TABLE OF CONTENTS

Airbus
A318/A319/A320/A321

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ATA 28
Fuel Tank Safety

Awareness Training and enhanced Airworthiness Program
acc. EASA Decision No 2009/007/R

Training Letter

Phase 1

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- The LTT production process ensures that the Training Manual contains a complete set of all necessary pages in the latest finalized revision.

FUEL TANK SAFETY

AWARENESS TRAINING AND ENHANCED AIRWORTHINESS PROGRAM EASA DECISION NO 2009/007/R

ABBREVIATIONS

ALI	Airbus: Airworthiness Limitation Item Boeing: Airworthiness Limitation Inspection Airworthiness Limitation Instruction
AMM	Aircraft Maintenance Manual
AWL	Airworthiness Limitations
ASM	Air Separation Module
CDCCL	Critical Design Configuration Control Limitations
CMM	Component Maintenance Manual
CMR	Certification Maintenance Requirements
EASA	European Aviation Safety Agency
FAA	Federal Aviation Administration
FAL	Fuel Airworthiness Limitations
FQI	Fuel Quantity Indication
FQIS	Fuel Quantity Indication System
Fuel ALI	Fuel Airworthiness Limitation Items
INT/POL	Interim Policy
JAA	Joint Aviation Authorities
LEL	Lower Explosion Limit
MPD	Maintenance Planning Data
NAA	National Aviation Authorities
NTSB	National Transportation Safety Board
PPM	Parts Per Million
SB	Service Bulletin
SFAR	Special Federal Aviation Regulation
SPM	Standard Practices Manual

INTRODUCTION OF THE SFAR 88

BACKGROUND INFORMATION

General

Since 1959 there have been 17 fuel tank ignition events, resulting in:

- 542 fatalities
- 11 hull losses
- 3 others with substantial damage.

Causes

- 3 unknown
- 4 caused by external wing fires
- 4 electrostatics
- 2 lightning
- 2 pumps or wiring suspected
- 1 by small bomb
- 1 maintenance action

TWA Flight 800

Twenty minutes after taking off from New York‘s JFK International Airport on July 17, 1996, Paris–bound TWA Flight 800 exploded. All 230 passengers were most likely killed from what medical examiners described as ”phenomenal whiplash”.

It is widely accepted that an explosion in the central fuel tank of the aircraft caused its destruction. However, it is unclear exactly what caused this explosion. Researchers examined retrieved parts of the airplane and other similar models to seek explanations for Flight 800‘s explosion. It has been billed as the longest and most expensive accident investigation in American aviation history.

There were several factors that made TWA Flight 800 a ticking time bomb. The two key factors that contributed to the dangerous environment for the 25 year–old Boeing model 747–131 were the condition of the aircraft‘s electrical hardware and the presence of a highly explosive fuel–air ratio in the central fuel tank.

After arriving at JFK International Airport from Athens, Greece, the plane sat on the ground for four hours with the air conditioning units operating before departing for Paris at 8:19 p.m.. The plane exploded 20 minutes later, while ascending at 13,760 ft.

The central fuel tank, which is capable of holding 13,000 gallons of jet fuel, only contained 50 gallons at the time it exploded, meaning that it was less than one–half percent full. TWA Flight 800 was using Jet A fuel, which is most commonly used for commercial jets. The central fuel tank is located on the underside of the fuselage, directly between the wings.

5 Key Accidents	707 Elkton MD 747 Madrid	737 Manila 747 New York	737 Bangkok
Safety Approach: Ignition Sources	Prevent ignition sources (improvements to affected model after accident)	Re-examine design and maintenance to better prevent ignition sources (SFAR 88) Whole Fleet Solution	Recognition that our best efforts may not be adequate to prevent all explosions
Flammability	Some R&D. Not found to be practical. No requirements established.	FAA research led to inerting developments. Industry (ARAC) deemed it impractical.	FAA Simplified system developed. Recognized that inerting is practical, and may be needed to achieve balanced solution

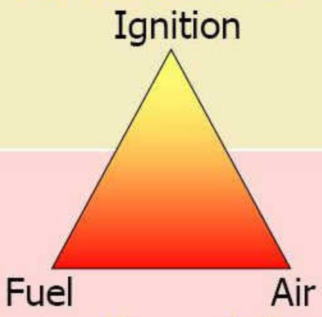


Figure 1 Background for the Introduction of the SFAR 88

Thai B737–400

On March 2001, a B737, operated by Thai Airways, was destroyed by an explosion and fire at Bangkok International Airport, Thailand.

After investigation, the NTSB has determined that the center fuel tank exploded, shortly after the main fuel tanks were refueled. The cause of the explosion was the ignition of the flammable fuel/air mixture in the center fuel tank. The source of the ignition energy for the explosion could not be determined with certainty, but the most likely source was an explosion originating at the center tank fuel pumps.

NOTE: The pumps were operating dry (no fuel passing through them) at the time of the explosion!

Figure 2 Thai 737–400 Fuel Tank Explosion

ACCIDENT FINDINGS

WHAT CAUSED THE CRASH OF TWA 800?

The National NTSB (**T**ransportation **S**afety **B**oard) considered TWA 800 the "most extensive and encompassing accident investigation ever undertaken by the safety board." The NTSB determined that the probable cause of the TWA Flight 800 accident was an explosion of the CWT (**C**enter **W**ing **F**uel **T**ank), resulting from ignition of the flammable fuel/air mixture in the tank. The source of ignition energy for the explosion could not be determined with certainty. However, of the sources evaluated by the investigation, the most likely was a short circuit outside of the CWT that allowed excessive voltage to enter through electrical wiring associated with the fuel quantity indication system.

The Ignition Source

Upon realizing that the central fuel tank of TWA Flight 800 exploded and that the explosion was not likely by a bomb, the NTSB focused on finding the source of ignition. However, after scrutinizing all of the recovered wreckage, which accounts for over 95 % of the plane, they found nothing to support any plausible theory of ignition. The investigation focused on examining the electrical wiring near the central fuel tank, which consists largely of wiring for the FQIS (**F**uel **Q**uantity **I**ndicating **S**ystem) and for control of the fuel pumps. Unfortunately, most of this wiring was burned or damaged from the explosion, thus hindering an analysis into the role that it could have played in causing the explosion. However, this did not leave the NTSB completely in the dark concerning ignition sources. Electrical arcing and autoignition are two source theories that were tested by the NTSB.

Electrical Arcing

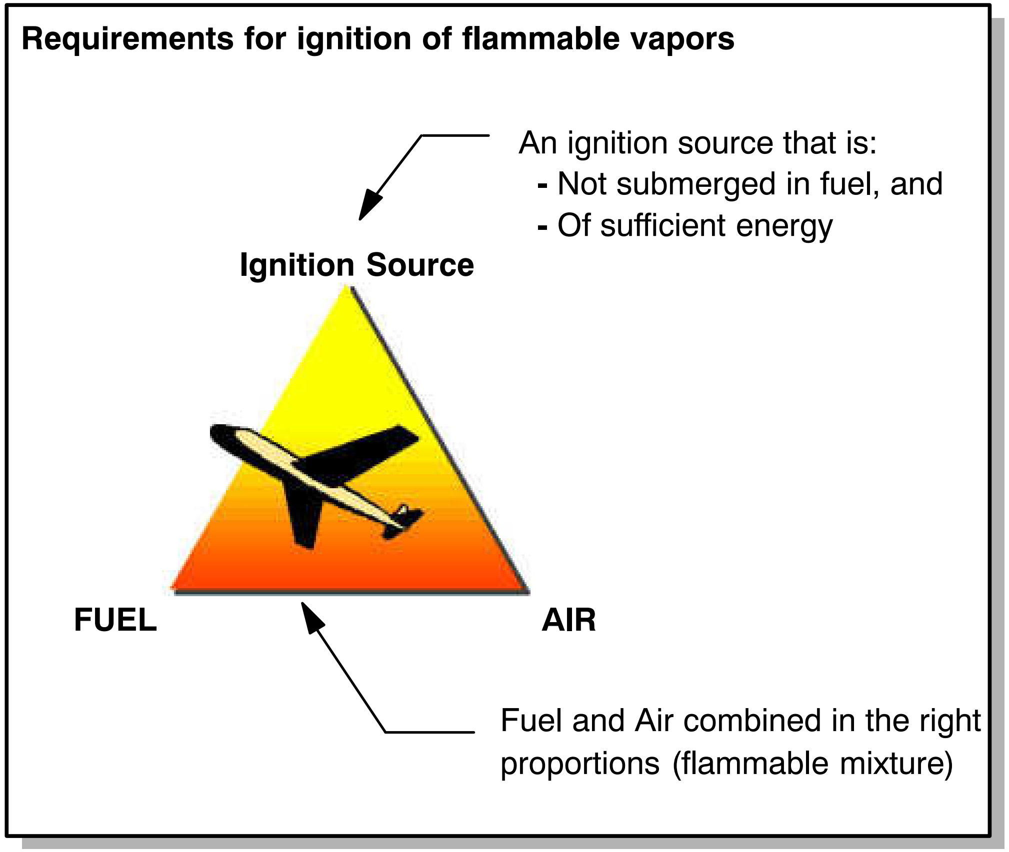
In search of answers to the question of ignition, the NTSB conducted an investigation into the state of electrical wiring in operational Boeing 747s and similar models from other manufacturers to see if a spark could occur in the central fuel tank. The findings from this investigation were discouraging. Between May of 1997 and July of 1998, the NTSB examined a number of existingjets, of which many were old, reaching ages up to 27 1 /2 years old. Findings include „sharp metal shavings both on and between wire bundles", and three–quarter inch coatings of lint on wires, what NTSB investigators describe as syrup: a sticky combination of spilled beverages, leaking water and lavatory fluids, dust and other materials that build up over years of service.

The presence of sharp metal shavings, which can be attributed to drilling, can strip insulation away from wires. As a result, the core conducting wires become exposed and enhance the likelihood of a spark. Exposed wires that are coated with „syrup" or metallic drill shavings can be dangerous because either substance can act as a conductor. Consequently, substances such as these could function as a base point for an electric arc, which could ignite the contents of a fuel tank. The NTSB initiated simulations with these conditions to see if it was possible to create an electrical arc. In one rare case, when bare wires were bundled close to each other, an arc was created.

Autoignition

Another possible source of ignition is from the terminals of the FQIS wires in the central fuel tank on which copper sulfide can build up. This phenomenon has been observed in aging electrical systems, and is a result of the natural deterioration of wiring. The buildups can become sources of localized heat. This can cause a threat because of autoignition. If the localized heat source is hot enough, the fuel around it may reach a temperature at which it will automatically ignite.

Another theory of how autoignition could have occurred within the central fuel tank of TWA Flight 800 involves the scavenger pump and faulty check valves. The scavenger pump is a possible source of ignition because it resides within the central fuel tank. NTSB officials believe that fuel was being transferred between tanks when the explosion occurred, suggesting that the scavenger pump in the central fuel tank was operating. If the scavenger pump was operating and its check valve was too tight, it may have allowed only fuel, and not vapor to pass through it, resulting in a concentration of vapor around the check valve of the scavenger pump. The vapors have a lower autoignition temperature than the liquid and the pump is a significant source of energy that could become hot enough to cause autoignition of fuel vapor.



ELECTRICAL ARCING

DRILL SHAVING AND CONTAMINATION ON WIRE BUNDLES

Figure 3 Accident Findings

CONSEQUENCES

AIRCRAFT FUEL SYSTEM SAFETY PROGRAM (AFSSP)

(Refer to: Aircraft Fuel System Safety Program Report prepared by the International Aviation Industry, August 4, 2000)

In wake of the tragic TWA Flight 800 accident the collective realization emerged that additional information needed to be gathered regarding the condition of airplane fuel tank systems in the world fleet. Consequently, the industry in 1997 committed itself to assessing the state of the inservice fleet around the world. To accomplish this ambitious goal, the AFSSP (**A**ircraft **F**uel **S**ystem **S**afety **P**rogram) was formed. Participants in this voluntary industry program include present and past turbine−powered airliner manufactures, airlines, industry organizations, and airworthiness authorities from around the world. The following excerpt outlines the goals of the AFSSP:

"The industry is fully committed to enhancing aviation safety and believes that efforts should be based on facts. The data available at this time indicates that the best prevention strategy should focus on improvements - design, operation, or maintenance - to enhance fuel tank systems.Therefor the industry plans to voluntarily undertake either a sampling of high−time aircraft or major fuel tank inspection programs to verify

- the integrity of wiring and grounding straps;
- the condition of fuel pumps, fuel lines and fittings; and
- the electrical bonding on all equipment.

