Aging Systems Workshop Fuel Tank Safety- FINAL RULE November 8, 2001

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    - Flammability Minimization
  - Part 91, 121 etc.

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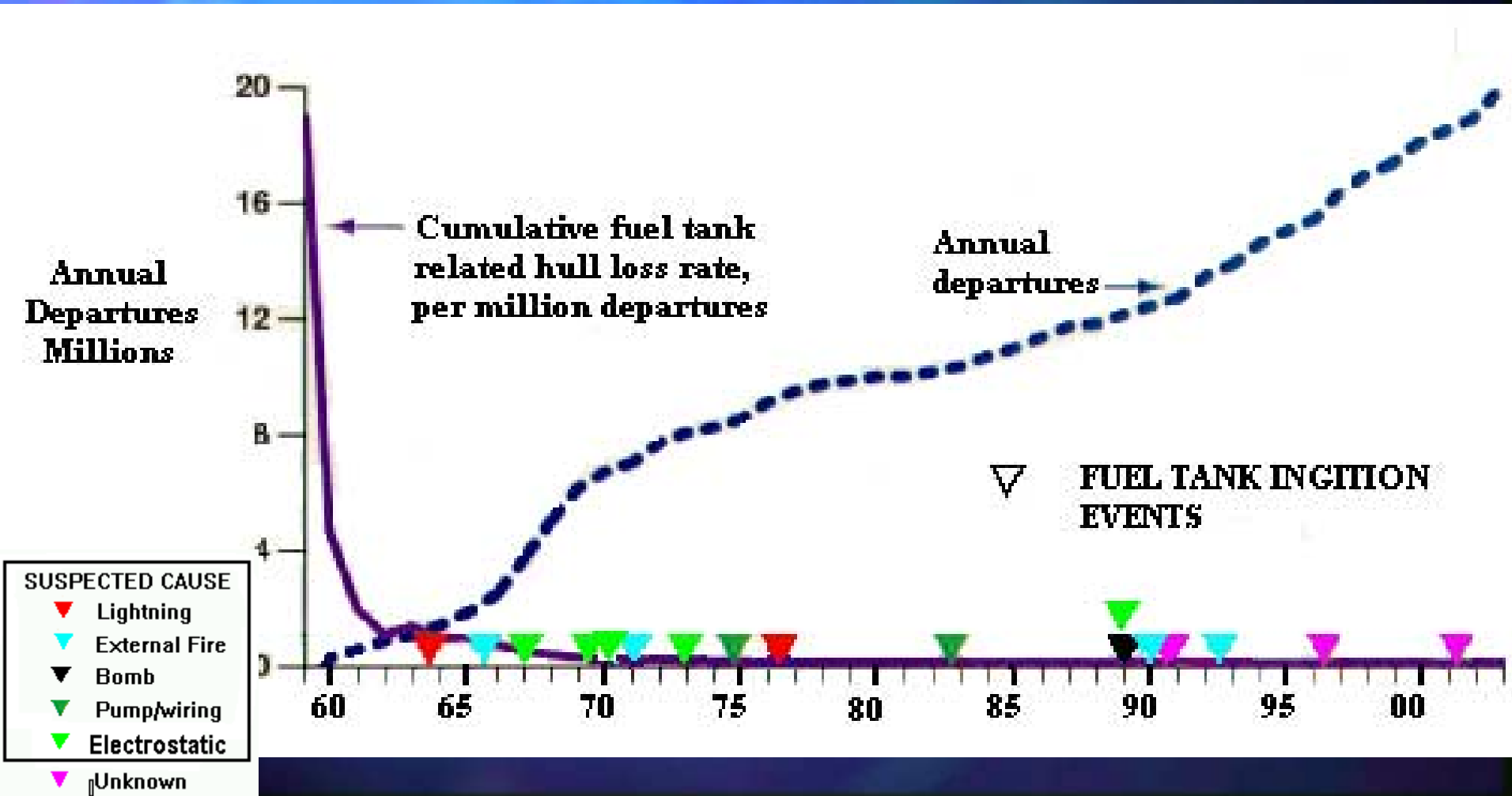
Service History Summary (ARAC)

