FULL-SCALE TEST EVALUATION OF AIRCRAFT FUEL FIRE BURNTHROUGH RESISTANCE IMPROVEMENTS

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Fuselage burnthrough refers to the penetration of an external jet fuel fire into the interior of an aircraft during a postcrash fire. The time to burnthrough is critical because in a majority of survivable aircraft accidents accompanied by fire, ignition of the interior of the aircraft is caused by burning jet fuel external to the aircraft. Therefore, the integrity of the aircraft and its ability to provide a barrier against fuel fire penetration is an important factor related to the survival of aircraft occupants. Fuselage burnthrough resistance becomes particularly important when the fuselage remains intact following a crash, which occurs frequently in survivable accidents. The best example of an accident with large loss of life where fuselage burnthrough was determined to be critical to the outcome was the 737 accident in Manchester, England in 1985. In this accident, the investigators concluded that burnthrough occurred within 60 seconds and did not allow sufficient time for all occupants to escape (55 people died from the effects of the fire).

Fuselage burnthrough resistance may be simplistically viewed as the time interval for a fuel fire to penetrate three fuselage shell members: aluminum skin, thermal acoustical insulation, and sidewall; panel/cabin flooring. Flame penetration may occur in other areas as well, such as windows, air return grilles, and seams/joints. The burnthrough resistance of the aluminum skin is well known. It takes only about 20 to 60 seconds for the skin to melt, depending on its thickness. The thermal acoustical insulation is the next impediment to burnthrough following the melting of the aluminum skin. In past FAA outdoor fuel fire burn tests on surplus fuselages, it was determined that the fiberglass insulation provided an additional 1 to 2 minutes of protection, if it completely covered the fire area and remained in place. Thus, the method of securing the insulation to the fuselage structural members is important. The sidewall panels/flooring offer the final barrier to fire penetration. Sandwich panels comprised of honeycomb cores and fiberglass facings are effective barriers; however, full-scale fire tests also show that the fire can penetrate into the cabin through the air return grilles, seams/joints or window reveals. Moreover, some airplanes utilize aluminum sidewall panels which offer minimal burnthrough resistance. FAA researchers are focusing on the thermal acoustical insulation as the most potentially effective and practical means of achieving a burnthrough barrier.

A full-scale test article shown in figure 1 is utilized, to evaluate improved materials/concepts when installed realistically inside a fuselage and subjected to an external fuel fire. The test article is a 20-foot-long barrel section, constructed of steel framing members, inserted in the aft end of a 707 fuselage. A 10-foot-long by 8-foot-wide fuel pan subjects the test article to an intense fuel fire. The steel framing members assure reuse of the test article. Edge effects are avoided by making the test section longer than the fuel pan. Aluminum sheet is riveted to the steel framing in a thickness typical of fuselage skin construction.

Aircraft thermal acoustical insulation bating is typically comprised of lightweight fiberglass encapsulated in a thin film moisture barrier, usually polyester or polyvinyl fluoride. Several materials have been tested which exhibit marked burnthrough resistance compared to the baseline thermal acoustical batting. The effective materials include a heat stabilized oxidized polyacrylonitrile fiber (OPF) as a replacement for the fiberglass, a lightweight ceramic fiber matt used in conjunction with the present fiberglass, and a polymide film as a replacement for the polyester or polyvinyl fluoride films. A comparison of full-scale test temperature readings taken at the inside of the insulation and near the ceiling illustrate the burnthrough protection provided by the OPF insulation, shown in figure 2. Both the OPF and fiberglass insulation materials were securely attached to the framing members. It takes about 1.5 to 2 minutes for the fuel fire flames to penetrate the aluminum skin and fiberglass batting, whereas the OPF insulation did not burn when subjected to a fuel fire for over 5 minutes. Although the OPF insulation clearly prevented flame penetration and did not visibly burn, low concentrations of toxic gases measured within the test article indicate that the OPF may have thermally decomposed slightly.

