DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

Fuel Tank Ignition Prevention Measures

AGENCY: Federal Aviation Administration, DOT.

NOTICE: Notice of request for comment on National Transportation Safety Board recommendations.

SUMMARY: This notice solicits public comment on the feasibility of implementing four recommendations proposed by the National Transportation Safety Board (NTSB) that are intended to reduce the likelihood of airplane fuel tank ignition. The NTSB recommendations resulted from an accident on a Boeing Model 747 operated by Trans World Airways (TWA) that occurred after taking off from Kennedy International Airport in New York, on July 17, 1996. The cause of the accident has not been determined. However, evidence suggests that explosion of fuel vapors within the center wing fuel tank occurred due to a yet to be determined ignition source. The FAA is not currently considering or proposing any regulatory action. The purpose of this notice is to gather technical information needed to formally respond to the NTSB recommendations.

DATES: Comments must be received on or before August 1, 1997.

ADDRESSES: Comments on this notice may be mailed to: Federal Aviation Administration, Transport Airplane Directorate, Aircraft Certification Service, ANM–100 (Attn: Mike Dostert, ANM–112), 1601 Lind Avenue SW., Renton, Washington 98055–4056.

FOR FURTHER INFORMATION CONTACT: Mike Dostert, FAA, Airframe and Propulsion Branch (ANM–112), Transport Airplane Directorate, Aircraft Certification Service, 1601 Lind Avenue SW., Renton, Washington 98055–4056; telephone (206) 227–2132.

SUPPLEMENTARY INFORMATION:

Comments Invited

Interested persons are invited to participate in evaluation of the NTSB recommendations by submitting written data, views, or arguments as they may desire. Comments relating to the environmental, energy, or economic impact that might result from adopting the recommendations contained in this notice are invited. Substantive comments should be accompanied by cost estimates. All comments received on or before the closing date for comments will be considered by the FAA before preparing a formal response to the NTSB recommendations.

Background

On July 17, 1996, a Boeing Model 747 operated by Trans World Airways was involved in an accident after taking off from Kennedy International Airport in New York. Although no specific cause for the accident has been determined, evidence suggests that the center wing fuel tank exploded due to a yet to be determined ignition source. The accident investigation has focused on a missile, bomb, or mechanical failure as the possible source of ignition of fuel vapors within the tank. On December 13, 1996, the NTSB issued four recommendations to the FAA requesting, in part, that the FAA require the development and implementation of design or operational changes that will preclude the operation of transport category airplanes with explosive fuel-air mixtures in the fuel tanks. The following is a summary of the four recommendations that are published in their entirety later within this notice.

The first recommendation would require development of an airplane design modification, such as nitrogen-inerting systems, and the addition of insulation between heat-generating equipment and fuel tanks. (A–96–174)

The second recommendation would require modifications in operational procedures to reduce the potential for explosive fuel-air mixtures in the fuel tanks of transport category aircraft. In the Model 747, consideration should be given to refueling the center wing fuel tank (CWT) before flight, whenever possible, from cooler ground fuel tanks; proper monitoring and management of the CWT fuel temperature; and maintaining an appropriate minimum fuel quantity in the CWT. (A–96–175)

The third recommendation would require that the Model 747 Flight Handbooks of TWA and other operators of Model 747s, and other aircraft in which fuel tank temperature cannot be determined by flightcrews, be immediately revised to reflect the increases in CWT fuel temperatures found by flight tests, including operational procedures to reduce the potential for exceeding CWT temperature limitations. (A–96–176)

The fourth recommendation would require modification of the CWT of Model 747 airplanes and other airplanes on which the fuel tanks are located near heat sources, to incorporate temperature probes and cockpit fuel tank temperature displays to permit determination of the fuel tank temperatures. (A–96–177)

The flammability temperature range of jet engine fuel vapors varies with the type of jet fuel, the ambient pressure in the tank, and the amount of dissolved oxygen that may evolve from the fuel due to vibration and sloshing that occurs within the tank. At sea level pressures and with no sloshing of vibration present, Jet A fuel, the most common commercial jet fuel in the United States has flammability characteristics that tend to make the fuel-air mixture too ‘‘lean’’ to ignite at temperatures below approximately 100°F and too ‘‘rich’’ to ignite at temperatures above 175°F. This range of flammability (100°F to 175°F) is reduced to cooler temperatures as the airplane gains altitude due to the corresponding reduction of pressure. For example, at an altitude of 30,000 ft. the flammability temperature range is approximately 60°F to 120°F. The flammability region of Jet B (JP–4), another fuel approved for use on most commercial transport category airplanes but primarily used for military jets, is in the temperature range of 15°F to 75°F at sea level, and -20°F to 35°F at 30,000 ft. Therefore, Jet B fuel characteristics result in flammable fuel vapors being present within airplane fuel tanks for a much larger portion of the flight. Most commercial transports are approved for operation at altitudes in the range of 30,000 to 45,000 feet. The FAA has always assumed that airplanes could be operated for some portion of flights with flammable fuel vapors in their fuel tank ullage (the vapor space above the level of the fuel in the tank). Commercial transport operated in the United States, and in most overseas locales, use Jet A fuel, which minimizes exposure to operation in the flammability region.

The FAA philosophy regarding flammable fuel vapors is that the best way to ensure airplane safety is to preclude ignition sources within fuel tanks. This philosophy includes application of fail safe design requirements to fuel tank components (lightning design requirements, fuel tank wiring, fuel tank temporary limits, etc.), which would preclude ignition sources from being present in fuel tanks even when component failures occur. Implementation of the NTSB recommendations would require a significant change in airplane design and/or operational practices currently in use. These changes could have major effects on passengers and the aviation community.

The effectiveness and feasibility of the proposals need to be fully evaluated. Past studies of nitrogen inerting have shown that few benefits are provided by nitrogen inerting of fuel tanks and that the cost of these systems is prohibitive. However, since these studies were conducted, advances in technology for separating nitrogen from air and instances of tank ignition may now make it possible to show that inerting of fuel tanks is cost beneficial. The FAA needs accurate information regarding the NTSB proposals in order to prepare a formal response to these recommendations. This notice requests information regarding the NTSB proposals.

History

Since the introduction of turbine powered transport category airplanes, the FAA and aviation industry have evaluated numerous techniques and systems for reducing the severity or occurrence of airplane fires and explosions. The evaluations have focused primarily on post crash situations because reviews of service history showed existing design standards provided adequate protection from fuel tank ignition from causes other than post crash fires. The following methods have been evaluated for reducing the post-crash fire/explosion hazard: (1) Crash-Resistant Fuel Tanks and Breakaway, (2) Self-Closing Fittings, (3) Engine Ignition Suppression System, (4) Fuel Tank Nitrogen Inerting System, (5) Fuel Tank Foam Filler Explosion Suppression System, (6) Fuel Tank Chemical Agent Explosion Suppression System, (7) Anti-Misting Kerosene (AMK), (8) Fuel Tank Vent Flame Arrestor, (9) Surge Tank Chemical Agent Explosion Suppression System, (10) Design to Assure Fuel Tank-to-Engine Shutoff Valve Activation, (11) Fire-Resistant Fuel Tank Access Panels, and (11) Revised Location of Fuel Tank and Engines.