- **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.**

Chronology of Ignition Events Since 1959



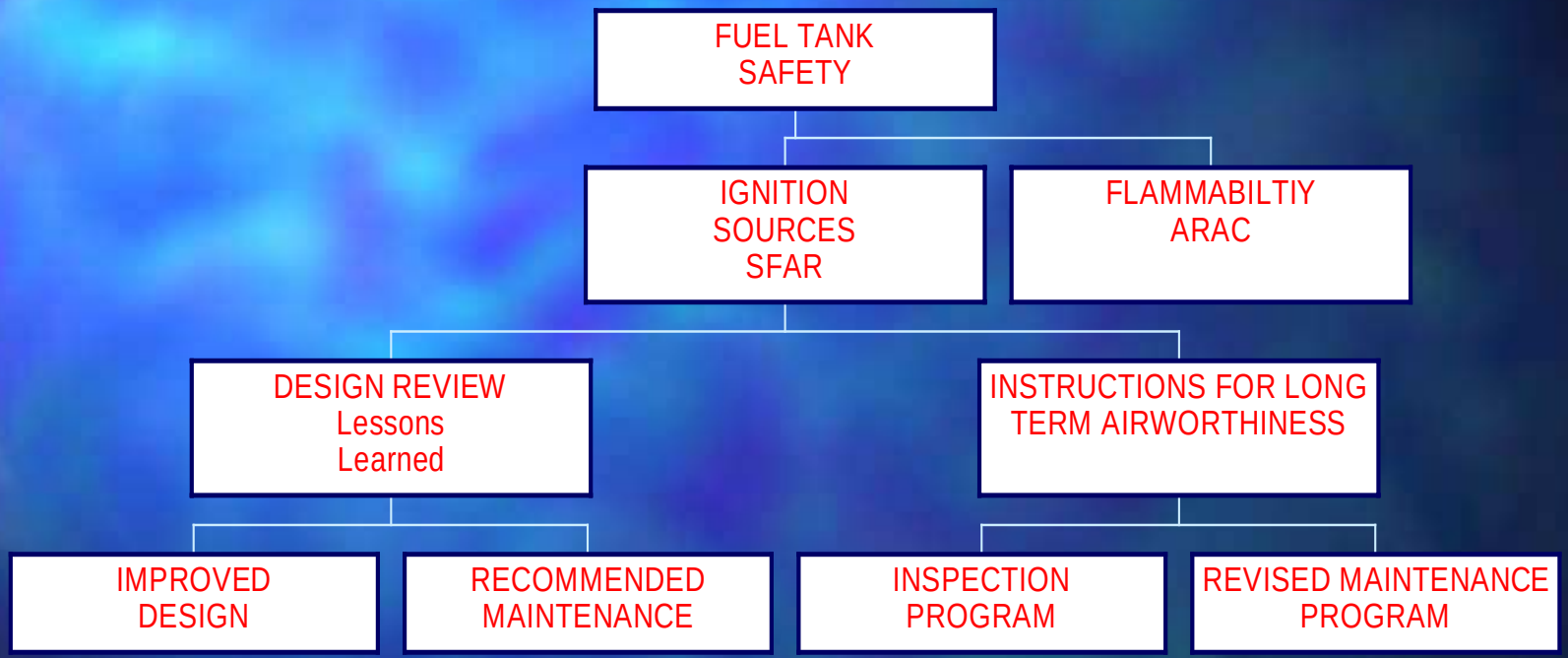
Historical review

- MILITARY - 12 hull loss accidents on military version of B-707 and B52 airplanes
  - All tanks fueled with higher volatility JP-4 fuel
    - Military has converted to low volatility JP-8
  - 10 of 12 occurred in body or center wing tanks
  - 7 occurred on ground during refueling or maintenance
  - 5 in flight - specific cause not identified in many incidents- pumps and fuel quantity indicating system (FQIS) wiring suspected
    - Military has imposed new dry run requirements on pumps