The inspection program will not be limited to the Boeing 747; rather, Airbus, Boeing, Lockheed Martin, and McDonnell Douglas have agreed to jointly sponsor a program that covers all of their respective models. In addition, the airlines represented by the ATA, AEA, and the AAPA have agreed to participate in these inspections. The inspection programs findings will be coordinated through the international industry fuel tank inspection task forces. The industry proposes that task force participation include the FAA and international authorities. Subject to agreement with the authorities, the industry would propose to share findings and plans with the public on a timely basis."

The following mission statement was developed by the AFSSP to guide and focus the efforts of this program:

*"Through worldwide industry collaboration, take appropriate action to **ensure, maintain and enhance the safety of fuel systems** throughout the life of the aircraft."*

In the Aircraft Fuel System Safety Program Report prepared and issued by the International Aviation Industry August 4, 2000 the following statements are given among others under paragraph:

2.6 Actions and Recommendations

...

Based on AFSSP findings, the industry recommends additional training for manufacturing and maintenance personnel, and will be reviewing or modifying the existing fuel system maintenance practices to:

- Substantiate the integrity of bonding straps through
  - Long−term periodic visual/tactile inspection to verify bond integrity
  - Enhancements to existing maintenance instructions for bonding jumper maintenance and replacement
- Provide periodic inspection criteria for FQIS (**F**uel **Q**uantity **I**ndicating **S**ystem) wiring and components that are more detailed to better define conditions and items to be inspected during general tank inspections.
- Provide for the periodic in−situ inspection of fuel pumps and associated wiring, fuel lines, and fittings.

The following items are presently part of the periodic heavy maintenance or structural inspections that are already being conducted, so no change to existing practices is recommended.

- Inspection for foreign object debris.
- General tank condition.

...

However, findings outside of this inspection program have shown that improper repair or maintenance of fuel system components can lead to safety issues.

Therefore, the industry believes it is critical to have well−documented maintenance procedures and qualified repair stations and personnel maintaining fuel system components to ensure that design integrity is maintained.

Official Report:

„The probable cause of the TWA Flight 800 accident was an explosion of the center fuel tank (CWT)... neither the energy release mechanism nor the location of the ignition inside the CWT could be determined from the available evidence.“

National Transportation Safety Board(NTSB)-2000

Figure 4 TWA Flight 800 accident

REGULATION

AIRWORTHINESS DIRECTIVES ISSUED

General

As a result of this accident, multiple ADs (**A**irworthiness **D**irectives) on multiple models were issued.

BACKGROUND

Subsequent to accidents involving Fuel Tank System explosions in flight (Boeing 747–131 flight TWA800) and on the ground, the FAA (**U**nited **S**tates **F**ederal **A**viation **A**dministration) published Special Federal Aviation Regulation 88 (SFAR88) in June 2001. SFAR 88 required a safety review of the aircraft Fuel Tank System to determine that the design meets the requirements of FAR § 25.901 and § 25.981(a) and (b).
A similar regulation has been recommended by the European JAA (**J**oint **A**viation **A**uthorities) to the European National Aviation Authorities in JAA letter 04/00/02/07/03–L024 of 3 February 2003. The review was requested to be mandated by European National Airworthiness Authorities using JAR § 25.901(c), § 25.1309.

In August 2005 the EASA (**E**uropean **A**viation **S**afety **A**gency) published a policy statement on the process for developing instructions for maintenance and inspection of Fuel Tank System ignition source prevention that also included the EASA expectations with regard to compliance times of the corrective actions on the unsafe and the not unsafe part of the harmonised design review results. On a global scale the TC (**T**ype **C**ertificate) holders committed themselves to the EASA published compliance dates (see EASA policy statement). The EASA policy statement was revised in March 2006 resetting the date of 31 December 2005 for the unsafe related actions to 1 July 2006.

Fuel Airworthiness Limitations are items arising from a systems safety analysis that have been shown to have failure mode(s) associated with an “unsafe condition“ as defined in FAA‘s memo 2003–112–15 “SFAR 88 - Mandatory Action Decision Criteria“. These are identified in Failure Conditions for which an unacceptable probability of ignition risk could exist if specific tasks and/or practices are not performed in accordance with the manufacturers requirements.

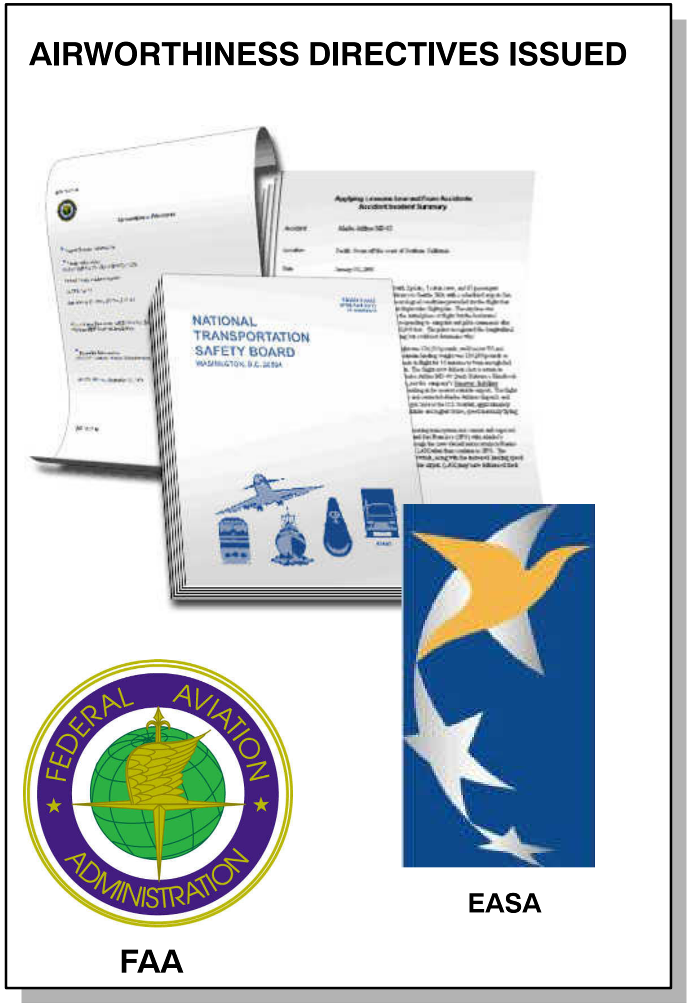
This EASA Airworthiness Directive mandates the Fuel Airworthiness Limitations CDCCL(**C**omprising maintenance/inspection tasks and Critical **D**esign **C**onfiguration **C**ontrol **L**imitations) for the type of aircraft, that resulted from the design reviews and the JAA recommendation and EASA policy statement mentioned above.

Enhanced Airworthiness Program

The FAA and EASA have indicated that operators must train their maintenance and engineering personnel regarding the changes brought about by SFAR 88.

See *EASA ED Decision No 2009/007/R of the Executive Director of the Agency.*

Fuel System Safety Compliance Data



Phase One
SFAR Rule Implementation

June 6, 2001
SFAR 88 Rule became effective. Applicable TC, STC holders had to comply by December 6, 2002

Phase Two
FAR Rule Implementation

June 6, 2001
FAR Parts 25,91,121,125,129 amended to require instructions for maintenance and inspection of the fuel tank system had to be incorporated into the operators Maintenance Program and be FAA approved by June 7, 2004

Enhanced Airworthiness Program.
Covering Phase 1+2 and Continuation Training
EASA DECISION NO 2009/007/R

The FAA and European Aviation Safety Agency (EASA) have indicated that operators must train their maintenance and engineering personnel regarding the changes brought about by SFAR 88.
March, 2009

Figure 5 Fuel System Safety Compliance Data

CONSEQUENCES FOR MAINTENANCE AND OVERHAUL

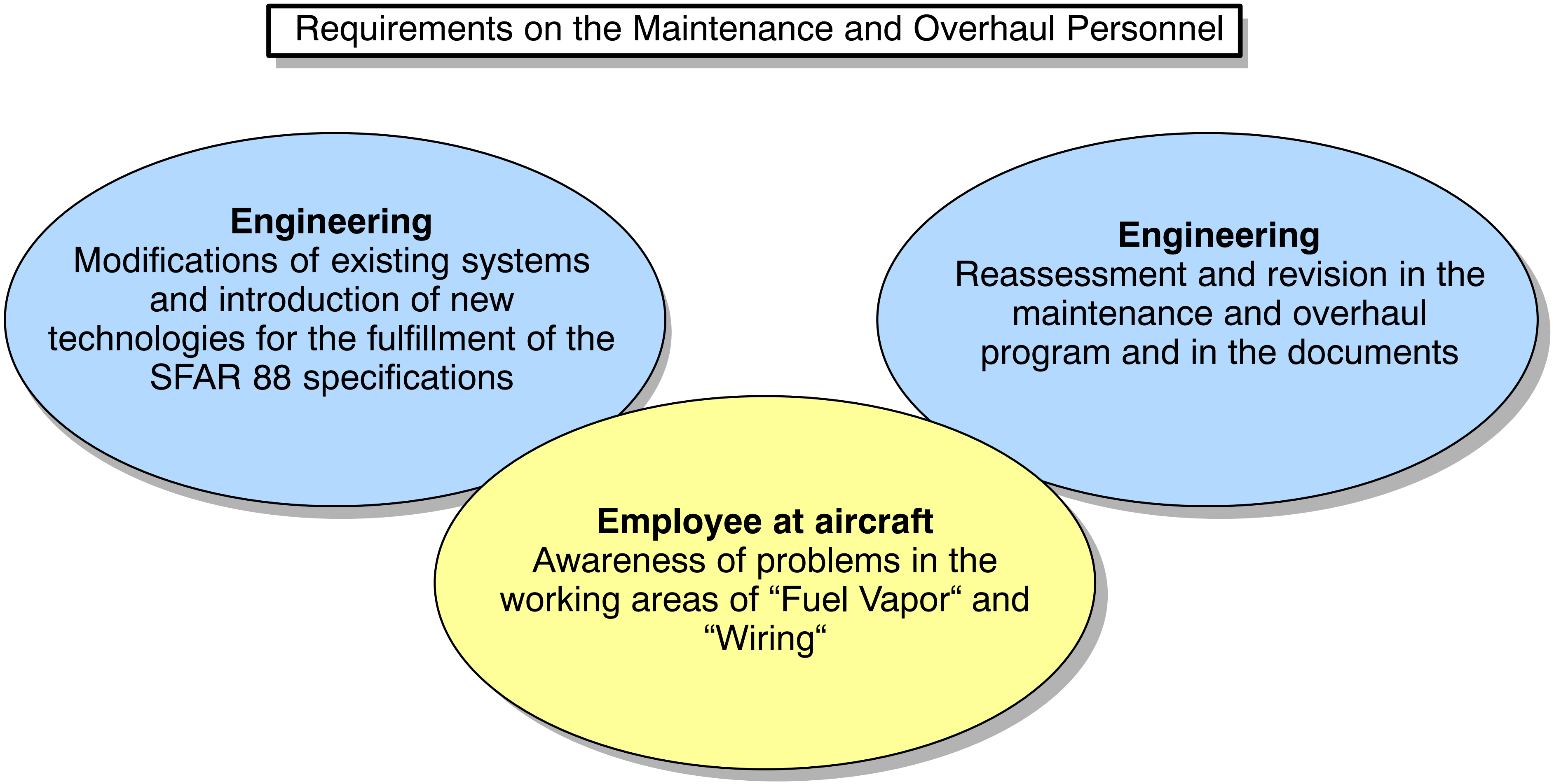


Figure 6 Requirements on the Maintenance and Overhaul Personnel

Modifications of existing systems
and introduction of new technologies for the fulfillment of the SFAR 88 specifications

Specific control specifications are demanded in the aircraft documentation. Possible damages can be discovered at SFAR 88 relevant components and system components.

Example:

- Fuel Pumps
  – Internal components of the “stator wiring“ as a source of spark discharge.
  – Damages at external cables and corroded connections as a source of spark formation.
  – Avoidance of “fuel pump“ operation in empty fuel tanks.

