JENSEN HUGHES

Advancing the Science of Safety

Quantifying the Impact of Portable Fire Extinguisher Agents on Cultural Resource Materials: Fire and Non-Fire Exposure Tests

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OBJECTIVES

- Quantify impact of discharging agent on materials
- Provide data to NFPA 909 and 914 for extinguisher selection
- Evaluate effectiveness of cleaning methods
- Establish cost-effective and repeatable test protocol for future use

OBJECTIVES

Extinguisher Selection Matrix

Materials	Extinguishing Agent				
	ABC Dry Chem.	CO_2	FE-36	Halotron I	Water
Architecture (brick, concrete, tile, plaster)	**For each combination:** • List effects of agents • Cleaning methods • Recommendation of agent for use with material?				
Ethnographic Collections (bark, baskets, dolls, tools)					
Glass and Ceramics (China, crystal, earthware, pottery)					
Leather and Related Materials					
Metals (Brass, bronze, iron, silver)					
Paper					
…					

RESEARCH TEAM

This project was carried out under a Institute of Museums and Library Services National Leadership Grant:

- CWF –material selection, quantify agent effects, evaluate cleaning methods
- Jensen Hughes – fire and non-fire testing
- FPRF – facilitator for technical review and dissemination
- Amerex – in-kind contribution of extinguishers

TECHNICAL OVERSIGHT PANEL

- Steve Carter, Orr Protection Systems
- Laura E. Doyle, U.S. General Services Administration
- David Frable, U.S. General Services Administration
- Deborah L. Freeland, Arthur J. Gallagher & Co.
- Cindy Greczek, Colonial Williamsburg Foundation
- Gregory E. Harrington, NFPA
- Michael Kilby, Smithsonian Institution
- Nancy Lev-Alexander, U.S. Library of Congress
- Jacob Ratliff, NFPA
- Joseph A. Senecal, Kidde-Fenwal
- Craig Voelkert, Amerex Corporation
- Rob Waller, Protection Heritage Group

BACKGROUND

Phase I FPRF study conducted by Jensen Hughes in 2010:

- Detailed review of portable extinguishers
- Identification of material characteristics for agents and collection materials
- Comprehensive literature review of the effects of extinguishers and decomposition products
- Characterized fire scenarios and fire loss review for museums, libraries, and other heritage buildings
- Developed preliminary test plan for non-fire exposure tests, fire exposure tests, and physical impact tests

APPROACH

- Non-fire (neat) exposure tests
  - Chemical, physical, and thermal effects from extinguisher agents
- Fire exposure tests
  - Chemical, physical, and thermal effects from extinguisher agents
  - Decomposition product effects
  - Limited direct smoke/thermal effects from fire
  - Low fire size to room volume ratio

TEST SETUP

- Test Enclosures: nominally 10 m (33 ft) by 10 m (33ft) by 3 m (9.8ft)
- Three target arrays:
  - Direct
  - Indirect, mounted on wall
  - Indirect, mounted on a stand
- Non-fire tests @ Jensen Hughes Lab
- Fire tests @ Naval Research Lab

EXTINGUISHERS

- Collection areas are typically light (low) hazard
- Minimum UL 711, 2A rating required for light hazard
- Five extinguishers/scenarios selected (all have 2A ratings):
  - ABC Dry Chemical [Amerex B456];
  - Water Mist [Amerex B272NM];
  - Halotron [Amerex 398];
  - FE-36 [Ansul Cleanguard FE13]
  - ABC Dry Chemical and Water Mist

TARGET MATERIALS

- 10 cm by 10 cm (4 in by 4 in)
- Thirteen representative materials:
  - Black iron sheet
  - Copper sheet
  - Aluminum sheet
  - Vegetable tanned leather
  - Tulip poplar wood, unvarnished
  - Cherry wood, varnished with shellac
  - Linen canvas, oil paint
  - Linen canvas, acrylic paint
  - Travertine tile, tumbled finish
  - Marble tile, tumbled finish
  - White-tailed deerskin
  - Unglazed terracotta tile
  - Glazed ceramic tile

NON-FIRE EXPOSURE TESTS

SCOPING TEST RESULTS

Conducted to determine:

- Separation distance between extinguisher and direct array:
  - Between 3.0 m (10 ft) and 4.9 m (16 ft)
- Separation distance between direct and indirect arrays
  - 1.5 m (5 ft)
- Lateral offset between direct and indirect arrays
  - 1.8 m (6 ft)

