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FEDERAL AVIATION AGENCY
AIRCRAFT DEVELOPMENT SERVICE
ENGINEERING AND SAFETY DIVISION

PROGRAM FOR INVESTIGATION OF AIRCRAFT LIGHTNING PROTECTION MEASURES

As a result of the crash of Pan American 707 Aircraft N 709PA near Elkton, Maryland, on December 8, 1963, the FAA proposes to conduct both long-range and short range studies of aircraft/fuel/lightning strike hazards. Although the accident investigation in this case is far from complete, sufficient evidence exists to warrant the immediate initiation of short-range studies and tests to decrease the probability of aircraft fuel ignition as a result of lightning strike. Assuming That the final analysis of the Elkton accident bears out the preliminary evidence, this represents the first instance in which an aircraft was destroyed by lightning igniting jet fuels. It also represents the clearest problem yet posed by lightning strikes and should enable us to make a more direct attack on the problem than has been possible in the past.

Many valuable research programs of the past, directed toward the protection of aircraft from lightning hazards, have been carried out by government agencies and industry. Results of those programs will provide background for the proposed work. However, the solutions to the short-range program presented can not be general in nature. They must be directed toward the development of specific hardware and specific modifications to be made to specific aircraft and components Accordingly, the basic objectives of the short-range program are to:

1. Determine and demonstrate, as accurately as possible, the fuel/lightning hazards which may have been responsible for the Elkton accident and indicate areas of similar problems common to all aircraft.
2. Develop definite means and/or equipment to defeat those hazards.
3. Prove that the means for defeating those hazards does not introduce new hazards.

Short-Range Program

Phases I and II of this program are to be conducted simultaneously.

Phase I

Lightning

This phase of the work should be conducted by a laboratory qualified to study and evaluate lightning phenomena, i.e., Lightning and Transient Research Institute. The work should make use of an actual 707 (or KC-135) outer wing panel as delivered from the production line, and should subject that panel to a range of simulated conditions from crossfield streaming through the most severe lightning strokes. The work in this phase includes but is not limited to the following test series.

1. With minimum (preferable no) change to the test wing panel, determine the possibility of internal arcing when the tank is struck externally, but not penetrated, by lightning. Suspected areas include the overwing tank filler cap, underwing tank access doors, and fuel quantity gage probes. Bonding effectiveness should be evaluated.
2. If lightning striking the tank externally does produce internal arcing consider and test promising techniques for preventing such arcs.

3. Repeat 1. to demonstrate that internal arcing has been stopped. (Note: Test series 1,2 and 3 do not require combustible fuel mixtures within the tank as they are purely ignition source investigations. In the remaining test series of this phase, combustible fuel concentrations will be used within the tank. The tank itself will require protection against explosion by the use of blow-out panels or other means. The fuel problems and the tank blow-out protection features should be handled by the Phase II contractor.)
4. Produce hazardous aircraft/fuel/lightning conditions and determine the possibility of fuel ignition through vent openings.
5. If ignition occurs in test series 4, determine locations and types of lightning diverters (including plastic wing tip/heavy conductor technique to reduce ignition probability.
6. Repeat 3, with an explosive fuel vapor in the tank to demonstrate that internal arcing will not occur.
7. Repeat 4, incorporating the superior flame arresting devices evaluated as part of Phase II to determine the value of those devices against high energy ignition sources (lightning strokes).

Phase II

Fuel Problems

This phase of the work should be conducted by a laboratory qualified to study the ignition, flammability, and explosive characteristics of fuels, explosion suppression and flame arresting techniques, i.e, - Atlantic Research Corporation. The work should make use of actual 707 hardware, including vent, vent duct, surge tank and reserve tank. In this phase

of the work, it is assumed that flammable/explosive fuel vaoprs exist within the reserve tank and that very potent ignition sources exist in the vicinity of the tank vent. It will also be assumed that a variety of combinations of fuel liquid and vapor may be present in the venting system. The work in this phase includes but is not limited to the following test series.

1. Determine conditions under which the ignition of fuel vapors outside the vent, produces flame flow through the vent, vent duct and surge tank capable of triggering an explosion within the reserve tank.
2. Using the most hazardous conditions determined under 1. evaluate the the protection offered by;
   a. Providing high vent exit velocities by adding air, not to dilute effluent vapors but to counteract flame propagation.
   b. Flame arrestors (including Pinkel's suggested design).
   c. Explosion Suppression Systems.
   d. Labyrinth vent ducts.
   e. Any other method, technique or hardware.
3. Determine design criteria for the best method, technique or device for stopping flame propagation through the vent tube.
4. Conduct an investigation to ascertain that the means for stopping flame propagation does not add other problems or hazards to aircraft operation.
5. Work closely with the Phase I contractor to carry out the objectives of Phase I, parts 4, 5, 6 and 7.

The successful conclusion of this short-range progr am will provide a most valuable input to the follow-up long-range program aimed at:

1. Refining the results of this work.

2. Expanding the results of this work to general requirements for all jet transports, which have similar or even identical problems.
3. Conducting advanced studies of both lightning and fuel hazards.
4. Developing advanced protection and prevention concepts.