



## Fuel System Lightning Protection

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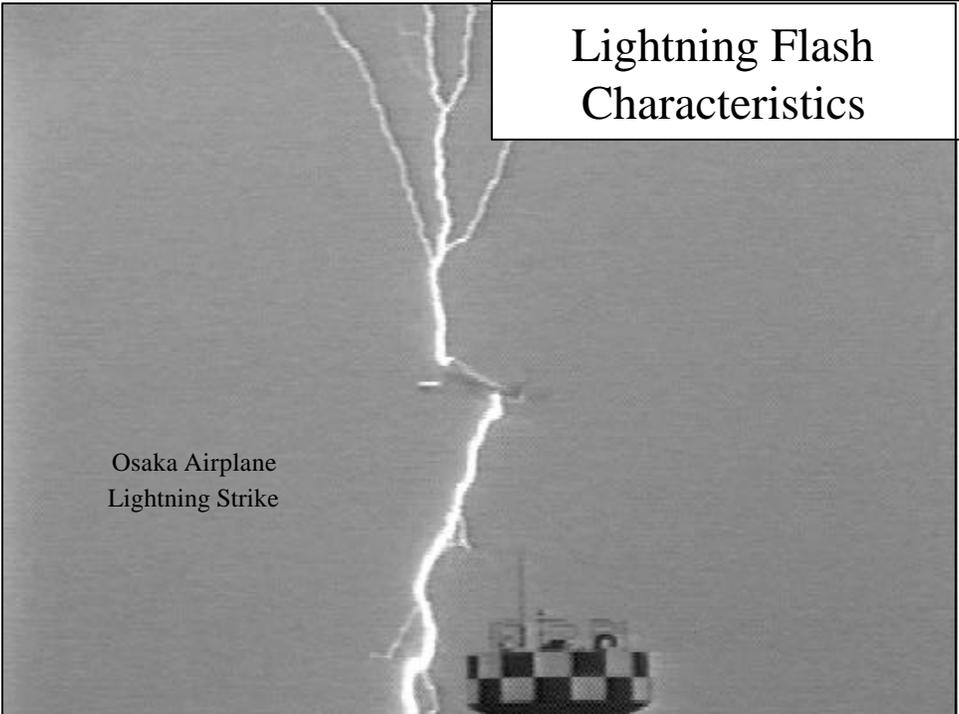


## Presentation Topics

- ✍ Lightning characteristics
- ✍ Lightning effects on fuel systems
- ✍ Part 25 lightning regulations
- ✍ Lightning protection approaches

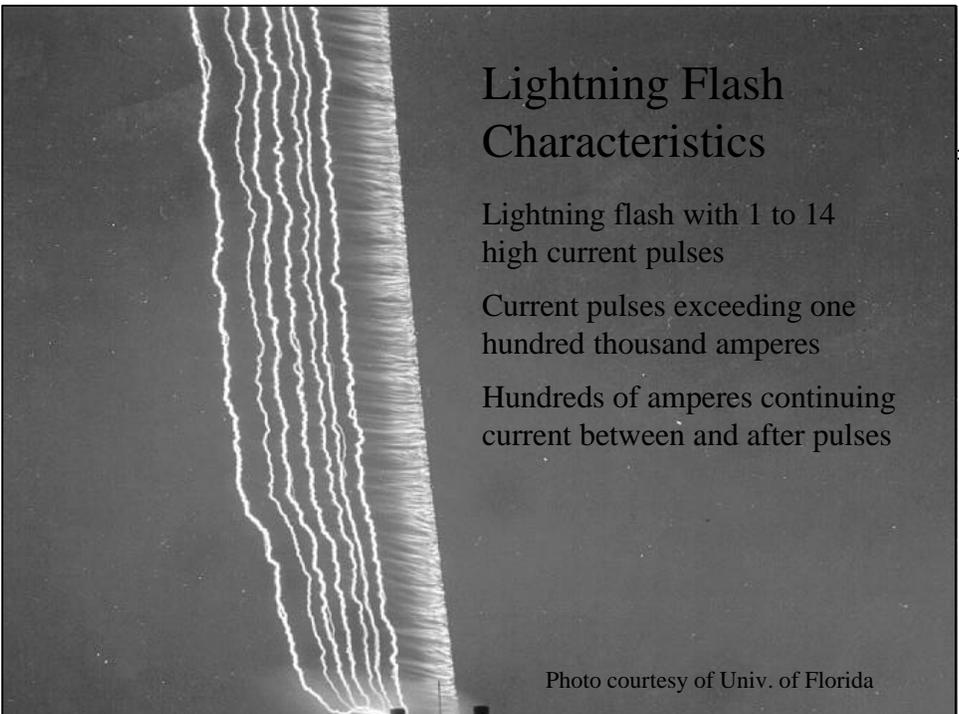
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## Lightning Flash Characteristics



