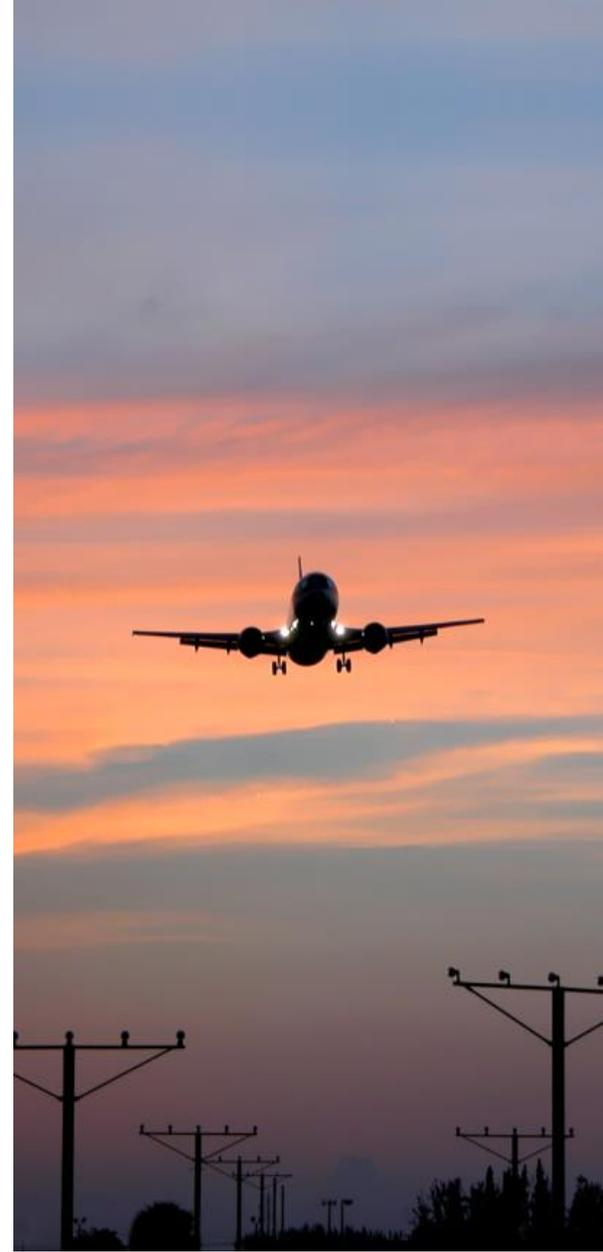


Fire Suppression in Class E Cargo Compartments

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Objective

- **Calculating Air Exchange Rates**
- **Measuring the effectiveness of a zone based water mist system**



Measuring Air Exchange Rates in Fire Resistant Containers (FRC)



- Oxygen starvation is an important factor in FRCs.
- Air exchange rates determine the effectiveness of oxygen starvation and fire suppression agents in Class E cargo containers.
- The upper limit of an effective air exchange rate is yet to be determined.

Experimental Setup



CO₂ cylinder fitted with a tape heater around the regulator to minimize freezing, or use a heated regulator.



Fan placed in the center of the container to ensure a well-mixed condition. CO₂ released underneath the fan.

Experimental Setup continued

- Tube leads from the regulator into the container through a small opening in the side.
- The tube sits in the center of the container underneath a fan to provide for a well-mixed environment.
- A gas analyzer with the capability to continually measure and record the concentration of carbon dioxide within the container.