All of these techniques and systems, with the exception of mandating the location of fuel tanks and engines, have been or are currently being considered by the FAA. Initial consideration with respect to crash-resistant fuel tanks, self-closing breakaway fittings, and engine ignition suppression was reflected to Advance Notice of Proposed Rulemaking (ANPRM) No. 64–12, which was issued in 1964 to solicit the views of all interested persons on the practicability, and possible regulations for these various techniques. The FAA concluded, after consideration of comments submitted in response to Notice No. 64–12, the technical information available at that time did not provide a sufficient basis on which to develop precise regulatory standards.

The FAA subsequently extended its fuel system fire safety program to include consideration of means to prevent fires and explosion within the fuel tank and the tank vapor and vent spaces. Based on information developed by FAA-sponsored government-industry conferences on fuel system fire safety in 1967 and 1970, and an FAA-industry advisory committee established in 1968, the FAA concluded that there are three systems capable of preventing fuel tank and vent system fires and explosions arising from ignition within the fuel system. These are fuel tank nitrogen inerting, foam filler, and chemical agent explosion suppression systems.

In 1969, the FAA initiated research into the feasibility of nitrogen inerting of fuel tanks of transport category airplanes based on systems under development by the military. The systems were intended to reduce the likelihood of a fuel tank explosion due to a fuel tank penetration by hostile enemy fire. The FAA interest in these systems focused on the potential for reducing the likelihood of fuel tank explosion due to post crash ground fire. The FAA contracted with the Parker Hannifin Company for designing and manufacturing the inerting system, and for installation in the DC–9 aircraft under subcontract to Lockheed Aircraft Services Company. The system consisted of storage bottles, pressure regulating hardware, and the installation of valves to maintain a constant positive pressure and the desired concentration of nitrogen in the fuel tanks. The combined system weight was 643 pounds. Results of the testing showed that the system provided adequate inerting of the fuel tanks. However, the penalty in airplane performance due to increased weight and maintenance costs was very high and the costs of such a system were shown to outweigh the benefits at that time.

Since these studies were conducted, new military nitrogen inerting designs have been developed and are installed in all Air Force C–5 and C–17 military transport category airplanes, the F–22 fighter and the V–22 tiltrotor. Foam filler explosion suppression systems are installed in a variety of military airplanes. Chemical agent explosion suppression systems are installed in the surge tanks of several civil transport category airplanes. These systems are intended to provide protection against fuel tank ignition from external sources, hostile enemy fire in the case of the military aircraft, and lightning in the case of the chemical agent explosion suppression systems installed on civil transports.

In 1971, NTSB Recommendation A–71–59 requested action to require ‘‘fuel system fire safety devices which will be effective in prevention and control of both inflight and post crash fuel system fires and explosions.’’ This recommendation resulted from an accident in 1971 in New Haven, Connecticut, where 27 of 28 passengers survived the initial ground impact but died due to post crash fire/explosion. In 1972, the Aviation Consumer Action Project petitioned for rulemaking requesting action to require nitrogen fuel tank inerting systems on all transport category airplanes. Based on these requests, the FAA issued Notice of Proposed Rulemaking (NPRM) No. 74–16, which proposed fuel tank inerting in transport category airplanes. The majority of comments received opposed this proposal because it was argued that the explosion prevention systems would have little or no effect in reducing the fire and explosion hazards of impact-survivable accidents when a fuel tank is ruptured. Comments received and subsequent cost benefit analysis showed that fuel tank explosions had occurred due to post crash fire ignition of fuel tanks that remained intact and the ignition of the fuel tank was caused by propagation of fire through the fuel tank vent system. However, no clear benefits could be shown for the use of an inerting system in the prevention of ignition of fuel tanks. In addition, with technology available at that time, nitrogen inerting was not considered feasible because: (1) inerting is not effective in the majority of accidents because fuel tank rupture occurs and suppression of the fire would not occur due to ignition from sources outside the tank; and (2) in accidents where intact fuel tank explosions occurred, it was determined that installation of flame arrestors in the vent lines would eliminate the ignition source and offer a lower cost means of reducing the likelihood of post crash explosion. In view of these comments, the FAA concluded that a public hearing should be held to obtain information needed to determine whether a requirement should be developed to reduce the fire and explosion hazards to both inflight and impact-survivable accidents.

In 1978, the FAA established a Special Aviation Fire and Explosion Reduction (SAFER) Advisory Committee to recommend ways to improve survivability in the post-crash environment. The SAFER committee reviewed service history at that time and evaluated numerous potential methods of reducing the incidents of post crash fire and fuel tank explosions. The committee concluded that nitrogen inerting provided little or no benefit and was very costly. The Aerospace

Industries Association estimated that total installation and operational costs through 1996 would be 19 billion dollars.

The FAA research and development testing showed that, during simulated ground fire conditions, a fuel tank explosion would not occur from an under-wing fire as long as a small volume of fuel remained within the fuel tank. Therefore, only minimal benefits could be shown. Two other methods for reducing post crash fires; incorporation of flame arrestors in fuel tank vents and incorporation of a method for shutting down fuel to the engines using both the normal and emergency shutdown means, were recommended by the SAFER Committee. In addition, initial testing of Anti Misting Kerosene showed promising potential for reducing post crash fires. Therefore, NPRM 74–16 was withdrawn because other methods for reducing post crash fires were determined to be more practical and effective.

Fuel Tank Ignition Experience

During the SAFER Committee's evaluation of the methods of reducing post crash fires, the service history of fuel tank explosions was prepared. A list of civilian transport category airplane accidents was compiled that included fuel tank explosions resulting from post crash ground fires. In addition, during evaluation of the benefits of nitrogen inerting systems as proposed in NPRM 74–16, a list of fuel tank explosions that occurred during normal operations was prepared. Experience on military aircraft was not included in the SAFER committee review. Evaluation of data available at that time indicated that three accidents resulted from fuel tank explosion inflight where benefits of nitrogen inerting could be claimed. In two of these cases, design modifications were made to eliminate the source of ignition. The remaining case resulted from an uncontrolled engine fire, and improvement in engine fuel shutoff features was incorporated to address this issue. Therefore little or no benefit could be shown for requiring nitrogen inerting.

