that an infinite number of cabin fire scenarios are theoretically possible, and that the exposure condition a material is subjected to can differ significantly for different scenarios. Moreover, for any given scenario, the heat exposure of any material changes (it usually increases) with time and is greatly dependent on the location of that material within the cabin. Therefore, it is impossible to define with an acceptable degree of accuracy a representative exposure condition for any material. Instead, it is proposed that smoke and toxicity be measured at the maximum heating level that does not cause the sample to ignite spontaneously, which corresponds to the smokiest or most-toxic condition for most aircraft materials. The two-zone concept is proposed for flammability, since both the Bunsen burner and radiant panel test incorporate piloted ignition sources (in contrast to the nonflaming smoke and toxicity tests).

Research Requirements

The detailed research requirements to develop and verify the interim standard proposal have not yet been developed; however, some basic requirements are evident. These requirements are related to two areas: laboratory testing and fire dynamics. In the laboratory scale work, the greatest needs exist in the toxicity area, where a data bank must be generated upon which to base acceptance limits. This data is not available for either the two-zone or worst test condition strategy. In addition, it is desirable to modify the exposure conditions within the combustion tube furnace to provide a more realistic unidirectional exposure for composite materials (panels). With regard to the radiant panel and NBS smoke chamber tests, some additional data may have to be generated. In the area of fire dynamics, the full-scale and modeling tests at NAFEC, and perhaps other Facilities, must be redirected to focus attention on stratification effects and radiative exposure conditions within the cabin. It may also be desirable to refocus mathematical modeling work on the tractability and behavior of smoke in the fuselage cabin, and the radiation resulting therefrom. Finally, the worth of any standard must be judged primarily on the safety benefit it provides. Therefore, it would be necessary to evaluate the safety benefit of the proposed interim standard by conducting full-scale post crash fire tests using the C-133 test article.
### FAA Proposed Interim Standard

#### Flammability

<table>
<thead>
<tr>
<th>TWO ZONE</th>
<th>LOWER ZONE</th>
<th>UPPER ZONE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vertical Bunsen Burner Test (FAR 25.853)</td>
<td>Radiant Panel Test (ASTM E-162)</td>
</tr>
<tr>
<td></td>
<td>Existing Exposures</td>
<td>Existing Exposures</td>
</tr>
<tr>
<td></td>
<td>Modified NBS Smoke Chamber</td>
<td>Modified NBS Smoke Chamber</td>
</tr>
<tr>
<td></td>
<td>Non-Piloted 2.5 W/cm²</td>
<td>Non-Piloted 5.0 W/cm²</td>
</tr>
<tr>
<td></td>
<td>Combustion Tube</td>
<td>Combustion Tube</td>
</tr>
<tr>
<td></td>
<td>Non-Flaming 2.5 W/cm² (550°C)</td>
<td>Non-Flaming 5.0 W/cm² (700°C)</td>
</tr>
</tbody>
</table>

#### Worst Test Condition

- **Upper Zone**: Radiant Panel Test
- **Lower Zone**: Bunsen Burner Test

#### Smoke

- Modified NBS Smoke Chamber
- Non-Piloted Maximum Non-Flaming Exposure

#### Toxicity

- Combustion Tube
- Maximum Non-Flaming Exposure
APPLICABILITY OF PROPOSED INTERIM CABIN MATERIALS STANDARDS

The proposed interim standard would apply to the following:

- Models under future application for type certificate and models currently undergoing type certification.

- Materials used in complete cabin refurbishments as described in FAR 121.312.

- After a 3 year grace period, materials used in seat cushions, upholstery and carpets under FAR 121.
SUB-GROUP ASSIGNMENTS

(SAFER Technical Group on Compartment Interior Materials)

A. Accident Statistics Review Sub-Group
   Chairman: S. Davis

B. R & D Review Sub-Group
   Chairman: M. Salkind

C. Short-term Action Sub-Group
   1. Co-chairman: E. Bara
      • Materials systems: C. Sarkos; J. Simon
      • Materials:
         -- Fabrics: W. Long
         -- Polymers: J. Parker; G. Nelson; G. Wear
   2. Co-chairman: H. Schjelderup
      • Toxicology: C. Crane
      • Materials evaluation and testing: R. Bricker; G. Nelson; C. Wear
      • Airline operations:
         -- Evacuation slides: J. Fargo
         -- Passenger carry-on materials: C. May; B. Aubin
SUMMARY OF PROCEEDINGS

SAFER Technical Group on Post-Crash Fire Hazard Reduction
Meeting of June 28-29, 1979, at NAFEC

A. The group was welcomed by Mr. Tom O'Brien, Acting Deputy Director of the National Aviation Facilities Experimental Center (NAFEC), who announced that FAA's entire fire safety R & D effort would be concentrated at NAFEC in the future. Mr. John H. Enders, Chairman of the basic SAFER Advisory Committee, followed with an outline of the Committee's goals. The Executive Director then introduced Mr. Edward F. Versaw, the elected Group Leader for this Group, who presided for the entire meeting. The proceedings were recorded on tape.

B. Ground rules. The Group Leader announced several ground rules covering the Group's activities, including the following:

1. This meeting, and all subsequent meetings of the Group, will be open to the public on a space-available basis.

2. A nonmember may make an oral statement before the Group if he asks permission from the Executive Director not later than a day before the meeting, and is recognized by the Group Leader. A nonmember may make a written statement to the Group (via the Executive Director) at any time.

3. A summary of the Group's proceedings will be prepared by the Executive Director and distributed to all interested persons.

C. Scope and objectives. The Group Leader stated that the Group, under the SAFER Advisory Committee charter, was to examine the factors affecting the ability of the aircraft cabin occupant to survive in the post-crash environment and the range of solutions available. To define the Group's scope, he added that the Group would:

1. Confine itself to transport category airplanes, and to the reduction of hazards associated with combustible fluid fires;

2. Evaluate the state of the art of existing and completed R & D programs in terms of their contribution to airplane safety, and determine:
   - With respect to completed programs, whether the R & D findings warrant rule making action or the publication of guidance materials;
   - With respect to existing programs, whether they should be continued to completion, redirected along potentially more fruitful lines, or aborted altogether; and
The need for new R & D programs;

1. By October 1, 1979, submit a preliminary report containing the Group's recommendations (if any) for early adoption of new or revised standards within its area of concern.

D. Review and update of the pertinent service record. T. Horeff presented a series of charts (Enclosure I) summarizing the data currently available on impact-survivable accidents involving U.S. air carriers world-wide, and some additional data on fuel tank explosion incidents involving civil and military transport airplanes. In answer to questions asked by various members, T. Horeff stated that:

1. There had been a number of fire incidents/accidents in which hydraulic fluid was the source of fuel, but he knew of none involving fatalities;

2. An "impact-survivable" accident was defined as one in which at least one person survived.

3. In general, the fire fatality data available are not differentiated with respect to causative factors, such as burning or inhalation of toxic gases. It is only in recent years that the NTSB has attempted to collect such data.

4. Except for the KC-135 accident, the incidents/accidents dealing with fuel tank explosions (Enclosure I, last page) were not impact survivable.

5. The vast majority of the airplanes involved in the accident record carried jet A fuel.

6. The impact-survivable accident record for U.S. air carriers generally similar to the record for world air carriers.

T. Horeff continued with a chart (Enclosure II) listing recent fire accident studies. The Executive Director said that he would attempt to obtain a copy of any of these studies for any member who asks for it.

E. Assessment of the adequacy of pertinent Federal Aviation Regulations.

1. T. Horeff listed (Enclosure III) a number of current FAR's relating to minimizing fuel spillage in transport airplanes, and discussed the rationale behind their adoption.

2. A member then described in detail how the airframe industry copes with the FAR's that deal with fuel system safety.
following major areas: power-plant protection; fuel system fire protection; and fuel tank crashworthiness.

In answer to questions posed by various members, T. Peacock stated that:

- Auxiliary tanks are not generally subjected to crash tests. He knows of no crash data documentation on those tanks.
- Flame arrestors are not installed in the vent systems within the tanks; they are not effective in preventing flash-over between tanks.
- Fuel spillage via fuel tank vent lines is not likely to occur in the crash situation.
- Bladder weight represents only a small fraction of the total weight (including the containing structure) chargeable to a bladder-cell installation.
- Under crash conditions, assuming the loads imposed were high enough for penetration and low enough to allow the tanks to break away from the structure, bladder cells are more likely to contain their fuel than integral wing tanks.

3. T. Boreiff continued with a presentation (Enclosure 17) on NBS recommendations to FAA concerning fuel system safety, and FAA's response to those recommendations. In answer to a question by R. Voix, T. Boreiff stated that the three fuel system safety approaches mentioned in NPRM 74-16 were: reticulated polyurethane foam; liquid nitrogen fuel tank inerting; and explosion suppression.

F. Review of current R & D programs. The Group Leader urged the Group, when listening to the presentations that several members were scheduled to make various approaches to post-crash fire hazard reduction, to consider the following pertinent factors: effectiveness; reliability; weight; maintenance; retrofit; cost; and development status. He proposed that each member rate the various approaches with respect to those factors using a simple code as follows: U (for unfavorable), F (for favorable), and O (for neutral). After the presentations were completed, a Group rating would be attempted. The individual presentations were as follows:

1. Crashworthy fuel systems
   - C. Pedriaul, "Crashworthy Fuel Systems" (slides & film).
2. Anti-misting fuels.

3. Fire-resistant fuels.
   - W. Weatherford, "Research Conducted by U.S. Army on Development of Fire Resistant Fuels for Helicopters and Diesel Engines" (slides & film).

4. Fuel tank inerting systems
   - R. Hotteri, "Aircraft Fuel Tank Fire and Explosion Inerting Systems" (slides).
   - S. Kimmel, "Liquid Nitrogen Fuel Tank Inerting System" (slides).
   - G. Yanatt, "Inert Gas Generating System for Fuel Tank Inerting" (slides).
   - G. Grabowski, "Explosion Suppression Systems" (no slides).

Following these presentations, R. Kirsch and R. Salmon provided some clarification on FAA-NAFEC's fuel wing spillage test facility and T. Peacock made some additional remarks about the application of fire-resistant tanks to transport category airplanes.

The Group Leader also noted receipt of a written statement, submitted by D. Goodrum of Fairchild Industries, which dealt with a total fire suppression system being supplied to the Air Force.

C. Discussion of the need to redirect or modify existing R & D program and whether the state of the art warranted short-term rule making. The Group Leader now proposed that the Group attempt a rough screening of the various approaches to post-crash fire hazard reduction which are under current development so as to concentrate the Group's efforts on the most promising for the short term. For the screening exercise, he identified the approaches listed below and suggested that the screening focus on effectiveness, reliability, weight, maintenance, retrofittability and development status.

1. Explosion suppression
2. Fuel tank foam, foil
3. Fuel tank inerting
4. Crash resistant tanks
   - wing
   - fuselage

5. Anti-misting fuel

In the discussion that followed, various members raised the following concerns:
- the need to consider all the aspects of safety involved in the proposed screening factors;
- the need for additional safety factors;
- the need for a consistent screening code that had been suggested by the Group Leader.

Fuselage

In the discussion, it was clear that these questions could not be completely resolved in the time available to the Group. T. Peacock then suggested that the group be formed to continue with the work assigned of the Group (i.e. testing and necessary screening) within the framework established by the Group's SAFER Advisory Committee. These sub-groups would report to the Group at the next meeting. There was general agreement on this suggestion.

After some additional discussion on the matter, Group Leader indicated the sub-groups should be established. The Group Leader, with the Group's approval, set up the following sub-groups in the Group:
- Explosion Suppression and Tank Detonation Sub-group on Crash Resistant Fuels; and a Drafting Sub-Group to study a possible update for service on these aspects as shown in enclosure 1.

T. Peacock emphasized that the sub-groups (and the Group itself) are charged with the following basic tasks: first, to determine what specific short-term research action (if any) can be taken, on the basis of present and historical knowledge, which could contribute significantly to safety; second, to assess pertinent safety programs and determine whether they should be continued in their current forms, along potentially more competitive lines, or added altogether. He also suggested a further charge: if there are additional development activities that are necessary before rule-making can be undertaken, the sub-group is to report that fact to the Group.

The Group Leader noted that the Drafting Sub-Group would receive the group's report to the basic SAFER Advisory Committee. A draft a final report would be reviewed by the Group at its next meeting.

H. Technical group members, alternative and authorized substitutes participated in the meeting:
- B. Bortz, member
- W. G. Braden, member
- T. Flaherty, member
- R. G. S. Foringer, observer
- J. D. Gallaway, member
I. Nonmember attendance. Other than members, alternates or authorized substitutes, there were 25 persons in attendance at the meeting. Of these, 3 were U.S. government employees.

J. Agenda, time, and place for the next meeting of the SAFER Technical Group on Post-Crash Fire Hazard Reduction. The Executive Director announced that separate meetings of this Technical Group, the Technical Group on Compartment Interior Materials, and the basic SAFER Advisory Committee were tentatively scheduled for the last full week of September 1979, at NASA's Ames Research Center in Palo Alto, California. The agenda for this Group would include, among other things, a review of the Drafting Sub-Group's draft report.