INSTRUMENTATION

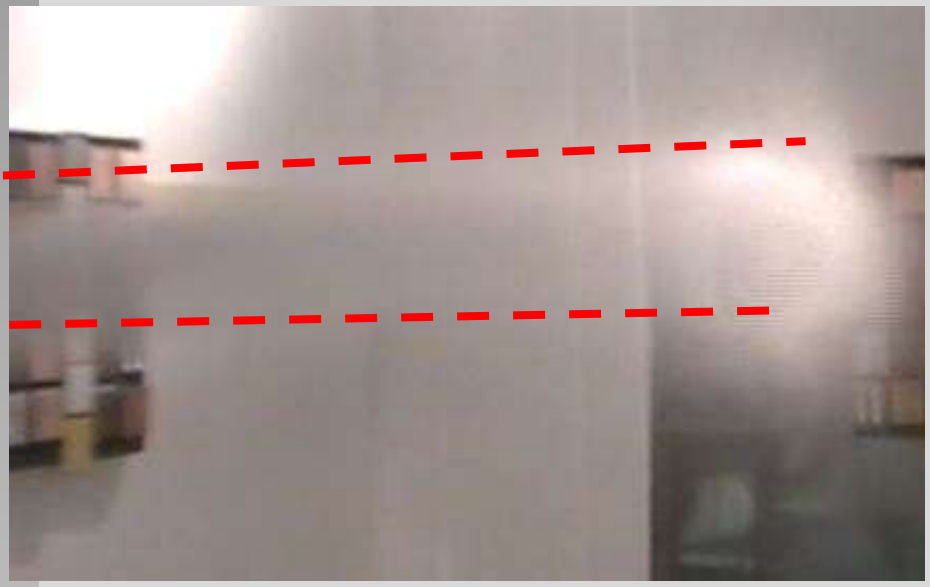
- Agent deposition on materials (scales: 0.1 g and 0.001 g resolution)
- Temperature/relative humidity measurements
- Temperature in test enclosure
  - Thermocouples at 0.3 to 2.7 m (1 – 9 ft) above floor; at 0.6 m (2 ft) increments
- Temperature at center of direct array
- Video cameras
- Infrared camera – capture spray impact pattern

PROCEDURES

1) Weigh and mount all samples on arrays in examination room
2) Install arrays in test enclosure
3) Discharge extinguisher(s) at direct array until empty
4) Remove sample arrays 5 minutes after end of discharge (soak period)
5) Photograph, document, and weigh test samples
6) Ventilate and clean test enclosure

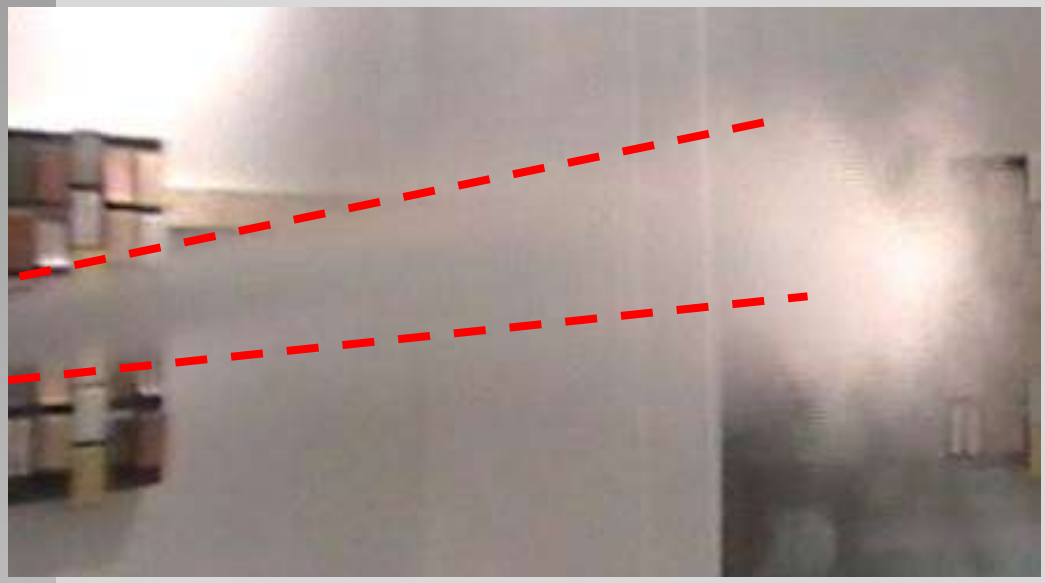
RESULTS

- Halotron
  - Narrow stream of gas with some liquid agent
  - Infrared useful for qualitative assessment of impact area



RESULTS

- FE-36
  - Narrow stream of liquid
  - Liquid impact area identifiable from frost on samples
  - No IR camera for test



