International Aircraft Materials Fire Test Working Group

Update on Flammability Testing of Magnesium Alloy Components

Presented to: IAMFT WG, Niagara Falls

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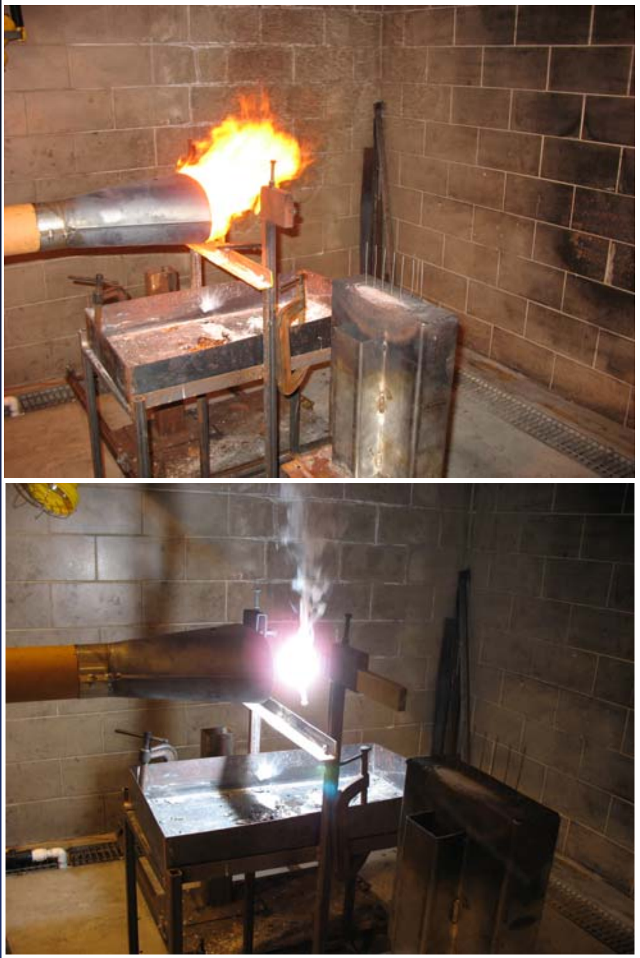
Date: June 17, 2008

Magnesium Alloy Flammability

- Background
- Fire Threats
- Test Method Development
- Lab Testing Thus Far
- Planned Full Scale Testing
- Closing



Magnesium Alloy Flammability

Background

- Renewed interest in using mag-alloys in commercial aviation
- Current FAA TSO C127 "Rotorcraft and Transport Airplane Seating Systems" makes reference to SAE specification, which bans use of magnesium in seats
- SAE specification references tests conducted 30 years ago at FAATC

Magnesium Alloy Flammability

What are advantages and drawbacks?

Benefits

- Lightweight*
- Machinability
- Recyclable
- Abundant

*Boeing estimates $1 million lifetime saving to the operator for every 100 lb of weight saving.

