FedEx's
Fire Suppression System

FedEx's Fire Suppression System

FedEx DC-10 after September 1996 cargo fire

- Fires are classified by the materials involved in their combustion.

- Class A – Common Combustible Solids

  Wood, Paper, Cloth, Rubber, Trash, Plastic, etc

- Class B – Flammable Liquids

  Gas, Oil, Paint, Solvents, Lacquers, Tar, etc

- Class C – Electrical

  Wiring, Motors, Appliances, etc.

- Class D – Combustible Metals

  Magnesium, Lithium, Sodium, etc.

FedEx's Fire Suppression System

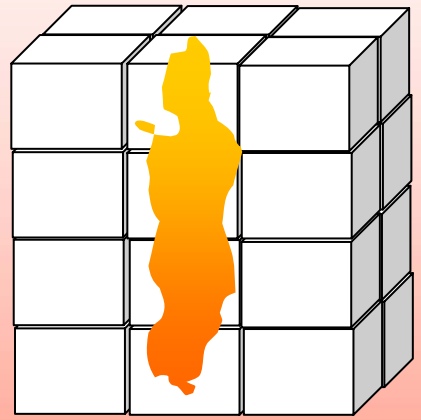
FedEx uses cardboard boxes (18"x 18"x 18") filled with 2.5 lbs of shredded paper, an FAA standard.

FedEx's Fire Suppression System

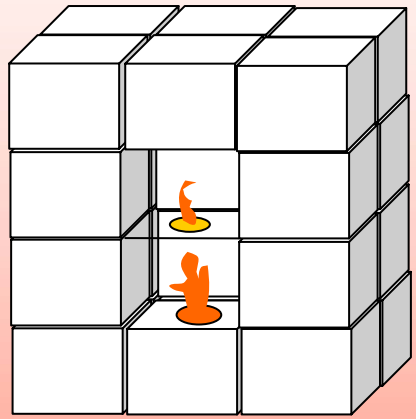
to contain the fire in a large ULD.

To verify that oxygen starvation alone would not entirely suppress a fire; an AMJ was filled with a standard fire load and allowed to burn without an extinguishing agent.

FedEx's Fire Suppression System



Fire initiated on the outside of the fire load spreads quickly due to the lack of obstructions and an abundance of oxygen.



Fire initiated towards the center of the fire load has to burn through additional boxes in order to propagate.

Issues influencing the design the Fire Suppression System

- Weight
- Cost
- Effectiveness
- Personnel Interaction
- Method of loading cargo

Types of Suppressants Considered

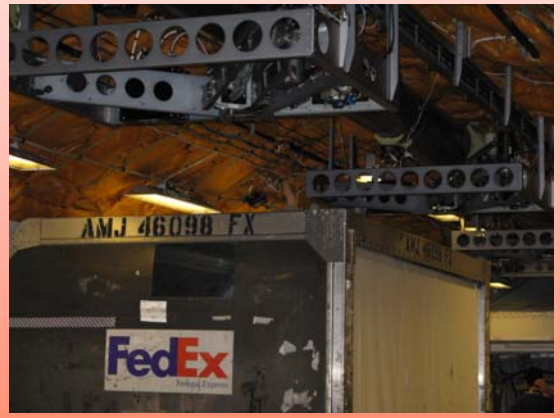
- Dry Powder
- Gas
- Foam
- Coating on ULD

Cargo Foam

- Starts cooling the container when injected.
- Wets the cargo it contacts reducing the spread of fire.
- Displaces oxygen.
- Traps toxic gases.
- Releases Argon when the foam breaks down.
- Is Biodegradable and Non-toxic.
- Ansul Proprietary

FedEx's Fire Suppression System

FedEx has developed a Fire Suppression System that will suppress a fire for four hours regardless if the freight is containerized or palletized



An aircraft based system for containerized freight.

A Fire Containment Cover for palletized freight.