However, in the almost 20 years since the SAFER Committee recommendations were issued, additional incidents of fuel tank ignition have occurred. The FAA has compiled an updated list of incidents of fuel tank ignition that includes three inflight incidents evaluated by the SAFER Committee, other related events from that time period, recent events, and also military experience. A review of the data shows that fuel tank ignition and explosion events have occurred in all portions of airplane operations and maintenance. The majority of the events have occurred in tanks loaded with JP–4 fuel, a fuel type that produces flammable vapors at lower temperatures and a consequent increase in exposure to ignition for typical airplane operations. The cause of many of the military accidents can be traced to a combination of using JP–4 fuel and maintenance or design practices that differ from that of commercial airplanes. It should be noted that the military has phased out use of JP–4 fuel within the United States and adopted JP–8, a fuel similar to Jet A–1, as a replacement fuel. However, the significant number of military fuel tank explosion events in relation to the number of total operating hours indicates that use of more volatile fuels increases the likelihood of fuel tank ignition.

The following list includes incidents where a specific cause was identified and improved design standards have prevented reoccurrence of incidents due to these causes. The list should be reviewed carefully when using the data to derive benefits from implementing the proposed NTSB safety recommendations.

(a) COMMERCIAL FUEL TANK EXPLOSION/IGNITION EXPERIENCE

Model	Operator/location	Year	Fatal	Hull loss	Fuel type	Inerting benefit	Phase of operation	Description/Cause
B707	OSO	1959	4	Yes	UNK	Yes	Flight	
B707	Elkton	1963	81	Yes	JP–4	Yes	Flight	Lightning, In flight explosion.
B707	San Francisco	1965	0	Yes	Jet A	Possible	Flight	#4 Engine fire heated wing upper surface above 900F—Partially full fuel tank exploded resulting in loss of 21 ft. of wing. Landed safely.
B727	Southern Air Transport-Taiwan.	1964	1	No	Jet A	No	Ground maintenance.	While purging center tank for entry, static discharge from CO_2 Firex Nozzle to center tank access door caused wing tank explosion.
B727	Minneapolis	1968	0	No	Jet A	Yes	Ground refueling	Electrostatic Charge—Ground refueling system found as source of charging—minor damage to wing structure. Group equipment and airplane refueling system design standards have eliminated reoccurrence.
B727	Minneapolis	1971	0	No	Jet A	Yes	Ground refueling	See Above.
DC–8	Toronto Canada	1970 July	106	Yes	JP–4	Yes	Flight	Spolier deployed. Possible fuel tank explosion during go-around following ground impact during attempted landing.
DC–8	Travis AFB	1974	1	Yes	JP–4	No	Ground	World Airways DC–8 inboard main tank, exploded and burned at Travis AFB during maintenance. Open fuel cell, mechanic forced circuit breaker in.
DC–9	Air Canada	1982	0	Yes	Jet A–1	Possible	Ground maintenance.	During maintenance center wing fuel tank exploded. Dry running of pumps suspected cause.

(a) COMMERCIAL FUEL TANK EXPLOSION/IGNITION EXPERIENCE—Continued

Model	Operator/location	Year	Fatal	Hull loss	Fuel type	Inerting benefit	Phase of operation	Description/Cause
Beechjet 400	Jackson Miss	1989 June	0	No	JP–4/ Jet A	Yes	Ground Refueling.	During refueling of auxiliary tank ignition occurred. Tank remained intact but fuel leakage occurred. Electrostatic Charge discharge from polyurethane foam source of Ignition.
B727	Avionca	1989	107	Yes	Jet A	Possible	Climb	Bomb located over center wing fuel tank. Inerting benefit unknown.
B737	Philippine Airlines.	1990	8	Yes	Jet A	Yes	Taxi	Not determined—Empty Center Wing Fuel tank explosion.
B747	TWA 800	1996 July	230	Yes	Jet A	Yes	Climb	Bomb, Missile, Mechanical Failure?—Empty center wing fuel tank explosion.

(B) MILITARY NON-COMBAT FUEL TANK EXPLOSION/IGNITION EXPERIENCE

Model	Operator/location	Year	Fatal	Hull loss	Fuel type	Inerting benefit	Phase of operation	Description/Cause
B52	Loring AFB Maine.	1970 July	0	Yes	JP–4	Yes	Maintenance	Most likely ignition source traced to arcing or overheat of fuel pump shaft or fuel quantity probe.
B707	USAF Spain	1971 June	Yes	Yes	JP4	Yes	Decent 17K	Inflight explosion of #1 Main Tank. USAF determined chafing of boost pump wires located in conduits as possible ignition source.
B52H	Minot ND AFB	1975 Nov	0	Yes	JP–4	Yes	Maintenance Prior to Refueling.	Body tank exploded after midnight while on ramp. No specific evidence but suspected fuel pump locket rotor ignition source.
B747	Iranian Fuel Tanker.	1976	7	Yes	JP–4/ Jet A	Yes	Decent 8K ft	Lightning—wing tank.
KC135Q	Plattsburg AFB NY.	1980 Feb	....	Yes	JP–4	Yes	Refueling	Aft body tank, faulty fuel probe found as problem.
B52G	Robins AFB Georgia.	1980 Aug	Yes	Yes	JP–4	Yes	Maintenance on ramp.	While transferring fuel from body tanks to wing tanks the empty mid body tank exploded. Investigation showed electrical arcing occurred in the mid body boost pump due to mis positioned phase lead wire inside the pump.
KC135A	Near Chicago	1982 March	Yes	Yes	JP–4	Yes	12K descent	Forward body tank exploded, initial cause listed as VHF antenna.
B52G	Grand Forks AFB ND.	1983 Jan	....	Yes	JP–4	Yes	Maintenance on ramp.	While troubleshooting a fuel transfer malfunction center wing tank exploded due to an electrical fault associated with the EMI filter on a valve.
KC135A	Altus AFB Okl	1987 Feb	Yes	Yes	JP–4	Yes	Landing roll out	During landing roll out an explosion and fire occurred following copilot transmission on UHF radio. The UHF wire run near the right aft wing root in the fuselage was melted due to an electrical fault. Fuel vapors in the area of the aft body tank were ignited.
B52H	Swayer AFB Mich.	1988 Dec	Yes	Yes	JP–4	Yes	During touch and go landing.	At 20 feet AGL the empty aft body tank exploded. Pump num operating in the aft body tank was cause. Evidence of arcing a overheat was found.

(B) MILITARY NON-COMBAT FUEL TANK EXPLOSION/IGNITION EXPERIENCE—Continued

Model	Operator/location	Year	Fatal	Hull loss	Fuel type	Inerting benefit	Phase of operation	Description/Cause
KC135A	Loring AFB Maine.	1989 Sept	Yes	Yes	JP–4	Yes	Parked following flight.	During system shutdown explosion in the aft fuselage tank occurred. Source of ignition was believed to be a hydraulically driven fuel pump mounted inside the aft body fuel tank.
KC135A	Loring AFB Maine.	1989 Oct	Yes	Yes	JP–4	Yes	In flight local pattern.	Explosion in the aft body fuel tank caused hull loss. Aft body f hydraulically driven pump implicated as source of ignition.
KC135R	Mitchell Field Milwaukee.	1993 Dec	Yes	Yes	JP–4	Yes	Ground maintenance.	During maintenance center wing tank exploded. Center wing fuel tank fuel pump implicated as source of ignition.