Osaka Airplane  
Lightning Strike

## Lightning Flash Characteristics



Lightning flash with 1 to 14  
high current pulses

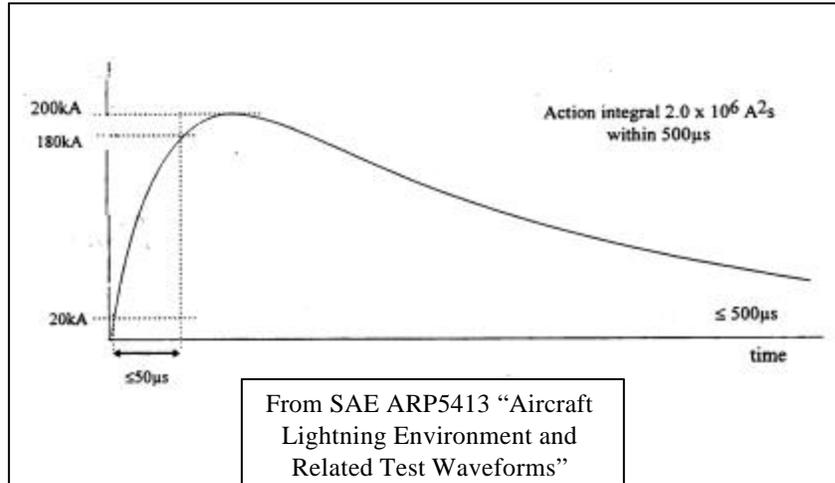
Current pulses exceeding one  
hundred thousand amperes

Hundreds of amperes continuing  
current between and after pulses

Photo courtesy of Univ. of Florida



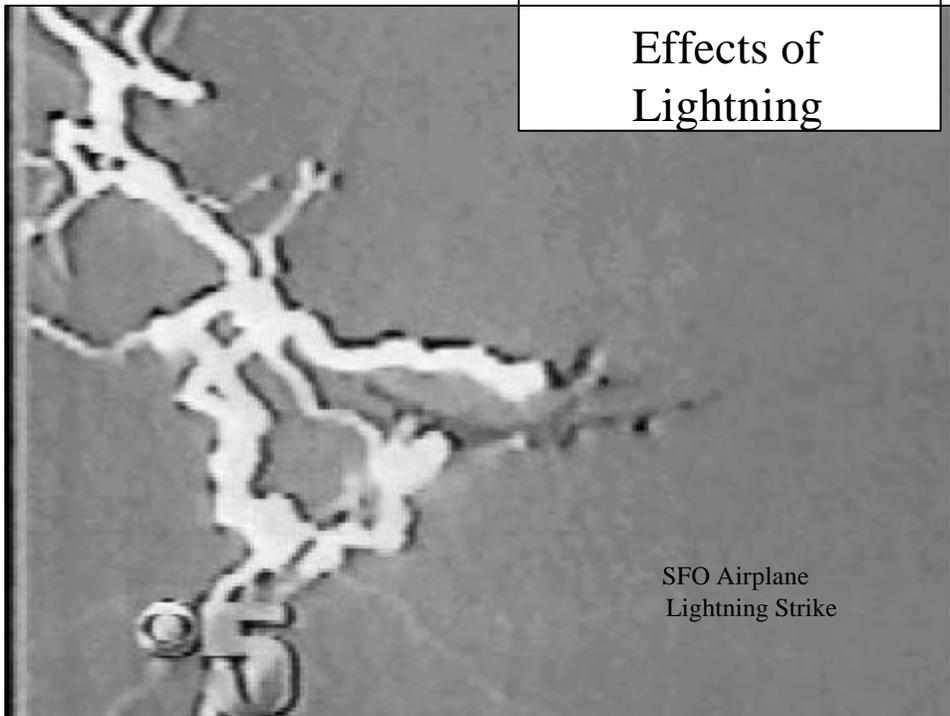
## Component A Test Waveform



From SAE ARP5413 "Aircraft  
Lightning Environment and  
Related Test Waveforms"