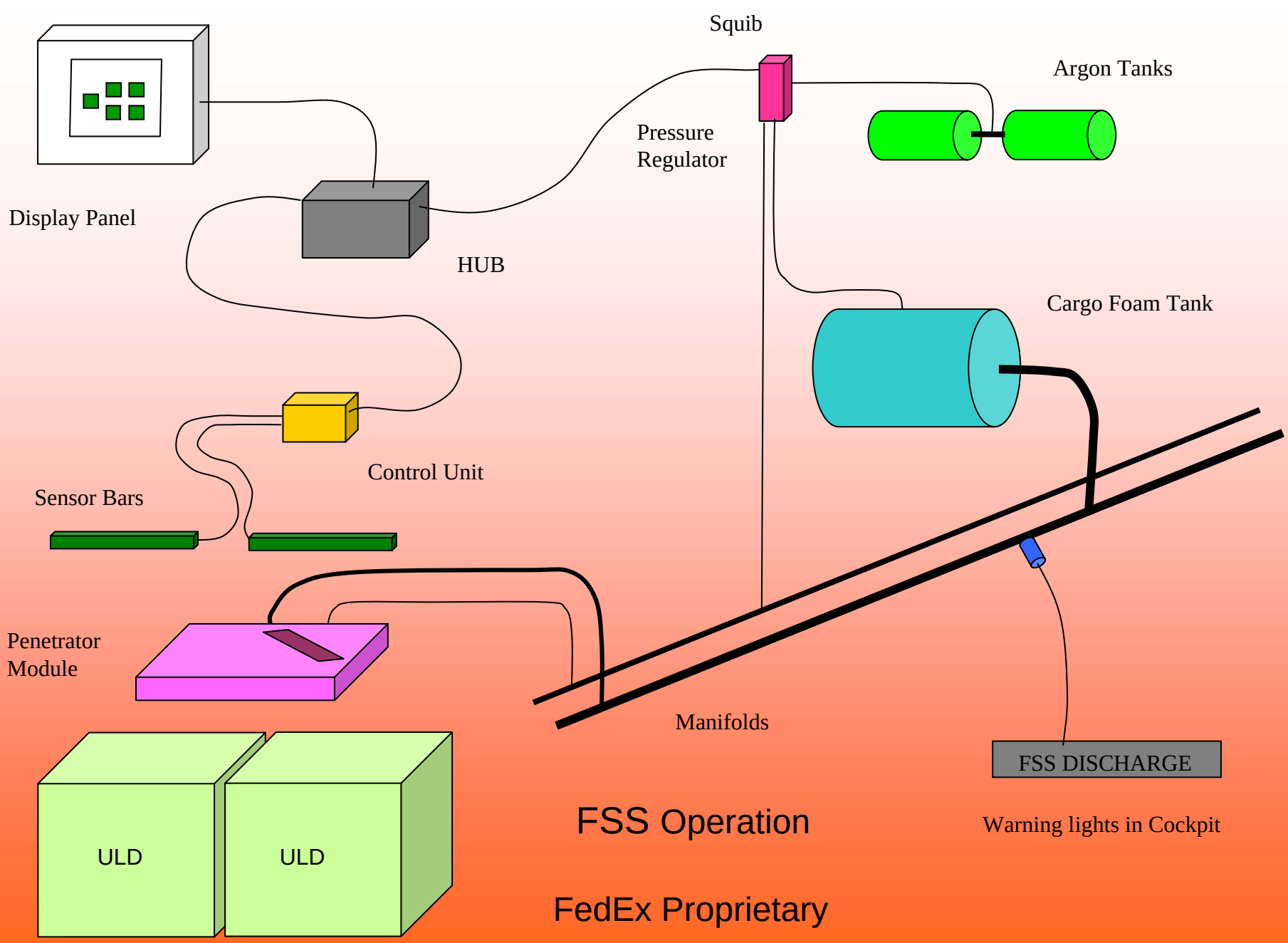
FedEx's Fire Suppression System

Active Fire Suppression System

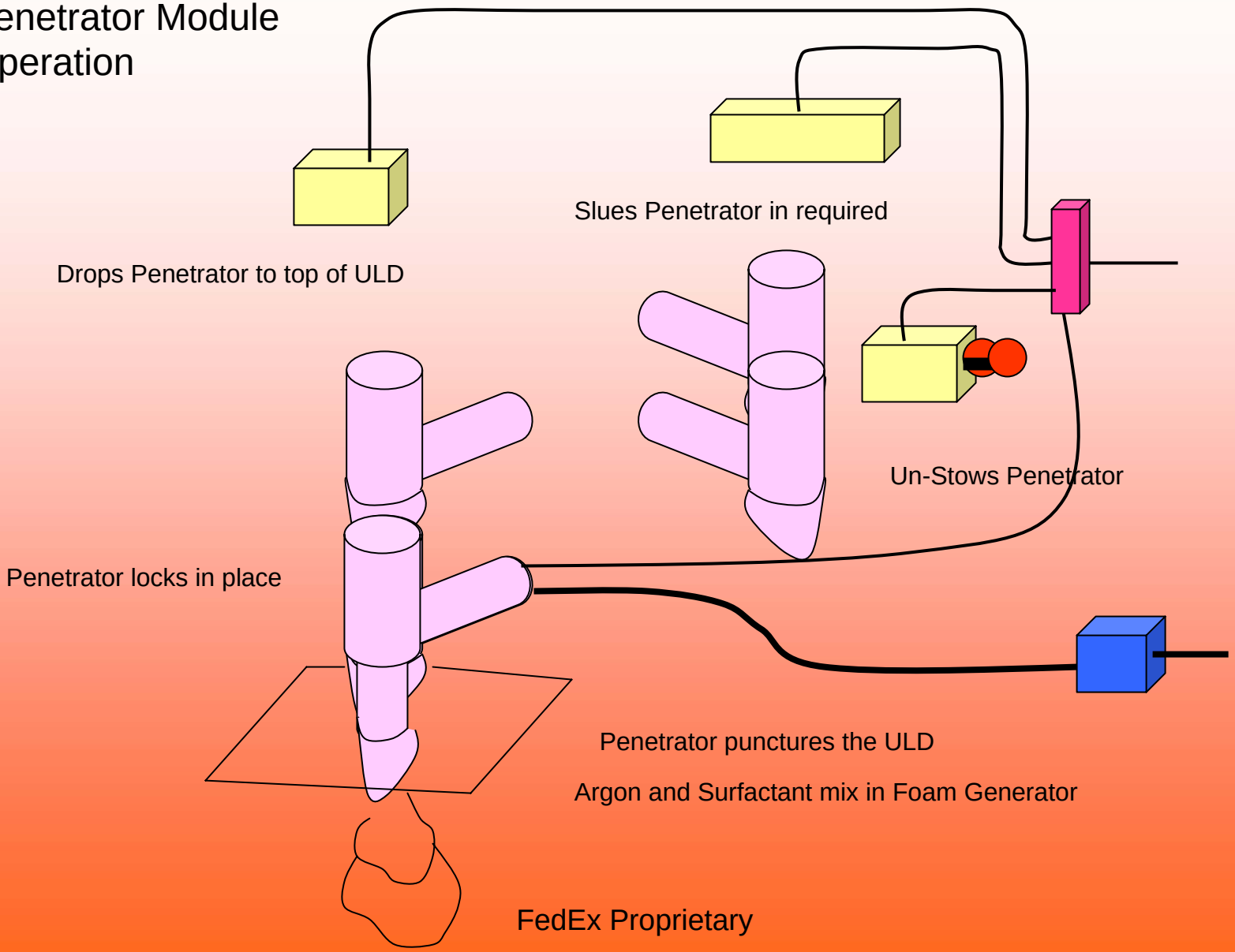
- Mounted on board the aircraft
- For use with enclosed ULDs
- Automatic detection and activation
- No Ground or Flight Crew interaction required