Triggering Events
Fuel Tank Explosions

- Three UNEXPLAINED ACCIDENTS
  - 1990, Philippine Airlines 737 center tank explosion, 8 fatalities
  - July 17, 1996 TWA 747 center tank explosion, 230 fatalities
  - March 3, 2001, Thai Airlines 737-300 center tank explosion, 1 fatality,
- Cause of these accidents is CWT explosion due to unknown ignition source
- FAA has always assumed flammable vapors exist in fuel tanks
  - Current regulations require prevention of ignition sources
- Since 1959, 17 fuel tank ignition events have occurred in the transport fleet
- Therefore, the existing regulations have not prevented fuel tank explosion related accidents

FAA FUEL TANK SAFETY INITIATIVES



Flammability Reduction

- NTSB issued four recommendations to the FAA on December 13, 1996 regarding fuel tank flammability reduction
  - Recommended FAA require design or operational changes that preclude operation with explosive fuel-air mixture in fuel tanks
  - Recommended short term operational requirements intended to reduce operation with explosive vapors in fuel tanks.
  - Recommendations applied to transport category airplanes
- Requirement to limit fuel tank flammability is a major shift in FAA regulations
- FAA published request for comments to NTSB recommendations in Federal Register on April 3, 1997
- FAA and SAE co-sponsored Transport Fuel Flammability Conference on October 7 -9, 1997 in Washington, D.C.
- FAA determined a short term ARAC study needed
  - Comments to the Notice and at the Conference indicate disagreement on approach to flammability reduction methods

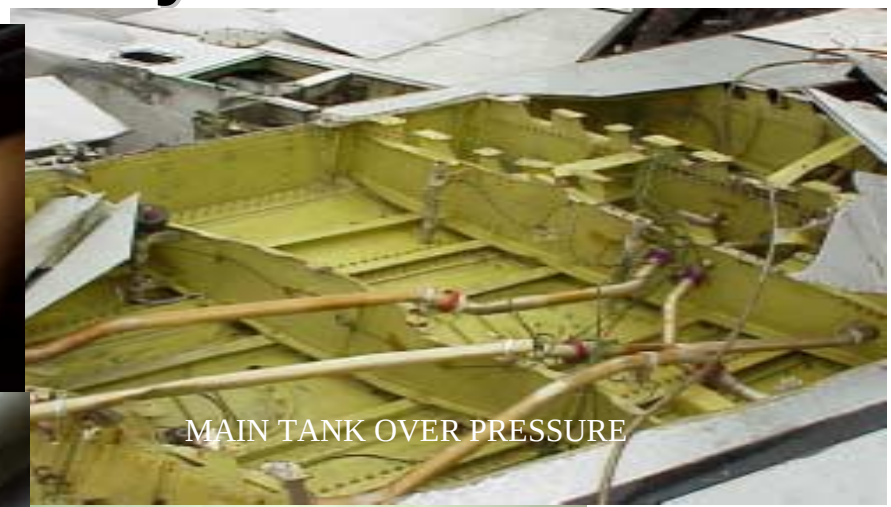
TWA 800 Accident Investigation

- TWA Flight 800 Accident Occurred on July 17, 1996
- NTSB/FAA accident investigation included:
  - Review of Boeing 747 fuel tank system design features
  - Inspection of in-service Boeing 747 airplanes
  - Inspection of retired Boeing 747 airplanes
  - Testing and analysis of fuel tank components
- AIA/ATA fuel tank safety team inspected multiple airplanes of in-service fleet.---Over 900 airplanes total.
- These and other inspections of in-service airplanes showed that corrosion, wear, debris in tanks and long term maintenance actions were not adequately accounted for in the initial design
- Other transport airplanes have similar fuel tank system designs and are therefore subject to the same concerns

Failure Conditions Identified
(see Preamble)