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## Effects of Lightning



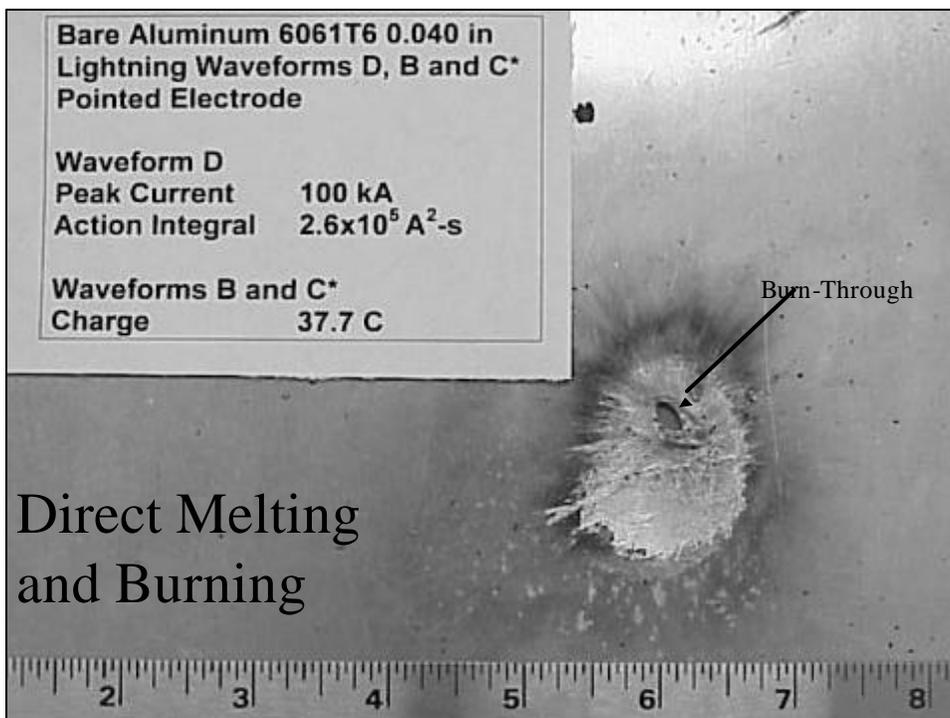
SFO Airplane  
Lightning Strike



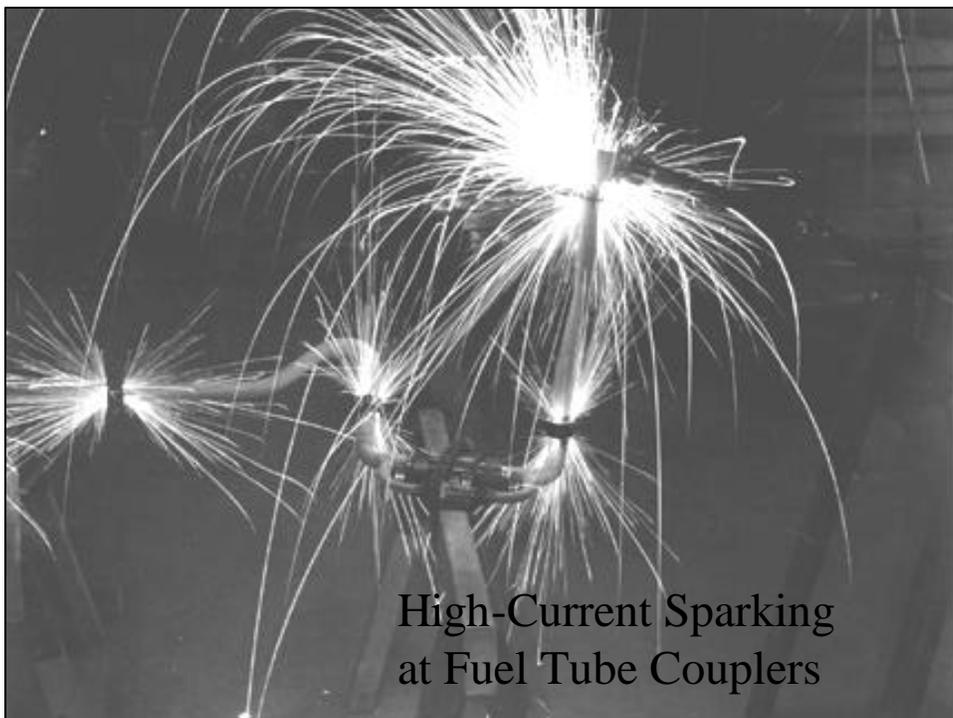
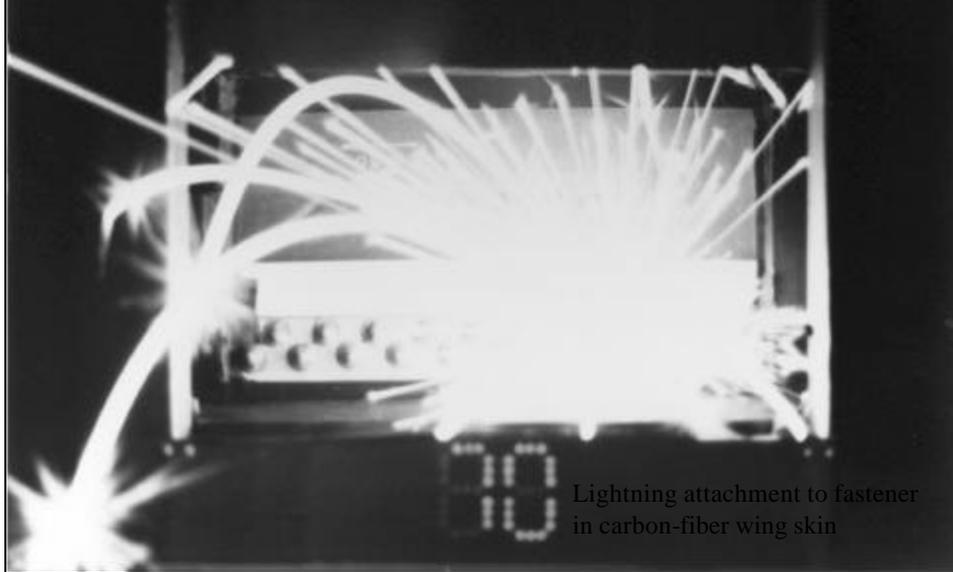
## Effects of Lightning

- ✍ Direct melting, burning and puncture at lightning attachment points
- ✍ Arcing and sparking in the vicinity of attachment points
- ✍ Arcs from high current induced in electrical conductors in path of lightning currents
- ✍ Sparks from high voltage across poorer electrical conductors