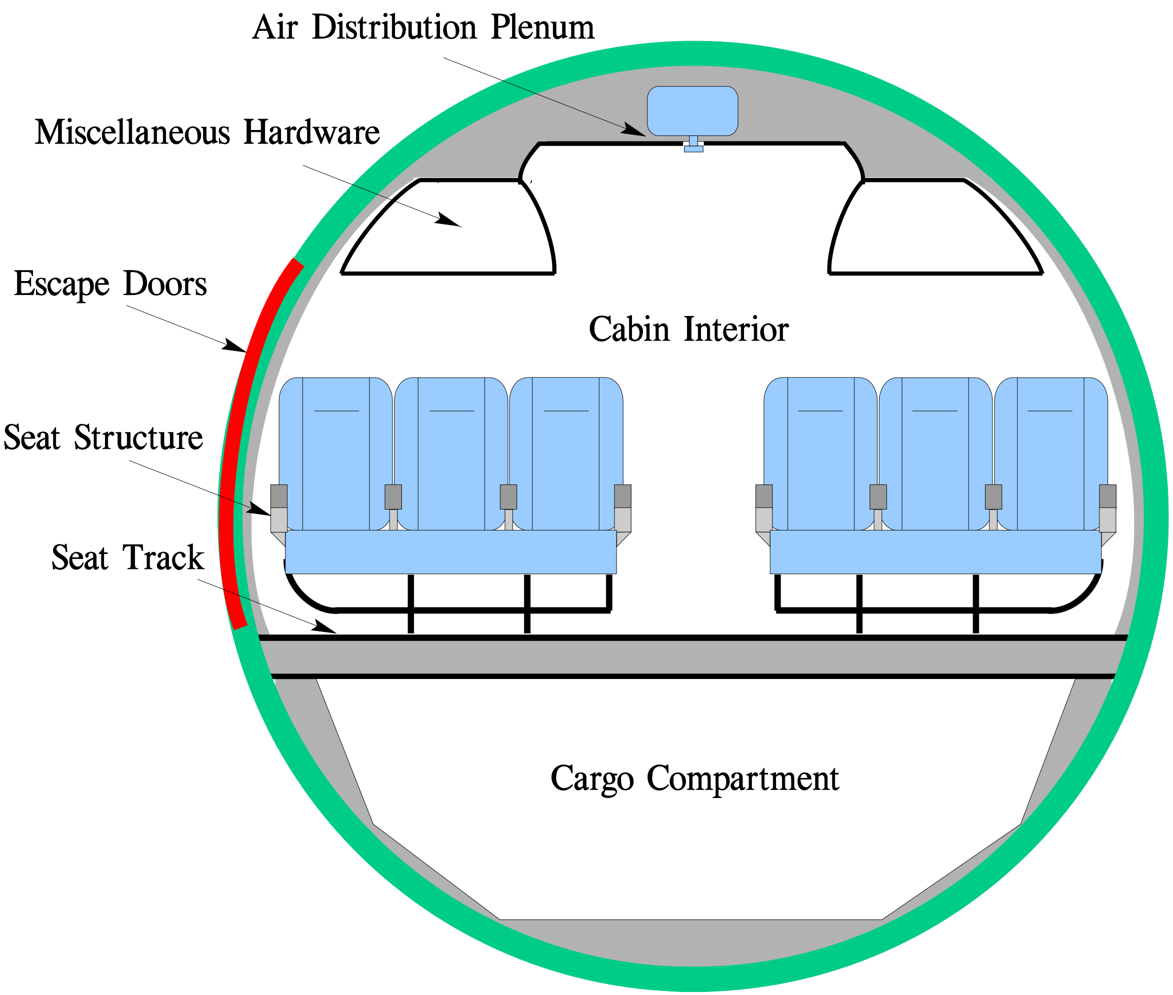
Magnesium Alloy Flammability

What are advantages and drawbacks?

Disadvantages

- Corrosion
- Flammability
- Manufacturing/housekeeping challenges during machining

Magnesium Alloy Flammability: Potential Use Locations



Magnesium Alloy Flammability

What are fire threats?

In-Flight Fire

Electrical arc, hidden fire adjacent to mag-alloy component

Postcrash Fire

Direct threat of fire entering cabin, flashover, passenger and firefighter protection

Magnesium Alloy Flammability

How do we develop an appropriate test method?

Clearly define the threat(s)

Replicate as many aspects of threat conditions as possible

Correlate with results of full-scale testing

Magnesium Alloy Flammability

What Has Been Done?