Prepared By: Irrum Fagin 7/16/79
Executive Director, SAFER Advisory Committee

3 Enclosures
TOTAL SURVIVABLE/FATAL TURBINE AIRCRAFT ACCIDENTS

U.S. AIR CARRIERS WORLD-WIDE, 1964 - 1976

<table>
<thead>
<tr>
<th>ACCIDENTS</th>
<th>FATALITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIRE</td>
<td>NO FIRE</td>
</tr>
<tr>
<td>27</td>
<td>5</td>
</tr>
</tbody>
</table>

32 ACCIDENTS - 1148 FATALITIES

95.6% of fatalities in survivable/fatal accidents to U.S. air carriers were in accidents where fire occurred.
RELATIONSHIP OF SURVIVABLE AND NON-SURVIVABLE/FATAL ACCIDENTS

U.S. AIR CARRIERS WORLD-WIDE, 1964 - 1976

FATAL ACCIDENTS

<table>
<thead>
<tr>
<th>Survivable</th>
<th>Fatalities</th>
<th>Non-Survivable</th>
<th>Fatalities</th>
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<tbody>
<tr>
<td>32</td>
<td>1148</td>
<td>43</td>
<td>1468</td>
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</tbody>
</table>

TOTAL FATAL ACCIDENTS - 75
TOTAL FATALITIES - 2616

ESTIMATED 450 FATALITIES DUE TO FIRE IN SURVIVABLE ACCIDENTS REPRESENT 17% OF THE TOTAL FATAL ACCIDENT FATALITIES.
<table>
<thead>
<tr>
<th>NO.</th>
<th>FUEL RELEASE MODE</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>TOTAL</td>
</tr>
<tr>
<td>17 (3)</td>
<td>WING SEPARATION</td>
<td>743</td>
</tr>
<tr>
<td>8 (2)</td>
<td>TANK DAMAGE</td>
<td>264</td>
</tr>
<tr>
<td>1 (1)</td>
<td>ENGINE COMPONENT DAMAGE</td>
<td>48</td>
</tr>
<tr>
<td>1</td>
<td>FUEL LINE DAMAGE</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1098</td>
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</table>

Estimated 450 fatalities due to fire represent about 39% of the fatalities in the total 32 survivable/fatal accidents.
<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>Aircraft</th>
<th>Cause</th>
<th>Fatalities</th>
<th>Injury</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>3/2/77</td>
<td>Tallahassee, FL</td>
<td>C-121</td>
<td>Human error</td>
<td>118</td>
<td>60</td>
<td>178</td>
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<tr>
<td>4/4/77</td>
<td>New York, NY</td>
<td>DC-9</td>
<td>Separation</td>
<td>355</td>
<td>85</td>
<td>440</td>
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<tr>
<td>7/6/77</td>
<td>St. Louis, MO</td>
<td>L-108C</td>
<td>Collision</td>
<td>3</td>
<td>5</td>
<td>8</td>
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<tr>
<td>3/1/78</td>
<td>Los Angeles, CA</td>
<td>DC-10</td>
<td>Collision</td>
<td>200</td>
<td>684</td>
<td>884</td>
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</tbody>
</table>

Enclosure I - p. 4938
### Total Survivable/Fatal Aircraft Fire Accidents

#### U.S. Air Carriers World-Wide, 1969-1978

<table>
<thead>
<tr>
<th>No.</th>
<th>Fuel Release Mode</th>
<th>Total</th>
<th>Due to Fire</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>Wing Separation</td>
<td>805</td>
<td>290*</td>
</tr>
<tr>
<td>10</td>
<td>Tank Damage</td>
<td>601</td>
<td>230*</td>
</tr>
<tr>
<td>1</td>
<td>Engine Component Damage</td>
<td>48</td>
<td>48</td>
</tr>
<tr>
<td>1</td>
<td>Fuel Fire Damage</td>
<td>63</td>
<td>63</td>
</tr>
<tr>
<td>1</td>
<td>Unknown</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>31</td>
<td></td>
<td>3500</td>
<td>594*</td>
</tr>
</tbody>
</table>

*Estimated 594 fatalities due to fire represent 40% of the total fatalities in these 31 fatal fire accidents.*
<table>
<thead>
<tr>
<th>DATE</th>
<th>AIRPLANE MODEL</th>
<th>LOCATION</th>
<th>OPERATIONAL MODE</th>
<th>PROBABLE CAUSE</th>
<th>FUEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/24/77</td>
<td>L-382B</td>
<td>OAKLAND, CA</td>
<td>MAINT.</td>
<td>INTERNAL OVERTEMP. - JP-4</td>
<td>JP-4</td>
</tr>
<tr>
<td>12/11/77</td>
<td>DC-8-33</td>
<td>LAKE CITY, FL</td>
<td>MAINT.</td>
<td>ARCING-BOOST - JLT A</td>
<td>JLT A</td>
</tr>
</tbody>
</table>

*Note: A LIGHTNING STRIKE on 3/22/78 to a B-747 using JET A affected fuel transfer valve without causing an explosion.*
RECENT FIRE ACCIDENT STUDIES

1975 - 1979

1. NASA CR 157690, "AN ANALYSIS OF AIRCRAFT ACCIDENTS INVOLVING FIRES," MAY 1975

2. CRC REPORT NO. 482, "AVIATION FUEL SAFETY - 1975," NOVEMBER 1975


4. PAPER PREPARED BY A. F. TAYLOR, "AN EVALUATION OF WORLDWIDE TRANSPORT AIRCRAFT FIRE EXPERIENCES," SEPTEMBER 1976


6. PAPER PREPARED BY H. C. BLACK, "TRANSPORT CATEGORY AIRPLANE POST CRASH FULL SYSTEMS FIRE AND EXPLOSION HAZARD REDUCTION," JUNE 1977

7. AGARD ADVISORY REPORT, "AIRCRAFT FIRE SAFETY," DRAFT DATED JUNE 1979
CURRENT TRANSPORT AIRCRAFT DESIGN RULES TO MINIMIZE FUEL SPILLAGE

FAR 25.721(a) & (b)  Failure of main landing gear during takeoff and landing should not cause the spillage of enough fuel from the fuel system to constitute a fire hazard. Landing with any one or more landing gear legs not extended should also not result in spillage of enough fuel to constitute a fire hazard.

(Amend. 25-15 adopted 9/15/67 and 25-32 adopted 2/24/72)

FAR 25.994  Fuel system components in nacelles or in the fuselage must be protected from damage which could cause the release of fuel in a wheels-up landing.

(Amend. 25-23 adopted 4/8/70)
CURRENT TRANSPORT AIRCRAFT DESIGN RULES TO MINIMIZE FUEL SPILLAGE

**FAR 25.963(d)** - FUEL TANKS IN THE FUSELAGE MUST BE ABLE TO RESIST RUPTURE AND RETAIN FUEL UNDER EMERGENCY LANDING CONDITIONS AND MUST BE LOCATED SUCH THAT SCRAPING WITH THE GROUND IS UNLIKELY.

(AMEND. 4b-6 ADOPTED 8/12/57)

**FAR 25.993(a)** - FUEL LINES IN THE FUSELAGE MUST BE ABLE TO DEFORM AND STRETCH WITHOUT LEAKAGE.

(AMEND. 25-15 ADOPTED 9/15/67)
CAB LETTER, 11/30/65, CITING 11/11/65 B-727 SALT LAKE CITY ACCIDENT

"FUEL LINES SHOULD BE REROUTED THAT THEY PASS THROUGH THE FLOOR BEAMS NEAR THE CENTERLINE OF THE AIRCRAFT AND . . . BE MADE OF STAINLESS STEEL WITH A WALL THICKNESS OF SUFFICIENT DIMENSION TO WITHSTAND RATHER SEVERE IMPACTS."

"GENERATOR LEADS SHOULD BE ROUTED SO THAT THERE IS MAXIMUM SEPARATION BETWEEN THESE LEADS AND THE FUEL LINES. EACH LEAD SHOULD BE IN A SEPARATE, STRONG, AND FLEXIBLE PLASTIC CONDUIT."

FAA RESPONSE

AIRWORTHINESS DIRECTIVE NO. 66-30-02, EFFECTIVE 11/12/67

NEW AIRWORTHINESS REQUIREMENT ADOPTED 9/15/67
NEW HAVEN ACCIDENTS

"YOU ARE ASSIGNED TO IMPLEMENT THE FOLLOWING REQUIREMENTS IN THE AIRWORTHINESS REQUIREMENTS TO INCREASE IN-FLIGHT AND POST-CRASH SAFETY FOR FUEL SYSTEM SAFETY DEVICES WHICH WILL BE EFFECTIVE IN THE PREVENTION AND CONTROL OF BOTH IN-FLIGHT AND POST-CRASH FUEL SYSTEM FIRES AND EXPLOSIONS."

FAA RESPONSE

NOTICE OF PROPOSED RULEMAKING NO. 74-16
SUB-GROUP ASSIGNMENTS

(SAFER Technical Group on Post-Crash Fire Hazard Reduction)

A. Sub-group on Explosion Suppression, Fuel Tank Foam/Foil, and Fuel Tank Inerting

Chairman: A person* representing AIA
Members: B. Botteri and a person* representing ATA
Advisors**: R. Volz; L. Hebenstreit; R. Appleyard; G. Grabowski; C. Kimmel; S. Manatt.

B. Sub-group on Crash Resistant Fuel Tanks

Chairman: A person* representing AIA
Members: C. Pedriani and a person* representing ATA
Advisors**: H. Smith; E. Webb; G. Galloway

C. Sub-group on Anti-Misting Fuels

Chairman: T. Peacock
Members: W. Dukek; R. Mannheimer; and a person* representing ATA

D. Drafting Sub-Group

Chairman: E. Versaw
Members: Chairman of the above Sub-groups
Advisor**: I. Fagin

* These persons are to be nominated by AIA or ATA (as applicable) in the near future.

** These are volunteer advisors. The advice of other persons may be solicited at the discretion of the Sub-Group Chairman.
SUMMARY OF PROCEEDINGS

SAFER Conference of September 24-28
At The NASA/Ames Research Center

Overview. This conference consisted of three consecutive meetings of 1 1/2 days each as follows: A meeting of the Technical Group on Compartment Interior Materials headed by Mr. Martin F. Willett; a review of the Technical Group on Post-Crash Fire Hazard Reduction headed by Mr. Edward F. Versaw; and a meeting of the SAFER Committee headed by Mr. J. Enders.

During each of the technical group meetings, subgroup reports were discussed so that recommendations for short and long-term actions could be proposed to the main committee. At the SAFER Committee meeting, the two technical group Chairman presented their groups suggestions for consideration by the SAFER Committee to be recommended to the Administrator by Mr. Enders, Chairman.

Each of the three meetings were taped and in addition, the main SAFER Committee meeting was recorded by a court reporter. The transcript of this recording will be the official record of that meeting.

Technical Group on Compartment Interior Materials Meeting. This meeting was opened with welcoming remarks by Dr. Dean Chapman, Director, Astronautics Directorate NASA-Ames Research Center, after which the meeting was chaired by Mr. Martin F. Willett.

Subgroup reports were submitted for discussion and to provide material for the Group Chairman's presentation to the SAFER Committee. The areas encompassed by the subgroups were as follows:

1. R & D Review
2. Accident Statistics Review
3. Short-Term Action
   - Materials & Material Systems
   - Toxicology
   - Airline Operations
   - Heat Resistance of Evacuation Systems
   - Materials Evaluation & Testing

Participants in this meeting were:

M. E. Wilfert, Group Leader
J. H. Enders, SAFER Committee Chairman
E. Bara, Member
T. Batey, Authorized substitute
H. P. Branting, Member
C. R. Crane, Member
A. D. Delman, Member
J. J. Fargo, Member
Technical Group on Post-Crash Fire Hazard Reduction Meeting. The welcoming remarks for this session were provided by Dr. Harold P. Klein, Director of Life Sciences, NASA-Ames Research Center. Mr. Edward Versaw, Chairman, structured this session in a similar manner to the Interior Materials meeting, operating as a working group to formulate suggestions for the SAFER Committee to consider as recommendations to be presented to the Administrator.

Subgroups within this group were as follows:

1. Explosion suppression, fuel tank foam/foil, and fuel tank inerting.
2. Crash-resistant fuel tanks.
3. Anti-misting fuels.

Two presentations were made to add to the group's information. There were:


"ICI Fibrous Flame Suppressors," by Mr. A. Brown of MFS Products.

Those who participated in this meeting were:

E. F. Versaw, Group Chairman
J. H. Enders, SAFER Committee Chairman
B. P. Botteri, Member
W. G. Dukek, Member
SAFER Committee Meeting. Mr. Clarence Syvertson, Director, NASA-Ames Research Center, presented the opening remarks after which the meeting proceeded under the chairmanship of Mr. John H. Enders.

In order to best utilize the time allotted for the main committee meeting, Mr. Enders structured the proceedings so that each technical group chairman could present the proposed recommendations of his group after which discussions could be held and decisions could be made as to those short-term and long-term recommendations which would be presented to the Administrator.

After lengthy discussions, the Committee decided on the following:

Short-Term Recommendations - Interior Materials

- Retain FAR 25, Appendix F, referenced Bunsen Burner test.
- FAA had request ASTM Committee F-7 to modify method F-501 to correct a method for materials that drip and melt away from the flame and subsequently to modify FAR 25 test method for materials (Appendix F).

Short-Term Recommendations - Post-Crash Fire Hazard

- Amend FAR 25 to require fuel tank vent protection during ground fires.
Request that the FAA examine, through an ANPRM, the feasibility of amending the regulations to require design practices which minimize the probability of failure to achieve fuel shutoff in potential fire situations.

The FAA should request the NTSB to implement the proposals by the coordinating research council for improved accident reporting relevant to fuel fires.