Passive Fire Suppression System

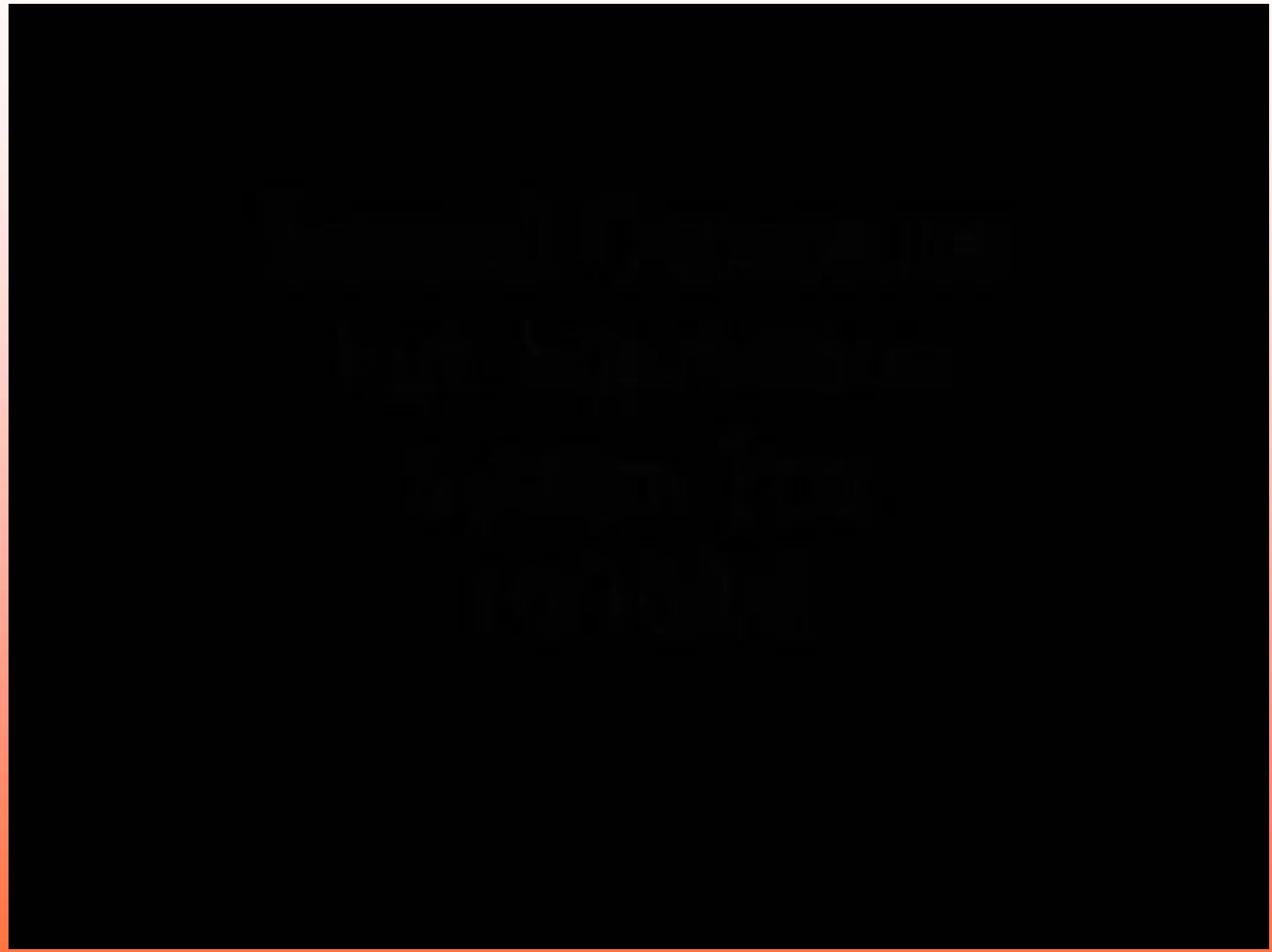
- Individual Pallet Bags / Fire Containment Covers
- For use with open ULDs / Pallets
- Suppresses the fire by limiting the oxygen
- Installed prior to freight being loaded on aircraft
- No Flight Crew interaction


Squib
Argon Tanks
Pressure
Regulator
Display Panel
HUB
Cargo Foam Tank
Control Unit
Sensor Bars
Penetrator
Module
Manifolds
FSS DISCHARGE
ULD
ULD
FSS Operation
Warning lights in Cockpit
FedEx Proprietary

Penetrator Module Operation



FedEx’s Fire Suppression System



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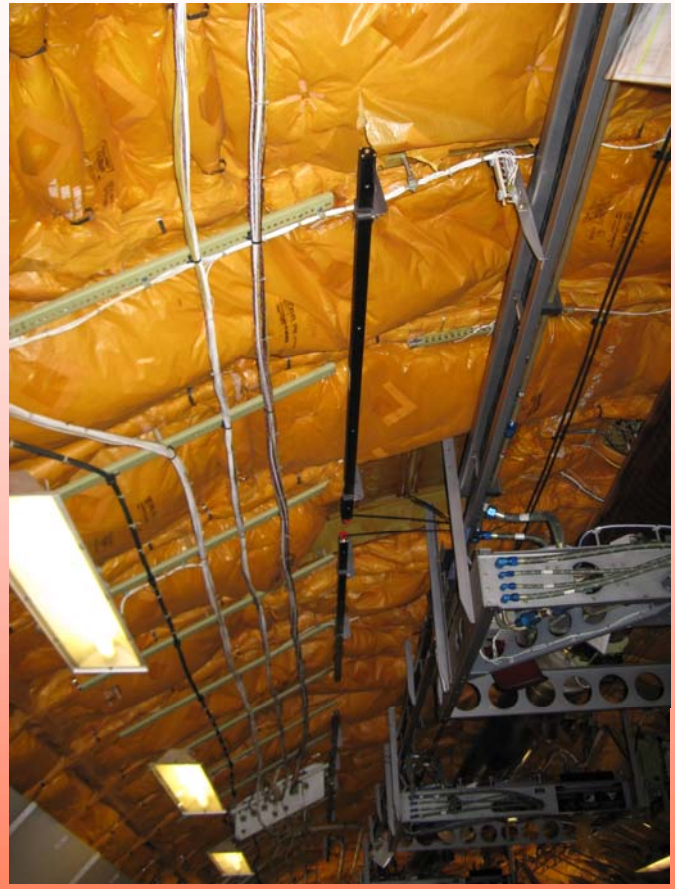
View of the main deck of an MD-11 prior to the Fire Suppression System being installed