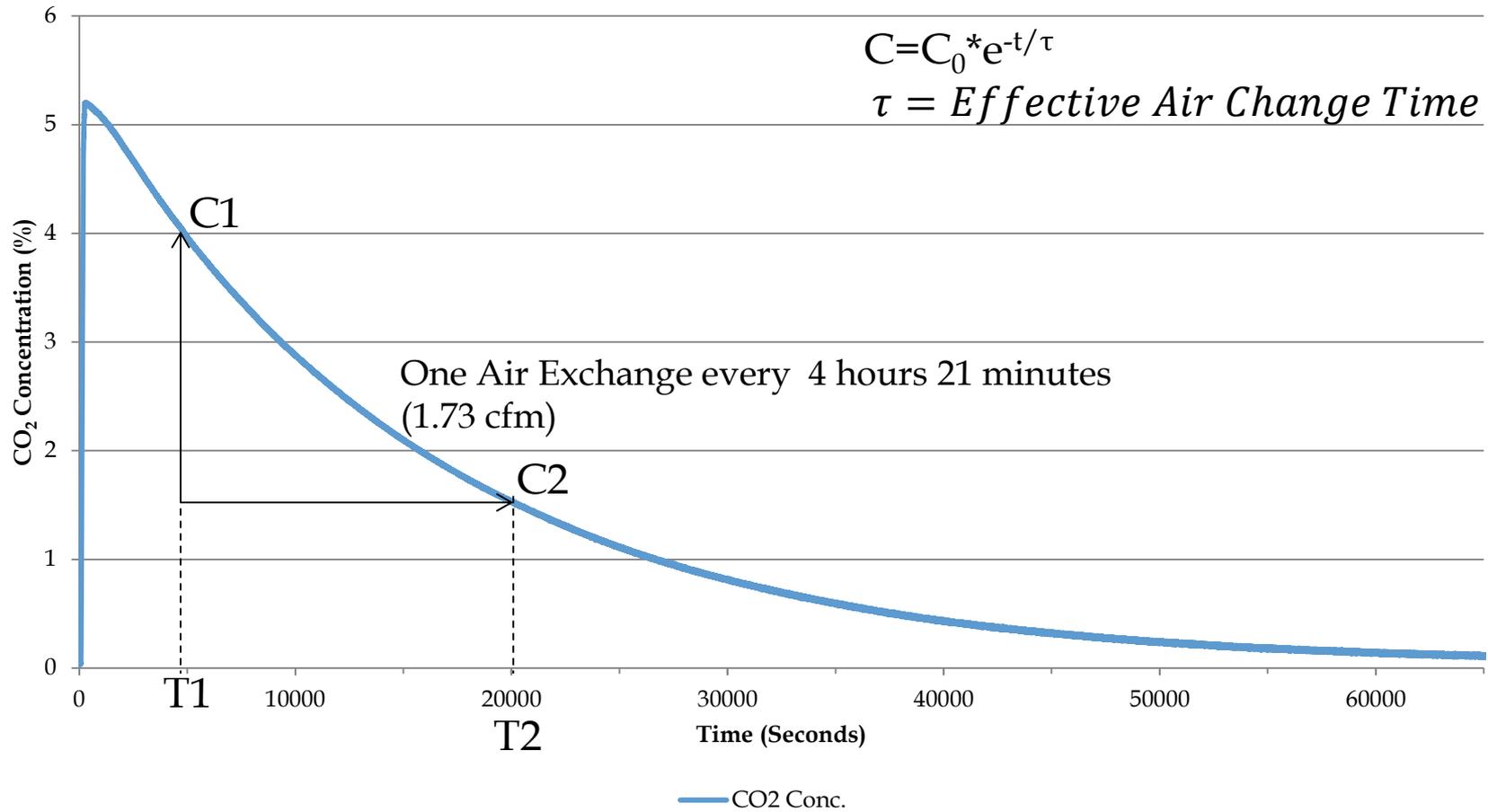
Procedure

- Measure and record the concentration of CO₂ in the container throughout the test.
- Turn the fan on for to ensure a well-mixed condition.
- Close the container as it would be in normal usage.
- Heat the CO₂ regulator mildly.
- Release CO₂ into the container until the concentrations of CO₂ within the container reach ~5%.
- Wait for CO₂ levels to reach approximate atmospheric conditions.
- Determine the air exchange rate from the calculations mentioned later in the presentation.

Alternative Procedure

- Measure and record the concentration of CO₂ in the container throughout the test.
- Turn the fan on for to ensure a well-mixed condition.
- Release the contents of a CO₂ fire extinguisher into the container.
- Close the container as it would be in normal usage.
- Wait for CO₂ levels to reach approximate atmospheric conditions.
- Determine the air exchange rate from the calculations mentioned later in the presentation.

Theoretical Perfectly Mixed Exponential Decay Curve



Formula

- Air exchange Rate = $\frac{\text{Compartment Volume}}{T2-T1}$
 - Where C2 = 37% of C1
- Multiple concentrations (C1) can be used to calculate the air exchange rate, from which an average value can be determined.

Zone Based Water Mist System

Objective:

- To determine the effectiveness of a water mist system as a viable fire suppression system in a Class E cargo compartment.

Zone Based Water Mist System



- Air exchange rate tests are being conducted to replicate air exchange rates in a real world scenario.
- Air exchange rate will be targeted at one volume exchange every 7 minutes.
- Volume of DC-10 Cargo hold ~ 18465 cu.ft.

Zone Based Water Mist System

- Environmental Engineering Concepts water mist system used in Class C testing is being repurposed for use in Class E Cargo.
 - High Pressure, Pump Driven System
 - Zones will be divided by each container position.
 - System Flow Rate ~ 0.54gpm (1 zone) to 1.84gpm (4 zones)
 - System Operating Pressure ~ 550psig (4 zones activated) to 1150psig (1 zone activated)

Zone Based Water Mist System

- Activation of Water Mist System
 - Automated activation triggered when ceiling temperature reaches 200°F.
 - The system stays on until ceiling temperatures decrease to under 200°F.
- Effectiveness of the system will be based on the amount of water used in various test scenarios.

Zone Based Water Mist System

- Test scenarios to measure the effectiveness of the system.
 - Full and half load pallet fires.
 - Full and half load fires in Polycarbonate / Aluminum AAYs.

Future Work

- Conduct tests to determine the upper limit of air exchange rates in containers.
- Conduct tests to determine an appropriate fire load that contains lithium batteries.
- Conduct tests with zone based water mist systems on a standard fire load and on lithium battery fires in the main cargo deck.
- Conduct tests with medium expansion foam driven by an inert gas in the test container.