- Fuel Quantity Indication System
  – Faulty insulation of the cables and corroded connections.
  – Unprotected laying of FQI cables together with high voltage lines.

- Fuel Quantity Indication Probes
  – Contaminations in the fuel tanks produce a risk of short circuits.

- Bonding Straps
  – Failure because of corrosion or improper fastening.
  – Failure because of mechanical wear and tear due to movements.

- Pneumatic system failures
  – Due to leakages of the “pneumatic system“ the components of the fuel tanks are heated up.

Reassessment and revision in the maintenance and overhaul program and in the documents

Selection of available and scheduled changes in the maintenance specifications for "fuel tank maintenance" and "inspection":

- Improved instructions for the topic "bonding", as well as regular "bonding checks".
- Leakage inspection at the fuel center tank and condition of the "vapor seals" and "drip shields".
- Execution of "FQI probe gap check" before closing fuel tanks.
- Execution of „bonding check" and "control of foreign objects" before closing fuel tanks.
- Leak check after disturbances at a "hot air duct" nearby fuel tanks.
- Maintenance and overhaul on "fuel pumps" only in accordance with CMM.
- Measures for avoiding dry running of "fuel pumps" in accordance with AMM.
- A redundant lay–out in safety relevant areas of "bonding straps".
- In SFAR 88 relevant areas an increased execution of "double checks".

AIRBUS

Fuel Airworthiness Limitations (FALs)

- **A318/A319/A320/A321** Doc. 95A.1931/05
- **A300–600** Doc. 95A. 1929/05
- **A310** Doc. 95A. 1930/05
- **A330** Doc. 95A. 1932/05
- **A340** Doc. 95A. 1933/05

BOEING

Airworthiness Limitations (AWLs) and Certification Maintenance Requirements (CMRs) Maintenance Planning Data (MPD)

- **B737–100/200/200C/300/400/500** Doc. D6–38278–CMR
- **B747–100/200/300/SP** Doc. D6–13747–CMR
- **B747–400** Doc. D621U400–9
- **B777** Doc. D622W001–9
- **B757/B767**

DOUGLAS

Trijet Special Compliance Items Report

- **MD11** Doc. MDC-02K1003

Lufthansa Technik Internal Documents

Lufthansa Technik Standard Practices Manual

- **LHT-SPM** Approved by FRA WE

ATR

Airworthiness Limitations (AWLs) and Certification Maintenance Requirements (CMRs)

- **ATR42** MRB Rev.10 Part02
- **ATR72** MRB Rev.14 Part02

Figure 7 Documentation to implement the SFAR 88

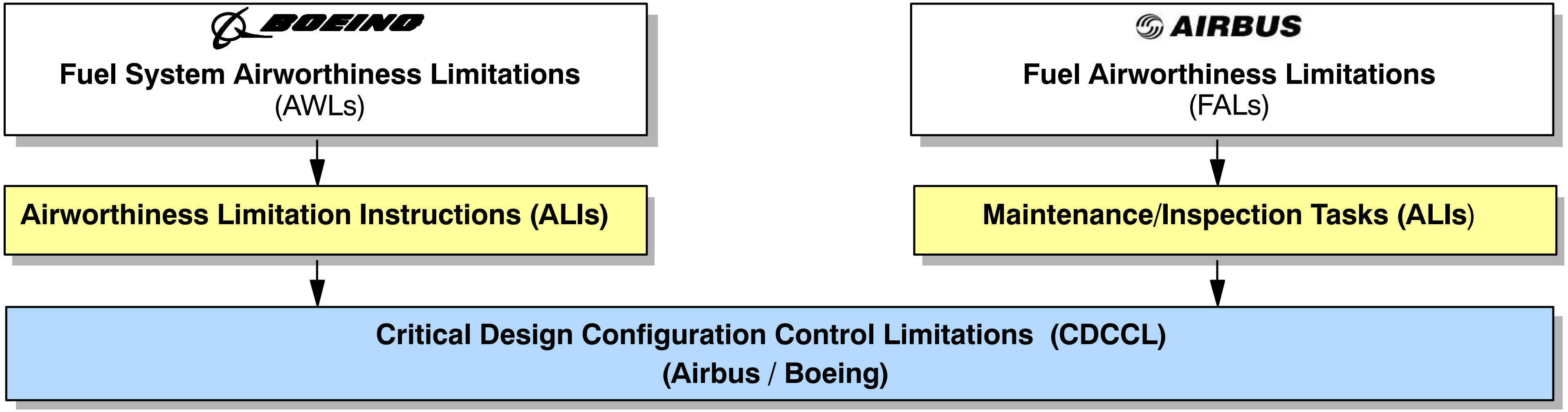
AIRWORTHINESS LIMITATIONS

INTRODUCTION

This SFAR 88 rule required manufacturers to enhance airplane maintenance programs to maintain design features that are necessary to prevent an ignition source in the fuel tanks. The result of this effort was the incorporation of several AWLs (**A**irworthiness **L**imitations) for Boeing, and FALs (**F**uel **A**iworthiness **L**imitations) for Airbus into maintenance program documents. These AWL's are divided into two categories:

- CDCCL (**C**ritical **D**esign **C**onfiguration **C**ontrol **L**imitations) for Boeing and Airbus:
  - These are critical fuel system design features which must be maintained in order to minimize the creation of a fuel tank ignition source. CDCCLs are identified in the AMMs, CMMs, and Special Compliance Items document (for Long Beach models). Some examples of CDCCLs are the bonding and grounding of fuel system components, and the routing of fuel system wiring.
- ALIs (**A**irworthiness **L**imitation **I**nspections)only for **Boeing**:
  - These are repetitive inspections which are required to help ensure that components which are subject to degradation or damage do not deteriorate to the point where they may fail and create an ignition source in the fuel tanks. Some examples of ALIs are verification of fault current bonds, and inspection of wiring insulation and clamping.
- ALIs (Maintenance / Inspection Tasks) only for **Airbus**:
  - These tasks must be included in an operator's approved maintenance program/ schedule. The task interval may be quoted in any usage parameter (FH, FC or Calendar Time) depending on the cause of potential degradation that, if not detected and addressed, could lead to an unacceptable risk.

The AWLs for each model have been released in the appropriate maintenance documents for each model. The documents, by model, are listed in the training information attachment. AWLs are expected to be mandated by FAA Airworthiness Directives. Operators should pay particular attention to AWLs during modifications, as SFAR 88 imposes a more significant regulatory approval burden on ALI/CDCCL changes than many other maintenance program changes. All changes to a CDCCL or ALI or a procedure involving a CDCCL or ALI must be approved by the appropriate regulatory office. The relevant authority varies by country and model.



What do the “Airworthiness Limitation Instructions“ (ALIs) say?

In terms of SFAR 88, an „Airworthiness Limitation Item“ is a mandatory maintenance or inspection of the fuel system that can include „Critical Design Control Configuration Limitations“.

In addition, further required actions can be performed to ensure that unsafe conditions do not occur and are not introduced into the fuel system as a result of maintenance actions, repairs or alterations throughout the operational life of the aircraft.
ALI‘s are controlled according to a fixed interval. This can be “Flight Hours“, „Flight Cycles“ or “Calendar Time“.

What do the “Critical Design Configuration Control Limitations“ say?

A CDCCL is a “Fuel Airworthiness Limitation“, and a requirement to preserve a critical ignition source prevention feature of the fuel system design.
CDCCL‘s are necessary to prevent the occurrence of an unsafe condition of the aircraft identified by the SFAR 88.
Possible ignition sources for example can be present by a change of the original configuration of the “fuel vapor area“ or at components of the “fuel system“ after performing Alterations, Repairs or Maintenance actions

FUEL AIRWORTHINESS LIMITATIONS EXAMPLE

EXAMPLE OF AIRBUS FUEL AIRWORTHINESS LIMITATIONS

Fuel Airworthiness Limitations (FALs)

Maintenance / Inspection Tasks (ALIs)

Critical Design Configuration Control Limitations (CDCCL)

AIRBUS

Customer Services Directorate

A340 Fuel Airworthiness Limitations

SECTION 1

MAINTENANCE / INSPECTION TASKS

	TASK REF	TASK TITLE	INTERVAL	APPLICABILITY
1	28-18-00-02-1	Detailed inspection of vapour seal / drip shield	6 Years	A340-200/-300 POST MOD 49520 A340-500/-600

AIRBUS

Customer Services Directorate

A340 Fuel Airworthiness Limitations

SECTION 2

CRITICAL DESIGN CONFIGURATION CONTROL LIMITATIONS

	CDCCL	Requirement	Reference	Applic ability
1	Air gap between a fuel quantity indicating probes and the aircraft structure.	Critical to prevent spark generation during lightning strike conditions and must not be compromised The gap stated in the relevant maintenance procedure in the AMM must be achieved during installation of a fuel quantity probe.	AMM 28-42-15-400 28-42-16-400 28-42-17-400 28-42-18-400 28-42-19-400 28-42-21-400	ALL
2	Separation of fuel quantity and level indicating system wiring from other wiring.	To prevent cross coupling of high voltage transients and thereby keep unsafe ignition energies from inside the tank it is required that operators obey the wire routing and separation standards given in the Electrical Standard Practices Manual (ESPM).	ESPM 20-10-00 20-33-11 20-33-20 20-33-21 20-33-22	ALL

Figure 8 Example of Airbus FALs

AI|FAL Example|L1

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Selection of Airbus “Critical Design Configuration Control Limitations“

AIRBUS

Customer Services Directorate

A340 Fuel Airworthiness Limitations

SECTION 2

CRITICAL DESIGN CONFIGURATION CONTROL LIMITATIONS

	CDCCL	Requirement	Reference	Applicability
1	Air gap between a fuel quantity indicating probes and the aircraft structure.	Critical to prevent spark generation during lightning strike conditions and must not be compromised The gap stated in the relevant maintenance procedure in the AMM must be achieved during installation of a fuel quantity probe.	AMM 28-42-15-400 28-42-16-400 28-42-17-400 28-42-18-400 28-42-19-400 28-42-21-400	ALL
2	Separation of fuel quantity and level indicating system wiring from other wiring.	To prevent cross coupling of high voltage transients and thereby keep unsafe ignition energies from inside the tank it is required that operators obey the wire routing and separation standards given in the Electrical Standard Practices Manual (ESPM).	ESPM 20-10-00 20-33-11 20-33-20 20-33-21 20-33-22	AL

A340

AIRCRAFT MAINTENANCE MANUAL

TASK 28–42–16–400–801

nstallation of the FQI, Center Tank Probe

R WARNING : THIS PROCEDURE USES A FUEL SYSTEM ITEM THAT IS IN A CATEGORY KNOWN AS
R A CRITICAL DESIGN CONFIGURATION CONTROL LIMITATION (CDCCL) CDCCL
R IDENTIFIES AN ITEM THAT CAN BE THE SOURCE OF A POSSIBLE FUEL TANK
R IGNITION. YOU MUST KEEP ALL CDCCL ITEMS IN THE APPROVED
R CONFIGURATION. DAMAGE, WEAR OR CHANGES TO A CDCCL ITEM CAN CAUSE A
R POSSIBLE FUEL TANK EXPLOSION.

WARNING : MAKE SURE THAT THE SAFETY DEVICES AND THE WARNING NOTICES ARE IN POSITION BEFORE YOU START A TASK ON OR NEAR:
- THE FLIGHT CONTROLS
- THE FLIGHT CONTROL SURFACES
- THE LANDING GEAR AND THE RELATED DOORS
- COMPONENTS THAT MOVE.

MOVEMENT OF COMPONENTS CAN KILL OR INJURE PERSONS.

WARNING : OBEY THE FUEL SAFETY PROCEDURES. THIS CAN PREVENT INJURY AND DAMAGE.

Figure 9 Example of A340 Removal/Installation Center Tank Middle-FQI-Probe

FUEL CHARACTERISTICS

TYPES OF TURBINE ENGINE FUEL

Turbine engine fuels used for jet engines are kerosene type fuels which are closely related to diesel gasoline.

There are 4 main types of turbine engine fuel. These are called

- Jet A1,
- Jet A,
- Jet B and
- JP 5.