Although test results are very promising, there is additional work underway, or planned, as follows:

1) Evaluation of additional potentially effective materials/concepts (e.g., polyimide foam, intumescent paint, etc.).

2) Determination of the effect of steel framing members employed to secure insulation batting samples in the test article on the time to burnthrough (commercial transport aircraft primarily utilize aluminum alloy structural members).

3) Determination of the benefit of burnthrough resistant thermal acoustical insulation in terms of additional survival time, when the test article is fully furnished with cabin materials.

4) Development of a small-scale performance fire test method for aircraft fuselage burnthrough resistance.

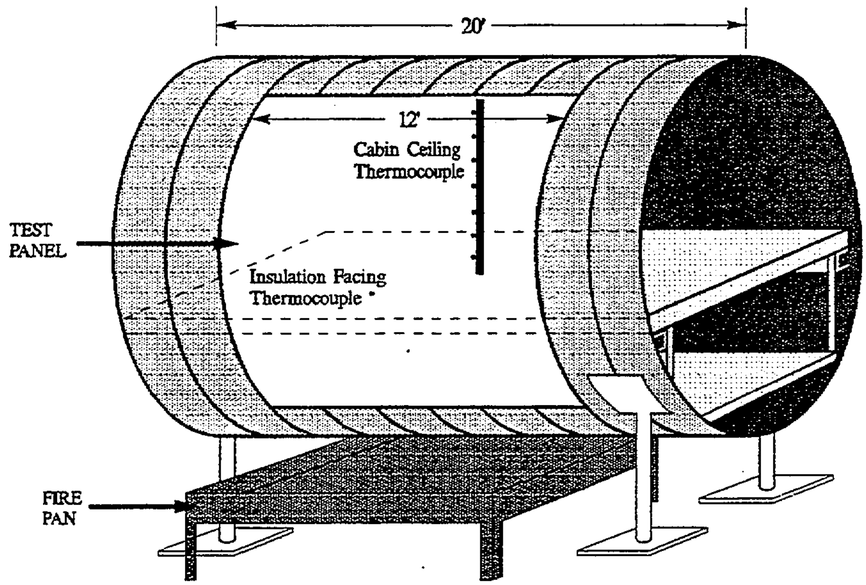

Figure 1

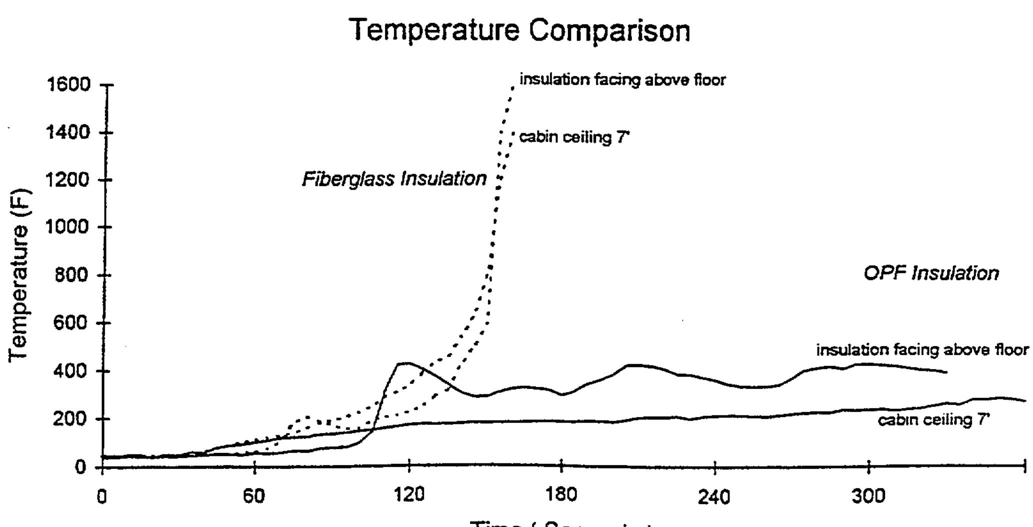

Figure 2