

into and out of fuel tanks such that heating of the fuel would not occur. Design features such as locating the air conditioning equipment away from the fuel tanks, providing ventilation of the air conditioning bay to limit heating and to cool fuel tanks, and/or insulating the tanks from heat sources, would be practical means of complying with the regulation proposed by the ARAC.

In addition to its recommendation to revise § 25.981, the ARAC also recommended that the FAA continue to evaluate means for minimizing the development of flammable vapors within the fuel tanks to determine whether other alternatives, such as ground-based inerting of fuel tanks, could be shown to be cost effective.

To address the ARAC recommendations, the FAA continued with research and development activity to determine the feasibility of requiring inerting for both new and existing designs.

FAA Rulemaking Activity

Based in part on the ARAC recommendations to limit the flammability on new type designs, the FAA developed and published Amendment No. 25–102 in the **Federal Register** on May 7, 2001 (66 FR 23085). The amendment includes changes to § 25.981 that require minimization of fuel tank flammability to address both reduction in the time fuel tanks contain flammable vapors, (new § 25.981(c)), and additional changes regarding prevention of ignition sources in fuel tanks. The new § 25.981(c) is based on the FTHWG recommendation to achieve a safety level equivalent to that achieved by the fleet of transports with unheated aluminum wing tanks, between 2 to 4 percent flammability. The FAA stated in the preamble to Amendment 25–102 that the intent of the rule was to—

* * * require that practical means, such as transferring heat from the fuel tank (e.g., use of ventilation or cooling air), be incorporated into the airplane design if heat sources were placed in or near the fuel tanks that significantly increased the formation of flammable fuel vapors in the tank, or if the tank is located in an area of the airplane where little or no cooling occurs. The intent of the rule is to require that fuel tanks are not heated, and cool at a rate equivalent to that of a wing tank in the transport airplane being evaluated. This may require incorporating design features to reduce flammability, for example cooling and ventilation means or inerting for fuel tanks located in the center wing box, horizontal stabilizer, or auxiliary fuel tanks located in the cargo compartment.

Advisory circulars associated with Amendment 25–102 include AC 25.981–1B, “Fuel Tank Ignition Source Prevention Guidelines,” and AC

25.981–2, “Fuel Tank Flammability Minimization.” Like all advisory material, these advisory circulars describe an acceptable means, but not the only means, for demonstrating compliance with the regulations.

FAA Research

In addition to the notice published in the **Federal Register** on April 3, 1997, the FAA initiated research to provide a better understanding of the ignition process of commercial aviation fuel vapors and to explore new concepts for reducing or eliminating the presence of flammable fuel air mixtures within fuel tanks.

Fuel Tank Inerting

In the public comments received in response to the 1997 notice there was reference made to hollow fiber membrane technology that had been developed and was in use in other applications, such as the medical community, to separate oxygen from nitrogen in air. Air is made up of about 78 percent nitrogen and 21 percent oxygen, and the hollow fiber membranes act as a molecular sieve, using the size difference between the nitrogen and oxygen molecules to separate the nitrogen-enriched air (NEA) from the oxygen. In airplane applications NEA is produced when pressurized air from the airplane engines is forced through the hollow fibers. The NEA is then directed, at appropriate nitrogen concentrations, into the ullage space of fuel tanks and displaces the normal fuel vapor/air mixture in the tank.

Use of the hollow fiber technology allowed nitrogen to be separated from air which eliminated the need to carry and store the nitrogen in the airplane. Researchers were aware of the earlier system's shortcomings in the areas of weight, reliability, cost, and performance. Recent advances in the technology have resolved those concerns and eliminated the need for storing nitrogen on board the airplane.

Criteria for Inerting

Earlier fuel tank inerting designs produced for military applications were based on defining “inert” as a maximum oxygen concentration of 9 percent. This value was established by the military for protection of fuel tanks from battle damage. One major finding from the FAA's research and development efforts was the determination that the 9 percent maximum oxygen concentration level benchmark established to protect military airplanes from high-energy ignition sources encountered in battle was significantly lower than that needed

to inert civilian transport airplane fuel tanks from ignition sources resulting from airplane system failures and malfunctions that have much lower energy. This FAA research established a maximum value of 12 percent as being adequate at sea level. The test results are currently available on FAA Web site: <http://www.fire.tc.faa.gov/pdf/tno2-79.pdf> and will be published in FAA Technical Note “Limiting Oxygen Concentrations Required to Inert Jet Fuel Vapors Existing at Reduced Fuel Tank Pressures,” report number DOT/FAA/AR–TN02/79. As a result of this research, the quantity of nitrogen-enriched air that is needed to inert commercial airplane fuel tanks was lessened so that an effective flammability reduction system can now be smaller and less complex than was originally assumed. The 12 percent value is based on the limited energy sources associated with an electrical arc that could be generated by airplane system failures on typical transport airplanes and does not include events such as explosives, turbulent flow flame propagation, or hostile fire.

As previously discussed, existing fuel tank system requirements (contained in earlier Civil Air Regulation (CAR) 4b and now in 14 Code of Federal Regulations (CFR) part 25) have focused solely on prevention of ignition sources. The flammability reduction system is intended to add an additional layer of safety by reducing the exposure to flammable vapors in the heated center wing tank, not necessarily eliminating them under all operating conditions. Consequently, ignition prevention measures will still be the principal layer of defense in fuel system safety, now augmented by substantially reducing the time that flammable vapors are present in higher flammability tanks. It is expected that by combining these two approaches, particularly for tanks with high flammability exposures, such as the heated center wing tank or tanks with limited cooling, risks for future fuel tank explosions can be substantially reduced.

Boeing Application for Certification of a Fuel Tank Inerting System

On November 15, 2002, Boeing Commercial Airplanes applied for a change to Type Certificate A20WE to modify Model 747–100/200B/200F/200C/SR/SP/100B/300/100B SUD/400/400D/400F series airplanes to incorporate a new flammability reduction system that inertes the center fuel tanks with nitrogen-enriched air. The Model 747–100/200B/200F/200C/SR/SP/100B/300/100B SUD/400/400D/400F series airplanes, approved under