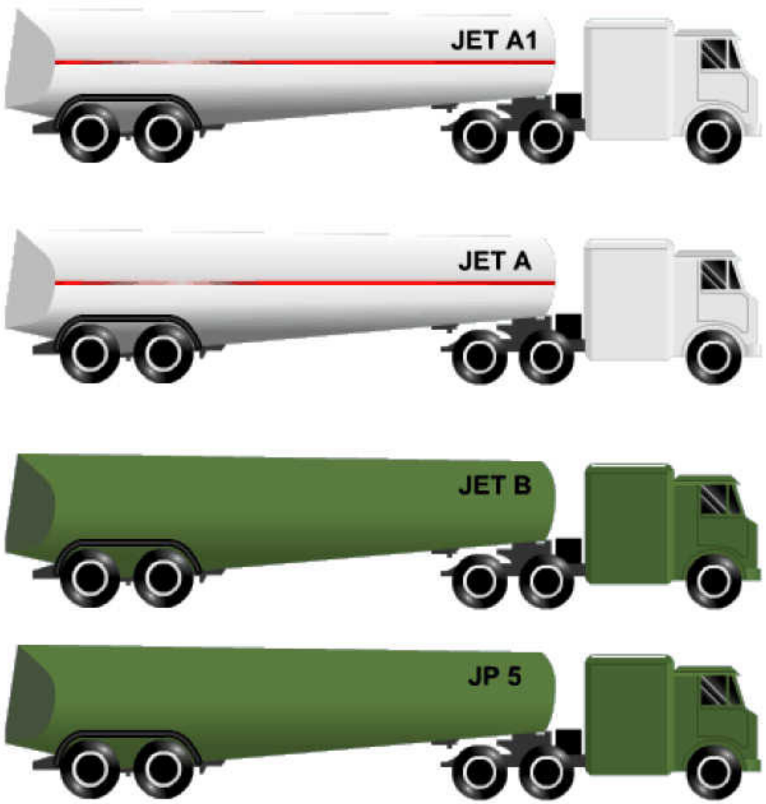

Figure 10 Types of Engines Fuel

Types of Turbine Engine Fuel (cont.)

The fuel types differ in their main characteristics.

Jet A1 is the most commonly used fuel type for jet engines in Europe.

This fuel type is reasonably safe for you to handle because it has a high flash point of plus 38° C and a low freezing point of minus 47° C. The American name for this type of fuel is JP 1A.

Jet A is the most commonly used fuel type for jet engines in America.

It is very similar to Jet A1 with the same high flash point of plus 38° C but with a lower freezing point of -40° C. In the USA this fuel is also called JP 1.

Jet B fuel is mainly used for military jet engines.

Theoretically, it can also be used for civil aircraft engines but Jet B has an extremely low flash point of minus 20° C to provide good ignition capabilities. This means it requires extreme care in handling. Jet B has a very low freezing point of minus 60° C. The American name for this type of fuel is JP 4.

JP 5 is another type of military jet fuel.

It is preferred by the military on aircraft carriers because its very high flash point of plus 65° C makes it very safe for handling. JP 5 has a relatively low freezing point of minus 48° C.

You must record the type of fuel used when refueling. This is important, because each type of fuel has different handling and operating characteristics.

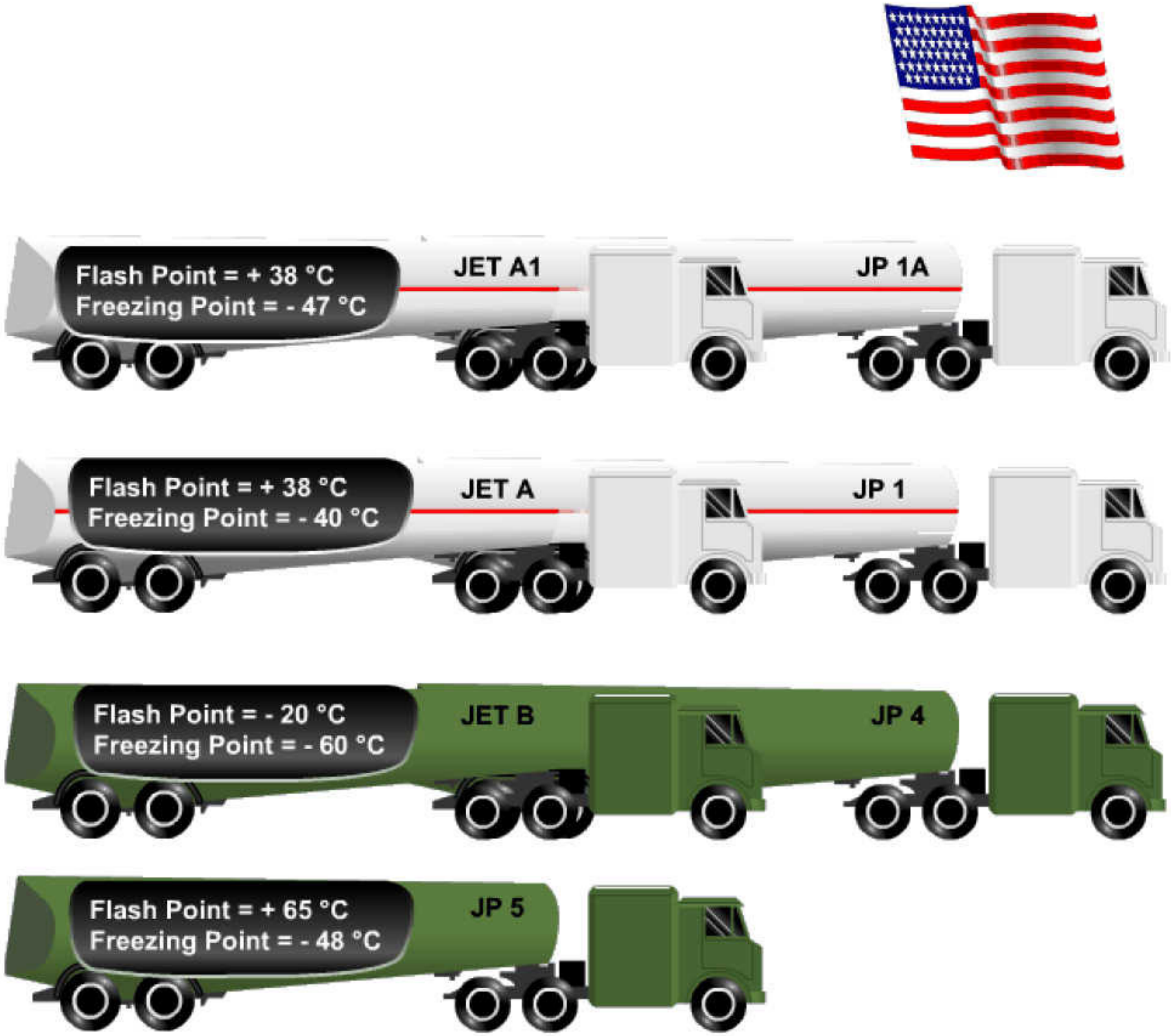

Figure 11 Fuel Main Caracteristics

CHARACTERISTICS OF TURBINE ENGINE FUELS

The main requirements of turbine engine fuels are a low freezing point and a flash point low enough to provide good ignition capabilities but as high as possible for safe fuel handling.

Turbine engine fuels must also have a low tendency to vaporize in high flight altitudes.

Engine fuels need to be widely available all over the world and must have a low tendency to carry water.

Different fuels have different freezing points depending on their composition.

The freezing point is the temperature at which some elements of the fuel start to crystallize and the fuel flow slows down. The required freezing point of fuel for turbine engines should be below minus 40° Celsius.

The flash point of fuel is the lowest temperature at which the fuel creates just enough vapors to build up a fuel/air mixture that can be inflamed. To reduce any fire hazards, the flash point of the fuel used for civil aircraft should be as high as possible. If the flash point is reached, the fuel/air mixture burns, but if the external flame is removed, the fuel/air mixture extinguishes.

The volatility is another very important characteristic of jet fuels. Volatility of fuel is its ability to vaporize. A highly volatile fuel is very desirable for engine starts in cold weather and in flight, and fuel with low volatility is desired to eliminate vapor lock and to reduce fuel losses by evaporation.

Jet fuel, like all other fluids vaporizes if the ambient pressures decreases. The higher you fly the more the ambient pressure decreases. Ambient pressure decrease causes fuel to vaporize.

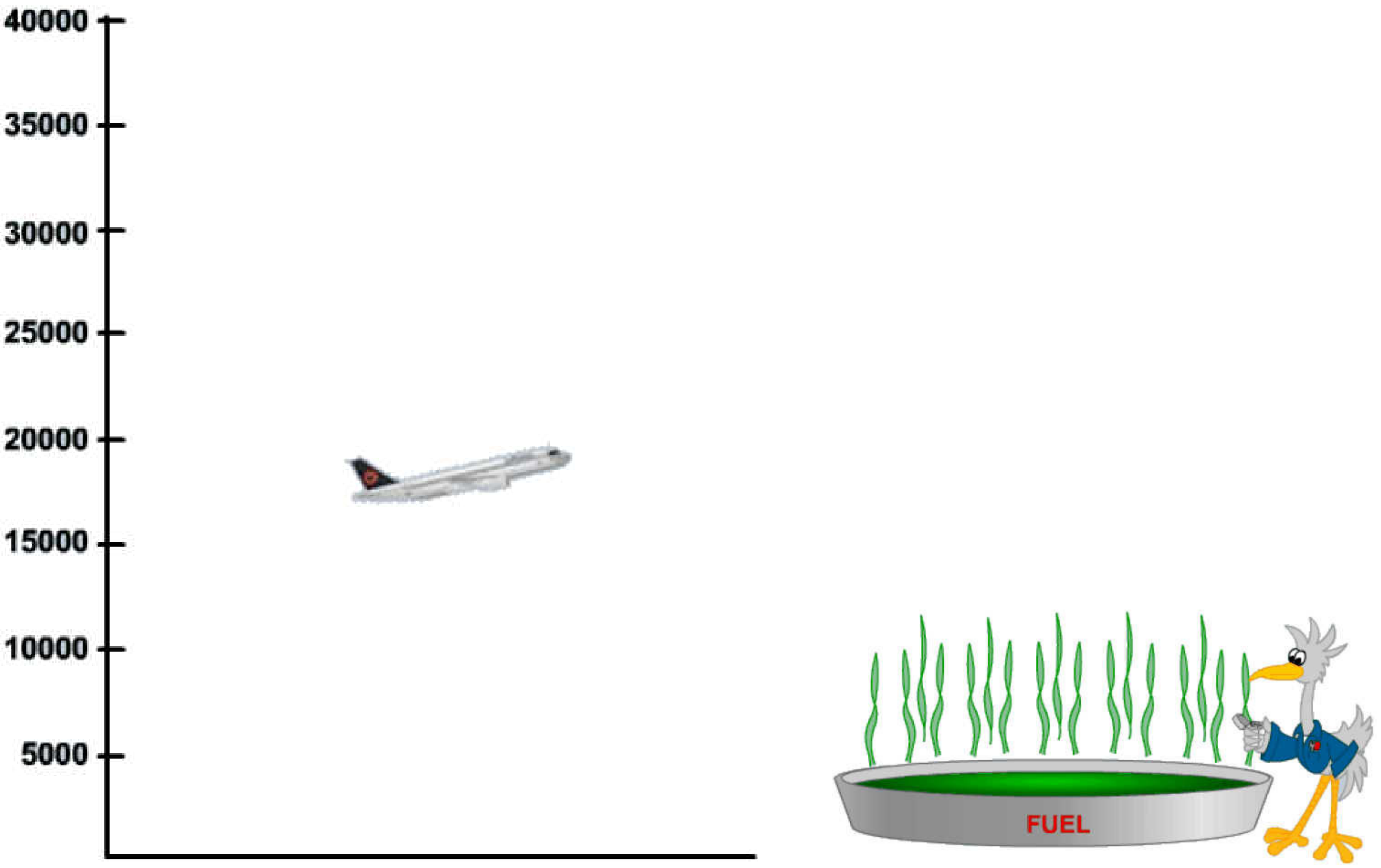

Figure 12 Fuel Characteristic

Characteristics of Turbine Engine Fuels (cont.)

Another very important characteristic of fuel is its density. This is the ratio between mass and volume. This ratio changes with the fuel type and fuel temperature.

Jet A1 and Jet A have the same density of 0.81kg/ltr. at a temperature of 15° C.