**Long-Term Recommendations - Interior Materials**

- Expedite and coordinate C-133 and similar full-scale fire tests.
- Define a design post-crash fire scenario(s).
- Establish contribution of cabin interior materials relative to the post-crash fire hazard.
- Expedite the development of the OSU chamber and evaluate its use as a regulatory tool (within 3 years).
- Complete preliminary evaluation of the test procedure and present materials for evacuation slides by May 1980.
- Accelerate toxicity research effort to identify and understand the biological chemical and physical factors that must be integrated into comprehensive fire risk assessments for materials in specific use configuration.
- Promote open forums, documents, and presentations to make the subject of toxicology more understandable to regulatory bodies, flight crews, and to the public.
- Develop cabin interior material data bank.
- Continue development of low-smoking, fire-resistant seat foams.
- After ASTM-F7 has modified test F-501 to correct the melt and drip-away from the flame, subsequently modify the FAR 25 test method for materials (Appendix F).
- Develop for new seat designs, fire blocking layer (fire barrier) to protect present polyurethane foam cushioning material (1 year).
Coordinate and accelerate development of analytical post-crash aircraft fire modeling.

Long-Term Recommendations - Post-Crash Fire Hazard

- Continue and expedite FAA/NASA research to establish a realistic airplane crash scenario with increased emphasis on post-crash fuel system failure modes and effects on cabin fire safety.
- From the crash scenario, develop fuel system design criteria which transport category aircraft must meet in order to minimize post-crash fuel fires.
- Support a transport helicopter post-crash fire study similar to the preceding recommendation.
- Expand the investigation of AMK and its properties with respect to all operational aspects of commercial transport aircraft.

(The following associated recommendations are not in order of priority):
- Develop AMK performance specification.
- Investigate the applicability of anti-misting concepts broadened specification hydrocarbon fuels.
- Encourage NASA to include AMK technology in its long-range fuel program for advanced engine systems.
- Investigate reduced flash point of kerosene fuels.
- Broaden large-scale validation test.

- That FAA evaluate the use of self-contained smoke masks, gloves, clothing, or other personal protection equipment for crew members and handicapped passengers in order that they can better complete emergency evacuation under the post-crash condition.

Participants on the SAFER Committee Meeting were:

J. H. Enders, Chairman
J. E. Dougherty, Alternate for Green
J. M. Chavkin, Member (pending approval)
W. T. Edwards, Alternate for Del Balzo
M. L. Goland, Member
G. N. Goodman, Member
B. V. Hewes, Member
C. F. Hitchcock, Member
K. E. Hodge, Member
C. Huggett, Member
E. L. Hutcheson, Member
C. W. McGuire, Member
L. R. Perkins, Member
E. Podolak, Member (pending approval)
General Comments

1. Since the first four long-term recommendations under interior Materials are interrelated, it is the Committee's request that they be tied together during their long-term handling.

2. The subject of smoke hoods was discussed at length. It was decided that the subject should be referred back to the Technical Group on Compartment Interior Materials to determine, indeed, whether alleged significant improvements have been made to these devices to warrant a recommendation for their renewed study.

3. It was the specific request of the technical groups (supported by the SAFER Committee) that they receive information with regard to the FAA response to each of the recommendations.

4. The SAFER Committee charged the Chairman, Mr. Enders, with the task of presenting the contained recommendations to the Administrator at the earliest possible convenience and to reflect, in his presentation, the Committee's discussions leading to these recommendations.

5. As a matter of note, the Chairman expressed dismay that the NTSB observer did not attend this conference in view of the importance that aircraft accident investigation has in structuring a sound aircraft fire safety improvement program.

6. Details of future SAFER meetings will be announced pending the briefing of the Administrator.

Prepared By: 
Executive Director, SAFER Advisory Committee

Chairman: 
Chesley B. Boswell
Chairman, SAFER Advisory Committee
SUMMARY OF PROCEEDINGS
SAFER Meeting of March 4-6, 1980
At The Aerospace Corporation

The meeting was recorded on tape which will be the official record of proceedings. This document will serve as a summary of those proceedings. A final report of all SAFER activities will be made available after the termination of the committee in June 1980.

OVERVIEW. The fourth meeting of the SAFER Advisory Committee was held March 4-6 in El Segundo, California, at the conference facilities of the Aerospace Corporation. The primary purpose of this meeting was for the FAA to respond to the formal SAFER recommendations which were presented to the Administrator subsequent to the SAFER conference of September 24-28, 1979.

At the beginning of this meeting, time was allotted for updating the committee on several items of old business and to accommodate the members in an on-site inspection of the fire safety related aspects of aircraft construction at the Douglas Aircraft Company at Long Beach.

Formal responses were presented by the FAA after which open discussions took place.

The structure of the final SAFER report was considered and assignments were made for contributions of that report. The final SAFER meeting will take place at NAFEC, probably in mid-June for the purpose of reviewing the final draft SAFER report.
SUMMARY

March 4. Dr. A. B. Greenburg, Vice President and General Manager of Government Support Operations of the Aerospace Corporation, welcomed the group to the Aerospace facilities. The opening remarks were made by John R. Harrison, Director of the Office of Aviation Safety, who commended the group on their efforts and charged that, since an excellent network of technical exchange has been established by the committee and its technical support groups, the final SAFER report should be more than a documentation of activities, and should be constructed in such a way that it would serve as a useful reference over the next few years for those involved in aspects of improvement in aircraft cabin interior materials and in the post-accident fire incident.

Four brief updating presentations were made resulting from assignments made during the previous SAFER meeting.

Mr. Ben Botteri, Chief of the Fire Protection Branch at the Air Force Propulsion Laboratory, presented a summary of the AARD Report No. 122 of the Propulsion and Energetics Panel's Working Group II on Aircraft Fire Safety. This report has been recently published and will be available to the public through normal N.T.I.S. distribution channels.

Dr. Clayton Hoggatt, Acting Deputy Director of the National Bureau of Standards, gave the aircraft accident statistics subgroup report, pointing out that this report had not been reviewed in its final form by our subgroup. The conclusions stated in the report were as follows:

1. "Statistics" cannot be used as a basis for making recommendations for design changes in aircraft.

There are gaps in the data which have been collected; the state-of-the-art has not enabled some of these gaps to be filled.

2. We are insufficiently responsive to thoroughly investigate each accident. By having an area of expertise as part of the investigating team at the time of investigation, it is more possible to determine the sequence of events between the two facilities.

There has been a lack of pertinent data on survivability of aircraft occupants and the available data are not readily retrievable which could facilitate a more thorough analysis of the incident.

3. It has been invariable involved in incidents in which there were fatalities.

Conclusions: The subgroup made the following recommendations in consideration of the SAFER committee.
1. There needs to be an improvement in data gathering. The AIA and FAA should be requested to work with NTSB to develop a more thorough standardized investigation report format. There should be a continuing procedures to review and update the data collection process. Concomitantly, there should be an improved data retrieval system to make the data available to more people.

2. Existing data should be more thoroughly investigated, vis-a-vis the NASA study.

3. Future changes in design and in regulations should be based on more complete data gathering and analysis.

Mr. Marty Wilfert, Senior Engineer/Scientist for the Douglas Aircraft Company, informed the committee of additional information gathered in the area of passenger smoke hoods. Conclusions reached were that there have been no new advancements which solve the concerns of the delay they might cause in passenger evacuation because of the possible confusion in the use of these devices by an untrained group and because of the risk of suffocation. Mr. Wilfert also mentioned that prospective manufacturers of these hoods are quite concerned with the product liability aspects. Mr. Ed Thomas of ATA added that the possible hampering of communication when using smoke hoods is also a problem with serious potential.

Dr. John Parker, Chief of the Chemical Research Projects Office at NASA Ames, reviewed work done in the area of cabin insulation materials as thermal barriers and proposed further study of this and of the use of reflective paints for such use.

During the afternoon of the first day, the committee members visited portions of the Douglas Aircraft Company assembly line so that they could see, first-hand, the installation of cabin interior materials and other factors pertinent to the committee's deliberations.

March 5. This day was devoted to the formal responses by the FAA to the recommendations made by the SAFER Committee.

Mr. Tom Horeff presented the responses to the long- and short-term recommendations which were of a regulatory nature. The recommendations and responses were as follows:

RECOMMENDATION. Retain the FAR 25, Appendix F, referenced burn test and request the ASTM Committee F-7 to modify method F-501 to correct the method for materials that drip and melt away from the flames and subsequently to modify the FAR 25 test method for materials (Appendix F).

RESPONSE. A letter from the FAA to the Chairman of the ASTM Committee F-7, dated February 8, 1980, requesting that the recommendation to modify method F-501 be included as an agenda item at the next scheduled meeting of Committee F-7, has been sent. The FAA will issue an
-3-

6. Amend the FAR 25 test method for materials (Appendix F) subsequent to modification of method F-501 by the ASTM.

7. RATIONALE. Amend FAR 25 to require fuel tank vent protection during normal flight.

8. RATIONALE. The FAA will issue an ANPRM to seek comments concerning the effectiveness of vent flame arrestors and surge tank suppression systems in delaying the ignition of fuel vapor within the system due to ground fires.

9. RATIONALE. Examine, through an ANPRM, the feasibility of amending the regulations to require design practices which maximize the probability of engine fuel supply shut-off in potential fire situations.

10. RATIONALE. The FAA will issue an ANPRM to seek comments concerning the feasibility and the availability of design practices which may exist to increase the probability of fuel shut-off in potential fire situations.

11. RATIONALES. Request the NTSB to implement the proposals by the Rotortrack Research Council for improved accident reporting relevant to fuel fires.

12. NTSB. In a FAD letter to NTSB solicit NTSB review of CRC proposal with the objective of satisfying the need for more accident information relative to fuel fires, and explosions. (This letter was signed by the Assistant Administrator on March 11, 1980.)

13. Hereil also mentioned that an R&D program to develop improved criteria for fuselage and wing crash-resistant fuel systems is planned by the FAA in FY-81 and that crash-resistant fuel system requirements were proposed at the Rotortrack Regulatory Review in December 1979.

14. The rotating questions following Mr. Herrell's presentation but in the interest of saving time during this day of FAA responses, they were deferred to the morning of the last day.

15. Mr. Edwards of NAFEC responded to the remaining recommendations which concerned long-term R&D. By way of background, Mr. Edwards indicated the management of the FAA Aircraft Safety R&D Program was given along with overviews of the cabin fire safety and the retired fuel R&D program.

16. Recommendations were grouped by Mr. Edwards into those which related to full-scale experiments, fire modeling, post-crash fire scenario analysis, laboratory test methodology development, survival and evacuation, standard and improvements, and those of a general nature. A thorough description of the plans for satisfying the SAFER recommendations was presented with proposed time tables for carrying out the efforts.

17. Finally, there was a description of work already initiated at NAFEC related to the SAFER goals. There was no apparent committee to be formed which regarded the research and development
March 6. The questions relating to Mr. Horeff's regulatory responses presented the previous day, were entertained. Mr. Horeff was questioned by Ed Thomas (ATA) with regard to Mr. Horeff's accident statistics which were not in agreement with those of the NTSB for the same time period. Mr. Horeff distributed information supporting his accident statistics.

There was confusion among the committee as to what was meant by the FAA response to the recommendation for requiring fuel tank vent protection during ground fires. There was concern that the FAA might again be favoring fuel-inerting systems. Mr. Horeff emphasized that this was not the case.

GENERAL COMMENTS:

The committee placed much emphasis on the setting of priorities in the proposed actions of the FAA in response to the SAFER recommendations. Realizing that, with budget limitations, the FAA will be able to accomplish all the SAFER tasks with equal emphasis, the committee wants a hard look to be taken where R&D money can be spent to produce the best payoff in practical increases in safety.

With regard to the recommendation alluding to fuel vent flame suppression, Dr. Huggett (NBS) proposed that basic testing should be done involving an aircraft wing, with the required lightning arrester installed, in a pool fire so that basic data can be obtained on the effectiveness of these arrestors in that situation. He also suggested that strong emphasis be placed on improved accident statistics. The lack of information in this regard had a significant effect on the committee's efforts.

Interest was expressed on the subject of paints which might delay the fire effects in certain critical areas of an aircraft and may have a side benefit of corrosion protection.

Capt. Vic Hewes (ALPA) emphasized consideration for more steel of cabin windows which can shrink in elevated thermal conditions allowing the more rapid entry of heat and flame. He expressed concern for the serious problem caused by melting and dripping of ceiling panels and the need for smoke/fire detectors in lavatories. He also suggested that the committee consider recommending the requirement for low-level emergency exit lighting in addition to the existing high-level lighting already installed.

Chairman Jack Enders made the point that in accidents/incidents where fire does not occur or where fire occurs and there are no fatalities, it is important to examine "what went right," as well as what accident causal factors were present.
Mr. Guy Goodman (ATA) informed the committee that in the future more considerations were being given to engine containment and providing protection to occupants when there is no containment.

Mr. Jack Wivel of British Airways stressed the importance of not impeding safety improvement by overregulation.

There was general agreement by the committee that to maintain continuity after SAFER, Ad Hoc committees should be established.

Presentations were made by Mr. Ev Justin of Boeing and Mr. Ed Reil of Lockheed outlining the efforts of these companies in fire safety improvement. Copies of their material is included with this summary.

The final item covered at this meeting was the structure of the final report of the committee which will reflect the committee's activities during its existence. A tentative report outline presented to the members contains 11 parts, each of which were assigned as responsibilities of specific individuals. These parts are listed below with the names of the responsible individuals. It was emphasized by the Chairman that anyone member of the SAFER Committee or its technical groups should feel free to contribute to any part of this report even though they may not have been named specifically, or have been asked by the person responsible for a particular part.