- Failure conditions identified in other transport airplane types that could lead to fuel tank ignition sources (45 ADs to date)
  - Electrical power wires inside fuel tanks
    - Wire chafing inside metal conduits in tanks
    - Wire arcing into tank wall from external wires
  - Fuel pump failures
    - Electrical arcing
    - Mechanical failures causing sparks or hot spots
    - Debris in pumps
  - Electrical Wiring Outside fuel tanks
    - Electromagnetic interference creating high energy on FQIS wiring
    - Inadequate Separation within Line Replaceable Units
  - Bonding jumper wire failures
    - missing
    - improperly connected
    - corroded

DER Workshop
- Fuel Tank Safety- Final Rule



Need for Fleet Review

- One time re-evaluation of the transport fleet is required
  - Revalidate that existing fuel tank system designs preclude ignition sources.
  - Define any necessary maintenance practices to prevent development of ignition sources.
- Improved standards are needed to provide robust design and improved maintenance practices:
  - ignition source prevention
  - improved design evaluation
  - maintenance practices

Affected Regulations

- **PART 21 (SFAR)** - Certification Procedures
- **PART 25** - Airworthiness Standards
- **PARTs 91, 121, 125, 129** - Operating Requirements

SYNOPSIS OF NPRM

- Final Rule Issued April 19, 2001
  - Available on web at:
    - http://dms.dot.gov/search
    - search for last 4 digits of docket number FAA-1999-**6411**
- **PART 21 SFAR- Type Certificate Holders**
  - **Revalidate Original Compliance based upon lessons learned**
- **PART 25- Airworthiness Standards**
  - **Revision of §25.981 "Fuel tank temperatures" to include consideration of other sources of tank ignition**
  - **Development of two Acs to replace AC 25.981:**
    - **AC25.981-1b "Fuel tank ignition source prevention guidelines",**
    - **AC25-981-2 "Fuel tank flammability minimization"**
- **PART 91, 121 etc.- Operating Requirements**
  - **Operator incorporation of fuel system inspection and maintenance program**

WHY AN SFAR?

- SIMILAR TO PREVIOUS FAA/INDUSTRY FLEET SAFETY REVIEWS
  - Thrust Reversers
  - Aging Airplanes
  - Cargo Doors
  - Icing
- SFAR ALLOWS
  - Formalized Process
  - Single Action
  - Enforceability