FedEx's Fire Suppression System

Similar view of the main deck of an MD-11 after to the Fire Suppression System has been installed

FedEx's Fire Suppression System



Installed Sensor Booms

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Installed Storage Tanks

Surfactant

Argon

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Installed penetrator modules

Penetrators can accommodate 96" or 79" tall ULDs

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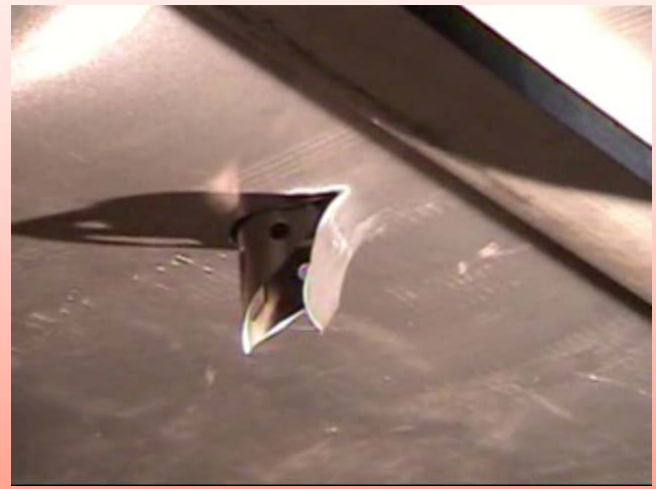
Method of injecting the Cargo Foam into the Container

Hooking a hose to each individual container for the extinguishing agent to enter the container



Design a mechanism to puncture the top of the ULD and fill the container with extinguishing agent

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Various puncture tips were designed and evaluated.

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Various locations within the load

Various door curtain material

Various retention modifications

Full scale, live fire tests using the cargo foam aerated with Argon as the extinguishing agent.

Modification to AMJs for use with the FSS

Paint or Decals

Side Flaps

Door Curtain

Door Bar Flap

Raised Threshold

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Fire Containment Covers

(aka Pallet Bag)

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FedEx material testing revealed that current FAR material and vertical or horizontal burn testing is not sufficient to withstand a full scale pallet bag burn test where temperatures of over 1500 deg F (815 deg C) has been witnessed for greater than half an hour.

Pallet bag protection was chosen as the length for the longest duration over water international flight – 777 ETOPS – 4 hrs.

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Early Research:

•Pallet bag made from E-glass cloth and coated with intumescent material.
•Standard pallet cargo net on top of pallet bag.
•Pallet fire cover performed very well!
•Intumescent coating was NOT waterproof.

Further development:

•A water proof silicone covered intumescent coating that is lighter weight and flexible.
•These recent materials do not intumesce as much and are not as effective by allowing too much heat to come through material.
•Subsequent testing showed that the cargo nets melted, and eventually caught on fire.
•Two solutions have been developed to prevent the cargo net from catching fire.

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- Two solutions to the cargo net burning issue have been developed.
  - Making the cargo net out of Kevlar.
  - A proprietary coating developed by AmSafe applied to the cargo net.

- Burn test have been conducted with 96" tall FCC and 108" tall FCC using FAA Class A fire load.

- All tests successful!

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Loader (prototype) developed by FedEx Strategic Projects to aid in loading pallet bag onto pallet & dolly – not essential just conceptual

FedEx's Fire Suppression System

Pallet bag in rolled-up position ready to load – total weight = 110 lbs (including 45 lb net). Can be loaded by hand without loader but difficult and time consuming . . .

Pallet bag being unrolled for loading – quick-zip net integral to pallet bag – no need to shrink wrap pallet load to protect from water and net does not get tangled!

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Pallet bag is in position and ready to be placed over a pallet and lower on to the load . . .

Pallet in place and ready to lower pallet bag onto load

Note: Cargo normally is not netted prior to pallet bag placement

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Pallet bag is lowered and the loader lifting hooks are unhooked from pallet bag prior to attaching net.