National Transportation Safety Board Recommendations: The following text is from NTSB letter to the FAA dated December 13, 1996, that transmitted Recommendations A–96–174 through –177.

On July 17, 1996, about 20:31 eastern daylight time, a Boeing 747–131, N93119, operated as Trans World Airlines Flight 800 (TWA800), crashed into the Atlantic Ocean, about 8 miles south of East Moriches, New York, after taking off from John F. Kennedy International Airport (JFK), Jamaica, New York. All 230 people aboard the airplane were killed. The airplane, which was operated under Title 14 Code of Federal Regulations (CFR) Part 121, was bound for Charles De Gaulle International Airport (CDG), Paris, France. The flight data recorder (FDR) and cockpit voice recorder (CVR) ended simultaneously, about 13 minutes after takeoff. Evidence indicates that as the airplane was climbing near 13,800 feet mean sea level (msl), an in-flight explosion occurred in the center wing fuel tank (CWT). (The flight engineer from the previous flight remembered having left about 300 pounds, or about 50 gallons, of fuel in the approximately 13,000 gallon capacity tank. The recovered fuel gauge indicated slightly more than 600 pounds (about 100 gallons) of fuel remaining in the CWT.) The CWT was nearly empty.

A substantial portion of the airplane wreckage has been recovered from the ocean floor. Among the debris found along the first part of the wreckage path were CWT parts from spanwise section. The cockpit of the airplane and pieces of the forward fuselage were found in a second debris field that was more than a mile from the beginning of the wreckage path. Fragmented wing and aft fuselage parts were recovered from a third debris field farther along the wreckage path.

Portions of the airplane have been reconstructed, including the CWT, the passenger cabin above the CWT, and the air conditioning packs and associated ducting beneath the CWT. The reconstruction thus far shows outward deformation of the CWT walls and deformation of the internal components of the tank that are consistent with an explosion originating within the tank. Airplane parts (includes portions of the fuselage structure from above, air conditioning packs and ducting from below, wing structure from both sides, all tires from behind, and numerous components that included the large fiberglass water and cargo fire extinguisher containers from forward of the CWT) from in and around the CWT recovered and identified to date contain no evidence of bomb or missile damage. The investigation into what might have provided the source of ignition of the fuel-air mixture (including a bomb or missile) in the CWT is continuing.

Since 1985, the Board has investigated or assisted in the investigation of two other fuel tank explosions involving commercial transport category airplanes. The most recent accident involved a Philippine Airlines Model 737–300 at Nimoy Aquino International Airport, Manila, Philippines, on May 11, 1990. In the accident, the CWT ullage (In a fuel tank, the ullage is the vapor-laden space above the level of the fuel in the tank.) fuel-air vapors exploded as the airplane was being pushed back from a terminal gate, resulting in 8 fatalities and 30 injuries. The ambient temperature at the time of the accident was about 95°F, and the airplane had been parked in the sun. Although damage to wiring and a defective fuel quantity sensor were identified as possible sources of ignition, a definitive ignition source was never confirmed.

The Board also assisted in the investigation of the crash of Avianca Flight 203, a Model 727, on November 27, 1989. The airplane had departed Bogota, Colombia, about 5 minutes before the crash. Examination of the wreckage revealed that a small bomb placed under a passenger seat, about the CWT, had exploded. The bomb explosion did not compromise the structural integrity of the airplane; however, the explosion punctured the CWT and ignited the fuel-air vapors in the ullage, resulting in destruction of the airplane.

Earlier, the Board conducted a special investigation of the May 9, 1976, explosion and in-flight separation of the left wing of an Iranian Air Force Model 747–131, as it approached Madrid, Spain, following a flight from Iran. Witnesses reported seeing a lightning strike to the left wing, followed by fire, explosion, and separation of the wing. The wreckage revealed evidence of an explosion that originated near a fuel valve installation in the left outboard main fuel tank. The Board's report (NTSB–AAR–78–12. The Board did not determine the probable cause of this foreign accident because it had no statutory authority to do so. Several hypotheses addressing the sequence of events and possible causes of the accident were presented in the Board's report.) noted that almost all of the electrical current of a lightning strike would have been conducted through the aluminum structure around the ullage. While the report did not identify a specific point of ignition, it noted that static discharges could produce sufficient electrical energy to ignite the fuel-air mixture, but that energy levels required to produce a spark will not necessarily damage metal or leave marks at the point of ignition.

Fuel tank explosions require an energy source sufficient for ignition and temperatures between the lower explosive (flammability) limit (LEL) (Marks' Standard Handbook for Mechanical Engineers, Eighth Edition, states, ''The lower and upper limits of flammability indicate the percentage of combustible gas in air below which and above which flame will not propagate. When a flame is initiated in mixtures having compositions within these limits, it will propagate and therefore the mixtures are flammable.'' Marks' states further, ''The autoignition temperature of an air-fuel mixture is the lowest temperature at which chemical reaction proceeds at a rate sufficient to result eventually (long time lag) in inflammation.'' In the TWA800 CWT, the LEL was about 115°F, and the autoignition temperature was about 440°F.) and upper explosive limit (UEL), which will result in a combustible mixture of fuel and air. Current FAA regulations require protection against the ignition of fuel vapor by lightning, components hot enough to create an autoignition, and parts or systems failures that could become sources of ignition. Specifically: (1) Fuel system lightning protection. The fuel system must be designed and arranged to prevent the ignition of fuel vapor within the system by (a) direct lightning strikes to areas having a high probability of stroke attachment; (b) swept lightning strikes to areas where swept strokes are highly probable; and (c) corona and streamering at fuel vent outlets. (§ 25.954), and (2) Fuel Tank Temperature. (a) The highest temperature allowing a safe margin below the lowest expected autoignition temperature of the fuel in the fuel tanks must be determined. (b) Not at any place inside any fuel tank where fuel ignition is possible may exceed the temperature determined under paragraph (a) of this section. This must be shown under all probable operating, failure, and malfunction conditions of any component whose operation, failure, or malfunction could increase the temperature inside the tank. (§ 25.981)

However, a 1990, Society of Automotive Engineers technical paper comments, ''. . . if the ignition source is sufficiently strong (such as in combat threats), it can raise the fluid temperature locally and thus ignite a fuel that is below its flash point temperature. This is particularly true with a fuel mist where small droplets require little energy to heat up.'' (Society of Automotive Engineers (SAE) Technical Paper Series 901949, Flammability of Aircraft Fuels, by N. Albert Moussa, Blaze Tech Corp., Winchester, Massachusetts, as presented at the Aerospace Technology Conference and Exposition, Long Beach, California, on October 1–4, 1990.) Elevated, possibly extremely high local temperatures would have been associated with the lightning strike of the Iranian Model 747 in 1976.