**Part 1:** Front End Matter - J. Enders and E. Wood

**Part 2:** Aircraft Fire Problem Definition - C. Huggard, Ed Thom, J. Fargo, and G. Walhout

**Part 3:** General Considerations of Aircraft Fire and Explosions - M. Goland and J. Del Balzo

**Part 4:** Assessment of Adequacy of Current Standards and Existing Technical Basis for Near Term Upgrading of Rules - J. Ros and J. Chavkin

**Part 5:** Fireworthy Materials - M. Wilfert, L. Parker, and E. Wood

**Part 6:** Toxicity and Smoke - L. Perkins, E. Budolak, and J. Punderson

**Part 7:** Fuel System Fire Hazards - J. Bert, E. Versaw, and R. Clarke

**Part 8:** R&D Considerations - A. Tobin and T. Edwards

**Part 9:** Crew Protection and Passenger Evacuation - B. V. Brown, R. Clarke, J. Searle, and C. Hitchcock

**Part 10:** SAFER Committee Findings and Recommendations - J. Enders and E. Wood

NOTE: It has been tentatively decided that the final responses to the SAFER recommendations will be placed in this area.
SAFER Committee Participants for This Meeting:
J. W. Underwood - Chairman
E. V. Wood - Executive Director
J. A. Berr
E. Pedonan
J. O. Herrett (Alternate for J. Underwood)
R. W. Clarke (Alternate for B. V. Hewes)
J. M. del Salvo
J. E. Dougherty
M. L. Goland
G. N. Goodman
B. V. Hewes
G. F. Bicecock
E. Huggins
E. R. Perkins
J. F. Keese
J. L. Baxter
E. L. Thomas
A. M. Trinsson (replacement for J. Hodge)

Prepared by:

[Signature]
Executive Director, SAFER Advisory Committee

CONCUR:

[Signature]
Chairman, SAFER Advisory Committee
### TOTAL NON-DETERMINATE/DETERMINATE AIRCRAFT ACCIDENTS

### Air Carriers_World-Wide, 1964-1978

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Explosions occurred during evacuation in about 32% of the total survivable/fatal fire accidents.
## Total Survivable/Fatal Aircraft Explosion Accidents

**U.S. Air Carriers World-Wide, 1964-1978**

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*Estimated 321 fatalities due to fire in accidents where explosions occurred during evacuation represent about 52% of the fatalities in these accidents.*
SHORT TERM RECOMMENDATIONS - POST-CRASH FIRE HAZARD

- AMEND FAR 25 to REQUIRE TANK VENT PROTECTION DURING GROUND FIRES.

Based on conclusion that vent flame arrestors or surge tank suppression systems currently used in most commercial production aircraft provide the majority of the protection that would be provided by inerting, quenching, and multi-tank suppression systems in their current state of development.

Recommendation was made to amend FAR 25 to conform to this existing technology.
SOME TANK COMPRESSION SYSTEMS ARE CURRENTLY USED IN SOME COMMERCIAL PRODUCTION AIRCRAFT TO COMPLY WITH FAR 25.835, ADDED 8/11/67, OR AC NO. 67-23-62, EFFECTIVE 9/10/67, WHICH REQUIRE PROTECTION AGAINST LIGHTNING-INDUCED IONITION AT FUEL VENT OUTLETS.

VENT BLADE ASSEMBLIES ARE ALSO USED IN SOME AIRCRAFT TO COMPLY WITH LIGHTNING PROTECTION REQUIREMENTS AND ARE USED IN OTHER AIRCRAFT AT BUILDERS' OPTION.
SHORT-TERM RECOMMENDATIONS - POST-CRASH FIRE HAZARD

FAA RESPONSE

VEHICLE AIRSOFT OR STATIC FIRE COMPRESSION SYSTEMS WILL DELAY BUT NOT PREVENT PROPAGATION OF FLAMES FROM A GROUND FIRE THROUGH THE VENT INTO THE FUEL TANKS.

VEHICLE AIRSOFT OR STATIC FIRE COMPRESSION SYSTEMS ARE NOT CAPABLE OF PROVIDING THE PROTECTION THAT WOULD BE PROVIDED BY INERTING, SOUDERING, AND MULTI-TANK COMPRESSOR SYSTEMS THROUGHOUT THE PERIOD OF TIME THAT THE FUEL TANKS REMAIN INTACT DURING A GROUND FIRE.
SHORT-TERM RECOMMENDATIONS - POST-CRASH FIRE HAZARD

FAA RESPONSE

PROPOSED REGULATORY LANGUAGE SHOULD BE OBJECTIVE IN NATURE IN SPECIFYING THE INTENDED PROTECTION, i.e., FUEL TANK VENT SYSTEMS MUST BE DESIGNED TO DELAY THE ILLIGATION OF FUEL VAPOUR WITHIN THE SYSTEM DUE TO EXTERNAL FIRES.

FAA WILL ISSUE AN ADVISORY TO SEEK COMMENTS CONCERNING THE EFFECTIVENESS OF VENT CLAMP ARRESTORS AND FUEL TANK SUPPRESSION SYSTEMS IN DELAYING THE ILLIGATION OF FUEL VAPOURS WITHIN THE SYSTEM DUE TO EXTERNAL FIRES.

FAA WILL MONITOR RESEARCH AND DEVELOPMENT PROGRAMS ON PROMISING APPROACHES TO PREVENT THE ILLIGATION OF FUEL VAPOURS DURING THE PERIOD OF TIME THAT THE FUEL TANKS STAY IN CONTACT DURING A GROUND FIRE.
SHORT-TERM RECOMMENDATIONS - POST-CRASH FIRE HAZARD

- EXAMINE, THROUGH AN ANALYSIS, THE FEASIBILITY OF AMENDING THE REGULATIONS TO REQUIRE DESIGN PRACTICES WHICH MAXIMIZE THE PROBABILITY OF ENGINE FUEL SUPPLY SHUTOFF IN POTENTIAL FIRE SITUATIONS.

- BASED ON DESIGN PRACTICE IN USE WHICH PROVIDES FOR CLOSURE OF BOTH TANK-TO-ENGINE AND ENGINE SHUTOFF VALVES DURING NORMAL SHUTDOWN.

- RECOMMENDATION WAS MADE TO AMEND FAR 25 AND/OR FAR 121 TO CONFORM TO THIS EXISTING TECHNOLOGY.
SHORT-TERM RECOMMENDATIONS - POST-CRASH FIRE HAZARD

- REQUEST THE ICAO TO IMPLEMENT THE PROPOSALS BY THE COORDINATING RESEARCH COUNCIL FOR IMPROVED ACCIDENT REPORTING RELevANT TO POST-CRASH FIRES.

Based on conclusion that investigations of better ways to protect aircraft and occupants against post-crash fires are hampered by inadequate data in accident reports.
Crash Resistant Fuel Cell Subgroup Conclusions

It is feasible to install crash-resistant fuel cells in fuselage cargo compartments.

It may be feasible to install some degree of crash-resistance at critical locations in some state-of-the-art aircraft wings, depending upon specific type design.

Further definition of criteria for improved crash-resistant fuel cells should evolve from total aircraft crashworthiness considerations if warranted by the results of additional accident data evaluation.
FAA RESPONSE

SPECIAL AVIATION FIRE AND EXPLOSION REDUCTION ADVISORY COMMITTEE

LONG-TERM RECOMMENDATIONS ON AIRCRAFT

CABIN INTERIOR MATERIALS

AND

POST-CRASH FIRE HAZARD

MARCH 5, 1980
PRESENTATION OUTLINE

- GENERAL
  - FAA AIRCRAFT SAFETY R&D PROGRAM
    MANAGEMENT

- INTERIOR MATERIALS
  - OVERVIEW OF CABIN FIRE SAFETY R&D
    PROGRAM
    - SAFER RECOMMENDATIONS
      - PLANNED R&D
      - RESULTS

- POST-CRASH FIRE HAZARD
  - OVERVIEW OF MODIFIED FUEL R&D PROGRAM
    - SAFER RECOMMENDATIONS
      - PLANNED R&D
      - RESULTS
FAA AIRCRAFT SAFETY R&D PROGRAM MANAGEMENT

ADMINISTRATOR

ASSOCIATE ADMINISTRATOR FOR AVIATION STANDARDS

PROGRAM MANAGEMENT STAFF

SAFETY REGULATIONS STAFF

OFFICE OF AVIATION SAFETY

OFFICE OF FLIGHT OPERATIONS

OFFICE OF AIRWORTHINESS

AIRCRAFT MANUFACTURING DIVISION

AIRCRAFT ENGINEERING DIVISION

AIRCRAFT MAINTENANCE DIVISION

REGION

MIKE MONROEY
AERONAUTICAL CENTER

CIVIL AEROMEDICAL INSTITUTE

ASSOCIATE ADMINISTRATOR FOR ENGINEERING AND DEVELOPMENT

NATIONAL AVIATION FACILITIES EXPERIMENTAL CENTER

AIRCRAFT SAFETY DEVELOPMENT DIVISION
CABIN FIRE PROBLEM

HIGH DENSITY PEOPLE/COMBUSTIBLES

ACCIDENT ANALYSIS

FIRE FATALITIES OCCUR IN CRASH ACCIDENTS
FIRE/TOTAL ACCIDENT FATALITIES 15 PERCENT
FIRE/SURVIVABLE ACCIDENT FATALITIES 40 PERCENT

IN-FLIGHT FIRE

U.S. AIRLINES RECORD FLAWLESS

FAA FIRE REGULATIONS

FLAMMABILITY HISTORY, 1947 - 1972
BUNSEN BURNER TEST
GOOD IGNITABILITY: LIMITED TEST CONDITIONS AND MEASUREMENTS

PROPOSED RULEMAKING
FLAMMABILITY, SMOKE, AND TOxicity
"PIECEMEAL" CRITICISM
OVERALL PROGRAM OBJECTIVES

CHARACTERIZE POSTCRASH TRANSPORT CABIN FIRE HAZARDS

ROLE OF INTERIOR MATERIALS

INCREASE THE SURVIVABILITY OF OCCUPANTS

DEVELOP TEST METHODS AND CRITERIA FOR INTERIOR MATERIALS

EXAMINE AND RECOMMEND

-FIRE MANAGEMENT/SUPPRESSION SYSTEMS

-EVACUATION AIDS

EXAMINE AND FOSTER THE USE OF IMPROVED MATERIALS
MAJOR PROGRAM TASKS

1. POSTCRASH CABIN FIRE HAZARDS CHARACTERIZATION

2. LABORATORY TEST METHODOLOGY DEVELOPMENT

3. SURVIVAL AND EVACUATION

4. FIRE MANAGEMENT AND SUPPRESSION

5. STANDARDS AND IMPROVEMENTS
PLANNED C-133 PROJECTS

1. CABIN HAZARDS WITHIN A BARE INTERIOR

2. CABIN HAZARDS WITHIN AN INTERIOR FURNISHED WITH "TYPICAL" WIDEBODY MATERIALS

3. CHARACTERIZATION OF A DESIGN FIRE

4. CABIN HAZARDS WITHIN AN INTERIOR FURNISHED WITH ADVANCED NASA MATERIALS

5. STUDIES TO CORRELATE SMALL-SCALE AND LARGE-SCALE TEST RESULTS
C-133

FULL-SCALE FIRE TEST FACILITY

UNIQUE DESIGN AND DIMENSIONS

SCHEDULED COMPLETION - MAY 1980

BEGIN TESTING - JULY 1980

SIGNIFICANT ACCELERATION IN TESTING

.ISOLATION FROM WINDS WHICH DESTROY TEST REPEATABILITY

.REGULARLY SCHEDULED TESTING INDEPENDENT OF WEATHER

.TESTING POSSIBLE IN WINTER
-MODELING-

INTRODUCTION

FULL-SCALE TESTS

-MOST DEFINITIVE SOURCES OF DATA, BUT COSTLY, TIME-CONSUMING

AND RELATIVELY INFLEXIBLE

MODELING

-LESS ACCURATE DATA, BUT MORE FLEXIBLE AND LESS TIME-CONSUMING

FAA SPONSORSHIP

-PHYSICAL FIRE MODELING...SCALED MODELS

-FROUDE...ATMOSPHERIC PRESSURE...NAFEC

-PRESSURE...30 ATMOSPHERES...FMRC NOW BUT LATER AT NAFEC

-MATHEMATICAL FIRE MODELING...SEMIEMPIRICAL COMPUTER PROGRAM FOR
PREDICTING FLAME SPREAD AND HAZARD DEVELOPMENT...UDRI...DAYTON

AIRCRAFT FIRE (DACFIR) MODEL
-MODELING-

GENERAL OBJECTIVES

DEVELOP RELIABLE PHYSICAL FIRE MODELING TECHNIQUES

BROADLY EVALUATE EFFECTS OF DIFFERENT MATERIALS AND MATERIAL SYSTEMS

EXAMINE DIFFERENT FIRE SCENARIOS, AMBIENT CONDITIONS, AND CONFIGURATIONAL FACTORS

ASSIST IN DETERMINING FULL-SCALE CONDITIONS

DEVELOP A RELIABLE MATHEMATICAL MODEL OF POSTCRASH CABIN FIRE (COMPUTER PROGRAM)