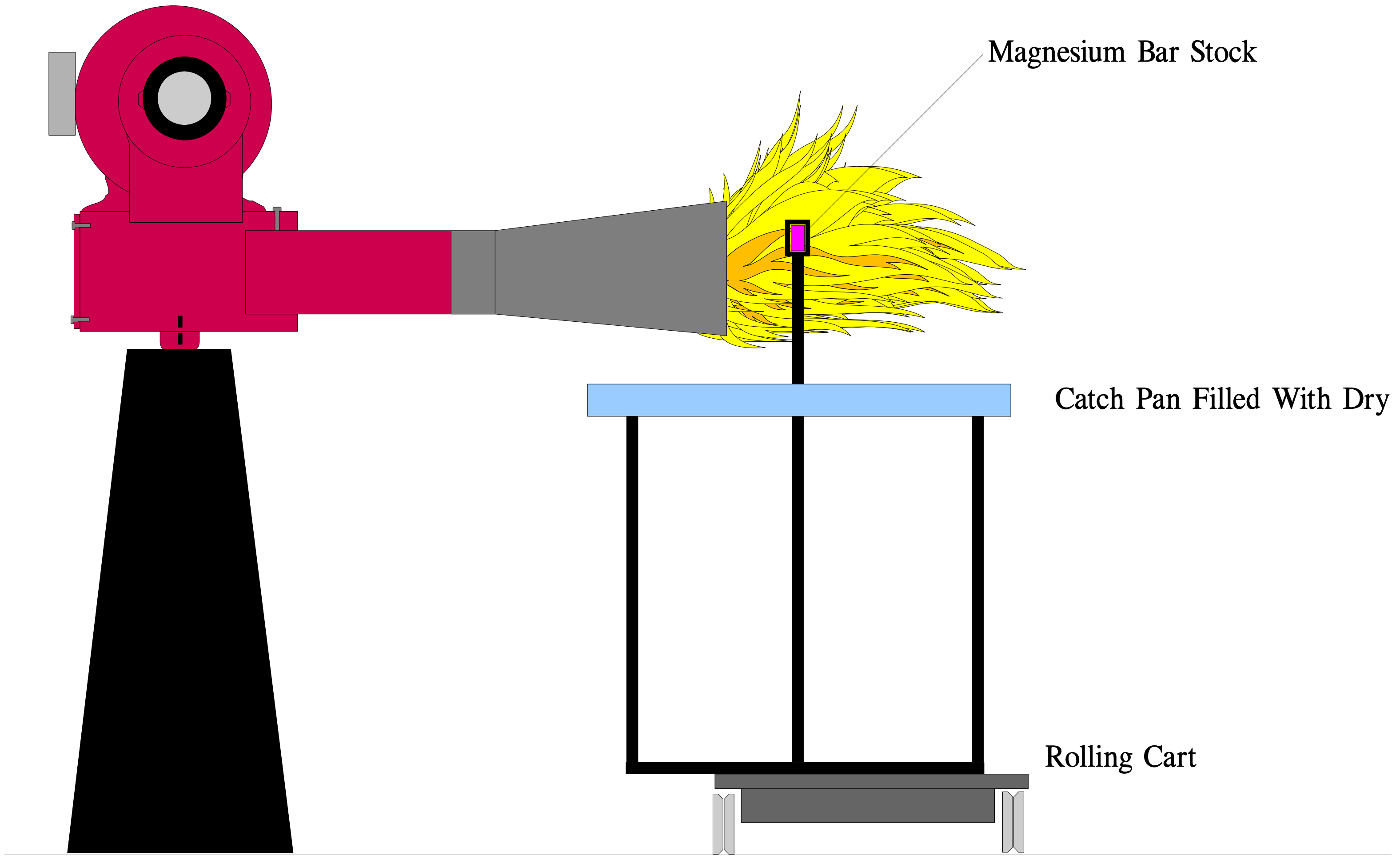
Initial Laboratory Scale "Fact-Finding" Experimentation