Despite the current aircraft certification regulations, airlines, at times, operate transport category turbojet airplanes under environmental conditions and operational circumstances that allow the temperature in a fuel tank ullage to exceed the LEL, thereby creating a potentially explosive fuel-air mixture. For example, on August 26, 1996, Boeing conducted flight tests with an instrumented Model 747 airplane that carried about the same small amount of fuel in the center wing tank as that carried aboard TWA800. All three air conditioning packs were operated on the ground for about 2 hours to generate heat beneath the CWT. The airplane was then climbed to an altitude of 18,000 feet msl. The temperature of the fuel in the center tank of the test airplane was measured at one location, and the air temperature within the tank was measured at four locations. In this test, the fuel-air mixture in the CWT ullage was stabilized at a temperature below the LEL on the ground. However, as the airplane climbed, the atmospheric pressure reducing the LEL temperature and allowing an explosive fuel-air mixture to exist in the tank ullage.

Fuel tank temperatures may also become elevated, allowing explosive fuel-air mixtures to exist in the ullage, when airplanes are on the ground between flights at many airports worldwide during warm weather months. When the temperature of a combustible fuel-air mixture exceeds the LEL, a single ignition source exposed to the ullage could cause an explosion and loss of the airplane. This situation is inconsistent with the basic tenet of transport aircraft design—that no single-point failure should prevent continued safe flight. (FAA Advisory Circular (AC) 25.1309–1A, System Design and Analysis, paragraph 5.a.1 states, ''In any system or subsystem, the failure of any single element, component, or connection during any one flight (brake release through ground deceleration to stop) should be assumed, regardless of its improbability. Such single failures should not prevent continued safe flight and landing, or significantly reduce the capability of the airplane or the ability of the crew to cope with the resulting failure conditions.'')

Without oxygen in the fuel-air mixture, the fuel tank ullage could not ignite, regardless of temperature or ignition considerations. The military has prevented fuel tank ignition in some aircraft through the creation of a nitrogen-enriched atmosphere (nitrogen-inerting) in fuel tank ullage, there by creating an oxygen-deficient fuel-air mixture that will not ignite. Although this technology could be applied to civil aircraft, there are no transport category airplanes of which the Board is aware that currently incorporate nitrogen-inerting systems to reduce the potential for fuel tank fires and explosions.

Nitrogen-inerting has been accomplished several ways: (1) By adding nitrogen to fuel tank(s) from a ground source before flight; (2) By charging onboard supplies of compressed or liquefied nitrogen in flight; or (3) By the use of on-board inert gas generation systems that separate air into nitrogen and oxygen. Such systems in current-generation military aircraft incorporate lightweight, permeable plastic membrane systems that produce high nitrogen flow rates and require only ''on-condition'' maintenance. Nitrogen-inerting using a ground source of nitrogen might prevent explosions such as those that occurred to the TWA800 and Avianca airplanes, but may not prevent an explosion after the fuel tanks have been emptied during flight through fuel consumption, or when ullage is exposed to warmer air as an airplane descends—situations that existed in the Iranian Air Force Model 747 accident. Nitrogen-inerting fuel tank ullage has been used for more than 25 years in military airplanes and could be used to protect commercial air transportation. However, the Board recognizes that development and installation of such systems are expensive and may be impractical because of system weight and maintenance requirements in some airplanes.

Therefore, the Board has considered other modifications of the airplane that would reduce the potential for aircraft fuel tank explosions. A reduction in the potential for fuel tank explosions could be attained by reducing the heat transfer to fuel tanks from sources such as hot air ducts and air conditioning packs (Airplanes other than the Model 747 also have heat-producing equipment in the vicinity of fuel tanks. For example, the A–320 and other Airbus Industries commercial transport category airplanes are similar to those from Boeing in that the air conditioning packs and ducts are beneath the CWT.) that are now located under or near fuel tanks in some transport category airplanes. This may be achieved by installing additional insulation between such heat sources and fuel tanks that must be collocated with heat-generating equipment such as hot air ducting and air conditioning packs.

Because the Board believes that the FAA should require the development and implementation of design or operational changes that will preclude the operation of transport category airplanes with explosive fuel-air mixtures in the fuel tanks, significant consideration should be given to the development of airplane design modifications, such as nitrogen-inerting systems and the addition of insulation between heat-generating equipment and the fuel tanks. Appropriate modifications should apply to newly certificated airplanes, and where feasible, to existing airplanes.

The Board recognizes that such design modifications take time to implement and believes that in the interim, operational changes are needed to reduce the likelihood of the development of explosive mixtures in fuel tanks. Two ways to reduce the potential of an explosive fuel-air mixture could be by refueling the CWT to a minimum level from cooler ground fuel tanks or by carrying additional fuel. Therefore, by monitoring fuel quantities and temperatures (when so-equipped), by controlling the use of air conditioning packs and other heat-generating devices or systems on the ground, and by managing fuel distribution among various tanks to keep all fuel tank temperatures in safe operating ranges and a to-be-determined minimum fuel quantity in the CWT, flightcrews could reduce the potential for fuel tank operations in the Model 747. The Board believes that pending implementation of design modifications, the FAA should require modifications in operational procedures to reduce the potential for explosive fuel-air mixtures in the fuel tanks of transport category aircraft. In the Model 747, consideration should be given to refueling the CWT before flight whenever possible from cooler ground fuel tanks, proper monitoring and managing of the CWT temperature, and maintaining an appropriate minimum fuel quantity in the CWT.

The Board has also found that the Trans World Airlines 747 Flight Handbook used by crewmembers understates the extent to which the air conditioning packs can elevate the temperature of the Model 747 CWT. The handbook notes that pack operation may elevate the temperature of the CWT by an additional 10 to 20°F. However, in the August 26, 1996, Model 747 flight tests with three air conditioning packs in operation the temperature of the center tank fuel increased by approximately 40°F. A 40°F temperature increase in the CWT of TWA800 would have raised the temperature of the ullage above the LEL of its fuel-air mixture. The handbook also states, ‘‘warm fuel . . . may cause pump cavitation and low pressure warning lights may come on steady or flashing.’’ The Board is concerned that the flight handbooks of other operators of the Model 747 may have similar deficiencies, Therefore, the Board believes that the FAA should require that the Model 747 Flight Handbooks of TWA and other operators of Model 747s and other aircraft in which fuel tank temperature cannot be determined by flightcrews be immediately revised to reflect the increases in CWT temperatures found by flight tests, including operational procedures to reduce the potential for exceeding CWT temperature limitations.

Although the TWA Model 747 Flight handbook (and the Boeing Airplane Flight Manual) instruct flightcrews not to exceed fuel temperatures of ‘‘54.5C (130F), except JP–4 which is 43C (110F),’’ the only fuel tank temperature indication displayed for flightcrews is that of the outboard main tank in the left wing. The designs of the Model 747 and some other airplanes currently provide no means to measure the temperature of the fuel or ullage of fuel tanks that are located near heat sources. The Board believes that flightcrews need to monitor the temperature of fuel tanks that are located near heat sources, including the CWT in Model 747s. Therefore, the Board believes that the FAA should require modification of the CWT of Model 747 airplanes and the fuel tanks of other airplanes that are located near heat sources to incorporate temperature probes and cockpit fuel tank temperature displays to permit determination of the fuel tank temperatures.