The net is a standard net and therefore the standard procedures are used for securing the net to the load.

FedEx's Fire Suppression System

FedEx's Fire Suppression System

- Conceptual pallet fire cover loader works very well
- Loading crews like using the pallet bag – easier to load/unload than pallet net alone
- Pallet bag loader needs to be optimized for each loading location.
- Pallet bags are bar coded for tracking similar to containers (asset numbers)
- Training on the use of the pallet bags is minimal - as easy as see one, do one, teach one
- Pallet bags much easier to load/unload using two people for the operation.
- Loading of pallet bag/net combination is faster than loading a net.

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Pallet fire test load (built to 96" AMJ profile) & instrumented
Standard load is 114 18" square boxes with 2 ½ lbs shredded paper.

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Pallet fire cover secured and ready to begin fire test

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Heat melts cargo net at 11 minutes into test. Internal temp close to 1400 degrees (thermocouple), temp on outside of cover approx 800 degrees (using IR camera).

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Cargo net melted to point where cargo shifts and net no longer holds freight. Pallet cover still kept fire enclosed.

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Test stopped after 4 hours- pallet fire cover removed showing fully engulfed cargo fire underneath

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Pallet fire cover fully removed – fire still burning after being doused with water – at least 50% of freight intact

- FedEx testing proves successful for WORST CASE fire scenario:
  - Fire at sea level
  - Can't use the argument of a "lighter weight material" that may not stand up to the maximum temps for 4 hours because the cabin will be depressurized to 25,000 feet and the fire will only smolder. Once the aircraft descends to land and oxygen reaches the fire it will become fully engulfed again.
  - Aircraft will be below 10,000 feet for 20-30 minutes in best case scenario as it descends to land at "closest airport" if over land.
  - Fire testing has demonstrated temps at over 1500 degrees F (815 deg C) in less than 5 minutes.
  - Fire testing done with fire started on outside of load immediately next to pallet fire cover.

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- Burn test have been conducted with 96" tall FCC and 108" tall FCC using FAA Class A fire load.

All tests successful!

Testing has been conducted to determine the effect of the cargo foam on fires containing Class D materials

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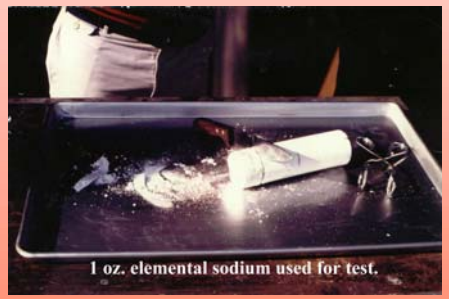
- FedEx carries many forms of freight that contain Class D materials. Magnesium, Lithium and Sodium are the most prevalent.
- Class D fires do not react favorably when standard fire extinguishing agents are used.
- Halon is ineffective in most cases. It may actually make the fire flare up.



- Nitrogen (N_2) can be ineffective due to the Nitrogen bonds breaking thus releasing more energy.
- Argon gas does not add energy to the event.

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Shaved Magnesium was placed in a metal bowl, set on fire and the foam was allowed to flow over it.

- The fire was contained
- The foam did not extinguish the Magnesium
- All the Magnesium was consumed
- Flickering light was seen through the foam.
- pH of the foam above the container was 11

FedEx's Fire Suppression System

The test was repeated with increased quantities of Magnesium shavings

- Foam did not extinguish the Magnesium.
- Gas was released
- Flickering light was seen through the foam.
- A foam mound was formed by the expelling gas

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10 grams of Lithium

- Gas released
- pH of the liquid in the bottom of the container was 14

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195 grams of Lithium

- Gas released
- Sediments found in bottom of container

Sodium is generally stored and shipped in kerosene, in well padded containers.

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13 grams of Sodium

The Sodium was NOT set on fire.

As the Cargo Foam breaks down, Argon is released and the foam returns to a liquid form, comprising mainly of water.