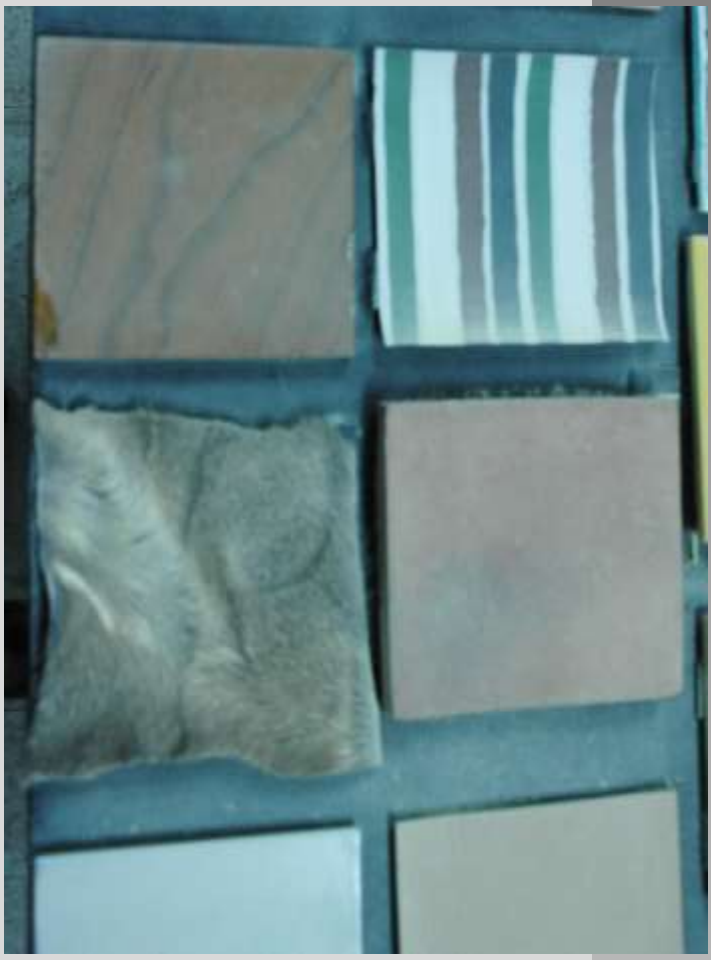
RESULTS

- Water Mist
  - Wide stream/cone of mist
  - Agent obscured samples for IR camera
  - Large wet area on floor

- ABC Dry Chemical
  - Medium stream of agent
  - Agent obscured samples for IR camera

RESULTS

- Direct Array Temperatures
  - Clean agents: lowest temperatures (FE-36: -41˚C; Halotron: -23˚C)
  - ABC Dry Chemical & Water Mist: negligible temperature change
- Extinguisher Agent Deposition
  - Slight deposition for most materials
  - Direct array samples had largest agent deposits, some fur samples gained up to 2.0g
  - Difficulties with mass measurement:
    - Some samples fell and broke,
    - Velcro adhesive removed bits from the backs of samples



FIRE EXPOSURE TESTS

SCOPING TEST RESULTS

- Fire Size:
  - UL 711, 1A crib too severe for unprotected person
  - UL 711, 1A crib extinguished by all extinguishers
  - UL 1715 wood crib selected
  - Ignition pan parameters established (heptane)
- Separation distance between wood crib and direct array set at 0.66 m (26 in)
- Same separation distances between direct and indirect arrays as non-fire exposure tests
- Initial attack distance was 1.8 m (6.0 ft)

UL 711, 1A

UL 1715

TEST SETUP AND INSTRUMENTATION

- Instrumentation same as non-fire tests
- Corrosion monitoring system
  - Copper and silver sacrificial circuits
  - Resistance measured before and after test to determine metal loss (in Angstroms, Å)

PROCEDURES

RESULTS

Test Number	Agent	Extinguishing Time (sec)	Extinguisher Discharge Time (sec)	Agent Discharged (kg (lb))
1B	ABC Dry Chem	3	33	4.5 (9.9)
2B	Water Mist	6	88	9.0 (19.8)
3B	Halotron	3	13	7.0 (15.5)
4B	FE-36	4	14	6.0 (13.2)
5B	ABC Dry Chem & Water Mist	1	ABC: 34 Water: 83	ABC: 4.5 (9.9) Water: 8.8 (19.4)
6B	ABC Dry Chem & Water Mist	1	ABC: 32 Water: 93	ABC: 4.5 (9.9) Water: 9.0 (19.8)

RESULTS – TEMPERATURE

- Direct sample array temperatures were notably higher than for non-fire tests

Test No.	Agent	Direct Sample Array Temp. At End of Discharge (°C)	Non-Fire Test Minimum Direct Sample Array Temp. During Discharge (°C)
1B	ABC Dry Chem.	55	20
2B	Water Mist	31	14
3B	Halotron	-3	-23
4B	FE-36	18	-41
5B	ABC & Water Mist	58	15
6B	ABC & Water Mist	61	15