Therefore, the Board recommends that the FAA:

(1) Require the development of and implementation of design or operational changes that will preclude the operation of transport category airplanes with explosive fuel-air mixtures in the fuel tanks:

(a) Significant consideration should be given to the development of airplane design modification, such as nitrogen-inserting systems and the addition of insulation between heat-generating equipment and fuel tanks. Appropriate modifications should apply to newly certificated airplanes and where feasible, to existing airplanes. (A–96–174)

(b) Pending implementation of design modifications, require modifications in operational procedures to reduce the potential for explosive fuel-air mixtures in the fuel tanks of transport category aircraft. In the Model 747, consideration should be given to refueling the CWT before flight whenever possible from cooler ground fuel tanks, proper monitoring and management of the CWT fuel temperature, and maintaining an appropriate minimum fuel quantity in the CWT. (Urgent) (A–96–175)

(2) Require that the Model 747 Flight Handbooks of TWA and other operators of Model 747s and other aircraft in which fuel tank temperature cannot be determined by flightcrews be immediately revised to reflect the increases in CWT fuel temperatures found by flight tests, including operational procedures to reduce the potential for exceeding CWT temperature limitations. (A–96–176)

(3) Require modification of the CWT of Model 747 airplanes and the fuel tanks of other airplanes that are located near heat sources to incorporate temperature probes and cockpit fuel tank temperature displays to permit determination of the fuel tank temperatures. (A–96–177)

Chairman Hall, Vice Chairman Francis, and Members Hammerschmidt, Goglia, and Black concurred in these recommendations.

FAA Discussion of NTSB Recommendations: The discussion that follows provides additional information and clarification of the NTSB recommendations.

As part of the discussion providing the background for the recommendations, the NTSB letter cites § 25.954, Fuel system lightning protection, and § 25.981, Fuel tank temperature, of 14 CFR part 25. The letter then states, ‘‘Despite the current aircraft certification regulations, airlines, at times, operate under environmental conditions and operational circumstances that allow the temperature in a fuel tank ullage to exceed the LEL (lower explosive limit), thereby creating a potentially explosive fuel-air mixture. When the temperature of a combustible fuel-air mixture exceeds the LEL, a single ignition source exposed to the ullage could cause an explosion and loss of the airplane. This situation is inconsistent with the basic tenet of transport aircraft design—that no single-point failure should prevent continued safe flight.’’ A footnote is then made referring to FAA Advisory Circular (AC) 25.1309–1A.

These statements in the NTSB letter appear to indicate a belief that the airworthiness standards of part 25 do not allow operation of airplanes with flammable vapors in the fuel tank ullage. In fact, the FAA has never attempted to preclude the operation of transport category airplanes with flammable fuel-air mixtures in the fuel tanks. Section 25.981 requires that the temperature of fuel in a tank on transport category airplanes be below the lowest expected auto ignition temperature of the fuel; not below the lower explosive limit. The auto ignition temperature is the temperature at which spontaneous ignition of the fuel will take place, which, for aviation turbine fuels, is in the range of 440°F to 490°F. Section 25.961 requires that the fuel system (e.g. pumps, valves etc.,) operate satisfactorily in hot weather. No regulation or policy currently in place is intended to prevent the operation of transport category airplanes with a flammable fuel-air mixture in the fuel tanks.

Based on the flammability characteristics of the various fuels approved for use on transport category airplanes, it has always been assumed by the FAA that airplanes may operate during some significant portion of the flight with flammable mixtures in their fuel tank ullage. The FAA has considered that design features which are intended to preclude the presence of an ignition source within the fuel tanks would provide an acceptable level of safety.

The NTSB statements also appear to indicate that the FAA has knowingly approved transport airplane fuel systems which have the potential for single failures to create an ignition source in the fuel tanks. In fact, the FAA has not knowingly approved any such fuel systems. At the time of its certification, the Model 747 fuel system design was found to comply with 14 CFR 25.901(b)(2), which stated, ''The components of the installation must be constructed, arranged, and installed so as to ensure their continued safe operation between normal inspections and overhauls.'' It was also found to comply with § 25.1309(b), which stated, ''The equipment, systems, and installations whose functioning is required by this subpart (F) must be designed to prevent hazards to the airplane if they malfunction or fail.'' While the current versions of §§ 25.901(c) and 25.1309(b) (and AC 25.1309–1A) did not exist at the time of application for the Model 747 type certificate and were therefore not part of the Model 747 certification basis, the FAA did apply §§ 25.901(b) and 25.1309(b), as they existed at that time, in a manner that was intended to require a fuel system which was fail-safe (i.e., single failures cannot be catastrophic) with respect to the creation of ignition sources inside the fuel tanks. On the Model 747, the approval of the installation of mechanical and electrical components inside of the fuel tanks was based on a system safety analysis and component testing that showed: (1) mechanical components were fail safe, and (2) electrical devices would not create arcs of sufficient energy to ignite a fuel-air mixture in the event of a single failure or a probable combination of failures.

The FAA approved the Model 747 fuel system, as well as many other transport airplane models, on this basis. The operational situation and the fuel tank temperature and loading conditions that existed in the center wing tank of the TWA airplane in the hours leading up to the accident were in no way unique. During warm and hot weather, most commercial transport category airplanes operate with flammable vapor within center wing, auxiliary, and main fuel tanks. Model 747 airplanes operating on many routes are regularly operated without mission fuel in the center wing tank. One to three air conditioning packs are normally operated on the airplane once the flightcrew is on board, depending on outside air temperature and passenger load, and extended delays in warm or hot weather have occurred many times since the Model 747 was certificated in 1970. The obvious difference on the day of the accident was that an ignition source of some sort made contact with the flammable mixture in the center wing tank.

The FAA has examined the service history of the Model 747 and other transport category airplane models and has performed a preliminary analysis of the history of fuel tank explosions on civil transport category airplanes and on military transport category airplanes which are based on a civil airplane type. While there were a significant number of fuel tank fires and explosions that occurred during the 1960's and 1970's on several airplane types, in most cases the fire or explosion was found to be related to maintenance errors or improper modification of fuel pumps which provided an ignition source. Some of the events were apparently caused by lightning strikes, including the 1976 Imperial Iranian Air Force 747 accident in Spain. In almost every case, the ignition source was identified and actions were taken to prevent similar occurrences. Because of the lessons learned from these events, the transport airplane industry has significantly improved its capability to provide airplanes that are fail-safe with respect to ignition sources in fuel tanks and which are able to maintain those fail-safe characteristics over the life of individual airplanes.

