Assessing the Thermal Threat of Chemical Disinfectants on Cargo Aircraft

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Federal Aviation Administration

Agenda

- **Background/Research Impetus**
- **Problem Statement**
- **Future Test Plan**
- **Initial Research**

Why is the FAA interested in disinfectants shipped on Cargo Aircraft?

Global Warming

From a study conducted at the University of California in 2011…

- Springtime temperatures of +24°C could lead to tarmac temperatures over +40°C
- Historically seen temperatures on the tarmac as high as 70°C in western European airports
- This is a combination of the **tarmac being approximately +20°C hotter than air temperature** and the effect of direct infrared radiation from the sun.

Problem Statement

- **The purpose of this research is to assess the likelihood of a thermal hazard event occurring during transport of chemical disinfectants via cargo aircraft.**

Guiding Questions:

- How hot does a typical cargo pallet become (instantaneous and sustained)?
- How does humidity and moisture content affect heating/temperature of cargo?
- How do chemicals in cargo respond to the discovered maximum/minimum and average temperature, humidity, and moisture content values?

Cargo Temperature Test (Phase 1)

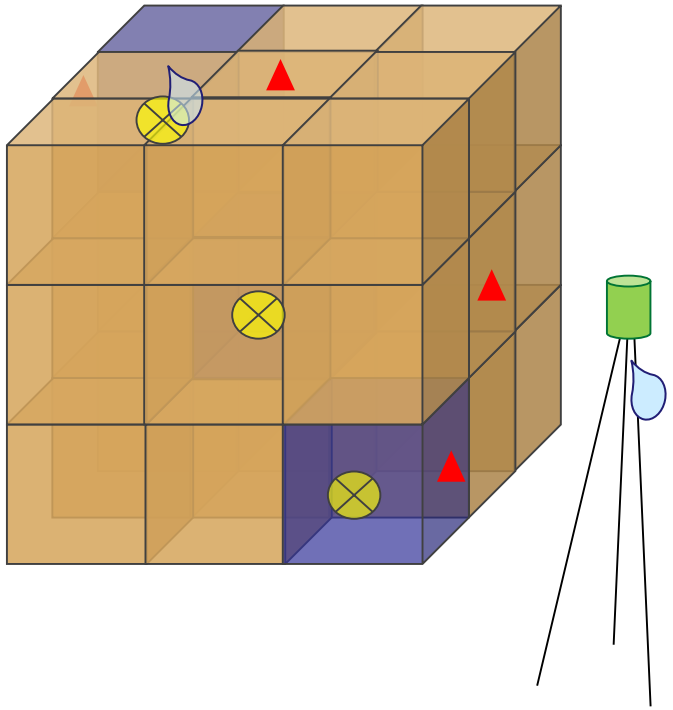
Simulated, full-scale cargo pack on ramp

- 27 empty boxes stacked, with thermocouples at specific locations (measuring surface and air temperature)
- 2 Box types: 4G double walled boxes,
  non-UN single walled boxes
- 2 wrapping types: container vs. netted/plastic wrapped pallet
- 4 total tests

Test Setup

- Centered in box, open-air type-K TC
- Centered on box face, touching surface type-K TC
- Humidity meter (one inside box, one outside air)
- Pyranometer to be tripod-mounted adjacent to box location