PREDICT EFFECTS OF CHANGES IN CABIN DESIGN AND INTERIOR MATERIALS
EXTRAMURAL EFFORTS

UDRI  -FURTHER DEVELOPMENT AND VALIDATION DACFIR
FMRC  -PRESSURE MODELING
       -SMOKE LAYER RADIATION
NASA (JSC)  -DACFIR VALIDATION TESTING
NASA (ARC)  -ADVANCED WINDOWS
       -CMA PROGRAM
NASA (JPL)  -THERMOCHEMICAL MODELING
NBS      -FIELD MODEL SOLUTIONS TO ASSIST UDRI DACFIR DEVELOPMENT
       .SMOKE LAYER GAS DYNAMICS
       .FUEL FIRE PENETRATION INTO FUSELAGE
       .FUSELAGE PRESSURE DISTRIBUTION
CAMI     -EVACUATION MODELING
INTRODUCTION

OBJECTIVE

- Laboratory test methodology development -
- Cabin materials screened using small-scale tests
- Flammability-ignitability, flame spread, heat, flashover
- Smoke-obscurant
- Toxicity-incapacitating or lethal nature of combustion products

To determine what test(s), test conditions, data or scientific treatment of data best relate to the fire hazards of burning cabin materials in a postcrash external fuel fire environment
-SURVIVAL AND EVACUATION-

INTRODUCTION

- FAA 90-SECOND EVACUATION DEMONSTRATION REQUIREMENT
- MUST QUANTIFY HUMAN TOLERANCE TO MAJOR PHYSICAL FIRE-RELATED HAZARDS
  - SMOKE AND IRRITANT GASES: IMPAIRMENT OF VISIBILITY
  - HEAT: THERMAL STRESS
  - OXYGEN DEPLETION: LIFE HAZARD
- SURVIVAL AND EVACUATION CLOSELY LINKED
- RAPID EVACUATION RATE IS OVERRIDING SAFETY CONSIDERATION
  - EMERGENCY LIGHTING FOR SMOKE-FILLED CABIN
  - HEAT RESISTANT EVACUATION SLIDES
  - SMOKE HOODS FOR PASSENGER/CREW PROTECTION
-SURVIVAL AND EVACUATION-

MAJOR ACTIVITIES

1. HUMAN SURVIVAL LIMITATIONS

2. EMERGENCY LIGHTING

3. EVACUATION SLIDES

4. SMOKE HOODS
-FIRE MANAGEMENT AND SUPPRESSION-

INTRODUCTION

. BUILDING FIRE PROTECTION PRIMARILY FIRE DETECTION, MANAGEMENT AND
SUPPRESSION
.
. SIMILAR CONCEPTS AIRCRAFT IN-FLIGHT FIRE PROTECTION
.
. CAN THESE OR OTHER CONCEPTS BE ADAPTED IMPROVEMENT POSTCRASH CABIN FIRE
SAFETY?

RECENT EXPERIMENTAL STUDIES

. FAA/NAFEC

. COMPARTMENTATION: QUESTIONABLE BENEFIT: UNKNOWN EFFECT ON EVACUATION
.
. HALON 1301: EFFECTIVE FIRES WHOLLY WITHIN CABIN; COUNTERPRODUCTIVE
EXTERNAL FUEL FIRE
.
. C-133: EFFECT OF GALLEY BLOCKAGE
.

. NASA/MCDONNELL/BOEING

. GALLEY AND CARGO COMPARTMENT HARDENING
FIRE MANAGEMENT AND SUPPRESSION

COMMENCING IN FY-80

PHASE I (CONTRACT)

.DETERMINE FEASIBILITY AND ESTIMATE COST/BENEFIT

.IDENTIFY PROMISING CONCEPTS REQUIRING EXPERIMENTATION

PHASE II (CONTRACT OR IN-HOUSE)

.EXPERIMENTAL STUDY PROMISING CONCEPTS

PHASE III (CONTRACT)

.DESIGN STUDY OF BEST RATED SYSTEM

.DERIVE HARD DATA INITIAL AND RECURRING COSTS

.CALCULATE ACCURATE COST/BENEFIT FOR COMPARISON ADVANCED MATERIALS SYSTEMS
-STANDARDS AND IMPROVEMENTS-

MAJOR ACTIVITIES

1. ACCEPTABILITY CRITERIA ANALYSIS

2. DATA BANK

3. IMPROVEMENTS IN SPECIFIC USAGE CATEGORIES
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NASA PLANNING

AIRCRAFT INTERIOR FIRE TECHNOLOGY

- NASA PROGRAM SHIFTING FROM EMPHASIS ON MATERIALS RESEARCH TO MORE
  SYSTEMS ORIENTED APPROACH:
  
  THREAT SCENARIO, FUEL SYSTEMS, TESTING, MODELLING, TOXICOLOGY,
  MATERIALS DEVELOPMENT

- NASA CURRENTLY ENGAGED IN LONG TERM PLANNING --
  COORDINATED AND CONSISTENT WITH SAFER CABIN INTERIOR R&D

- PLANNING COORDINATED WITH FAA AND NBS

- PLAN AND IMPLEMENTATION BEFORE SUMMER, 1980 TO IMPACT FY 82 FUNDING
  PLANS

- NASA HAS FUNDING PLACE HOLDER (FIREMEN II) -- NOT APPROVED FUNDING

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NASA

CABIN INTERIOR TECHNOLOGY

- FIREMEN -- $450K, R&T BASE -- $400K
- MATERIALS, MODELLING, FULL SCALE TESTING, TOXICITY
  - INTERIOR PANELS - FILMS, INKS
  - SEATS - NEOPRENE AND POLYIMIDE FOAM
    - BLOCKING LAYER
    - WOOL/ NYLON AND KERMEL/ WOOL FABRICS
    - FULL SCALE TESTING
  - MODELLING - GLOBAL ENCLOSURE
  - TESTING -
    BOEING 737
    CABIN FIRE SIMULATOR (DOUGLAS)
SAFER RECOMMENDATIONS

INTERIOR MATERIALS

POST-CRASH CABIN FIRE HAZARDS CHARACTERIZATION

FULL-SCALE EXPERIMENTS

- EXPEDITE AND COORDINATE C-133 AND SIMILAR FULL-SCALE FIRE TESTS
- ESTABLISH CONTRIBUTION OF CABIN INTERIOR MATERIALS RELATIVE TO THE POST-CRASH FIRE HAZARD

FIRE MODELING

- COORDINATE AND ACCELERATE DEVELOPMENT OF ANALYTICAL POST-CRASH AIRCRAFT FIRE MODELING

SCENARIO ANALYSIS

- DEFINE A DESIGN POST-CRASH FIRE SCENARIO(S)
SAFER RECOMMENDATIONS

LABORATORY TEST METHODOLOGY DEVELOPMENT

• EXPEDITE THE DEVELOPMENT OF THE OSU CHAMBER AND EVALUATE ITS USE AS A REGULATORY TOOL (WITHIN 3 YEARS)

• ACCELERATE TOXICITY RESEARCH EFFORT TO IDENTIFY AND UNDERSTAND THE BIOLOGICAL CHEMICAL AND PHYSICAL FACTORS THAT MUST BE INTEGRATED INTO COMPREHENSIVE FIRE RISK ASSESSMENTS FOR MATERIALS IN SPECIFIC USE CONFIGURATION
SAFER RECOMMENDATIONS

SURVIVAL AND EVACUATION

- THAT FAA EVALUATE THE USE OF SELF-CONTAINED SMOKE MASKS, GLOVES, CLOTHING, OR OTHER PERSONAL PROTECTION EQUIPMENT FOR CREWMEMBERS IN ORDER THAT THEY CAN BETTER COMPLETE EMERGENCY EVACUATION UNDER THE POST-CRASH CONDITION

- COMPLETE PRELIMINARY EVALUATION OF THE TEST PROCEDURE AND PRESENT MATERIALS FOR EVACUATION SLIDES BY MAY 1980
SAFER RECOMMENDATIONS

STANDARDS AND IMPROVEMENTS

- DEVELOP CABIN INTERIOR MATERIAL DATA BANK

- CONTINUE DEVELOPMENT OF LOW-SMOKING FIRE-RESISTANT SEAT FOAMS

- DEVELOP FOR NEW SEAT DESIGNS, FIRE BLOCKING LAYER (FIRE BARRIER) TO PROTECT PRESENT POLYURETHANE FOAM CUSHIONING MATERIAL (1 YEAR)
SAFER RECOMMENDATIONS

GENERAL

- PROMOTE OPEN FORUMS, DOCUMENTS, AND PRESENTATIONS TO MAKE THE SUBJECT OF TOXICOLOGY MORE UNDERSTANDABLE TO REGULATORY BODIES, FLIGHT CREWS, AND TO THE PUBLIC.
PROJECT: CABIN HAZARDS WITH UNFURNISHED INTERIOR

OBJECTIVE

- DEFINE INTERIOR HAZARD DEVELOPMENT AS CAUSED BY EXTERNAL FUEL FIRE WITH NO CABIN MATERIAL CONTRIBUTION

BACKGROUND

- LITTLE DATA IN EXISTENCE ON PENETRATION OF FIRE INTO FUSELAGE OPENING
- MOST PREVIOUS WORK ON FUSELAGE BURN-THROUGH AND IN-FLIGHT TYPE FIRES

TECHNICAL APPROACH

- DEVELOP POOL FIRE SCENARIO FOR C-133 WHICH WOULD REPRESENT A MAJOR FUEL FIRE
- CHARACTERIZE RESULTANT INTERIOR HAZARD DEVELOPMENT
PROJECT: CABIN HAZARDS/"TYPICAL" MATERIALS

OBJECT:

- HAZARD BURNING MATERIALS VIS-A-VIS FUEL FIRE
- RELATIVE IMPORTANCE HEAT, SMOKE, AND TOXIC GASES

BACKGROUND

- IMPORTANCE AND ROLE OF MATERIALS CONTROVERSIAL
- SAFER RECOMMENDATION

TECHNICAL APPROACH

- "TYPICAL" WIDE BODY MATERIALS
- 3 TEST CONDITIONS: "O" WIND, "O" WIND PLUS GUST, AND STEADY WIND
- COMPARE HAZARDS/SURVIVABILITY WITH AND WITHOUT INTERIOR MATERIALS
- C-133 -

PROJECT: CHARACTERIZATION OF A DESIGN FIRE

OBJECTIVE

- DEFINE DESIGN FIRE STANDARD FOR LARGE-SCALE TESTS

BACKGROUND

- RELATIVELY FEW DIVERGENT LARGE-SCALE TESTS
- SAFER RECOMMENDATION: ADVANTAGES
- C-133 BEST MEETS SAFER DESIGN FIRE CRITERIA

TECHNICAL APPROACH

- DETERMINE FIRE THAT PRODUCES DESIRED SURVIVAL TIME (E.g., 5 MINUTES)
- BARE INTERIOR
- DESCRIBE EXTERNAL AND INTERNAL CONDITIONS
PROJECT: CABIN HAZARDS/NASA ADVANCED MATERIALS

OBJECTIVE
- SAFETY △ IN-SERVICE VERSUS ADVANCED NASA MATERIALS

BACKGROUND
- ARE IN-SERVICE MATERIALS BEST AVAILABLE?
- WHAT IS SAFEST ENVIRONMENT POSSIBLE?
- SAFER RECOMMENDATION

TECHNICAL APPROACH
- SIMILAR TO "TYPICAL" MATERIALS TESTS
- RELY ON NASA EXPERTISE FOR ADVANCED MATERIALS
- EXAMINE AT LEAST 3 MATERIAL SYSTEMS UNDER DESIGN FIRE CONDITIONS
PROJECT: CORRELATE LARGE AND SMALL SCALE TESTS

C-133 BEST TEST ARTICLE NEW AVAILABLE

OTHER DEVELOPMENTS AND RECOMMENDATIONS MAY IMPACT ITS USE: E. G.,

- SAFER RECOMMENDATIONS
- GUIDANCE/DIRECTION CORRELATION STUDIES REVIEW
- DEVELOPMENTS IN FIRE MANAGEMENT AND SUPPRESSION STUDY
<table>
<thead>
<tr>
<th>FULL SCALE (C-133) EXPERIMENTS MAJOR PROJECTS</th>
<th>FY 80</th>
<th>FY 81</th>
<th>FY 82</th>
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- CABIN HAZARDS/BARE INTERIOR
- CABIN HAZARDS/"TYPICAL" WIDE BODY MATERIALS
- MOVE TO NEW FULL-SCALE FIRE TEST FACILITY
- CHARACTERIZATION DESIGN FIRE
- CABIN HAZARDS/ADVANCED NASA MATERIALS
- CORRELATION SMALL-SCALE/LARGE-SCALE TESTS

△ ACTIVITY INITIATED
△△ ACTIVITY COMPLETED (FINAL REPORT DEPT)
SUMMARY OF PRELIMINARY FINDINGS FOR FUEL FIRES

1. SIGNIFICANT STRATIFICATION OF HEAT, SMOKE AND GASES

2. HEAT AND SMOKE MORE HAZARDOUS THAN CARBON MONOXIDE

3. INSIGNIFICANT OXYGEN DEPLETION
C-133 SMOKE-TEMPERATURE RELATIONSHIP

-5'6" HIGH
-30' FROM FIRE DOOR
-8' x 10' FIRE
FULL-SCALE TESTS
(NO INTERIOR)

OBJECTIVE

- TO DETERMINE CABIN HAZARDS FROM INFINITE POOL FIRE WITH VARYING EXIT OPENINGS

TECHNICAL APPROACH

- POOL FIRE - 20' X 20'
- VARYING WINDS
- VARYING EXIT STATUS
SEATS
A. FLAME RETARDANT POLYURETHANE FOAM (COMFORT SECTION)
B. FLAME RETARDANT EXPANDED POLYURETHANE FOAM
   (FLOATATION SECTION)
C. SEAT FABRIC = WOOL/VINYL BLENDS

CEILING PANELS
\( \frac{1}{2}'' \) PVF/FIBERGLASS - EPOXY AND NOMEX - HONEYCOMB/FIBERGLASS - EPOXY

HATRACK
\( \frac{1}{2}'' \) PVF/FIBERGLASS - EPOXY AND NOMEX - HONEYCOMB/FIBERGLASS - EPOXY

SIDEWALL PANEL - HONEYCOMB
\( \frac{1}{2}'' \) PVF/FIBERGLASS - EPOXY AND NOMEX - HONEYCOMB/FIBERGLASS - EPOXY

WINDOW REVEAL
THERMOFORMED PART (POLYCARBONATE)

WINDOW SHADE
THERMOFORMED PART (POLYCARBONATE)

CARPET
WOOL
CABIN HAZARDS FROM C133
WITH INTERIOR MATERIALS

TEMPERATURE (FAR) x 10^-3
OPTICAL DENSITY PER FOOT
CARBON MONOXIDE (PERCENT)

TEST NO. 11 12/12/79
20' AFT OF DOOR OPENING
HEIGHT ABOVE FLOOR: 5'6"
FIRE MATERIAL TEST RESULTS

PRELIMINARY

- Burning material can significantly contribute to the internal cabin hazard during a post-crash fire.