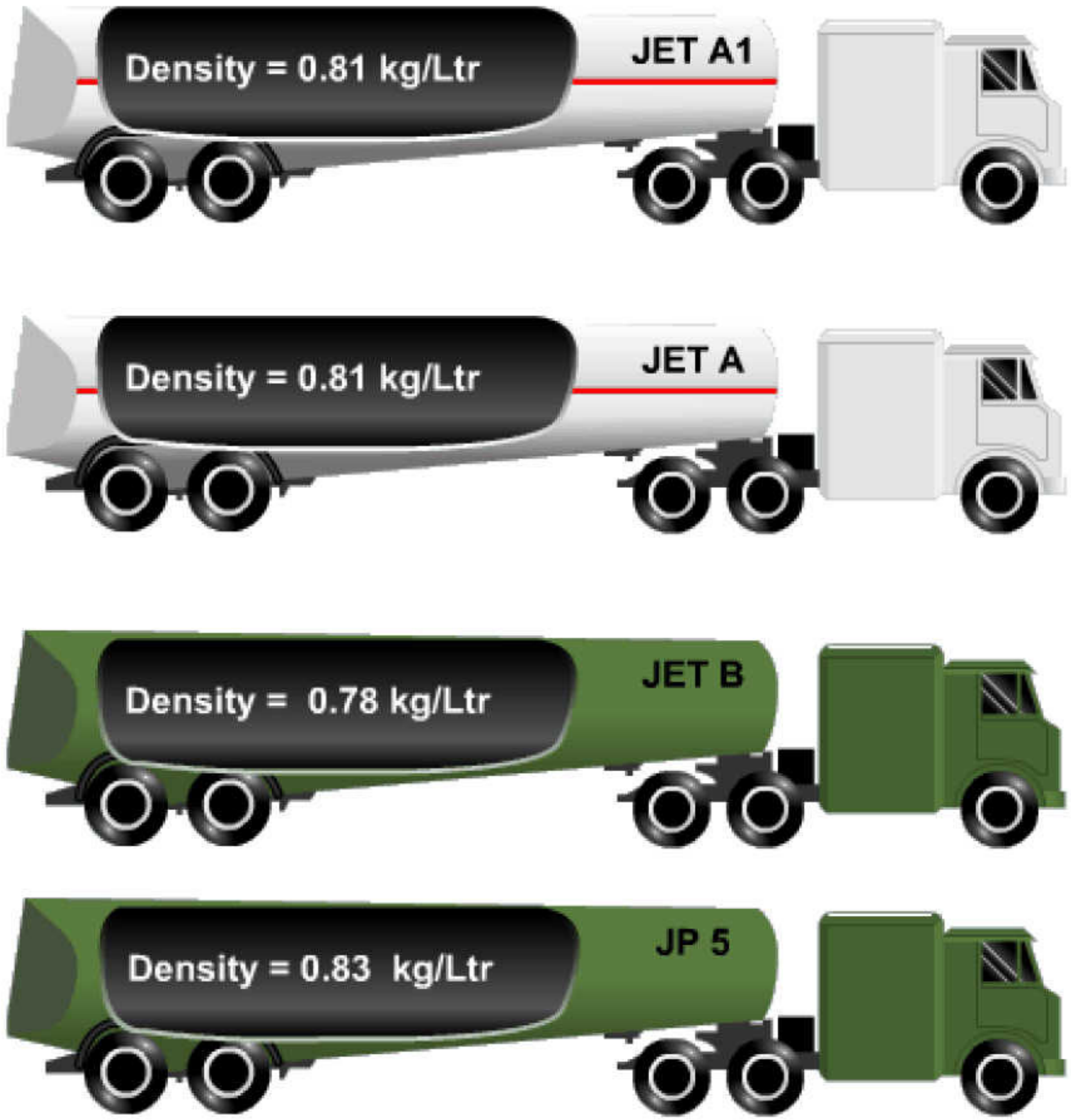

Figure 13 Fuel Density

Characteristics of Turbine Engine Fuels (cont.)

Other requirements on jet engine fuels are that it must be readily available so that the airlines can get the same fuel type all over the world. It must have adequate lubrication capabilities for the moving parts in the fuel system, and the fuel must have a low tendency to hold water to minimize water contamination problems.

Main Requirements for Turbine Engine Fuel:

- low Freezing Point
- Flash Point
  - low enough for ignition
  - as high as possible for safe handling
- low tendency to vaporize in high altitudes
- widely available
- low tendency to carry water
- high volatility desirable for engine starts
- aviable all over the world
- adequate lubrication capabilities
- low tendency to hold water

Figure 14 Fuel Requirements

ACCIDENT BOARD RECOMMENDATIONS

RECOMMENDATIONS TO MINIMIZE IGNITION SOURCES

The odds of one of these conditions causing the fuel to ignite in the central fuel tank are slim, but they still must be prevented from ever occurring. One key area for prevention is by regularly inspecting the wiring. Stripped insulation, which can lead to arcing, and copper sulfide buildup on FQIS terminals, which can create autoignition, would be discovered and be fixed. Inspectors should examine check valves and localized heat sources within the scavenger pump. Also, a cleaner environment should be maintained around the central fuel tank to prevent the buildup of possible conducting agents such as drill shavings and "syrup". Finally, the risk of arcing could be reduced if more durable insulation that covers electrical wiring is installed in new and old commercial airlines. This improvement may be especially important, as the average age of operational planes is steadily increasing.

There were numerous recommendations, which primarily involve the following:

- Reduce fuel tank flammability.
- Minimize fuel tank ignition sources.
- Re-evaluate airplane design and certification standards.
- Re-evaluate maintenance and aging of aircraft systems.

Fuel Tank Ignition Source Consideration

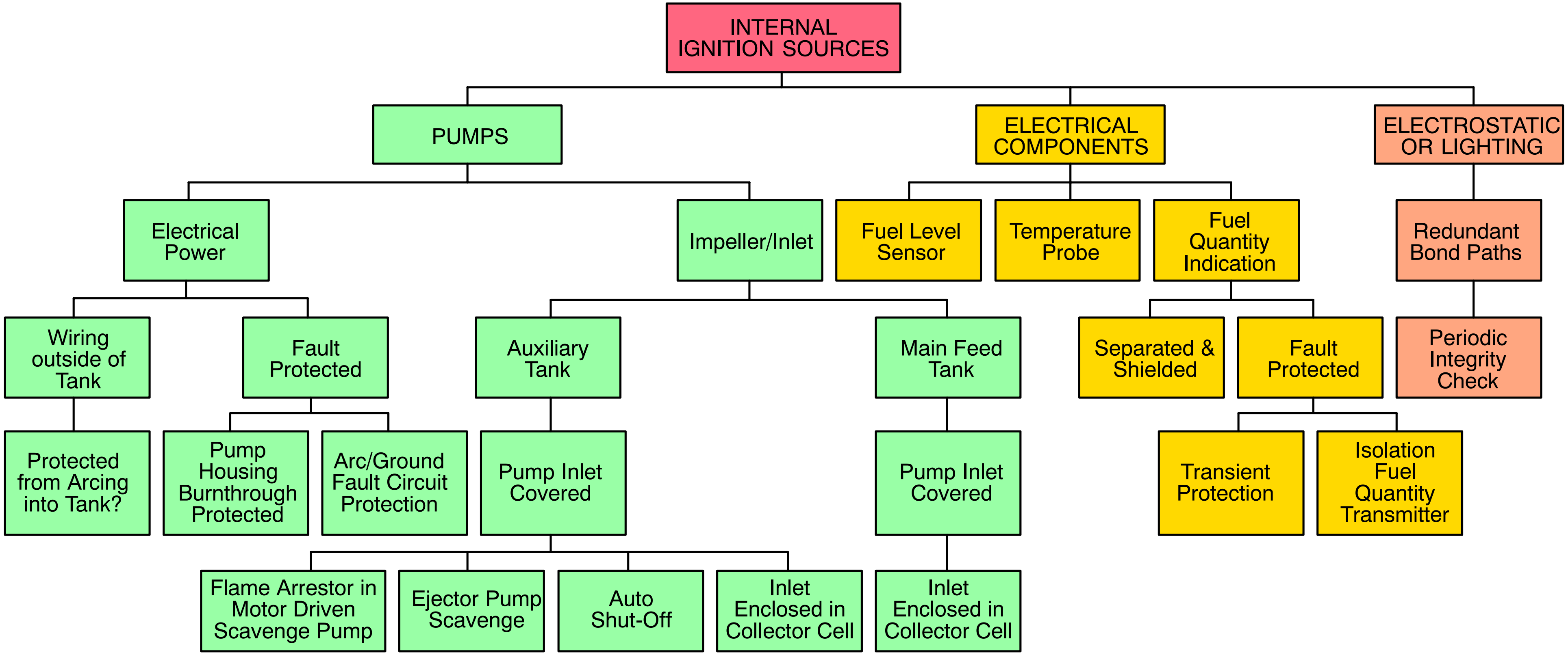

Figure 15 Internal Ignition Source Consideration

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Fuel Tank Ignition Source Consideration

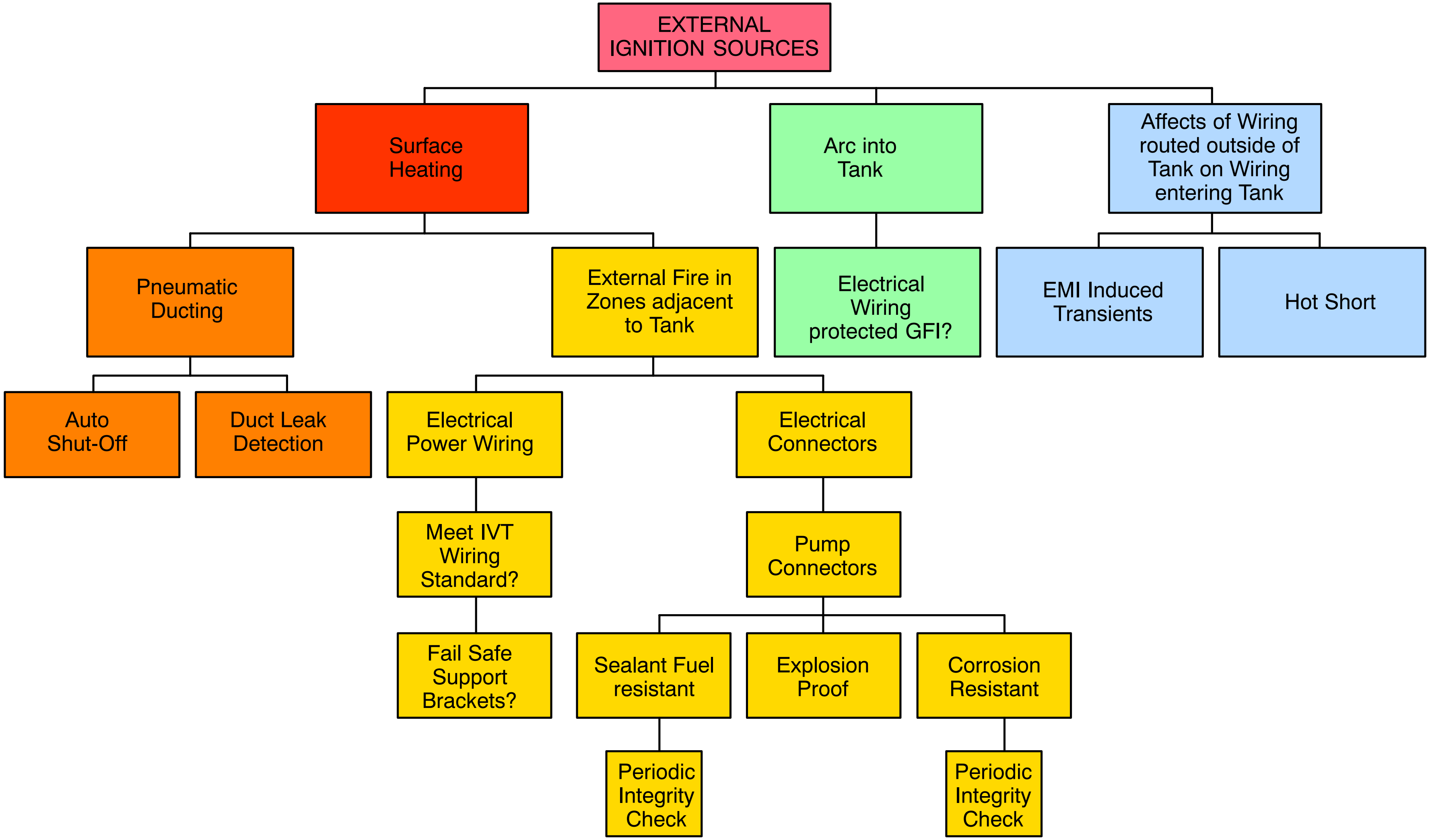


Figure 16 External Ignition Source Consideration

FACTORS FOR A FUEL TANK EXPLOSION

Main factors as ignition sources for a fuel air mixture explosion

A mixture of fuel and oxygen can be extremely

...explosive

OXYGEN

COMBUSTIBLE MEDIUM

IGNITION SOURCE

Some typical ignition sources are

...electrical sparks.