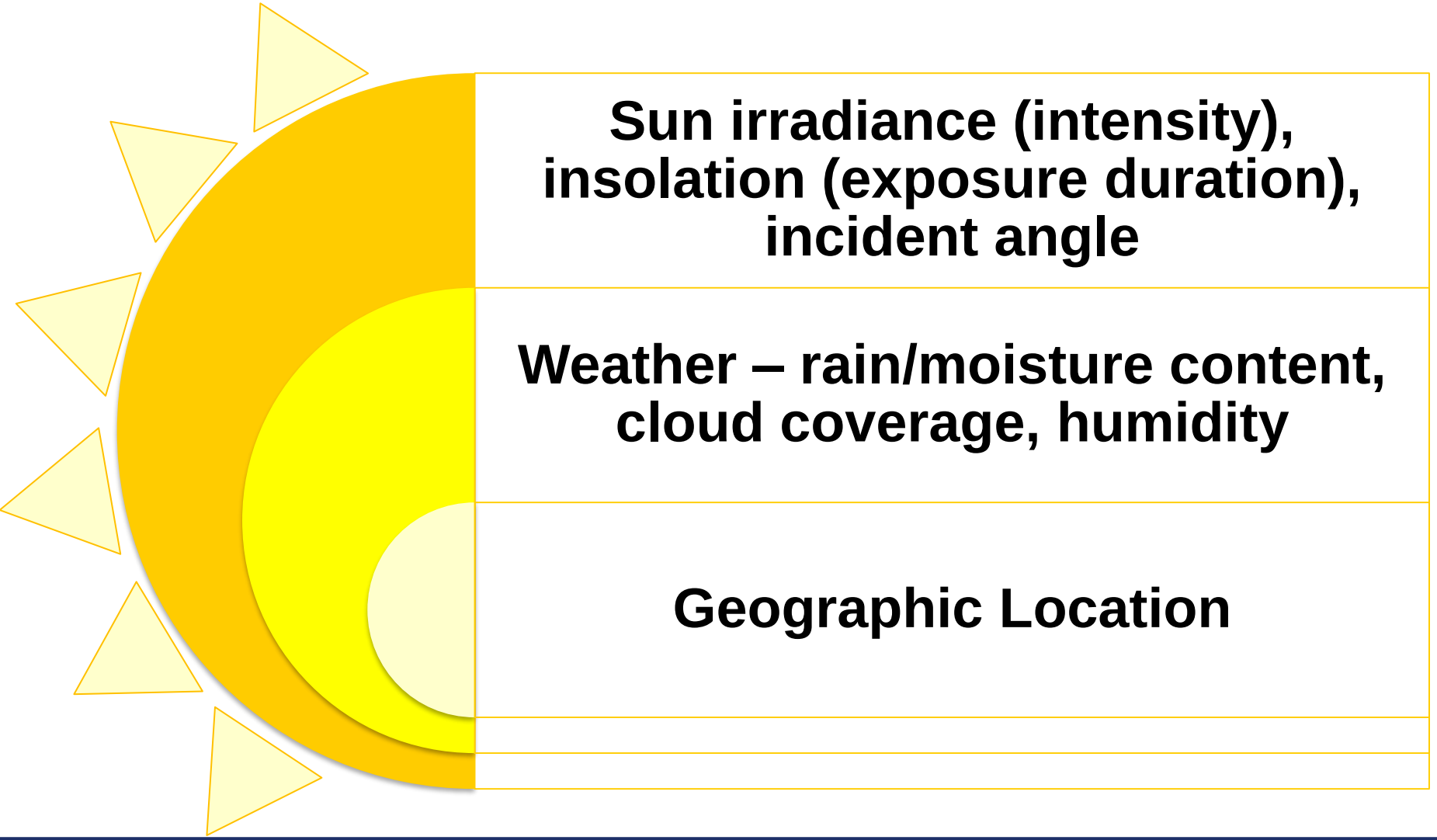
Boxes, although “empty” will be weighted down with bricks to avoid wind disturbance. (May add mass because mass is harder to heat up than air)



Cargo Temperature Test (Phase 1)

- Each test will run continuously for **1 week (first 2 days of data are critical)**
- Data acquisition every **5 minutes**
- In case of no rain, FAA will come up with a test where moisture content is simulated

Measurable Correlates



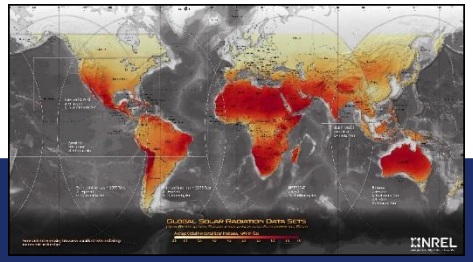
Testing Tools and Resources

Phase 1 (Empty Boxes)

- Type-K Thermocouples
- Hygrometers
- Cardboard Moisture Meter
- Pyranometer

Phase 2 (chemicals in boxes)

- add Toxic Gas Monitor
- add Camera inside box



National Solar Radiation Database

Federal Aviation Administration

Cargo Temperature Test (Phase 2a)

- Introduce disinfectants in box(es)
- **Test condition:** similar weather to phase 1
- **Set-up:** disinfectants will be placed in 1 box in the same wrapping configuration and box location where highest temperature was seen among phase 1 tests
- Camera and toxic gas monitor will be installed in chemical box
- 8-hr test, with an eye-witness in case of event