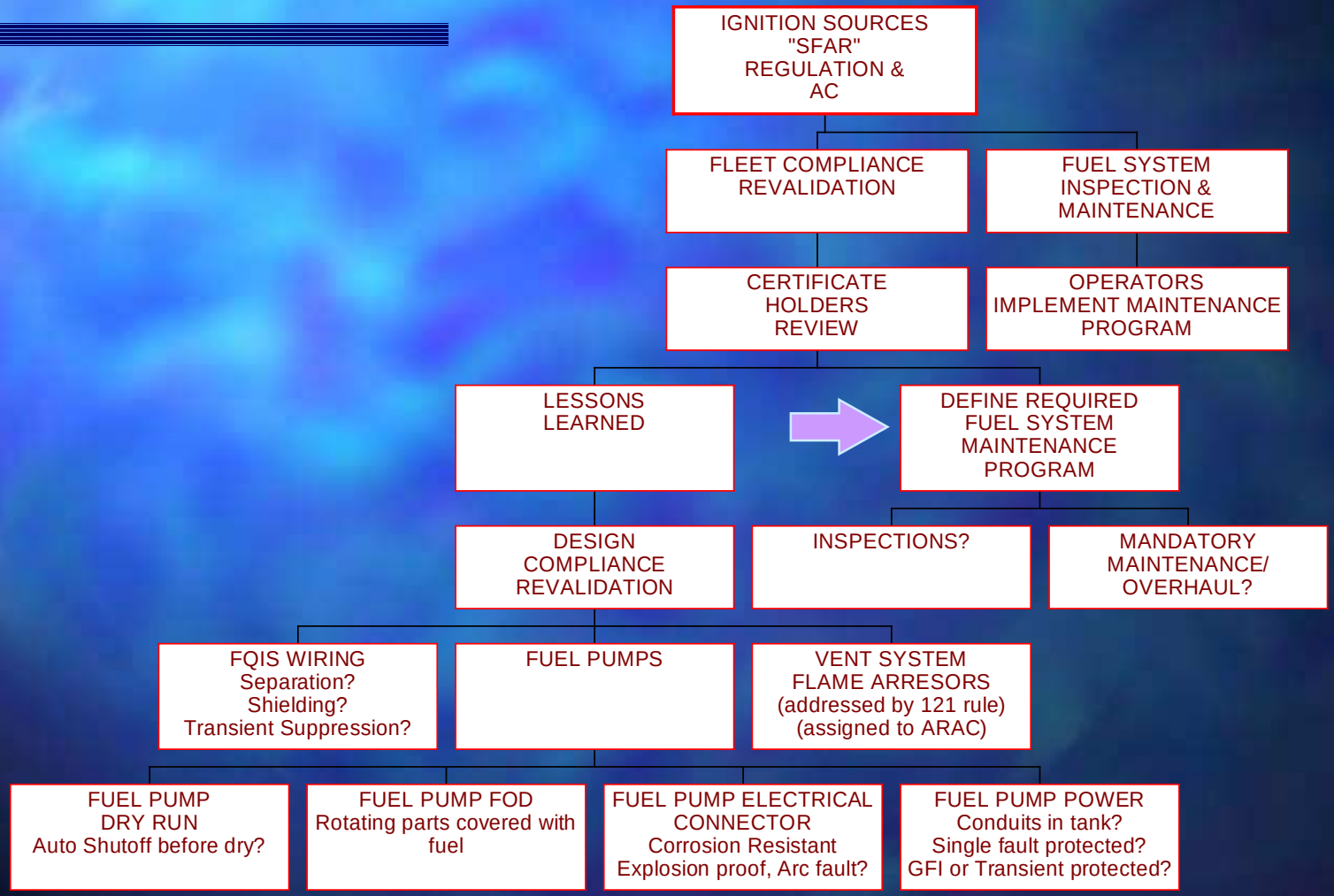
PART 21

-"Certification Procedures for Products and Parts"

Summary

- Part 21 - Certification Procedures
  - New Special Federal Aviation Regulation (SFAR)
    - Applies to "the holders of type certificates, and STCs that may affect the fuel tank system of turbine powered transport category airplanes"
      - 30 passengers or more or
      - 7500 lbs payload or more, certified after 1/1/58
    - Requires fleet review of fuel tank system designs
      - Addresses lessons learned
      - Demonstrate design precludes ignition sources
      - Develop all design changes necessary to meet requirements
      - Develop all necessary maintenance and inspection instructions
      - Submit a report to ACO
    - Compliance time is 18 months after the effective date of the final rule
      - For existing certification projects, 18 months after certification date or 18 months after SFAR effective date, whichever is later

Special FAR


IGNITION SOURCES
"SFAR"
REGULATION &
AC
FLEET COMPLIANCE
REVALIDATION
FUEL SYSTEM
INSPECTION &
MAINTENANCE
CERTIFICATE
HOLDERS
REVIEW
OPERATORS
IMPLEMENT MAINTENANCE
PROGRAM
LESSONS
LEARNED
DEFINE REQUIRED
FUEL SYSTEM
MAINTENANCE
PROGRAM
DESIGN
COMPLIANCE
REVALIDATION
INSPECTIONS?
MANDATORY
MAINTENANCE/
OVERHAUL?
FQIS WIRING
Separation?
Shielding?
Transient Suppression?
FUEL PUMPS
VENT SYSTEM
FLAME ARRESORS
(addressed by 121 rule)
(assigned to ARAC)
FUEL PUMP
DRY RUN
Auto Shutoff before dry?
FUEL PUMP FOD
Rotating parts covered with
fuel
FUEL PUMP ELECTRICAL
CONNECTOR
Corrosion Resistant
Explosion proof, Arc fault?
FUEL PUMP POWER
Conduits in tank?
Single fault protected?
GFI or Transient protected?