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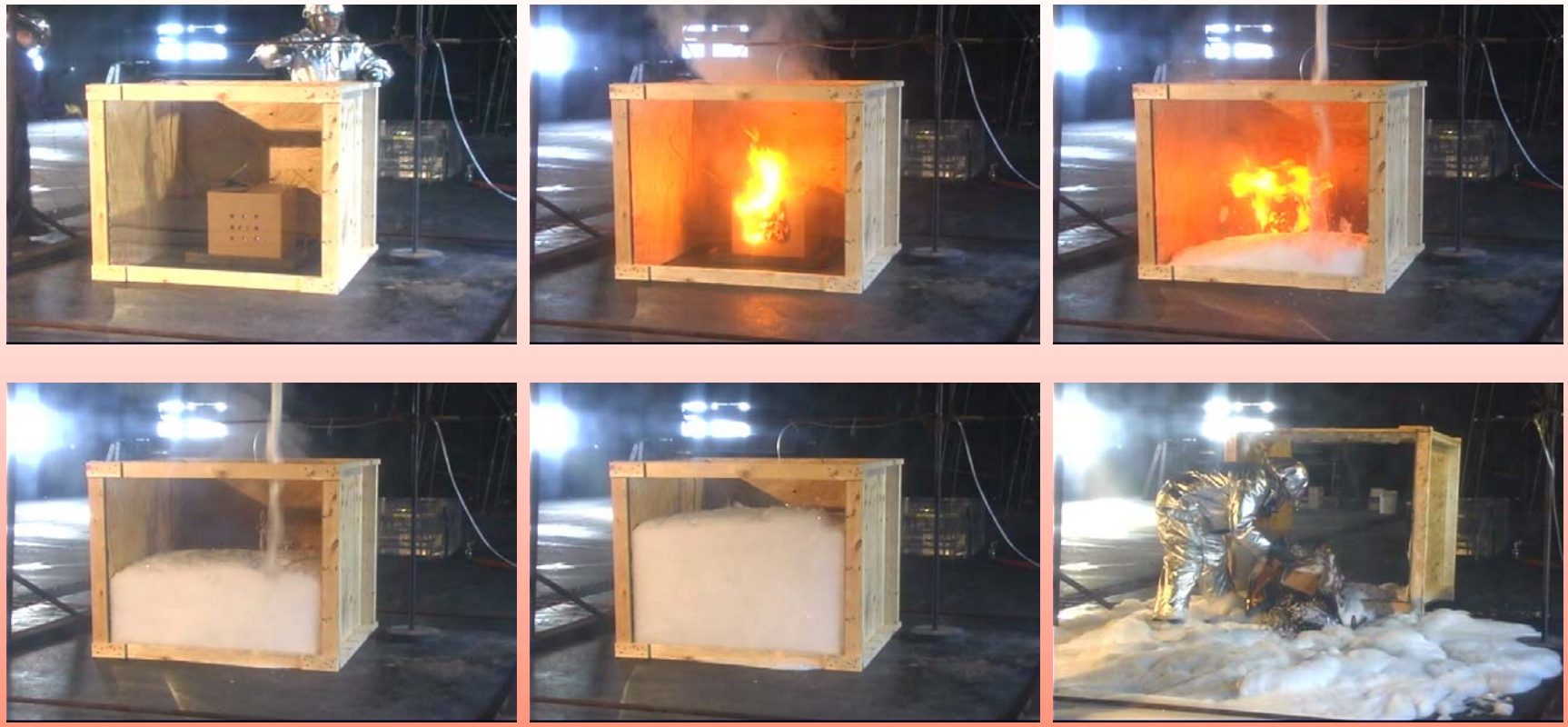
- Additional tests were performed.
- Increasing the foam depth or providing a path for the accumulating liquid to exit the area prevented the Sodium from exploding.

- Double the foam height — gas released, no explosion

- Sodium placed on screen — no gas observed, no explosion

FedEx's Fire Suppression System



Various amounts of Sodium were placed in the igniter box.

- Small quantities of gas released
- All the Sodium consumed
- pH of the liquid in the bottom of the box was 14

FedEx's Fire Suppression System



- During clean up from testing several large pieces some fizzing was observed
- Clean up was halted when sparks from several white pea size objects were observed.
- Clean up continued after the area was washed with water and no further activity was observed for ten minutes.
- pH of the liquid in the bottom of the pan was 10

One pound of Sodium in an AMJ

- Two layers of boxes were placed in an AMJ
- 450 grams of Sodium was placed a plastic bag.
- The plastic bag was placed in the box above the igniter box.
- The igniter was activated and set the load on fire.
- 55 gallons of cargo foam aerated with Argon was allowed to fill the AMJ. 55 gallons will be the standard amount carried aboard FedEx aircraft.
- Smoke continued to exit the AMJ for an hour.