- Major stratification of hazards exist.

- Initial fire spread in the cabin was slow (confined to area around doorway).

- Burning and deterioration of ceiling contributed to rapid spread of the fire later in the test (3 minutes).
- FIRE MODELING -

PLANNED RESEARCH AND DEVELOPMENT

MODELING TYPES

MATHEMATICAL
- ZONE MODELS (SEMI-EMPIRICAL)
- FIELD MODELS (FULLY THEORETICAL)

PHYSICAL
- FROUDE (REDUCED SIZE)
- PRESSURE (REDUCED SIZE AND INCREASED PRESSURE)
SAFER RECOMMENDATIONS

MAINTENANCE AND RESTORATION

FIELD MODELS

• DIRECT AND COMPLETE DEVELOPMENT OF DACFIR MODEL (UDRI)
• APPLY SMOKE LAYER RADIATION TECHNOLOGY TO AIRCRAFT CABIN FIRE (FACTORY MUTUAL)

• APPLY THERMOCHEMICAL MODELING TO SEATS AND CARPET (NASA/JPL)
• PERFORM 2-D FIELD MODEL EVALUATION OF SPREADING SMOKE LAYER IN AIRCRAFT CABIN (NBS)
• DEVELOP 3-D FIELD MODEL FOR FIRE PENETRATION IN A FUSELAGE OPENING (NBS)
• DETERMINE PRESSURE DISTRIBUTION AROUND FUSELAGE UNDER FIRE PLUME (NBS)
SAFETY RECOMMENDATIONS

PHYSICAL MODELING

FROUDE MODELING (NAFEC)

- ½ SCALE WORK: SCENARIO ANALYSIS
- ½ SCALE WORK: C-133 CORRELATION, DESIGN FIRE; COMPARTMENTATION, SMOKE AND GASES
- MODEL OF FULL-SCALE FIRE TEST FACILITY

PRESSURE MODELING

- CEILING FIRE VALIDATION (FACTORY MUTUAL)
- COMPLETE AIRCRAFT FUSELAGE MODEL (NAFEC FACILITY)
PHYSICAL MODELING ACCOMPLISHMENTS

- REDesign of C-133 TEST FIRE

- EXPERIMENTAL AND THEORETICAL CHARACTERIZATION OF POOL FIRE RADIATION THROUGH A DOORWAY

- DISCOVERY OF EFFECTS OF WIND AND DOOR OPENING CONFIGURATION

- CHARACTERIZATION OF TEMPERATURE STRATIFICATION EFFECTS

- NEW FLAMMABILITY RANKING SYSTEM

- VERIFICATION OF VALIDITY OF PRESSURE MODELING OF VERTICALLY BURNING MATERIALS
<table>
<thead>
<tr>
<th>FIRE MODELING MAJOR EFFORTS</th>
<th>FY 80</th>
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</table>

- DACFIR DEVELOPMENT/VALIDATION
- THERMAL DEGRADATION MODEL
- PLUME ANALYSIS
- SMOKE RADIATION
- THEORY WIND/DOORS FIRE
- DERIVE FRBOJE EQUATIONS
- COMPREHENSIVE FRBOJE EVALUATION
- NAFEC FRBOJE STUDIES
- CONSTRUCT NAFEC PRESSURE MODELING FACILITY
- FMRC P-MODELING STUDIES
- NAFEC P-MODELING STUDIES

**INTERIM REPORT**

- Activity Initiated
- Activity Completed
- Potential Continuation
NASA

FIRE MODELLING

- JPL

- GLOBAL MODEL - CABIN ENCLOSURE - VENTILATED

- LIMITED ENERGY RELEASE CRITERIA

- TRANSIENT, TWO-DIMENSIONAL

- CONSERVATION EQUATIONS FOR:
  - MASS
  - MOMENTUM
  - SPECIES
  - ENERGY

- BOUNDARY CONDITIONS
  - POOL OF FUEL
  - WALLS
  - OPENINGS
POST-CRASH CABIN FIRE HAZARDS CHARACTERIZATION

- SCENARIO ANALYSIS -

SAFER RECOMMENDATION

- DEFINE A DESIGN POST-CRASH FIRE SCENARIO(S)
LABORATORY TEST METHODOLOGY DEVELOPMENT

SAFER RECOMMENDATION

- EXPEDITE THE DEVELOPMENT OF THE OSU CHAMBER AND EVALUATE ITS USE AS A REGULATORY TOOL (WITHIN 3 YEARS)
OSD TEST CHAMBER PLANNED RESEARCH AND DEVELOPMENT

- WORK WITH ASTM TO STANDARDIZE AND ADOPT

- CONTINUE CHI PROGRAM

- USE FOR MATERIAL EVALUATION AT NAFEC

- ATTEMPT CORRELATION WITH REALISTIC FIRE BEHAVIOR IN FULL-SCALE AND MODEL SCALE TESTING

- PARTICIPATE IN SAFER RECOMMENDED GROUP FOR EVALUATION AS A REGULATORY TOOL
<table>
<thead>
<tr>
<th>LAB TEST DEVELOPMENT MAJOR EFFORTS</th>
<th>FY 80</th>
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<td>CY 83</td>
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- DEVELOP CTF TOXICITY TEST
- DEVELOP OSU TEST CHAMBER (SAFER CO-OPERATIVE EFFORT)
- BUNSEN BURNER/ELEVATED TEMPERATURE
- DEVELOP FLAME SPREAD TEST
- FLASHOVER STUDY
- FLAMING G COMBUSTION STUDY
- DEVELOP HCN, H₂S ANALYSIS
- DEVELOP FULL-SCALE TEST ANIMAL MODEL
- COMBINED HAZARD INDEX
- REVIEW CORRELATION STUDIES
- CORRELATION STUDY

△ ACTIVITY INITIATED
▲ ACTIVITY COMPLETED
□ POTENTIAL CONTINUATION
LABORATORY TEST METHODOLOGY DEVELOPMENT

SAFER RECOMMENDATION

ACCELERATE TOXICITY RESEARCH EFFORT TO IDENTIFY AND UNDERSTAND THE BIOLOGICAL, CHEMICAL, AND PHYSICAL FACTORS THAT MUST BE INTEGRATED INTO COMPREHENSIVE FIRE RISK ASSESSMENTS FOR MATERIALS IN SPECIFIC USE CONFIGURATION
-TOXICITY-

PLANNED FUTURE STUDIES
.C-133 MATERIALS GAS EMISSIONS AND TOXICITY MEASUREMENTS
LABORATORY TEST METHODOLOGY DEVELOPMENT
.FURTHER DEVELOPMENT OF COMBUSTION TUBE FURNACE
  - UNIDIRECTIONAL HEATING
  - FLAMING COMBUSTION
  - IRRITANT GASES EFFECTS
.DEVELOPMENT OSU CHAMBER HEAT/SMOKE/GASES
.CONTINUED PARTICIPATION NBS TOXICITY PROTOCOL (CAMI)

SURVIVAL AND EVACUATION
.STUDY ESCAPE IMPAIRMENT IRRITANT GASES
  - PRIMATES (ESCAPE)
  - RATS (INCAPACITATION)
.STUDY TOXICITY OF HEAT AND GASES IN COMBINATION
.DEVELOP "STATE-OF-ART" HUMAN SURVIVAL MODEL
CURRENT STATUS

NO STANDARDIZED COMBUSTION TOXICITY TESTS EXIST
SAFER AD HOC COMMITTEE ON TOXICOLOGY
MANY FUNDAMENTAL PROBLEMS STILL EXIST

RECENT FAA WORK

COOPERATIVE PROGRAM BETWEEN CAMI AND NAFEC
DEVELOPMENT OF COMBUSTION TUBE FURNACE
EVALUATED 75 CABIN MATERIALS
- ANIMAL TOXICITY AT CAMI
- TOXIC GASES YIELDS AT NAFEC
CORRELATION ANIMAL/TOXIC GASES DATA
- TOXICITY DESCRIBED BY SYSTEMIC POISONS
- IRRITANT GASES HAD NO DIRECT EFFECT ON TOXICITY

CURRENT FAA WORK

CAMI - NBS PROTOCOL
NAFEC C-133 SUPPORT
SAFER RECOMMENDATION

- PROMOTE OPEN FORUMS, DOCUMENTS, AND PRESENTATIONS TO MAKE THE SUBJECT OF TOXICOLOGY MORE UNDERSTANDABLE TO REGULATORY BODIES, FLIGHT CREWS, AND TO THE PUBLIC
COMMUNICATION OF TOXICOLOGY PROBLEM
(CAM. LEADERSHIP)

1. SPONSOR ANNUAL WORKING CONFERENCES OF PRINCIPAL INVESTIGATORS

2. PROMOTE GREATER COORDINATION OF FAA COMBUSTION TOXICOLOGY PROGRAMS WITH OTHER AGENCIES OF THE GOVERNMENT

3. BRING TO THE ATTENTION OF CREWS, AIRCRAFT OWNERS, AND OPERATORS PASSENGERS, AND THE GENERAL PUBLIC THE COMPLEX NATURE OF THE HAZARDS OF FOG IN AVIATION
SURVIVAL AND EVACUATION

SAFER RECOMMENDATION

- THAT FAA EVALUATE THE USE OF SELF-CONTAINED SMOKE MASKS, GLOVES, CLOTHING, OR OTHER PERSONAL PROTECTION EQUIPMENT FOR CREWMEMBERS IN ORDER THAT THEY CAN BETTER COMPLETE EMERGENCY EVACUATION UNDER THE POST-CRASH CONDITION
PROTECTIVE BREATHING/VISION DEVICES - STATUS

CURRENT

- OXYGEN MASKS STANDARDS - PAX CONTINUOUS FLOW TSO C64, CREW DEMAND TSO C78
- RESEARCH AND DEVELOPMENT CAMI PROGRAM
- SAE STANDARDS, AIO COMMITTEE - AIRCRAFT OXYGEN EQUIPMENT DRAFT AS 831 (1980)
- FAA STANDARDS, TSO - PROTECTIVE BREATHING EQUIPMENT (PORTABLE/NONPORTABLE (1980))
- FAA OPERATIONAL EQUIPMENT REQUIREMENTS - NPRM (1980)
### Training Devices

<table>
<thead>
<tr>
<th>Phase</th>
<th>Male/Female</th>
<th>Type</th>
<th>No. Types Tested</th>
<th>No. Passed (Demand with Positive Pressure)</th>
<th>No. Passed (Demand Only)</th>
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<td>Phase I</td>
<td>Male</td>
<td>Mask Goggles</td>
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<td>Fullface</td>
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<td>6</td>
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<td>Hoods</td>
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<td>2</td>
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<td>Phase II</td>
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<td>Mask/Goggles</td>
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<td>Phase III</td>
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<tr>
<td>Phase IV</td>
<td>Male/Female</td>
<td>Use of Fullface Masks during Decompressions</td>
<td>64 Tests Completed, Data Being Processed</td>
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<tr>
<td>Phase V</td>
<td>Male</td>
<td>Effect of Beards on Crew Oxygen Stays</td>
<td>54 Tests Completed, Beards Caused Decrease</td>
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<tr>
<td>Phase VI</td>
<td>Female</td>
<td>Same as Phase V; for Female Faces, No Success</td>
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*Approximately 2,850 Tests*
HEAT RESISTANCE OF EVACUATION SLIDE MATERIALS

PLANNED RESEARCH AND DEVELOPMENT AND SCHEDULE

1979     1980

- DEVELOP A LABORATORY TEST APPARATUS
- EXAMINE AND SELECT AN OPTIMUM REFLECTIVE COATING
- EVALUATE ADVANCE MATERIALS
- CONDUCT FULL-SCALE SLIDE POOL FIRE TESTS

AUGUST
MARCH
NOVEMBER
CURRENT MATERIALS
ADVANCED MATERIALS
SEPTEMBER
OVERVIEW OF STUDY TASKS

TASK 1
1.1 Survey of possible data base usage
1.2 Study of potential data system
1.3 Personnel involved data gathering

TASK 2
2.1 Survey of commercially available software package which may be applicable
2.2 Survey hardware systems which may be suitable to support data base requirements
2.3 Estimate administrative support and costs to operate most likely combination
2.4 Synthesis and analysis: to make data system recommendations

