



NTSB National Transportation Safety Board

Vulnerability of Supplemental Oxygen System Components to Fire

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Supplemental Oxygen Systems

- Primarily used for crew and supernumerary passengers
- Consist of :
 - Pressurized oxygen cylinders
 - Regulators & valves
 - Rigid tubing
 - Flexible hoses
 - Mask stowage boxes

Fire Safety Regulations

- 25.869 Fire Protection: Systems

(c) Oxygen equipment and lines must:

1. Not be located in any designated fire zone,
2. Be protected from heat that may be generated in, or escape from, any designated fire zone, and
3. Be installed so that escaping oxygen cannot cause ignition of grease, fluid, or vapor accumulations that are present in normal operation or as a result of failure or malfunction of any system.

Designated Fire Zone

- 25.1181 Designated fire zones

Regions included:

1. The engine power section;
2. The engine accessory section
3. Except for reciprocating engines, any complete powerplant compartment in which no isolation is provided between the engine power section and the engine accessory section;
4. Any auxiliary power unit compartment
5. Any fuel burning heater and other combustion equipment installation described in 25.859
6. The compressor and accessory sections of turbine engines; and
7. Compressor turbine and tailpipe sections of turbine engine installations that contain lines or components carrying flammable fluids or gases

Fire Safety Regulations

- 25.1441 Oxygen equipment and supply

(b) The oxygen system must be free from hazards in itself, in its method of operation, and in its effect upon other components

- 25.1453 Protection of oxygen equipment from rupture

Oxygen pressure tanks and lines between tanks and the shutoff means, must be:

(a) Protected from unsafe temperatures; and

(b) Located where the probability and hazards of rupture in a crash landing are minimized

Fire Safety Regulations

- 25.1707 System separation: EWIS*
 - (g) Except to the extent necessary to provide electrical connection to the oxygen system components, EWIS must be designed and installed with adequate physical separation from oxygen lines and other oxygen system components, so that an EWIS component failure will not create a hazardous condition.

*Electrical wiring interconnection systems

Recent Fires Involving Oxygen

- June 28, 2008 San Francisco, CA
Boeing 767-200 Freighter
ABX / DHL
- February 28, 2009 Tallahassee, FL
Bombardier CRJ-200 Passenger
ASA / Delta

ABX B-767-200



- Bang followed by loud hissing sound
- Rapid fire development
- Melted stainless steel

ABX B-767-200

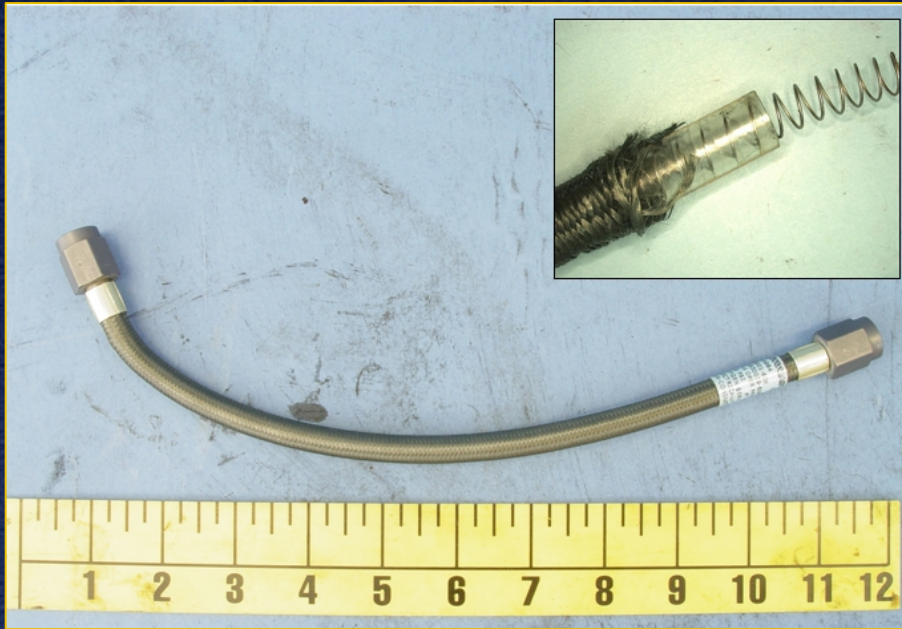


ABX B-767-200



- Burning behavior of pressurized flexible oxygen hoses
- External ignition of pressurized oxygen hoses
- Internal ignition of pressurized oxygen hoses

Fire Tests on Oxygen Hoses

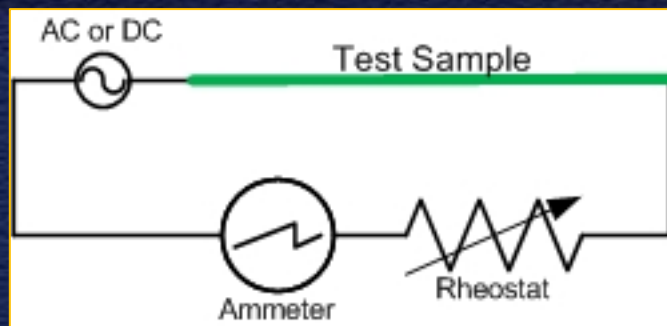


Hose Construction

- Protective over braid (Nomex)
- PVC tubing
- Internal stainless steel coil
- Crimped on aluminum end fittings

1. Explore possibility of causing ignition by passing electrical current through the hose (internal heating)
2. Explore possibility of causing ignition by external heating

Internal Heating Ignition Tests



1. 120 VAC, 2.3A. 2 minutes to failure. No ignition
2. 120 VAC, 3.0A. 1 minute to hissing sound, 1:20s smoke rising from length of hose, 1:30s hose fails with loud bang/pop ejecting incandescent particles and short duration fire
3. 120 VAC, 4.7A. 11s until white flash was observed followed by loud bang and ejection of incandescent particles and short duration fire
4. 120 VAC, 9.0A. 6s until loud bang and hissing sound, short duration fire
5. 28 VDC, 3.0A. 1:20 until hissing sound, hissing intensity grew, no ignition

External Heating Ignition Tests

- Nichrome heating wire wrapped around exterior of the hose, covering approximately a 1" section
- Current sufficient to make wire glow

Internal & External Heating Fire Tests



NTSB Recommendations to FAA

- A-09-043

Require the replacement of conductive flexible oxygen hoses with non conductive hoses

- A-09-047

Require manufacturers to ensure that oxygen system tubing is either non conductive or sleeved with non conductive material or otherwise physically isolated from electrical sources

- A-09-046

Require airplane manufacturers and modifiers to provide positive separation between electrical wiring and oxygen system tubing according to, at a minimum, AC 43.13-1A and AC65-15

CRJ-200



- Loud hissing sound
- Rapid burnthrough



CRJ-200



Oxygen Hose Fire Resistance Tests



- Exposure to pre existing fire:
 - Bunsen burner
 - Burning foam block



Bunsen Burner Test Video



Foam Block Test Video



Closing Thoughts..

- Oxygen system design and materials selection needs to account for the possibility of a fire
- Involvement of oxygen systems in fire has catastrophic results; Treat Oxygen system components with same regard as fuel system components
- Fire protection of oxygen system not specifically addressed in the FARs



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