...cable fire.

...hot surfaces.

...friction sparks.

...static discharge.

In aircraft maintenance and overhaul all areas of the fuel tanks have to be inspected for present damages and their possible causes.

Figure 17 Awareness of problems in the working areas of “Fuel Vapor“ and “Wiring“

CAUSES OF WIRING DEGRADATION

Vibration

High vibration areas tend to accelerate degradation over time, resulting in ”chattering” contacts and intermittent symptoms. High vibration can also cause tie−wraps, or string−ties to damage insulation. In addition, high vibration will exacerbate any existing problem with wire insulation cracking.

Moisture

High moisture areas generally accelerate corrosion of terminals, pins, sockets, and conductors. It should be noted that wiring installed in clean, dry areas with moderate temperatures appears to hold up well.

Maintenance

Unscheduled maintenance activities, if done improperly, may contribute to long term problems and wiring degradation. Repairs that do not meet minimum airworthiness standards may have limited durability. Repairs that conform to manufacturers recommended maintenance practices are generally considered permanent and should not require rework if properly maintained.

Metal shavings and debris have been discovered on wire bundles after maintenance or repairs have been conducted. Care should be taken to protect wire bundles and connectors during modification work, and to ensure all shavings and debris are cleaned up after work is completed.

As a general rule, wiring that is undisturbed will have less degradation than wiring that is reworked. As wiring and components become more brittle with age, this effect becomes more pronounced.

Indirect damage

Events such as pneumatic duct ruptures can cause damage that, while not initially evident, can later cause wiring problems. When such an event has occurred, surrounding wire should be carefully inspected to ensure no damage is evident.

Chemical contamination

Chemicals such as hydraulic fluid, battery electrolytes, fuel, corrosion inhibiting compounds, waste system chemicals, cleaning agents, deicing fluids, paint, and soft drinks can contribute to degradation of wiring. Wiring in the vicinity of these chemicals should be inspected for damage or degradation. Recommended original equipment manufacturer cleaning instructions should be followed.

Hydraulic fluids, for example, require special consideration. Hydraulic fluid is very damaging to connector grommet and wire bundle clamps, leading to indirect damage, such as arcing and chafing. Wiring that may have been exposed to hydraulic fluid should be given special attention during wiring inspections.

Heat

Wiring exposed to high heat can accelerate degradation, insulation dryness, and cracking. Direct contact with a high heat source can quickly damage insulation. Even low levels of heat can degrade wiring over long periods of time. This type of degradation is sometimes seen on engines, in galleys, and behind lights.

Installation

Wiring not installed properly can further accelerate the wiring degradation process. Improper routing, clamping, and terminating during initial installation or during a modifications can lead to wiring damage.

Wiring routing

- Eliminate potential for chafing against structure or other components
- Position to eliminate/minimize use as handhold or support
- Minimize exposure to damage by maintenance crews or shifting cargo
- Avoid battery electrolytes or other corrosive fluids

In general, wiring should be routed in such a manner to ensure reliability and to offer protection from the potential hazards shown in this slide.

The following pictures illustrate some of the hazards previously described.

- INDIRECT DAMAGE

- VIBRATION

- CHEMICAL CONTAMINATION/CLEANING

- HEAT

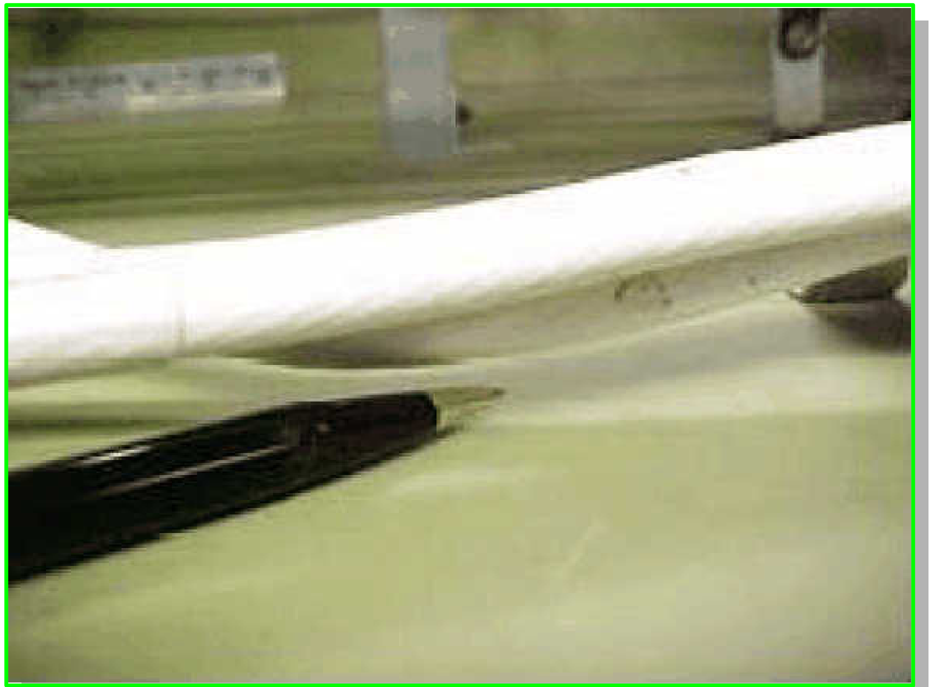
- INSTALLATION

Figure 18 Causes of Wiring Degradation

EXAMPLES OF WIRING PROBLEMS

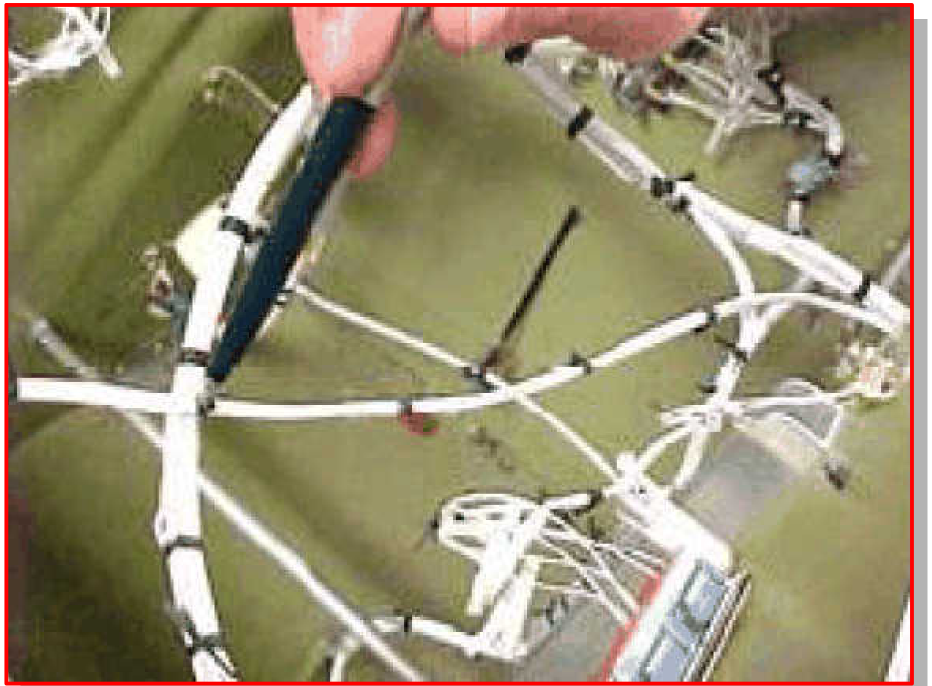
IMPROPER

Power cables can become damaged when riding on structure.



PROPER

Figure 19 Wires riding on Structure

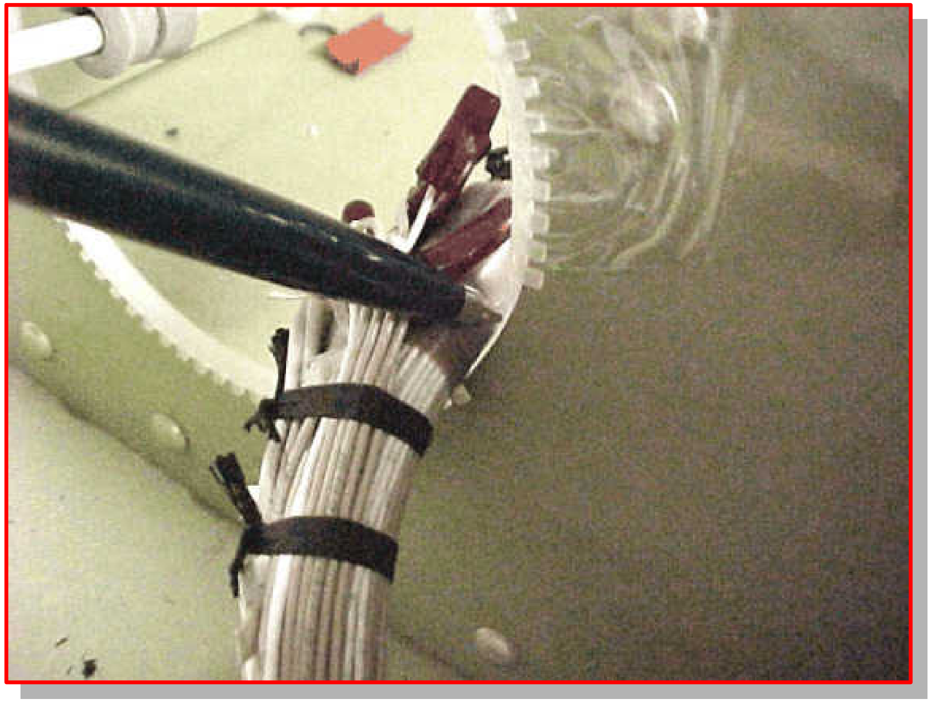


IMPROPER

Wire bundles that cross should be secured together to avoid chafing

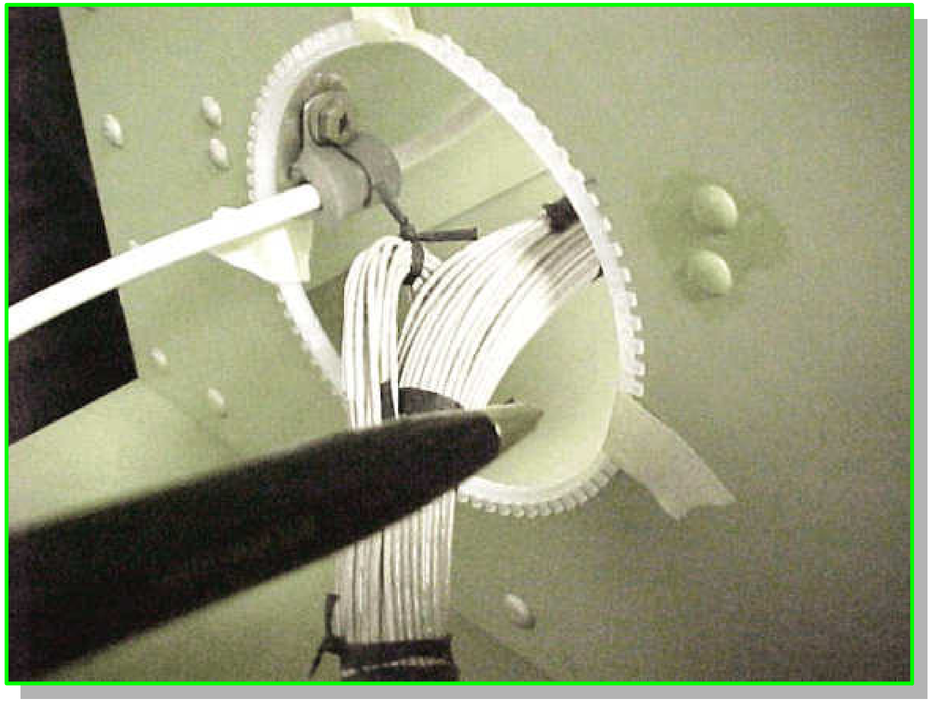
PROPER

Figure 20 Wires riding on other Wires



IMPROPER

If the grommet is too short, wire bundle chafing can occur.