Cargo Temperature Test (Phase 2b)

- Test same as Phase 2a
- Simulate spillage/mixing of different chemicals
  - Considering 49 CFR § 177.848 Segregation of hazardous materials

Disinfectant Selection Process

10 distinct classes of disinfectants:

- Hypochlorite and its solution
- Healthcare setting chlorine compounds
- Effervescent disinfectant tablets
- Peracetic acid
- Hydrogen peroxide solution
- Alcohols
- Iodophors
- Phenolics
- Aldehydes
- Quaternary ammonium compounds (QACs or Quats)

Listed 65 brand-name disinfectants based on:

- Active ingredient
- Product name
- Company
- Formulation type
- State of matter
- Use site
- Surface type
- Contact time

…and downloaded every SDS

Consulted *ICAO Technical Instructions for the Safe Transport of Dangerous Goods by Air* for:

- Proper shipping name
- Class/division
- Packing group
- Max net quantity per package
- Packing instructions for cargo aircraft

Packing Groups

Danger Level

Selected 15 brand-name disinfectant varieties

Test Result Predictions

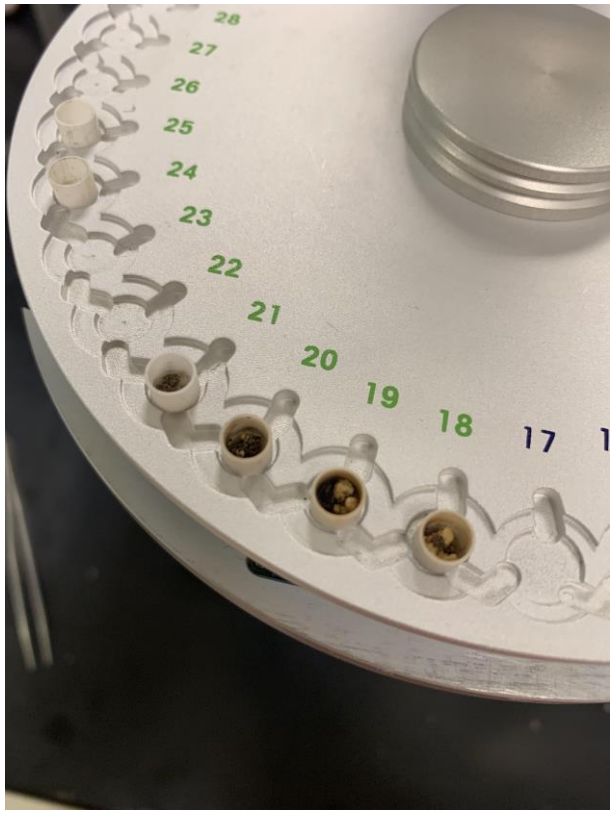
- Expect liquid disinfectants to boil off at or around 100°C since most are water-based. Thermal event may occur if pyrolsates are ignitable in test conditions.
- Expect solid disinfectants to be the most likely to cause a thermal event, especially if subject to moisture

Preliminary Research Thus Far

- Literature review: relevant ignition/autoignition ASTM standards, FAA reports, scientific journals, and the *Ignition Handbook* by Dr. Vytenis Brabrauskas
- **Variables affecting autoignition time and temperature of a substance:**
  - ***Gases:*** molecular structure, fuel concentration, pressure, vessel size, wall material, oxygen concentration
  - ***Solids:*** orientation of sample, exposed surface area, air flow rate, oxygen concentration, pressure, relative humidity, moisture content, polymer structure, type of test apparatus, mass of sample, long-term radiant exposure

Why not a bench scale laboratory test?

- **Mass of a sample has little effect on ignition except when examined on a microscale.** Relative to microscale, “decreasing the specimen mass produced a monotonically increasing T_{ig}” [Graf, S.H. Ignition Temperature of Various Papers, Woods, and Fabrics (1949)]
- Babrauskas claims microscale tests like TGA, DTA, DSC to be inappropriate as “no study exists that would document a relation between these **‘psuedo-ignition’ temperatures recorded for minuscule** [**0-10g] specimens** and real ignition temperatures on materials of end-use size or configuration.”
- **Chlorine-releasing products react violently** with the TGA platinum pans, and have since broken an integral part of the TGA.



Questions?

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