Who Is Affected?

- **PART 21 SFAR- Existing Fleet**
- Approx. 7000 U.S registered transport airplanes affected
- 600 smaller transports (turboprops and bizjets) operated in Part 121 and 4000 in Part 135 would not be affected.
- Effectivity chosen to cover majority fleet passenger carrying capacity, while limiting small business affects.

SOME AFFECTED MODELS

A300

A310

A320

A330,340

ATR72, ATR42

B707

B727

B737-100/200,

737-300/400

B737-500,600,700,800

B747-100,-200,/300

DC8

DC9

DC10

MD11

MD80 series

MD90,

B717

B777

B757

B767-200/300ER, -400

F 27

F 28

F50

F100

BAE ATP

BAE 41

BAE 146

747-400

B767-200

EMB 145

Shorts 360

Dornier 328

Brad CRJ

SAAB 340, 2000

Lockheed Electra

L 1011

DHC 7,-8

PART 21-- DESIGN CHANGES

- Part 21 requirements- within 18 months
  - Develop all design changes to the fuel tank system that are necessary to meet new fail safe requirements.
  - Allows ACOs the latitude to extend time provided:
    - 1) The safety review is completed with the compliance time
    - 2) Necessary design changes are identified within the compliance time; and
    - 3) Additional time can be justified based on the holders demonstrated aggressiveness in performing the safety review, the complexity of the design changes the availability of the interim actions to provide an acceptable level of safety.

Part 25- Ignition Sources

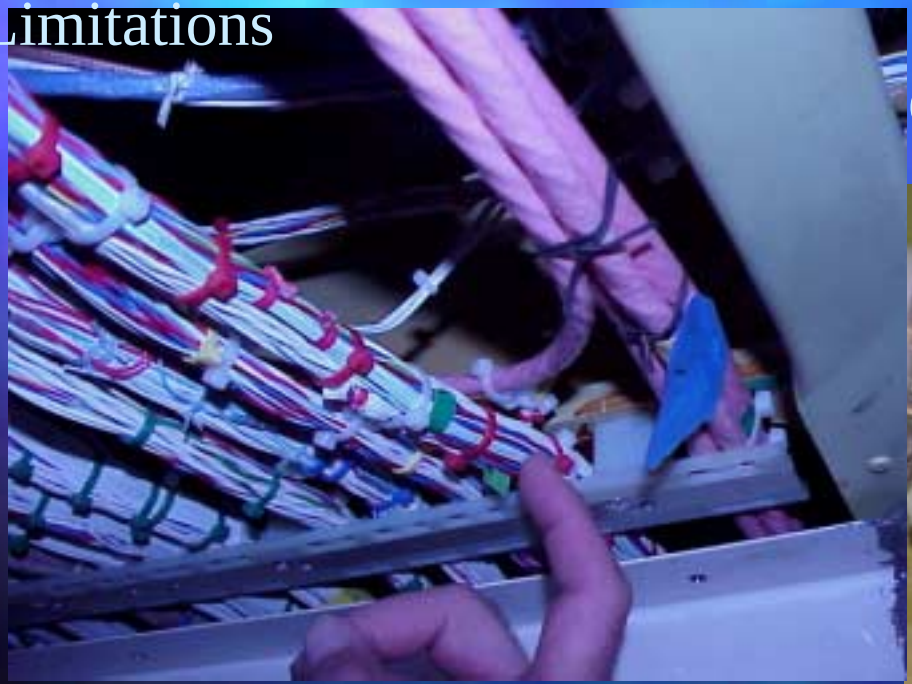
- Part 25 - Airworthiness Standards
  - Revised FAR 25.981
    - Is used for the Part 21 fleet review
    - Maintains existing Autoignition Requirements
    - Adds explicit requirements for analysis to demonstrate the design precludes failures that can cause ignition sources
    - Includes system safety analysis requirement
      - Maintains powerplant regulation philosophy of considering latent failures
      - adds specific consideration of
        - manufacturing variability
        - wear
        - corrosion
        - likely damage
      - includes consideration of specific risk similar to thrust reverser fleet review

Part 25- Ignition Sources

- Requires identification of critical design configuration control limitations (safety critical features like wire separation)
- requires visible means to identify critical features in areas of airplane where maintenance actions repairs or alterations may be apt to violate the critical configuration control limitations
  - e.g. color coding of wire to identify separation limitation

Markings- Examples

Visible Identification of Critical Design Configuration Control Limitations



Critical FQIS wiring color coded

Part 25 (Cont.)