PROPER

Figure 21 Wires riding on Lightening Hole

WIRING ROUTING

- Protect wires in wheel wells and other exposed areas
- Route wires above fluid lines, if practicable
- Use drip loops to control fluids or condensed moisture
- Keep slack to allow maintenance and prevent mechanical strain

Ensure that wires and cables are adequately protected in wheel wells and other areas where they may be exposed to damage from impact of rocks, ice, mud, etc. (If re–routing of wires or cables is not practicable, protective jacketing may be installed.) This type of installation must be held to a minimum.

Where practical, route wires and cables above fluid lines. Wires and cables routed within 6 inches of any flammable liquid, fuel, or oxygen line should be closely clamped and rigidly supported. A minimum of 2 inches must be maintained between wiring and such lines or related equipment, except when the wiring is positively clamped to maintain at least 1/2–inch separation or when it must be connected directly to the fluid–carrying equipment.

Ensure that a trap or drip loop is provided to prevent fluids or condensed moisture from running into wires and cables dressed downward to a connector, terminal block, panel, or junction box. Wires and cables installed in bilges and other locations where fluids may be trapped are routed as far from the lowest point as possible or otherwise provided with a moisture–proof covering.

This example shows a number of problems:

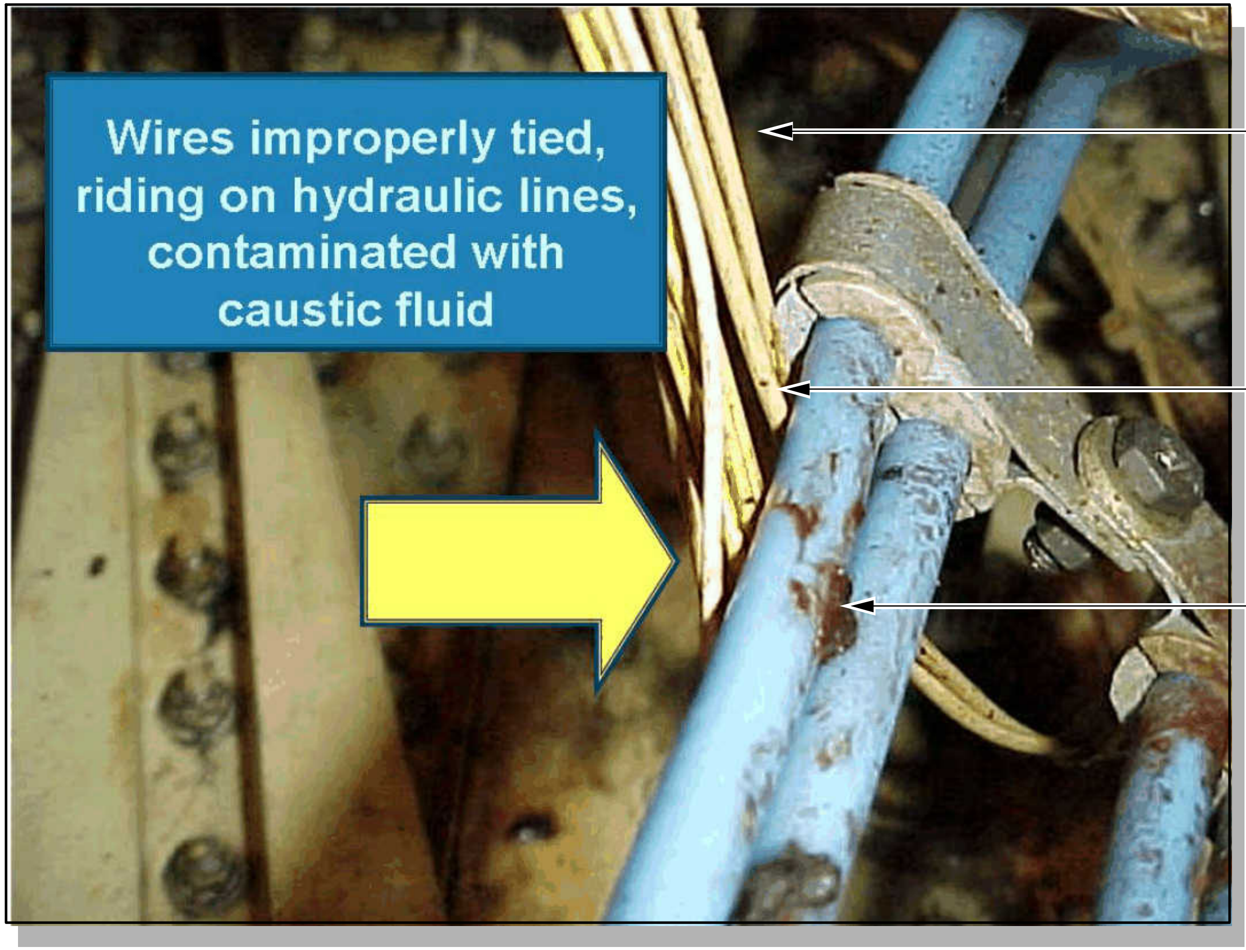


Figure 22 Wires in the bundle are not tied properly

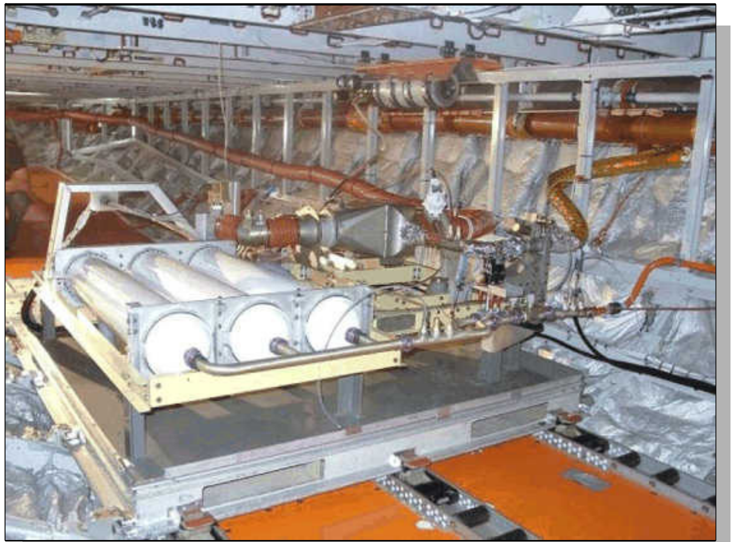
FLAMMABILITY REDUCTION SYSTEM (FRS)

AVOIDANCE OF THE EXPLOSION HAZARD BY NITROGEN INERTING

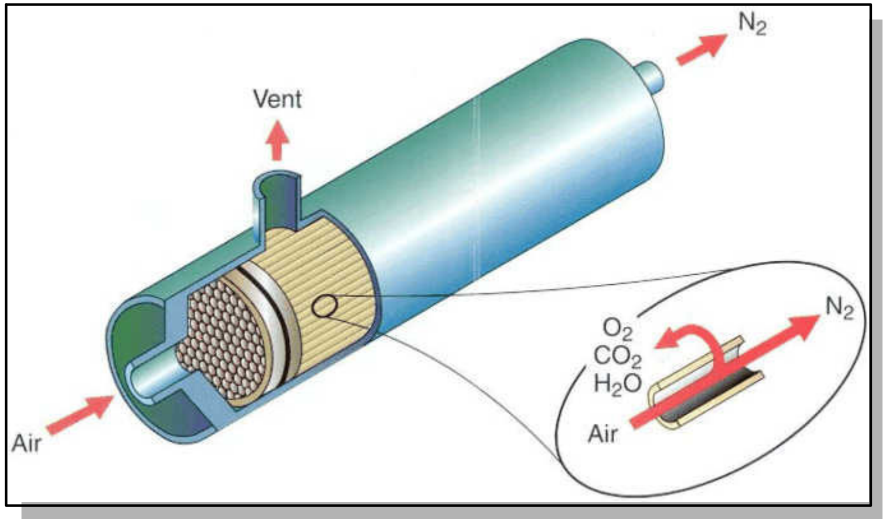
Beside the avoidance of igniting sources, the explosion hazard can be prevented by nitrogen enrichment of the fuel tanks, called FRS (“**F**lammability **R**eduction **S**ystems“). The pressurized air in the system is forced through the membrane fibers and allows fast gases to escape through the membrane wall and the nitrogen rich stream to pass through. By this possibility the level of the fuel center tank can be adjusted from “high flammability“ to “low flammability“.

It is planned that B737 delivered from February 2007 shall be equipped with the system. For aircrafts already delivered and still in operation, refitting will be carried out at given time.

FLAMMABILITY REDUCTION SYSTEM 747 SP



FLAMMABILITY REDUCTION SYSTEM A320 TEST VERSION



AIR SEPARATION MODULE (ASM)

Figure 23 Flammability Reduction System

SUMMARY

When aircraft maintenance is carried out in the area of the “fuel vapor seal“ or at components of the fuel system, which are indicated in the documents as

AWLs, FALs, ALIs or CDCCLs

then you must always work according to an authorized documentation, such as “AMM“, “CMM“ or “Job Card“ !

- Deviations of every type of the specifications listed in the manufacturer documentation are not permitted!
- If uncertainties arise in the context of the work execution with a documentation, then the work should never be continued on assumptions!
- In such cases “Product– or System Engineering“ authorized by the aircraft operator must be informed to guarantee the correct execution of the work and documenting these!

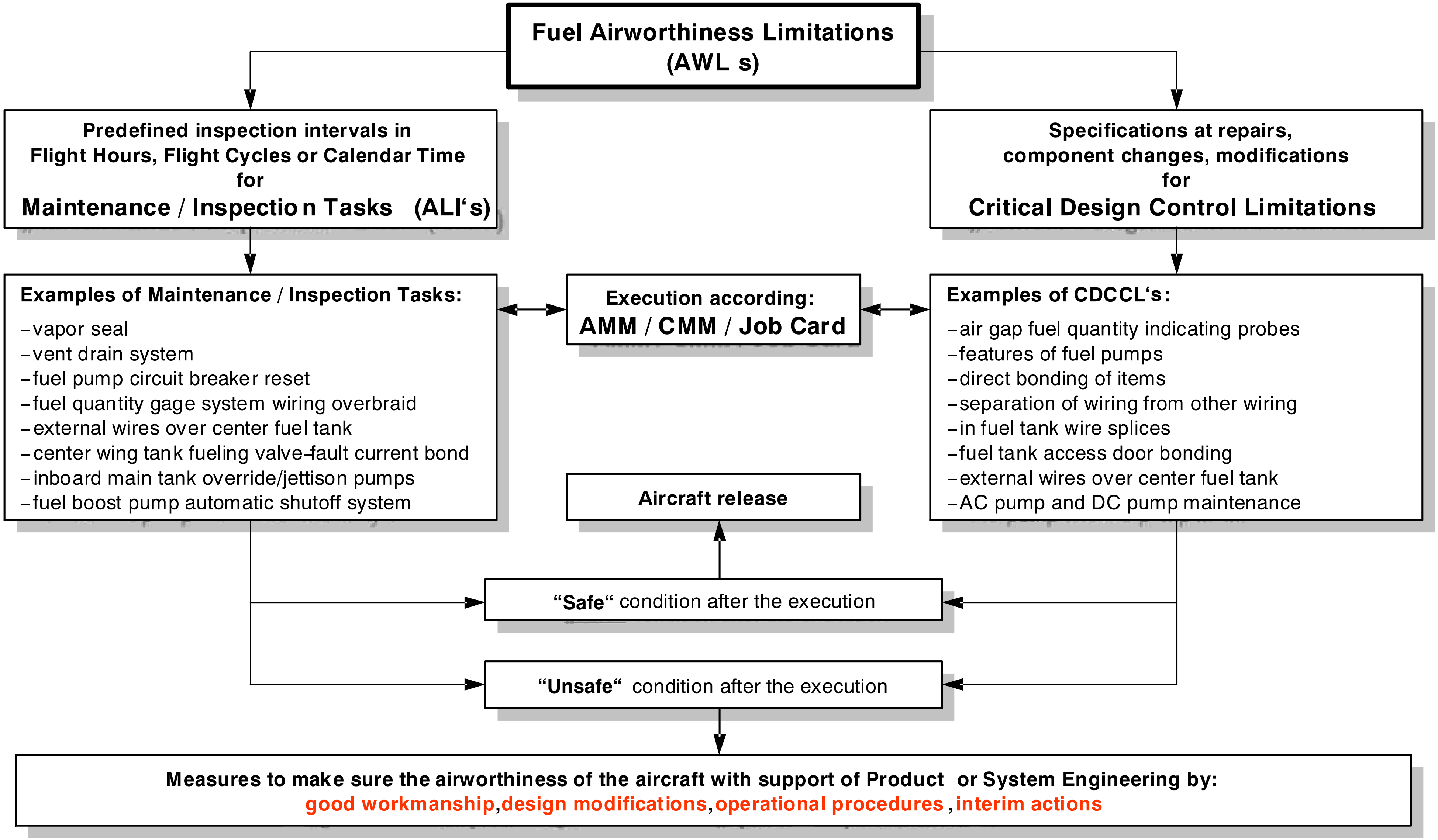


Figure 24 Control Sequence at "AWL" Relevant Components

EXAMPLE OF A320 FAMILY AIRWORTHINESS LIMITATIONS

AIRWORTHINESS LIMITATION PRECAUTIONS

Airworthiness Limitation Instructions (ALIs)

All occurrences of fuel tank system ALIs found in this chapter of the AMM are identified by this step after the General section in the applicable ALI inspection task.