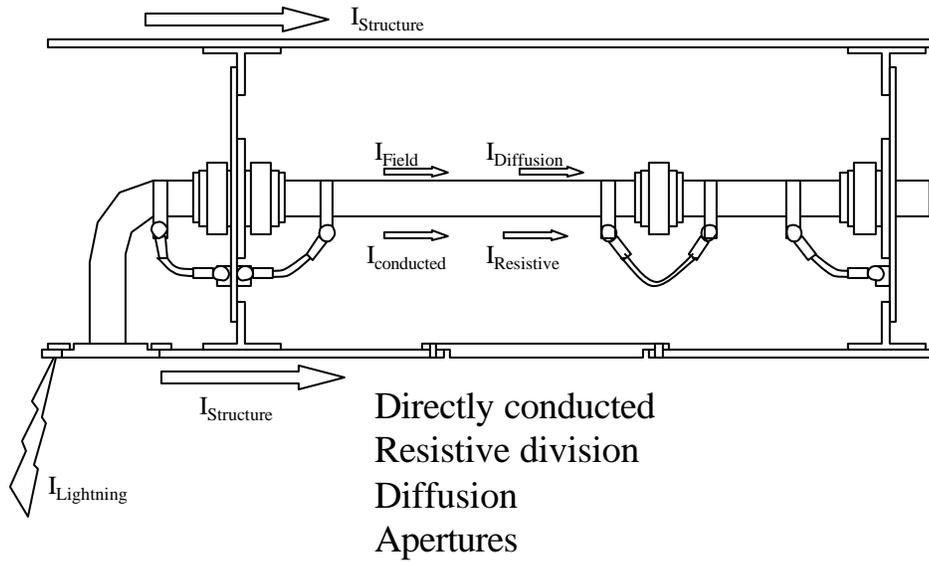
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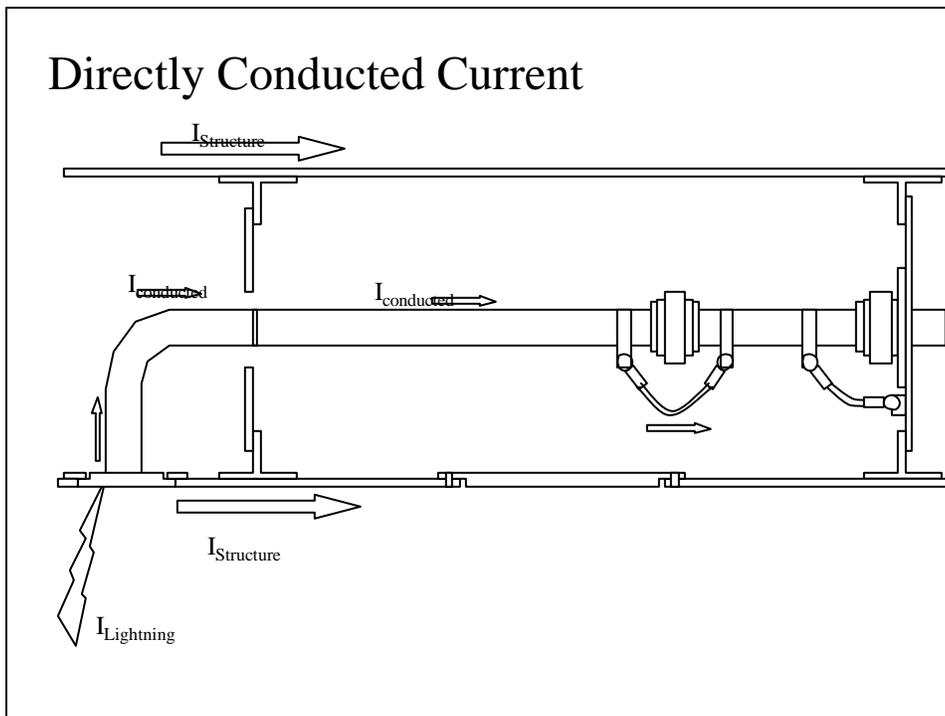
## Arcing and Sparking at Lightning Attachment Point



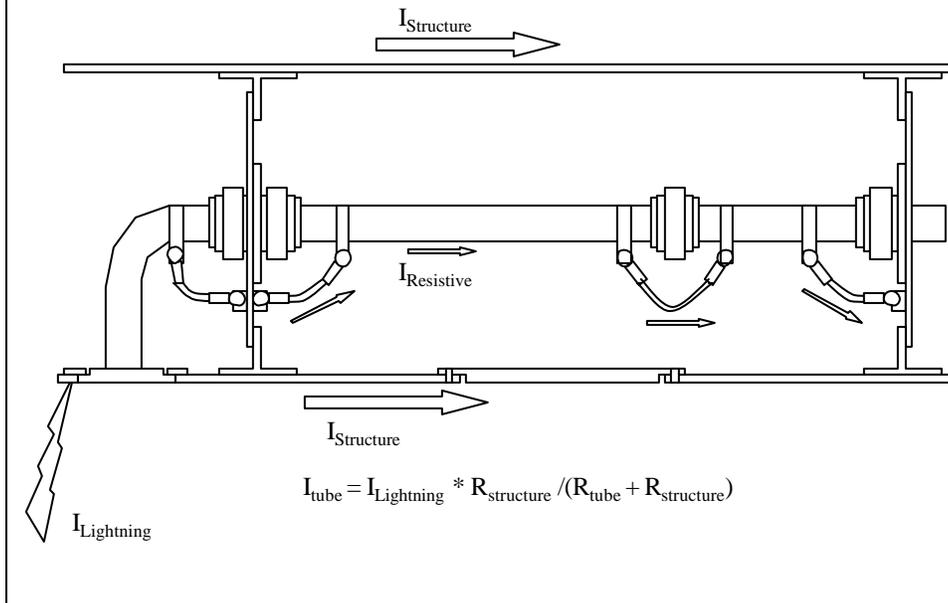
## How Does Lightning Energy Enter Fuel Tanks?



