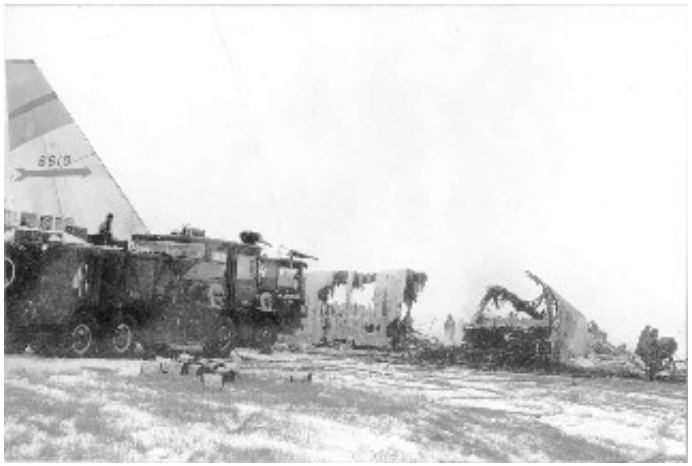
Icing in Aircraft Fuel Lines

Federal Aviation Administration

[1]



[3]

Presented to: Systems Meeting

By: Thomas Maloney, Rutgers Graduate Student

Rutgers Advisors: Professor Rossmann, Professor Diez

Date: 11-16-2011

Background

- **Boeing 777 accident (2008)** [2]
  - Blockage of the FOHE from ice.
- **Boeing 777 engine rollback (2008)** [2]
- **B52 accident (1958)** [2]
  - Fuel pump screen clogged with ice.
  - Over 200 previous “cause unknown” accidents later attributed to fuel icing.[3]
  - Fuel Heaters and Icing Inhibitors were introduced

Related Tests

- **U.S. Air Force** [2]
  - The type of ice is dependant on rate of cooling, water droplet size and agitation of the fuel
  - Provided SAE with information to develop recommendations for testing.
- **Boeing** [2]
  - Beaker test for basic understanding
  - Initial: direct injection of water
  - Snowball: test of the effect of a snowball (sudden injection of water)
  - Accretion: direct injection of water through a nozzle.
  - Environmental testing: Same as accretion test but with the outside of the fuel pipes exposed to approximate conditions of 777 crash.
- **Airbus (current)**
  - Accretion of ice is a quiescent environment.
- **Previous FAA**
  - Similar to the “initial” tests performed by Boeing. (direct water injection)

Objective

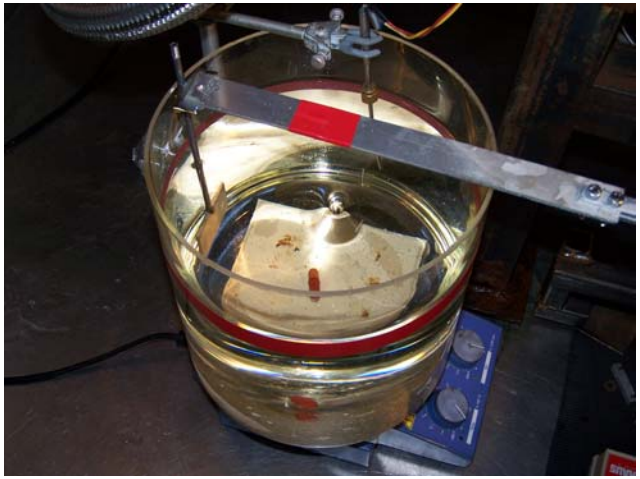
- **Perform experiments to better understand the nucleation properties of water in jet fuel**
  - Temperature effects
  - Effects of flow rate and flow structure
    - Turbulence
    - Reynolds number
  - Possibly material dependence
    - Type of material
    - Roughness of material

Test Facility (Altitude Chamber)

- **Temperature Potential: -51.1C**
- **Pressure Potential: 2.73psi (40,000ft)**
- **Humidity Control**
- **Current fuel storage within the chamber: 135 gal.**

Current FAA Tests

- **Beaker tests**
  - Fuel is saturated at approximately 21C
  - Stirring is applied and the temperature is dropped to approximately -20C
  - A piece of Aluminum within the beaker is weighed in real time via a load cell



Current FAA Tests (continued)

- **Larger scale pipe test**
  - Fuel is recirculated through a 12 inch section of a 1 inch diameter test pipe.
  - Both sides of the test pipe are fitted with ports for differential pressure measurement.
  - Possibility for testing nucleation properties of other materials.
  - Possibility for introducing the same test procedure to other fuel pipe components i.e. pipe bends.

Possible Concern

- **The fuel samples could run out of H2O before a sufficient amount of ice has accumulated.**
  - Water concentration tests via titration to test for water loss.
  - How to reintroduce water into the system if water loss is a problem.

Questions or Suggestions?

Contact information:

Thomas Maloney

1-609-485-7542

Thomas.Maloney@faa.gov

Citations

- [1] *BA38*. 2008. Photograph. *Wikipedia, the Free Encyclopedia*. By Marc-Antony Payne. Web. 14 Nov. 2011. <http://en.wikipedia.org/wiki/File:BA38_Crash.jpg>.
- [2] Department for Transportation, Air Accident Investigations Branch. *Report on the Accident to Boeing 777-236ER, G-YMMM, at London Heathrow Airport on 17 January 2008*. Working paper. Crown, 2010. Print.
- [3] Scotty, Leonard R. "Above and Beyond: Fire and Ice." *History of Flight, Aviation, Space Exploration | AirSpaceMag.com*. Web. 14 Nov. 2011. <http://www.airspacemag.com/military-aviation/Above--Beyond-Fire-and-Ice.html>.