NOTE: ALI – Refer to the Customer Services Directorate for important information on **A**irworthiness **L**imitation **I**nstructions (ALIs).

Inspection tasks that are ALIs are defined and controlled by Special Federal Aviation Regulation (SFAR) 88, and can be found in Section 9 of the MPD (**M**aintenance **P**lanning **D**ata) document.

These ALIs identify inspection tasks related to fuel tank ignition source prevention which must be done to maintain the design level of safety for the operational life of the airplane.

These ALIs are mandatory and cannot be changed or deleted without the approval of the FAA office that is responsible for the airplane model Type Certificate, or applicable regulatory agency. Strict adherence to methods, techniques and practices as prescribed is required to ensure the ALI is complied with.

Any use of methods, techniques or practices not contained in these ALIs must be approved by the FAA office that is responsible for the airplane model Type Certificate, or applicable regulatory agency.

NOTE: The Fuel Airworthiness Limitations are a part of the **A**irworthiness **L**imitation **I**nstructions (ALIs).

AIRBUS
Customer Services Directorate

A318/A319/A320/A321 Fuel Airworthiness Limitations

SECTION 0 - INTRODUCTION

1. SCOPE

This document contains the Fuel Airworthiness Limitations that arise from compliance with JAA's Interim Policy on Fuel Tank Safety (INT/POL/25/12) and FAA's Special Federal Aviation Regulation (SFAR) 88. They have been derived in accordance with JAA's draft Temporary Guidance Leaflet (TGL) 47 and FAA's Advisory Circular (AC) 25.981-1B. The nomenclature and means of promulgation follow the FAA's memorandum ref PS-ANM100-2004-10029 'Policy Statement on Process for Developing SFAR 88-related Instructions for Maintenance and Inspection of Fuel Tank Systems'. This latter document has been jointly developed between FAA and JAA to ensure a unified approach.

These requirements, together with the Life Limits / Monitored Parts, structural Airworthiness Limitation Items (ALI) and systems Certification Maintenance Requirements (CMR) comprise the Airworthiness Limitation Section which satisfies the requirements of JAR 25.1529 Appendix H paragraph 25.4.

IMPORTANT: At first delivery of an aircraft configuration into an operator's fleet, the requirements given in this document are mandatory, except in so far that interval escalations can be justified in accordance with the procedure stated herein. If a more restrictive Fuel ALI is issued on an aircraft configuration already in service, the requirement for existing operators to follow the revised FAL document will normally be mandated by Airworthiness Directive (Consigne de Navigabilité).

Non-compliance suspends the validity of the Airworthiness Certificate.

The identification of Fuel Airworthiness Limitations in no way diminishes the importance of other tasks and practices associated with the fuel system. Changes to these are subject to normal practices and procedures between the operator and his national authorities.

This document does not take into account Airworthiness Directives (Consigne de Navigabilité) which, if issued against an existing Fuel Airworthiness Limitation, supersede the specific requirement given in this document.

2. APPLICABILITY

Ref. 95A.1931/05	Issue 1 19 Dec 05	Section 0	Page 1

AIRBUS
Customer Services Directorate

A318/A319/A320/A321 Fuel Airworthiness Limitations

SECTION 2

CRITICAL DESIGN CONFIGURATION CONTROL LIMITATIONS

	CDCCL	Requirement	Reference	Applicability
1	Air gap between a fuel quantity indicating probes and the aircraft structure.	Critical to prevent spark generation during lightning strike conditions and must not be compromised The gap stated in the relevant maintenance procedure in the AMM must be achieved during installation of a fuel quantity probe.	AMM 28-42-15-400	ALL
2	Separation of fuel quantity and level indicating system wiring from other wiring.	To prevent cross coupling of high voltage transients and thereby keep unsafe ignition energies from inside the tank it is required that operators obey the wire routing and separation standards given in the Electrical Standard Practices Manual (ESPM).	ESPM 20-10-00 20-33-11 20-33-20 20-33-21 20-33-22	ALL
3	Direct bonding on items of equipment inside a fuel tank.	Direct bonding is critical to prevent spark generation during component failure and lightning strike conditions and must not be compromised Direct bonding in fuel tanks must be carried out during component installation to the appropriate bonding method and standard stated within the installation procedure in the AMM.	AMM 28-11-37 28-11-41 28-12-41 28-12-45 28-12-46 28-13-43 28-15-41 28-21-42 28-21-52 28-25-41 28-25-42 28-25-46 28-25-52 28-42-15 28-42-16 28-42-46 28-42-48 28-43-21 57-27-11	ALL
4	Safety critical features of fuel pumps	These features must be maintained throughout the full life of the fuel pump to avoid the possibility of generation of an ignition source by overheating or sparks caused by arcing, friction etc. Repair and overhaul of fuel pumps must be carried out in accordance with the equipment manufacturer's maintenance instructions or other maintenance instructions acceptable to the certifying authority.	CMM 28-21-51 28-22-19	ALL

Ref. 95A.1931/05	Issue 1 19 Dec 05	Section 2	Page 1

Figure 25 Example Of Fuel Airworthiness Limitations

CRITICAL DESIGN CONFIGURATION CONTROL LIMITATIONS

CDCCLs (Critical Design Configuration Control Limitations)

All occurrences of CDCCLs found in this chapter of the AMM are identified by this note after each applicable CDCCL design feature:

NOTE: CDCCL – Refer to the task: Fuel General (AMM 28–00–00/001), for important information on CDCCLs (**C**ritical **D**esign **C**onfiguration **C**ontrol **L**imitations).

Design features that are CDCCLs are defined and controlled by Special Federal Aviation Regulation (SFAR) 88, and can be found in Section 9 of the MPD (**M**aintenance **P**lanning **D**ata) document.

CDCCLs are a means of identifying certain design configuration features intended to preclude a fuel tank ignition source for the operational life of the airplane.

CDCCLs are mandatory and cannot be changed or deleted without the approval of the FAA office that is responsible for the airplane model Type Certificate, or applicable regulatory agency.

A critical fuel tank ignition source prevention feature may exist in the fuel system and its related installation or in systems that, if a failure condition were to develop, could interact with the fuel system in such a way that an unsafe condition would develop without this limitation.

Strict adherence to configuration, methods, techniques, and practices as prescribed is required to ensure the CDCCL is complied with.

Any use of parts, methods, techniques or practices not contained in the applicable CDCCL must be approved by the FAA office that is responsible for the airplane model Type Certificate, or applicable regulatory agency.

SEPARATION / ROUTING RULES (Airbus)

WARNING: THE CORRECT SEPARATION BETWEEN SENSITIVE WIRING AND WIRING OF OTHER SYSTEMS IS NECESSARY TO PRESERVE THE CRITICAL IGNITION SOURCE PREVENTION FEATURES OF THE SYSTEM DESIGN AND IS THEREFORE CLASSIFIED AS A CRITICAL DESIGN CONFIGURATION CONTROL LIMITATION (CDCCL).

A CDCCL MUST BE KEPT IN THE APPROVED CONFIGURATION TO ENSURE UNSAFE CONDITIONS DO NOT DEVELOP AS A RESULT OF MODIFICATION, MAINTENANCE OR REPAIR.

WARNING: BASED ON SFAR 88 FUEL IGNITION PREVENTION, THE REPAIR OF CABLES IS NOT TO BE PERMITTED.

AN UNSATISFACTORY CABLE MUST BE REPLACED WITH A NEW ONE THAT HAS THE SAME P/N.

A318/A319/A320/A321
AIRCRAFT MAINTENANCE MANUAL
AMM

TASK 28–21–52–400–001

Installation of the Fuel Pump Canister 1QM(4QM)

WARNING: THIS PROCEDURE USES A FUEL SYSTEM ITEM THAT IS IN A CATEGORY KNOWN AS A CRITICAL DESIGN CONFIGURATION CONTROL LIMITATION (CDCCL). CDCCL IDENTIFIES AN ITEM THAT CAN BE THE SOURCE OF A POSSIBLE FUEL TANK IGNITION. YOU MUST KEEP ALL CDCCL ITEMS IN THE APPROVED CONFIGURATION. DAMAGE, WEAR OR CHANGES TO A CDCCL ITEM CAN CAUSE A POSSIBLE FUEL TANK EXPLOSION.
WARNING: MAKE SURE THAT THE FLIGHT CONTROL SAFETY–LOCKS AND THE WARNING NOTICES ARE IN POSITION.
WARNING: MAKE SURE THAT THE GROUND SAFETY–LOCKS ARE IN POSITION ON THE LANDING GEAR.

1. Reason for the Job
   Self Explanatory

2. Job Set–up Information

C. Installation of the Fuel Pump Canister 1QM(4QM)

(1) Install the new sealing ring (8) and the new O–rings (18) and (22).

(2) Engage the connectors (1) and (2), while you put the canister (7) in position.

(3) Install the canister (7) with the screws (6).

NOTE: You must bond one of the screws (6)
(Ref. AMM TASK 28–21–52–991–001) (Ref. AMM TASK 20–28–00–912–002)

WARNING: THIS INSTRUCTION IS APPLICABLE TO A CRITICAL DESIGN CONFIGURATION CONTROL LIMITATION (CDCCL) ITEM. CAREFULLY OBEY ALL GIVEN INSTRUCTIONS WHEN YOU DO THIS STEP. IF YOU DO NOT OBEY THESE INSTRUCTIONS, A DANGEROUS CONDITION CAN OCCUR THAT CAN CAUSE A POSSIBLE FUEL TANK EXPLOSION.

EFFECTIVITY	28–21–052–400–001
ALL	Page 1 of 10 Print Date: February 19, 2008

All CDCCL items are identified by a WARNING in the procedures where they occur in the AMM and are identified by this warning after each applicable CDCCL design feature:
CDCCL–Refer to the task: Fuel General **(AMM 28–00–00/001)**

C. Critical Design Configuration Control Limitations (CDCCLs)

WARNING: OBEY THE MANUFACTURER'S PROCEDURES WHEN YOU DO ANY MAINTENANCE THAT MAY AFFECT A CDCCL. IF YOU DO NOT FOLLOW THE PROCEDURES, IT CAN INCREASE THE RISK OF A FUEL TANK IGNITION SOURCE.

(1) Make sure you follow the procedures for items identified as CDCCLs.

You must keep CDCCL items in a serviceable condition. It is possible that damage, wear or changes to a CDCCL item can cause a fuel tank explosion.
When a procedure identifies a CDCCL item, it is a mandatory condition that you do the instruction correctly and accurately as the procedure tells you.

Figure 26 Example of A320 Family Critical Design Configuration Control Limitations (CDCCLs)

TABLE OF CONTENTS

TABLE OF FIGURES