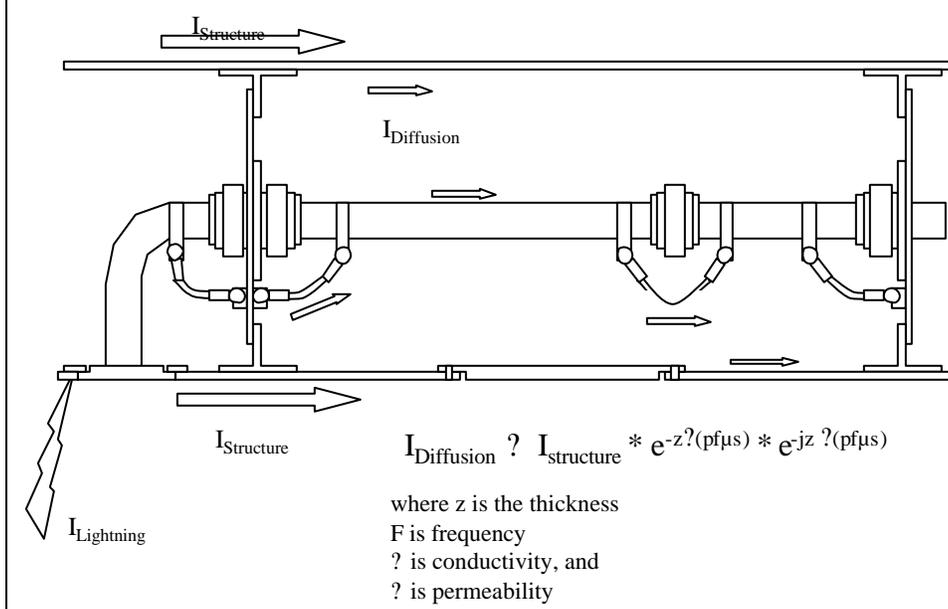
## Directly Conducted Current



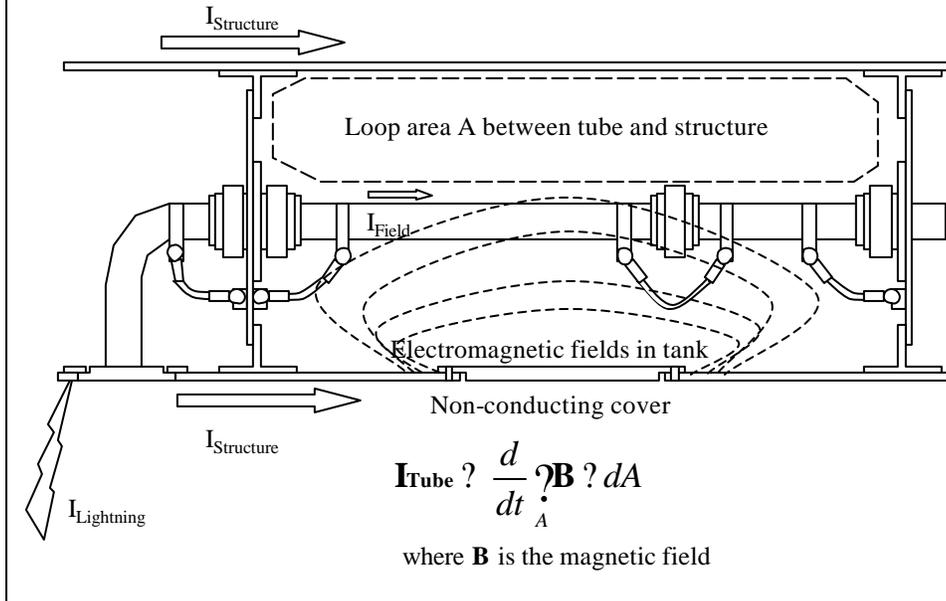
## Resistive Current Division



## Diffusion Through Structure



## Fields Through Apertures



## §25.954 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 strokes to areas where swept strokes are highly probable; and
  - ✍ (c) Corona and streamering at fuel vent outlets.
- ✍ (Amdt. 25-14, Eff. 8/11/67)



## § 25.981 Fuel Tank Ignition Prevention

✍ (a) No ignition source may be present at each point in the fuel tank or fuel tank system where catastrophic failure could occur due to ignition of fuel or vapors. This must be shown by:

...

✍ (3) Demonstrating that an ignition source could not result from each single failure, from each single failure in combination with each latent failure condition not shown to be extremely remote, and from all combinations of failures not shown to be extremely improbable. The effects of manufacturing variability, aging, wear, corrosion, and likely damage must be considered.