TASK 3
3.1 Preliminary design of model, data structure, and data base to some data base hardware and software requirements
3.2 Review of existing related work and past investigative contributions to data base design of testing framework
3.3 Synthesis and analysis to make final system structure and final system design
OVERVIEW OF STUDY TASKS

TASK 1
- SURVEY OF POTENTIAL USERS
- SURVEY OF POTENTIAL DATA SUPPLIERS
- PRELIMINARY DATA GATHERING

TASK 2
- SURVEY OF DEVELOPMENTAL GUIDELINES AND SOFTWARE
- SURVEY OF HARDWARE SYSTEMS

TASK 3
- REVIEW OF EXISTING MODELS
  - ADMINISTRATION
  - ASSESSMENT OF EFFECTIVE IMPLEMENTATION FOR
  - RECOMMENDATION

ESTIMATES OF ADMINISTRATIVE SUPPORT AND COST
THE DATABASE CONTENTS AND SCOPE ALSO VARIES WITH THE MATERIAL ATTRIBUTES INCLUDED. EACH MATERIAL MAY BE DESCRIBED WITH THE FOLLOWING SPECTRUM OF ATTRIBUTES:

- MATERIAL NAME
- MATERIAL MANUFACTURER
- DESCRIPTION
- FIRE TEST DATA
  - FIRE TEST RESULTS
  - FLAME SPREAD
  - FIRE CONTAINMENT/BURN THROUGH
  - HEAT RELEASE, ETC.
- SMOKE AND TOXICITY DATA
- PHYSICAL PROPERTIES
- COST DATA
STANDARDS AND IMPROVEMENTS

SAFER RECOMMENDATIONS

- CONTINUE DEVELOPMENT OF LOW-SMOKING FIRE-RESISTANT SEAT FOAMS

- DEVELOP FOR NEW SEAT DESIGNS, FIRE BLOCKING LAYER (FIRE BARRIER) TO PROTECT PRESENT POLYURETHANE FOAM CUSHIONING MATERIAL (1 YEAR)
- IMPROVEMENTS IN SPECIFIC USAGE CATEGORIES -

SEAT CUSHIONS

- OBJECTIVE:
  - CONDUCT STUDIES SUPPORT PROTECTION/REPLACEMENT URETHANES

- BACKGROUND:
  - URETHANE FOAMS MOST FLAMMABLE CABIN MATERIALS USED
  - SAFER RECOMMENDATION

- TECHNICAL APPROACH:
  - JOINT NASA/NAFEC EFFORT
  - NASA: SCREEN MATERIALS, CONDUCT INITIAL EVALUATION, FABRICATE SEAT ASSEMBLIES
  - NAFEC: CONDUCT DESIGN FIRE EXPERIMENTS IN C-133
NASA

SEAT TECHNOLOGY

• 1979 - MATERIAL SCREENING

MATERIALS SELECTED

FABRIC - KERMEL/WOOL, WOOL/NYLON

BLOCKING LAYER - VONAR 3, DURRETTE, KYNOL

ADHESIVE - R 2332 NF

CUSHION - POLYIMIDE, NEOPRENE

1980 - FABRICATE FULL SCALE COMPONENTS

- TEST SEATS AND BACKS - SEPT. 1980

CABIN FIRE SIMULATOR (DOUGLAS)

- TEST FULL SCALE SEATS - MARCH 1981

B737 CABIN (JOHNSON SPACE CENTER)
SAFER RECOMMENDATIONS

POST-CRASH FIRE HAZARD

- CONTINUE AND EXPEDITE FAA/NASA RESEARCH TO ESTABLISH A REALISTIC AIRPLANE CRASH SCENARIO WITH INCREASED EMPHASIS ON POST-CRASH FUEL SYSTEM FAILURE MODES AND EFFECTS ON CABIN FIRE SAFETY

- FROM THE CRASH SCENARIO, DEVELOP FUEL SYSTEM DESIGN CRITERIA WHICH TRANSPORT CATEGORY AIRCRAFT MUST MEET IN ORDER TO MINIMIZE POST-CRASH FUEL FIRES
FAA PLANNED RESEARCH AND DEVELOPMENT

TRANSPORT CRASH SCENARIOS

TASK I

- DEVELOPMENT OF CRASH SCENARIOS
  - REVIEW AND EVALUATION OF ACCIDENT DATA 5/80
  - CRASH DESIGN REQUIREMENTS AND PROCEDURES 7/80
  - HUMAN TOLERANCE AND OCCUPANT PROTECTION 8/80
  - CATEGORIZATION OF CRASH IMPACT CONDITIONS 9/80
  - ANALYSIS OF SELECTED AIRPLANE ACCIDENT CONDITIONS 10/80
  - FINALIZATION OF CRASH SCENARIOS 11/80

ESTIMATED COMPLETION

TASK II

- IDENTIFICATION OF STRUCTURAL AND SUBSYSTEMS FAILURES
  - STRUCTURAL SYSTEMS 11/80
  - PROPULSION AND FUEL SYSTEM 12/80
  - FIRE 12/80
  - MATRIX CATEGORIZATION 1/81
  - ASSESSMENT OF ADVANCED MATERIAL USAGE 2/81
FAA PLANNED RESEARCH AND DEVELOPMENT
TRANSPORT CRASH SCENARIOS (CONTINUED)

TASK III
- CRITERIA AND DESIGN PHILOSOPHY
  - US ARMY CRASH SURVIVAL DESIGN GUIDE (REVISED ) 10/80
  - DYNAMIC RESPONSE INDEX MODEL 12/80
  - MERIT FUNCTIONS 2/81

TASK IV
- AVAILABLE TEST DATA, TEST TECHNIQUES, AND
  ANALYTICAL METHODS
  - TEST DATA AND TECHNIQUES 1/81
  - IDENTIFICATION OF FUTURE TEST PROGRAM REQUIREMENTS 4/81
  - REVIEW OF AVAILABLE ANALYTICAL TECHNIQUES 3/81
  - RECOMMENDATION OF FUTURE ANALYTICAL EFFORTS 5/81
NASA PLANNED RESEARCH AND DEVELOPMENT

TRANSPORT POST-CRASH FIRE HAZARDS

MONTHS FROM CONTRACT

3

TASK I
- CRASH FIRE PROBLEM
  - REVIEW DATA - IN-HOUSE, INDUSTRY, AND LITERATURE
  - CATEGORIZATION OF DATA - FIRE FATALITIES AND CRASH CHARACTERISTICS
  - ANALYZE USE OF COMPOSITE MATERIALS

5

TASK II
- CRASH FIRE SAFETY CONCEPTS
  - REVIEW DATA - IN-HOUSE, INDUSTRY, AND LITERATURE
  - IDENTIFY NEW AND/OR EXISTING CRASH FIRE SAFETY CONCEPTS

7

TASK III
- CONCEPT CHARACTERIZATION
  - COST/BENEFIT ANALYSIS OF IDENTIFIED CONCEPTS

TASK II
PHASE I

- OBTAIN AND/OR REVIEW EXISTING ACCIDENT DATA
  - MANUFACTURERS, NTSB, FAA

- CATEGORIZATION OF CRASH IMPACT CONDITIONS
  - WEIGHT CONFIGURATION, CRASH ENVIRONMENT, TERRAIN/WATER
  - STRUCTURAL, PROPULSION, AND FUEL SYSTEM DAMAGE
  - STABILITY AND CONTROL FAILURES
  - POST-CRASH CONDITION, SURVIVABILITY
  - FUEL SPILLAGE, FIRE

- DEVELOP MATRIX OF POTENTIALLY SURVIVABLE CRASH CONDITIONS
  - STRUCTURAL CRASH IMPACT DYNAMICS ANALYSES OF ACCIDENT - AIRFRAMES, FUEL SYSTEMS, INTERIORS, EGRESS, FIRE
POST-CRASH FIRE HAZARD

SAFER RECOMMENDATIONS

- SUPPORT A TRANSPORT HELICOPTER POST-CRASH FIRE STUDY SIMILAR TO THE PRECEDING RECOMMENDATION
PHASE II

- IDENTIFICATION OF INJURY/FATALITY CAUSATIVE FEATURES
  - IDENTIFICATION OF STRUCTURAL AND SUBSYSTEM FAILURES - AIRFRAMES, CABIN, FUEL SYSTEM, EGRESS, FIRE, ETC.
  - FREQUENCIES OF OCCURRENCE/SEVERITY
  - INTERRELATIONSHIP OF CAUSATION FACTORS

PHASE III

- IDENTIFICATION OF TEST TECHNIQUES AND ANALYTICAL METHODS APPLICABLE TO ROTORCRAFT
  - CURRENT TEST TECHNIQUES
  - REVIEW OF AVAILABLE ANALYTICAL TECHNIQUES
  - IDENTIFICATION OF FUTURE ANALYTICAL EFFORTS

PHASE IV

- DEFINE AREAS OF RESEARCH AND DEVELOPMENT FOR IMPROVING ROTORCRAFT CRASHWORTHINESS
  - EVALUATE US ARMY EFFORTS
  - IDENTIFICATION OF FUTURE TEST PROGRAMS
SAFER RECOMMENDATIONS

POST-CRASH FIRE HAZARD

MODIFIED FUEL

- EXPAND THE INVESTIGATION OF AMK AND ITS PROPERTIES WITH RESPECT TO ALL OPERATIONAL ASPECTS OF COMMERCIAL TRANSPORT AIRCRAFT.
  - DEVELOP AMK PERFORMANCE SPECIFICATION.
  - INVESTIGATE THE APPLICABILITY OF ANTIMISTING CONCEPTS OF BROADENED SPECIFICATION HYDROCARBON FUELS.
  - INVESTIGATE REDUCED FLASH POINTS OF KEROSENE FUELS.
  - ENCOURAGE NASA TO INCLUDE AMK TECHNOLOGY IN ITS LONG-RANGE FUEL PROGRAM FOR ADVANCED ENGINE SYSTEMS.

BROADER LARGE-SCALE VALIDATION TEST.
ANTIMISTING FUEL PROGRAM

5-PHASE PROGRAM

- FEASIBILITY/SCOPE
- PROTOTYPE SCREENING
- PROTOTYPE DEVELOPMENT
- PROTOTYPE DEMONSTRATION
- RECOMMENDATIONS/INTRODUCTION SCHEDULE
ANTIMISTING FUEL PROGRAM

PROGRAM MANAGEMENT

PHASE I - FEASIBILITY/SCOPE


- RESPONSIBILITIES

  - DOT/FAA
    AIRCRAFT FUEL SYSTEM COMPATIBILITY
    LARGE-SCALE CRASH FLAMMABILITY RESISTANCE
    FLAMMABILITY CHARACTERISTICS
    RHEOLOGICAL PROPERTIES

  - U.K./RAE
    PRODUCTION
    BLENDING
    FLAMMABILITY CHARACTERISTICS
    RHEOLOGY
    FUEL SYSTEM COMPATIBILITY
PROGRAM MANAGEMENT (CONTINUED)

- U.S./NASA

ENGINE FUEL SYSTEM COMPATIBILITIES
BASIC RHEOLOGY

PHASES II, III, IV, AND V

- IN ACCORDANCE WITH ED-79-

- U.S./DOT/FAA, ALL TECHNICAL/BUDGETARY RESPONSIBILITIES
ANTIMISTING KEROSENE (AMK)

- COMPATIBILITY WITH GAS TURBINE ENGINE COMPONENTS
  - LEWIS RESEARCH CENTER/PRATT AND WHITNEY A.C. - $700K, 1 YR
  - FUEL INJECTOR, CONTROLLER, FILTER, COMBUSTOR, PUMP
  - PHYSICAL AND CHEMICAL CHARACTERIZATION - EFFECT ON MATERIALS

- RHEOLOGY AND FLUID PROPERTIES
  - JPL AND AMES RESEARCH CENTER - $300K/YEAR
  - GELLATION
  - SOLVENT EFFECTS
  - DROPLET PHYSICS
  - DRAG MEASUREMENTS
PHASE I - FEASIBILITY/SCOPE

- BASIC CHARACTERISTICS
- FLAMMABILITY LIMITS/EQUIPMENT PROJECTS
- RHEOLOGY/QUALITY CONTROL PROJECTS
- COMPATIBILITY PROJECTS
- SPECIFICATION OUTLINE PROJECTS
- PRODUCTION PROBLEMS PROJECTS
ANTIMISTING FUEL PROGRAM

PHASE I - FEASIBILITY/SCOPE

○ BASIC CHARACTERISTICS

- FLAMMABILITY LIMITS/EQUIPMENT PROJECTS

○ LABORATORY SCALE FLAMMABILITY RIG

○ EFFECT OF OTHER FLAMMABLES

○ P.M.F. DEFINITION DEVELOPMENT

○ IGNITION INTENSITY REQUIREMENTS

○ DROPLET CHARACTERIZATION

○ FLAME PROPAGATION RATE

○ POOL FIRE IGNITION SUSCEPTIBILITY
ANTIMISTING FUEL PROGRAM

PHASE I - FEASIBILITY/SCOPE

- BASIC CHARACTERISTICS

- RHEOLOGY/QUALITY CONTROL PROJECTS
  - VISCOSITY MANAGEMENT DEVELOPMENT
  - FLAMMABILITY VERSUS VISCOSITY
  - EFFECT OF SHEAR RATE ON VISCOSITY
  - HEAT TRANSFER CHARACTERISTICS
  - SPRAY/VAPORIZATION TECHNIQUES
  - ASTM FUELS METHODS APPLICABILITY
  - DEGRADATION TECHNIQUES
  - BLENDING TECHNIQUES
  - EFFECT OF STORAGE TIME
  - WATER PROPENSITY
  - PIPE FLOW CHARACTERISTICS
ANTIMISTING FUEL PROGRAM