RESULTS

Extinguisher Agent Deposition

Nominally the same as non-fire tests

- Slight deposition for most materials
- Direct array samples had largest agent deposits, some fur samples gained up to 2.0g
- Difficulties with mass measurement:
  - Some samples fell and broke,
  - Velcro adhesive removed bits from the backs of samples

SAMPLES- OBSERVATIONS

Water Mist

Halotron

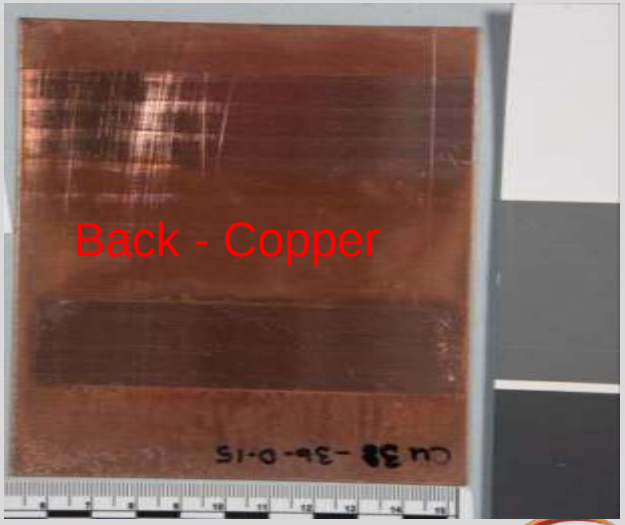
FE-36

SAMPLES- OBSERVATIONS

ABC Dry Chemical

SAMPLES- OBSERVATION - Halotron

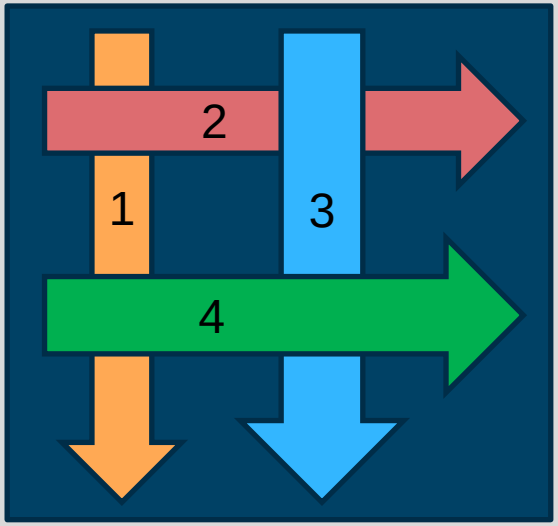
Acrylic Paint



CLEANING

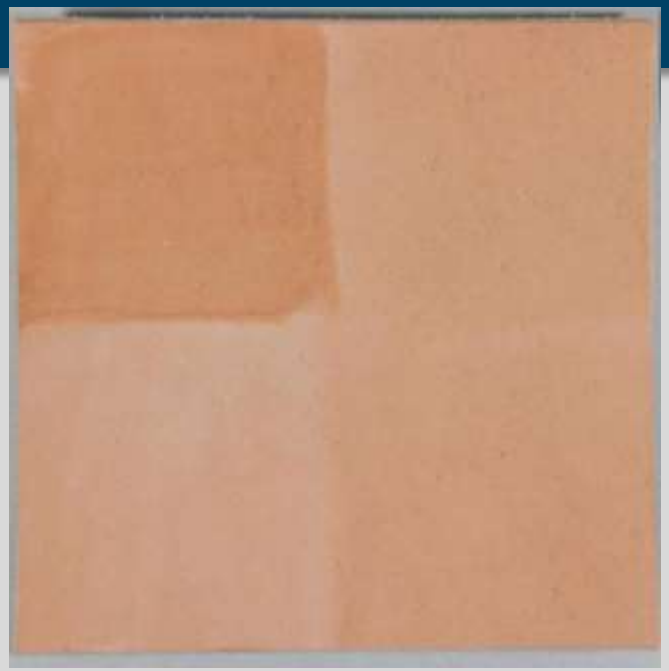
4 methods for cleaning chosen:

- Swabbing with Deionized water
- Soot eraser
- Brushing
- Vacuuming



CLEANING

Swabbing



Soot eraser

Brushing

Vacuuming

SUMMARY

- A reproducible test method was established for fire and non-fire tests
- Wide range of materials and extinguisher agents evaluated
- Conservator assessment/observation of materials is complete; analysis is ongoing
- Final project report in October 2016

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QUESTIONS?

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