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## Implications of §25.981(a)(3) for Lightning Protection

- ✍ A lightning strike is an environmental condition, and is not considered a failure
- ✍ Fuel system lightning protection design must consider the impact of single and latent lightning protection failures
- ✍ Most airplane lightning protection prior to SFAR 88 did not consider the effect of failures

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## Typical Design Features That Require Lightning Protection

- ✍ **Direct lightning attachment areas**
- ✍ **Structural joints and associated fasteners**
- ✍ **Openings in the tanks, such as access covers**
- ✍ **Penetrations into the fuel tanks**
  - ✍ Fuel plumbing, hydraulic tubes, conduits, pumps, wiring, and vents
- ✍ **Fuel tube couplers and joints, hydraulic tubes, conduits, and wires within tanks**

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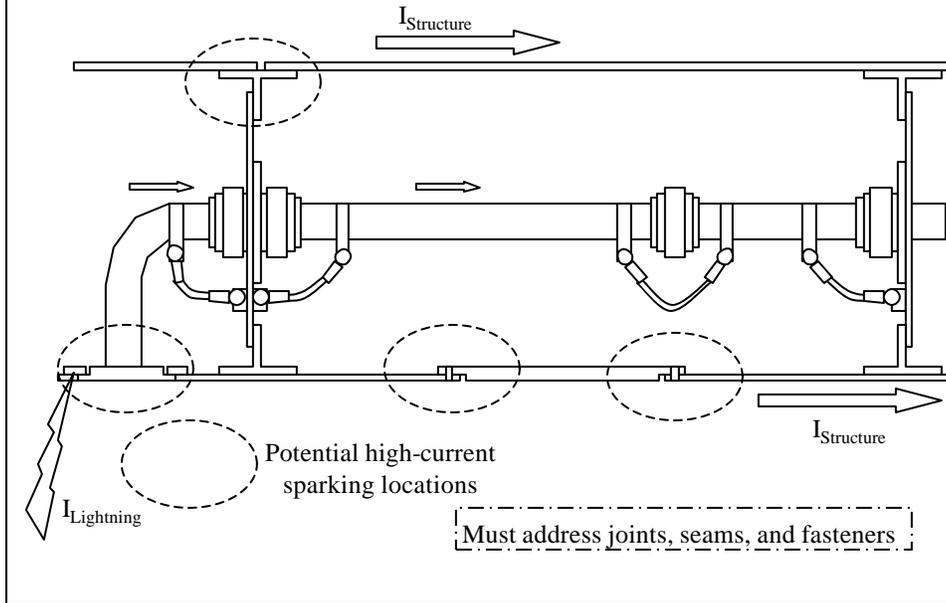


## Lightning Protection Approaches

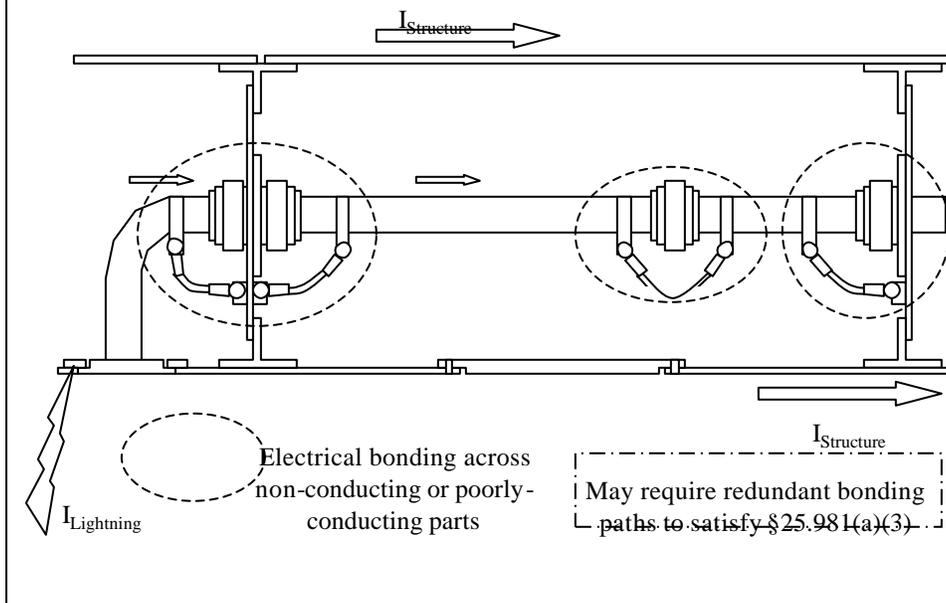
- ✍ **Provide highly conductive tank skins and structure**
  - ✍ This includes fasteners and joints
- ✍ **Control electrical penetrations into tanks**
  - ✍ By electrical bonding or electrical isolation
- ✍ **Control conductive paths within tanks**
  - ✍ By electrical bonding or electrical isolation