PHASE I - FEASIBILITY/SCOPE

- BASIC CHARACTERISTICS
  - COMPATIBILITY PROJECTS
    - SURVEY OF AIRCRAFT FUEL SYSTEMS
    - SURVEY OF ENGINE FUEL SYSTEMS
    - SURVEY OF AIRPORT FUEL MANAGEMENT SYSTEMS
    - FUEL SIMULATOR INVESTIGATIONS
    - ENGINE COMPONENT BENCH TESTING
    - ENGINE STARTING INVESTIGATION
    - IMPACT ON TURBINE COOLING SYSTEMS
    - ENVIRONMENTAL CONSIDERATIONS
    - HEAT EXCHANGER/FUEL HEATER EFFECTIVITY
ANTIMISTING FUEL PROGRAM

PHASE I - FEASIBILITY/SCOPE

- BASIC CHARACTERISTICS

- SPECIFICATION OUTLINE PROJECTS

  - EVALUATION OF SPECIFICATION CRITICAL SECTIONS
  - GEOGRAPHICAL CONSIDERATIONS
  - ALTERNATIVE FUELS COMPOSITION EFFECTS
  - BACTERIOLOGICAL CONSIDERATIONS
  - IMPACT OF OTHER ADDITIVES
  - ANTIMISTING QUALITY DETECTOR/INDICATOR
ANTIMISTING FUEL PROGRAM

PHASE I - FEASIBILITY/SCOPE

- BASIC CHARACTERISTICS

- PRODUCTION PROBLEMS PROJECTS

- BLENDING LOCATION
- BLENDING TECHNIQUES
- BLENDING QUALITY CONTROL CONSIDERATIONS
- STORAGE TANK/MATERIALS EFFECTS
- STORAGE STABILITY
- BLENDING VERSUS ALTERNATIVE FUELS
- POSSIBLE STORAGE FACILITY REVISION REQUIREMENTS
- IMPACT ON AIRPORT TRANSPORT SYSTEMS
- DEGRADATION LOCATION/TECHNIQUES
- INTERNATIONAL CONSIDERATIONS
- BLEND MIXING
ANTIMISTING FUEL PROGRAM

PHASE I - FEASIBILITY/SCOPE

- LARGE-SCALE EVALUATIONS, PROJECTS
  - LABORATORY TO FULL-SCALE RELATABILITY
  - CRASH SCENARIO PARAMETRIC RANGE
  - INSTRUMENTATION REQUIREMENTS
  - CRASH SITE ANALYSIS
  - CRASH VEHICLE(S) ACQUISITION/PREPARATION

PHASE I - FEASIBILITY/SCOPE

- PRELIMINARY COST/BENEFIT CONSIDERATIONS
  - ANALYSIS OF COST/BENEFIT FACTORS TO BE CONSIDERED
  - FLEET OR GEO-SEGMENTAL INTRODUCTION
  - MAXIMUM COST PROJECTIONS

PHASE I - FEASIBILITY/SCOPE

- DECISION ON FEASIBILITY
ANTIMISTING FUEL PROGRAM

PHASE II - PROTOTYPE SCREENING

- BASIC CHARACTERISTICS
- LARGE-SCALE EVALUATIONS
- COST/BENEFIT COMPARISON
- PROTOTYPE SELECTION
ANTIMISTING FUEL PROGRAM

PHASE III - PROTOTYPE DEVELOPMENT

- COMPATIBILITY RESOLUTION
- QUALITY CONTROL/SPECIFICATION DEFINITION
- PRODUCTION/SUPPLY ESTABLISHED
- UTILIZATION/ECONOMICS
- CRASH PREPARATION
ANTIMISTING FUEL PROGRAM

PHASE IV - PROTOTYPE DEMONSTRATION

- FLIGHT TEST
- FULL-SCALE CRASH TEST
- FINAL COST/BENEFIT ANALYSIS

PHASE V

- REGULATORY RECOMMENDATION/PROCESS
ANTIMISTING FUEL PROGRAM

PHASE I - FEASIBILITY/SCOPE

BASIC TESTS/CHARACTERISTICS
LARGE-SCALE EVALUATION
PRELIMINARY COST/BENEFIT
FEASIBILITY DECISION

PHASE II - PROTOTYPE SCREENING

BASIC TESTS/CHARACTERISTICS
LARGE-SCALE EVALUATION

PHASE III - PROTOTYPE DEVELOPMENT

COMPATIBILITY RESOLUTION
SPECIFICATION/Q.C. REQUIREMENTS
PRODUCTION/SUPPLY TECHNIQUES
LARGE-SCALE FLAMMABILITY DEMO.

PHASE IV - PROTOTYPE DEMO.

FULL-SCALE FLIGHT TESTING
FULL-SCALE CRASH TEST
FINAL COST/BENEFIT ANALYSIS

PHASE V - RECOMMENDATIONS/
INTRODUCTION SCHEDULE

TOTAL CONTRACT COST
(THOUSANDS OF $ )
based on observations during public hearings held by the Federal Aviation Administration (FAA) in 1977 on the hazards of interior aircraft and fuel system fires and explosions associated with transport category airplane accidents, the Special Aircraft Fire and Explosion Reduction (SAFER) Advisory Committee was asked to recommend ways to improve cabin occupant survivability in the post-crash environment. On November 27, 1979, Mr. John H. Wells, Chairman of the SAFER Advisory Committee, reported to the FAA that technical knowledge that could contribute significantly to safety which the committee recommended could be taken on the basis of present-day technical knowledge. One of these recommendations was to the FAA to request the National Transportation Safety Board (NTSB) to report on the proposals by the Coordinating Research Council (CRC) for improved accident reporting relevant to fuel fires.

The proposed proposal is presented on page 41 of CRC Report No. 467, "Aviation Fuel Safety -1979," a copy of which is enclosed. You will note it is recommended that NTSB Aircraft Accident Report Form 6120.2 be revised to focus attention on the need for more information relative to fuel and fires in reporting on transport category airplane accidents.

A review of aircraft accident fire experience revealed that much information relevant to aircraft fires and explosions was lacking from most accident reports and files. Information on the cause and nature of aircraft fires/explosions would be of considerable assistance in designing preventive measures and in research and development efforts directed towards reducing these accidents. Factors which would of interest concerning an improved-accident reportable post-crash fire/explosion environment would include ambient air temperature, wind direction, impact speed, deceleration distance, fuel storage damage, fuel type, fuel temperature, ignition source, time of ignition, location, time, rate, extent, and area of fuel spill, crash site conditions, types of interior materials involved, and cause of fatalities. While it may
not be possible to establish some of these factors in certain accidents, it appears that reporting and storing as much meaningful fire and explosion information as can be obtained would prove valuable in efforts to reduce aircraft fire and explosion hazards.

Your Mr. H. H. McCormick, observer of SAFEE Technical Group activities, indicated in a recent discussion with a member of our staff that Human Factors Groups are responsible in transport airplane accident investigations for documenting most of the above fire-related factors and that an effort is underway to establish computer storage codes for retrieval of such information. It is acknowledged that most of the CRC suggested additions to Form 61... are being covered in Human Factors Group reports, however, we submit your review of the SAFEE Advisory Committee recommendation with the objective of satisfying the need for more information relative to fuel, fires, and explosions.

Sincerely,

[Handwritten signature]

X. Bond
Assistant

Attachment

cc: AVS-1/ARF-1/ARF-300/AE-100/140/ARF/AR-1/1/1-20/A-20
AVS-1/APR-1/ASF-100/AVS-20
AVS-140/TShorei:dm2/12/80
AVIATION FUEL SAFETY - 1975

November 1975

COORDINATING RESEARCH COUNCIL, INC.
30 ROCKEFELLER PLAZA, NEW YORK, N.Y. 10020
Very few accident reports specify that the occupants were killed due to fire because in many cases it is difficult, even with autopsies, to separate impact from post-crash fire effects. Reports like the 1/30/74 B707 accident at Samoa are relatively rare. For most survivable fatal accidents, the investigators conclude that a combination of factors was responsible for fatalities.

Recommendations on Improved Accident Reporting

Aircraft accidents are reported using standardized forms. In the case of General Aviation, either NTSB Form 6120.1 is completed by the pilot/operator or NTSB Form 6120.4 is completed by the investigator. Both ask for data on fuel by volume and grade but do not seek information on mode of fuel release.

In the case of Air Carrier accidents, NTSB Form 6120.2 is used in reporting all civil aircraft accidents involving aircraft exceeding 12,500 pounds takeoff weight, helicopters and Alaskan air carriers. Usually this form is supported by attached statements as well as the report of the investigation team. Complete though this form is, it still lacks certain vital information relevant to fuel fires: unfortunately the usual attachments to this form in an Accident File also lack the information. A revision of the Form should focus attention on the need for information relative to fuel and fires.

The suggested additions to Form 6120.2 cover the following items:

Section V - Cause of fatalities, Fire, Asphyxiation or Trauma.

Section VII - Exit Time, Exits Used.
Location of Exits and Fatalities.

Section VIII - Fuel Aboard by Volume and Grade.
Source of Fuel Release.
Fire Extinguishing System.

Section X - Site Conditions, e.g., Surface.
Honorable Langhorne Bond
Administrator
Federal Aviation Administration
800 Independence Avenue, S. W.
Washington, D. C. 20591

Dear Mr. Bond:

This is in reply to your letter request of March 11, 1977, for a board review of a recommendation by the Special Aviation Fire and Explosion Reduction (SAFER) Advisory Committee concerning the collection of more information relative to fuels, fires, and explosions associated with aircraft accidents.

As you may know, our staff has initiated a major project to develop an improved aircraft accident data management system. This effort will include a review of the accident information requirements of the SAFER Advisory Committee and of other organizations, with a view toward improving the kinds and quality of data collected during accident investigations. Particular emphasis is being directed toward improving the quality and quantity of human performance and crash-survivability data. Obviously, the changes in accident requirements which result will necessitate revision of the SAFER Board Aircraft Accident Report Forms.

Because of the Federal Aviation Administration’s (FAA) extensive involvement in the investigation of selected aircraft accidents and because of our use of accident data, the Safety Board’s data project staff has been working closely with representatives of FAA’s Office of Aviation Safety. In that consideration is given to the needs of both organizations, a contribution to the day-to-day informal interaction between FAA and Safety Board staffs, bi-weekly progress meetings of the two groups are held.

Therefore, please be assured that your staff will be kept informed of our progress on this project and that the recommendations of the SAFER Committee and the Coordinating Research Council will be given full consideration for inclusion in the new aircraft accident data system.

Sincerely yours,

[Signature]

Chairman

[Name]

National Transportation Safety Board
Washington, D.C.

April 9, 1977
ADDITIONAL DISCUSSIONS
CREW PROTECTION AND PASSENGER EVACUATION

The scope and expertise of the SAFER Advisory Committee was limited to transport category aircraft and the design aspects of such aircraft as they relate to fire and explosion reduction. Because of the relatively short time involved for the Committee's efforts, attention was focussed primarily on impact survivable accidents where control of fire and explosions would enhance occupant survival. Certain of the discussions to the Committee were beyond this scope; however, since they did affect occupant survivability they are reflected here so they can be kept in view for regulatory activities outside SAFER.

1. Seating Density

If aircraft occupants are to evacuate the aircraft rapidly in an emergency, they must first of all be able to get out of their seats quickly. Yet airlines have been adding seats, thus reducing the space between the seat backs and passengers in the seat behind. If seats are too densely spaced, swift evacuation may be hampered in an emergency situation.

2. Protective Equipment

Any special protective equipment provided for crewmembers must be located at their stations and be readily accessible. Crew ability to aid passengers in evacuating an aircraft during a fire may be enhanced by protective breathing devices and gloves; however, tests should be conducted similar to earlier
tests carried out for passenger hoods which address the specific problems of time required to don the equipment, ability to direct passengers, be understood, and freedom of movement.

3. **Public Address System**

With reference to passenger egress, consideration should be given to the effective "passenger address system." It should be mandatory that all PA systems be independently powered and be capable of operating in a situation where all other systems have failed.

4. **Flight Attendant Stations**

A review should be conducted of the location, distribution, and structural integrity of flight attendant stations (jumpseats) in relation to:

a. visibility of cabin interiors and occupants (assessments of the cabin in a smoke and fire situation as well as ability to see areas in the cabin where passengers may need to be rescued by crash fire rescue (CFR) personnel after an evacuation is required).

b. having trained crewmembers dispersed throughout the entire aircraft, especially at exit areas, to provide more effective leadership, immediate opening of correct exits, and effective management of passenger flow to usable exits.

5. **New Training Initiatives**

Passenger education has been called "the missing link in air safety." (Ref. 11) Seat cards, oral briefings, and demonstrations before takeoff provide passengers with essential
information in case of an emergency (Ref. 12) and this area has been the focus of attention by government and industry over the years. Nonetheless, passengers continue to "tune out" this information, and there is very little data readily available to the general public on the hazards present in an aircraft fire, not to mention the related issue of toxicity. The SAFER Committee believes there is a need for continued emphasis on improved passenger education and recommends that the FAA promote open forums, documents, presentations, and other methods to make these subjects more readily understandable by the public. For example, the FAA could collaborate with the National Fire Prevention Association on such fire education issues as what to do if a fire breaks out in flight or after a crash, potential hazards from wearing readily flammable clothing, or smoking in the lavatory. These subjects could be incorporated into public service announcements.