The FAA recognizes, however, that the Philippine Airlines 737 accident in 1990 and the TWA Flight 800 accident are inconsistent with this perceived trend toward a very low rate of tank explosions. While no probable cause has yet been identified in either of these accidents, the presence of an ignition source originating with the accident airplanes has not been ruled out. In addition, it is clear that fuel tanks of all current designs are also vulnerable to ignition from bombs or missiles. Therefore the FAA has initiated evaluation of possible methods of reducing or eliminating the potential of fuel tank ignition. However, such evaluation requires analyses of the potential benefits of such design changes in terms of accident prevention, analyses of the additional costs to the industry and risks to an airplane caused by any additional systems.

Request for Information

Before initiating any action regarding these recommendations the FAA must determine the feasibility and the effectiveness of any proposed methods of reducing the potential of an explosive fuel-air mixture within airplane fuel tanks. The FAA therefore requests comments in that regard from the public, including the aviation industry, airplane manufacturers (both domestic and foreign), and any other interested persons. This information may include technical and economic data and information, arguments pro or con concerning technical feasibility, and any other information deemed pertinent.

The modern commercial transport category airplane requires maximum safety; however, new protective features must be justified by an increased level of safety with minimum added complexity, weight, and operational constraints. Estimates of probable costs and benefits derived from implementing the NTSB recommendations are important.

The following questions are intended to solicit comments regarding the NTSB recommendations.

Specific Questions

NTSB Recommendations 96–174 and –175 focus on controlling fuel temperatures within fuel tanks as a short term method of reducing the potential of an explosive fuel-air mixture within fuel tanks. Nitrogen inerting is proposed as a longer term methodology of reducing the potential of an explosive fuel-air mixture. These proposals are applicable to transport category airplanes. Recommendations number A–96–176 and –177 propose revisions to airplane flight manuals to include limitations on fuel temperatures and incorporation of fuel temperature indication systems to determine fuel tank temperatures, respectively. These two proposals are applicable to all airplanes. Therefore, comments to the questions below relating to Recommendations A–96–176 and –177 should include consideration of the appropriateness to transport category airplanes (which would include airplanes designed for business travel as well as airline service) and non-transport category airplanes. The latter would include airplanes intended for general aviation use as well as commuter airline service. Questions regarding each of these proposals are provided below. The FAA is particularly interested in comments to the specific questions in the following areas:

Controlling Fuel Temperatures

Initial evaluation indicates that if the NTSB proposal to modify airplane operational procedures to limit fuel temperatures was implemented, the use of more volatile fuels such as Jet B would likely be unacceptable. The use of fuels produced in countries outside the United States that are more volatile would also likely be unacceptable under certain conditions. In addition, the flammability characteristics of Jet A fuel vapors are such that fuel temperatures would be limited throughout the flight. For example, at an altitude of 30,000 ft. the maximum fuel temperature would be limited to approximately 60°F and at an altitude of 40,000 ft. it would be limited to approximately 50°F. When the effects of fuel shoshing and vibration are considered the allowable temperature would be reduced by approximately 10°F to 50 and 40°F respectively. The need to limit maximum fuel temperatures to this value is due to the change in the flammability temperature range with ambient pressure as discussed earlier in this notice. The fuel temperature limit established for each airplane type would vary due to differing cruise altitudes and fuel heating differences between airplane types. Therefore, for the purposes of cost estimates requested in this notice, a maximum fuel temperature limit in the range of 50–50°F is proposed. Within some fuel tanks, such as the center wing tank on many airplane types, fuel cools very slowly because very little of the fuel tank surface is exposed to ambient air, and the lower tank surfaces are heated by the air conditioning packs. Installation of insulation to reduce heating of the fuel, carrying reserve fuel within the center tank and/or transferring cooler fuel during flight, are proposed by the NTSB as possible means to maintain fuel temperatures below the proposed limit value.

Refueling Fuel Tanks From Cooler Ground Sources

While ''cool'' fuel may be available at some airports, a survey conducted in the 1970's of fuel temperatures from ground sources at major worldwide airports indicated that average fuel temperatures were in the range of 60–65°F. Fuel temperatures will increase in tanks adjacent to heat sources and on warmer days following refueling; therefore, cooling of fuel at many airports would likely be required to maintain fuel temperatures below the proposed maximum limit, which would vary with approved maximum altitude limits of each airplane model. The FAA is requesting additional information/opinions on the following:

(1) What is the maximum fuel temperature within a fuel tank that prior to flight would preclude a flammable mixture of fuel within the fuel tank during the subsequent flight?

(2) In consideration of the fuel properties noted above, is control of fuel temperatures a practical and effective way to reduce the likelihood of fuel tank explosions?

(3) Is more recent fuel temperature data available for fuel from ground sources at major airports worldwide?

(4) Is it technically feasible and operationally practical to cool fuel prior to loading into fuel tanks?

(5) Is equipment currently available for cooling of fuel prior to or during the airplane loading process.

Limiting Environmental Control System (ECS) Pack Operation

The NTSB also suggests controlling the use of ECS packs to reduce fuel heating within the center wing tank. The recommendation would likely require an alternate source of cool air for passenger comfort during ground operations.

(1) Would it be practical to limit ECS pack operation while on ground and inflight to reduce heat input to the center wing fuel tank?

(2) Is it practical to assume that external air conditioning is available at all international airports?

(3) If other sources of air conditioning were required, what would be the added recurring (including labor to monitor fuel temperatures and cabin temperatures) and non-recurring costs?

Carrying Additional Fuel

(1) Assuming that an airplane was dispatched with cooler fuel and fuel tanks were insulated from heat sources, what would be the minimum fuel level that would be required to maintain fuel temperatures below that where an explosive fuel-air mixture forms in the tank?

(2) Would fuel transfer from other fuel tanks with cooler fuel be a practical means of reducing the amount of fuel carried within the tank to maintain temperatures below that where an explosive fuel-air mixture forms in the tank?

Request for Cost Information for Limiting Fuel Temperatures

The NTSB recommendations focus on limiting fuel temperatures primarily on Model 747 airplanes. Many other airplane types, such as the Boeing Model 737, 757, 767, 777, and Airbus A320, A330, A340, have features such as hydraulic heat exchangers within wing fuel tanks or ECS packs located below the center wing fuel tank that may result in fuel tank heating.

(1) Regarding airplane type, what should be the applicability of the proposed recommendations?

(2) What would be the costs associated with:

(a) Eliminating the use of more volatile fuels such as Jet B, and JP–4?

(b) Tankering fuel within otherwise empty fuel tanks for the purpose of maintaining fuel temperatures below the flammability limits?

(c) Installing a fuel temperature indication system within each airplane fuel tank to monitor fuel temperatures?

(d) Cooling fuel during the fueling of airplanes when fuel temperatures from the airport fueling hydrant are above the limit of 40–50°F?

(e) Insulating fuel tanks from heat sources?

(f) Transferring from other fuel tanks with cooler fuel, while on ground and inflight?

(3) What are the operational considerations of such procedures?