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## Highly Conductive Structure



## Electrical Bonding Within Tanks



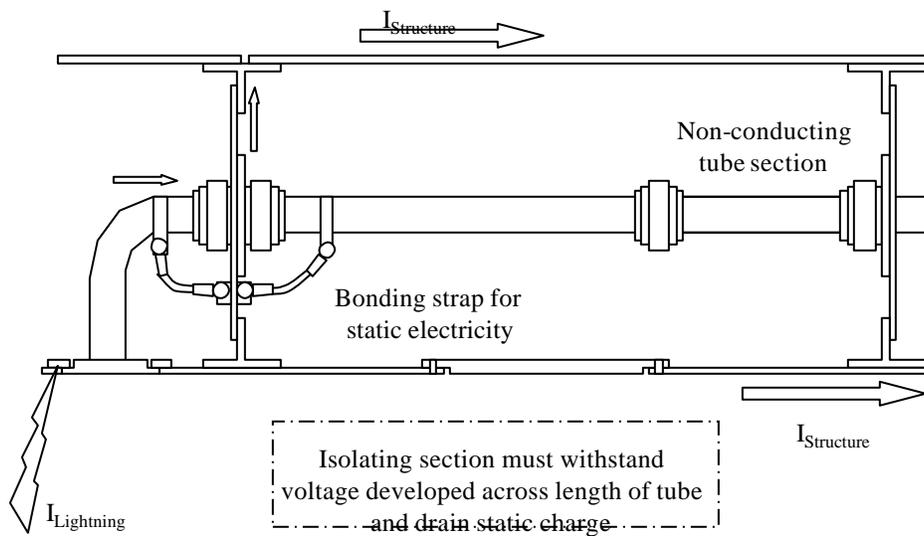


## Electrical Bonding Requirements

- ✍ Develop bonding approach to satisfy lightning, static and electrical fault requirements
- ✍ Identify mandatory bonding features
- ✍ Define allowable resistance and maximum current carrying limits

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## Electrical Isolation

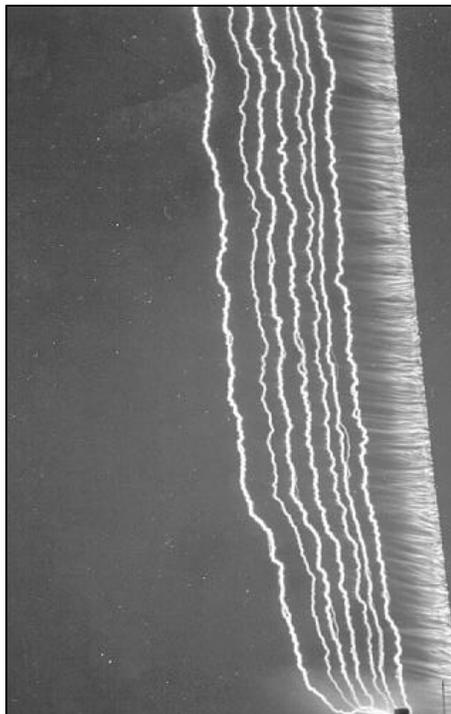




## References

- ✍ AC 20-53A, "Protection of Airplane Fuel Systems Against Fuel Vapor Ignition Due to Lightning", 4/85
- ✍ DOT/FAA/CT-83/3, "Users Manual for AC 20-53A Protection of Airplane Fuel Systems Against Fuel Vapor Ignition Due to Lightning", 10/84
- ✍ F.A. Fisher, J.A. Plumer, R.A. Perala, "Aircraft Lightning Protection Handbook", DOT/FAA/CT-89/22, 9/89
- ✍ SAE ARP5412, "Aircraft Lightning Environment and Related Test Waveforms", 11/99
- ✍ SAE ARP5414, "Aircraft Lightning Zoning", 12/99

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A photograph showing multiple bright, jagged lightning strikes against a dark sky, with a large, dense, vertical lightning channel on the right side.

## Wrap-Up

- Lightning characteristics**
- Lightning effects on fuel systems**
- Part 25 lightning regulations**
- Lightning protection approaches**