- Part 25, Appendix H “Instructions for Continued Airworthiness- (H25.4) Airworthiness Limitations section.
  - Requires including fuel tank safety limitations in the Instructions for Continued Airworthiness.
  - Revised Appendix H applies to new type design changes through the existing § 21.50, “Instructions for continued airworthiness and manufacturer’s maintenance manuals having airworthiness limitations sections.”

Part 25 - Flammability

- Flammability
  - New requirement to minimize exposure of fuel tanks to flammable vapors
  - Based on safety level of ARAC recommendation
  - Applies only to new designs and STCs as all new rules
    - Applicability to STCs determined by standard top down assessment
  - Intent stated in preamble as “equivalent to an unheated main tank”
  - May require cooling or other means on tanks located in fuselage and cargo compartments. (see AC25.981-2)

Part 25 - Flammability

§ 25.981 Fuel tank ignition prevention

(c) The fuel tank installation must include either--

(1) Means to minimize the development of flammable vapors in the fuel tanks (in the context of this rule means to incorporate practicable design methods to reduce the likelihood of flammable vapors); or

(2) Means to mitigate the effects of an ignition of fuel vapors within fuel tanks such that no damage caused by an ignition will prevent continued safe flight and landing.

Note: "Minimize" : the intent of the proposal is to require that fuel tanks are not heated, and cool at a rate equivalent to that of a wing tank in the transport airplane being evaluated.".

Part 25 Advisory Circulars

- Ignition Prevention
  - AC 25.981-1B was published at the same time as the SFAR
  - Acceptable method for demonstrating compliance with the proposed changes to § 25.981.
  - Acceptable method for use in the SFAR design review
  - Include a listing of lessons learned that should be addressed
- Fuel Tank Flammability
  - New AC published for the fuel tank flammability requirements for new designs (AC 25.981-2)

Operational Rule Changes

- Part's 91, 121, 125, 129 - Operating Requirements
  - Applies to operators of large transport airplanes as defined in the applicability of the SFAR.
  - Requires incorporation of FAA approved fuel tank system maintenance and inspection instructions into the maintenance and inspection programs
  - Instructions must:
    - "address the actual configuration of the fuel tank systems of each affected airplane"
    - be approved by cognizant Aircraft Certification Office (ACO)
  - Requires engineering (ACO) approval for subsequent changes to program .
    - E.g. Escalation in inspection intervals
  - Compliance time18 months longer than SFAR design review compliance time

Operational Rule Changes

- Determination of Airplane Configuration
  - Operators comments to NPRM indicated records inadequate to determine detailed configuration of airplanes in fleet
    - field approvals, STCs, Repairs not always documented
  - Inspection of each airplane may be required in many cases if assessment results in configuration control limitations.
    - E.g. FQIS wiring separation
  - Inspection may not be needed if fail safe features address possible configuration variability
    - E.g. Installation of transient protective features on FQIS

PRODUCTS FROM SFAR

- CERTIFICATE HOLDERS
  - Design Evaluation Report for Each Model
    - Defines any design configuration control limitations
  - “Developed” Design changes
  - Any Required Maintenance and Inspection Instructions for Each Model
- OPERATORS
  - Configuration Determination for each airplane
    - STCs, Field Approvals,
  - Overall Assessment of airplanes in their fleet
    - based upon TC and STC holder assessments.
  - Implement Maintenance and Inspection Program
- FAA
  - Possible AD’s - Model Specific Based on Design Evaluation