(4) Are there additional near term possibilities to reduce the potential of an explosive fuel-air mixture within fuel tanks? For any possible methods, the above questions should be answered.

Nitrogen Inerting

Information available from military airplanes indicates that with currently available technology, On Board Inert Gas Generating Systems (OBIGGS), possibly supplemented for ground conditions with ground based nitrogen sources, would be an effective means of inerting fuel tanks.

Results of the FAA test and other military tests would indicate that an effective inerting system would require a constant supply of nitrogen to the fuel tank. In 1993, McDonnell Douglas installed an inerting system on the C–17 military cargo airplane to reduce fuel tank ignition from penetration by unfriendly weapons fire. The system utilizes an on-board inerting system that separates nitrogen enriched air (NEA) from compressed air supplied by the engines. Each fuel tank is continuously supplied with NEA. The NEA is compressed to 3,000 psi and stored in 4 tanks to provide protection for on-ground use. Although a more modest system may be possible for transport category airplanes, the feasibility of using the C–17 system is questionable for commercial transport category airplanes. Total system weight is 2,146 pounds (including 328 lbs. of stored NEA). Additionally, the system design and hardware costs, increased fuel burn to provide compressed air to the system, and increased maintenance costs would have to be factored into an assessment of the feasibility of installing such a system on transport category airplanes.

Although the added weight and cost of the C–17 system may be prohibitive for commercial transport airplane operations, it may be possible to achieve the desired level of safety with a more modest inerting system. Based on review of transport airplane operations, the need for on-board storage of nitrogen can be eliminated if the system is designed for typical altitude changes and dissolved oxygen in the fuel is removed during the refueling process. Therefore, for the purposes of this notice, the FAA is assuming the portions of the airplane operating envelope to include only normal climb and decent rates and that scrubbing of oxygen from the fuel be completed during the refueling process while the airplane is on the ground. Possible sources of nitrogen for the scrubbing process may be on ground storage systems or from the OBIGGS installed on the airplane.

(1) What design and safety criteria should be developed and used to define a nitrogen inerting system providing protection for the scenario described by the NTSB recommendations?

(a) Would a system optimized for normal airplane climb and decent rates provide a desired level of safety enhancement?

(b) Is it appropriate to allow dispatch of an airplane with the inerting system inoperative under minimum equipment list requirements?

(c) Would the OBIGGS or ground based sources be the most cost effective source of nitrogen for scrubbing of the fuel? What would be the costs associated with two sources of nitrogen for fuel scrubbing?

(2) Incorporation of nitrogen inerting systems could result in negative impacts on other airplane systems, and could introduce additional safety concerns.

(a) What, if any, are the potential safety concerns regarding implementation of nitrogen inerting systems (e.g., overpressurization of airplane fuel tanks, and maintenance of personnel entering previously inerted tanks without appropriate breathing apparatus)?

(b) What, if any, negative impact could introduction of nitrogen inerting have on airplane systems?

(3) What would be the cost of incorporating a nitrogen inerting system utilizing OBIGGS sized to inert the tanks while on the ground and during normal climb and decent conditions:

(a) Cost of the hardware?

(b) Weight of the system?

(c) Cost of maintenance of the system?

(d) Added fuel consumption to supply bleed air to the inert gas separation system?

(e) Cost of modifications to airplane fuel/vent system?

(f) Cost of lost revenue due to increased weight of airplane with inerting system?

(g) Cost of reduced dispatch reliability?

(h) Cost of developing inerting systems consistent with commercial standards of reliability?

(4) If nitrogen inerting were implemented to reduce the potential for fuel tank ignition, additional benefits may result. Possible benefits include reduction of water within fuel tanks, the allowance of the use of more volatile fuels, and any oxygen generated by the OBIGGS system might be used to replace or supplement passenger oxygen systems.

(a) Would the reduction in water within fuel tanks result in less corrosion and any quantifiable reduction in airplane maintenance?

(b) Would the reduction in water within fuel tanks allow reduced intervals for sumping of fuel tanks and an associated reduction in labor costs?

(c) Would the continued use of more volatile fuels provide a benefit, particularly for engine starting in colder climates?

(d) Could oxygen generated by the OBIGGS system be used to replace or supplement passenger oxygen systems and provide a quantifiable benefit in weight and costs?

(e) Several accidents have been associated with oxygen bottles used for the passenger oxygen system. If on-board storage of oxygen could be reduced or eliminated by the OBIGGS, what, if any, safety benefits would result due to reduced potential for oxygen fed fires?

(5) What other methods, other than nitrogen inerting, will provide the desired level of safety enhancement and what costs are associated with these methods.

Applicability

The recommendations by the NTSB refer to transport category airplanes, aircraft, or airplanes, and appear to use the terms with intent. Thus, the desired applicability of each of the NTSB recommendations is different. These terms have specific definitions that are recognized throughout the aviation industry and the FAA regulations. The more generic term is aircraft. Part 1 of Title 14 of the Code of Federal Regulations defines aircraft as ‘‘a device that is used or intended to be used for flight in the air.’’ Airplane is a subset of aircraft and means ‘‘an engine-driven fixed wing aircraft heavier than air, that is supported in flight by the dynamic reaction of air against its wings.’’ A transport category airplane is an airplane that is certificated in accordance with the airworthiness standards of Part 25. The term ‘‘airplane’’ also includes non-transport category airplanes such as those intended for general aviation on commuter airline service.

When commenting on the technical feasibility and economic implications of the NTSB recommendations, the FAA is requesting that specific attention be given to the intended scope of those recommendations.

(1) What might be technically feasible for a transport category airplane may not be feasible for all aircraft. What is technically feasible for the range of products identified, and is there a range where the recommendations seem inappropriate?

(2) Transport category airplanes include those designed for business travel as well as those used for airline service. The FAA is interested in specific comments as to the feasibility of applying some of the concepts envisioned by the NTSB to that class of airplanes.

(3) It is also recognized that some airplanes and other aircraft have reciprocating engines that use a different and more volatile fuel than that used by turbine engines. What

unique situations does this present relative to the NTSB recommendations?

(4) The NTSB recommendations also distinguish in some cases between what might be done for new designs and what might be done for existing airplanes. The FAA is interested in specific comments as to the technical feasibility and economic impacts of applying the concepts in the NTSB recommendations separately to newly certificated aircraft, new production aircraft at some time in the future, or existing aircraft in service.

Conclusion

This notice seeks information from interested persons, including manufacturers and users of transport category airplanes and components, the general public, and foreign airworthiness authorities in determining the feasibility of NTSB recommendations to limit airplane operation with explosive fuel vapors within fuel tanks.

Issued in Renton, Washington, on March 28, 1997.

Darrell M. Pederson,

Acting Manager, Manager, Transport Airplane Directorate, Aircraft Certification Service, ANM–100.

[FR Doc. 97–8495 Filed 3–31–97; 12:57 am]

BILLING CODE 4910–13–M