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FedEx's Fire Suppression System

Results from one pound sodium burn:

- Fire was extinguished.
- Only six boxes were breached by the fire.
- The box containing the Sodium was breached.
- A one inch oval hole was found in the top sheet of the aluminum base plate below the box where the Sodium had been placed.
- Bubbling from the hole persisted for an hour.
- Argon gas was sprayed in the hole. No Affect
- Water was sprayed in the hole. No Affect
- pH of the liquid in the bottom of the AMJ was 10

Conclusion:

Cargo foam aerated with Argon gas, the type used by FedEx's Fire Suppression System, will contain Class D fires.

Questions?

FedEx's Fire Suppression System

Halon hoses in Class E compartment

Halon bottles in front of barrier

The Halon hoses will be manually attached to the Accessible Dangerous Goods (ADG) ULD prior to flight.

If required, the flight crew will discharge the Halon bottles.

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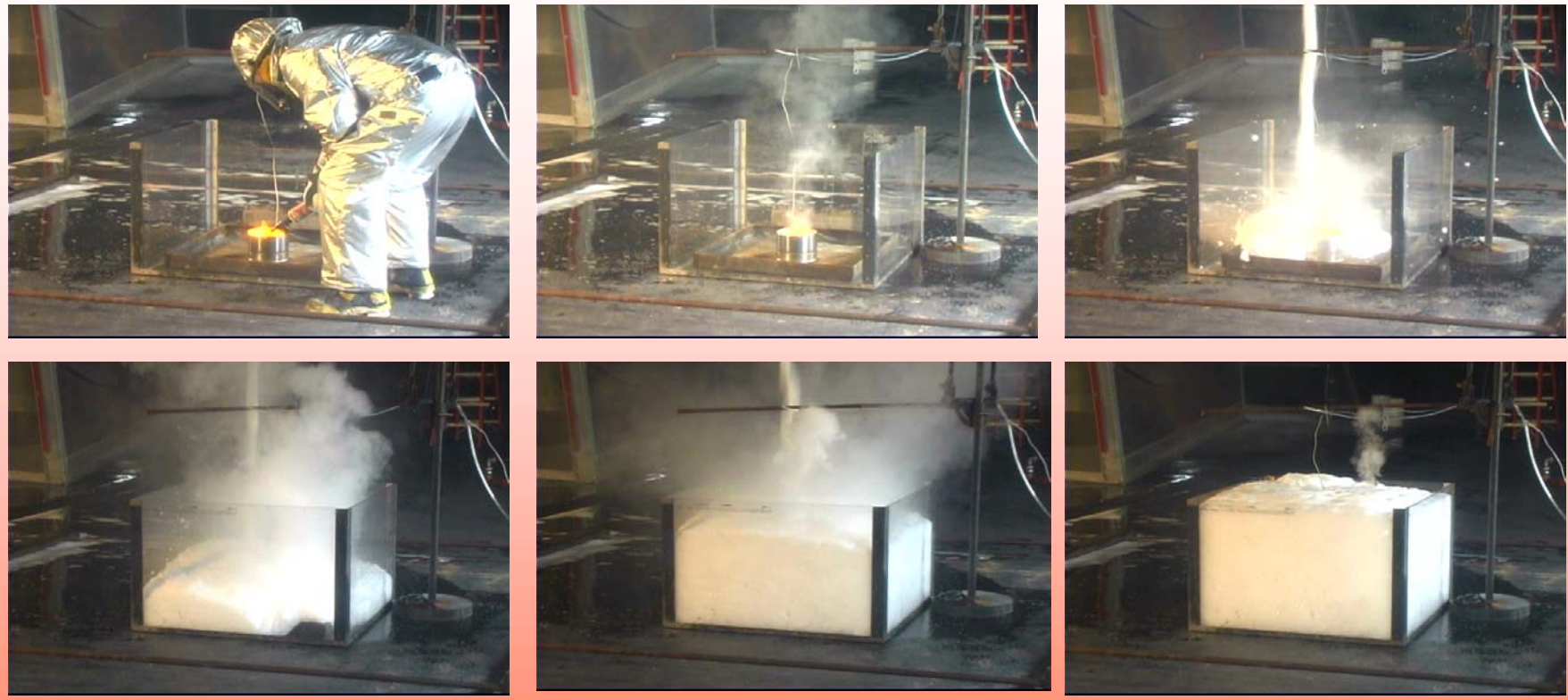

Sodium was ignited prior to the cargo foam being applied

- Gas released - No Explosion
- All the Sodium was consumed
- pH of the liquid in the bottom of the container was 14
- Doubling the amount of Sodium had no affect on the out come.