Oil Burner Testing

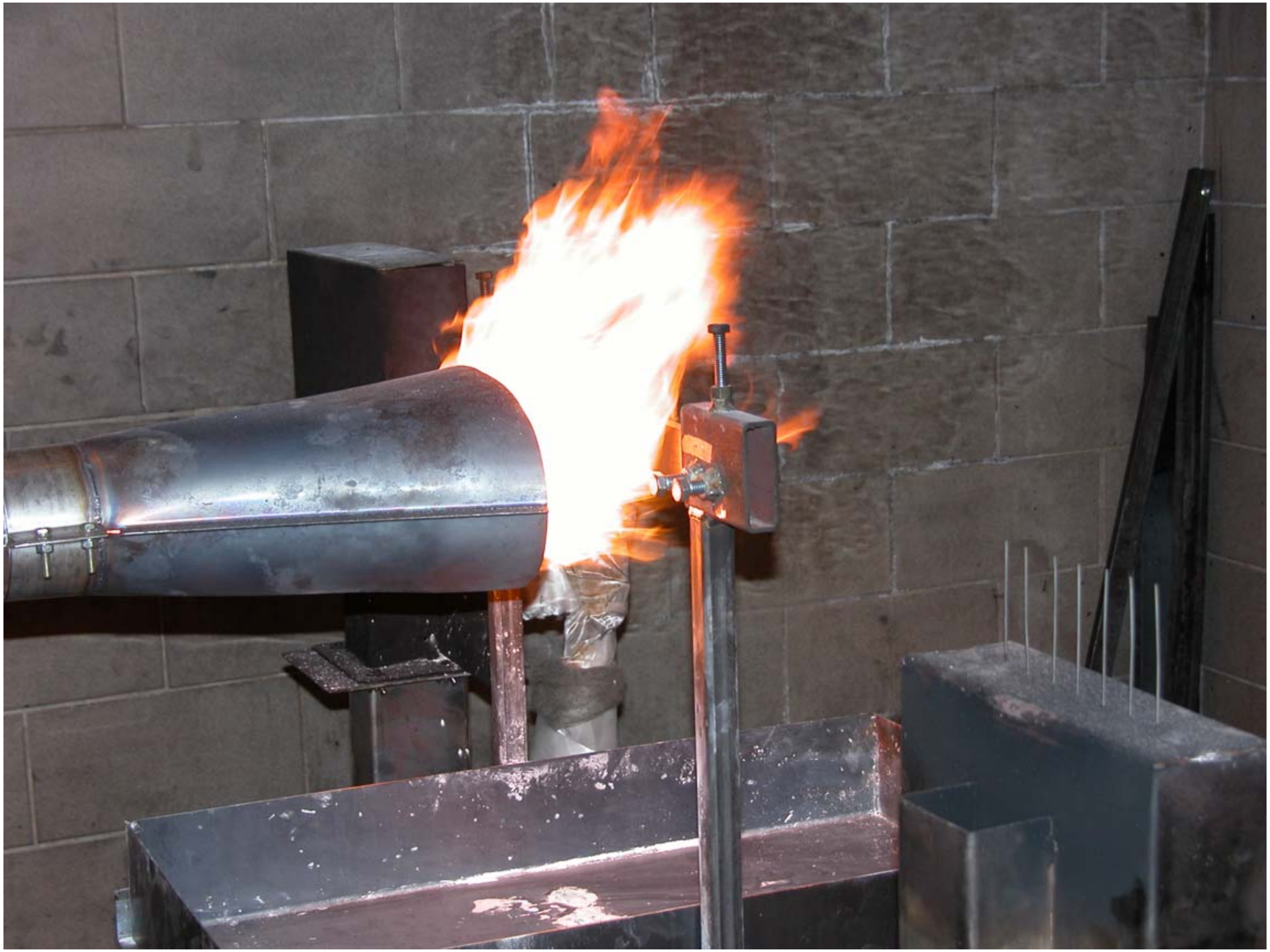
Handheld Extinguisher Testing

Miscellaneous Lab-Scale Flammability Testing

Initial Oil Burner Testing of Mag Alloy



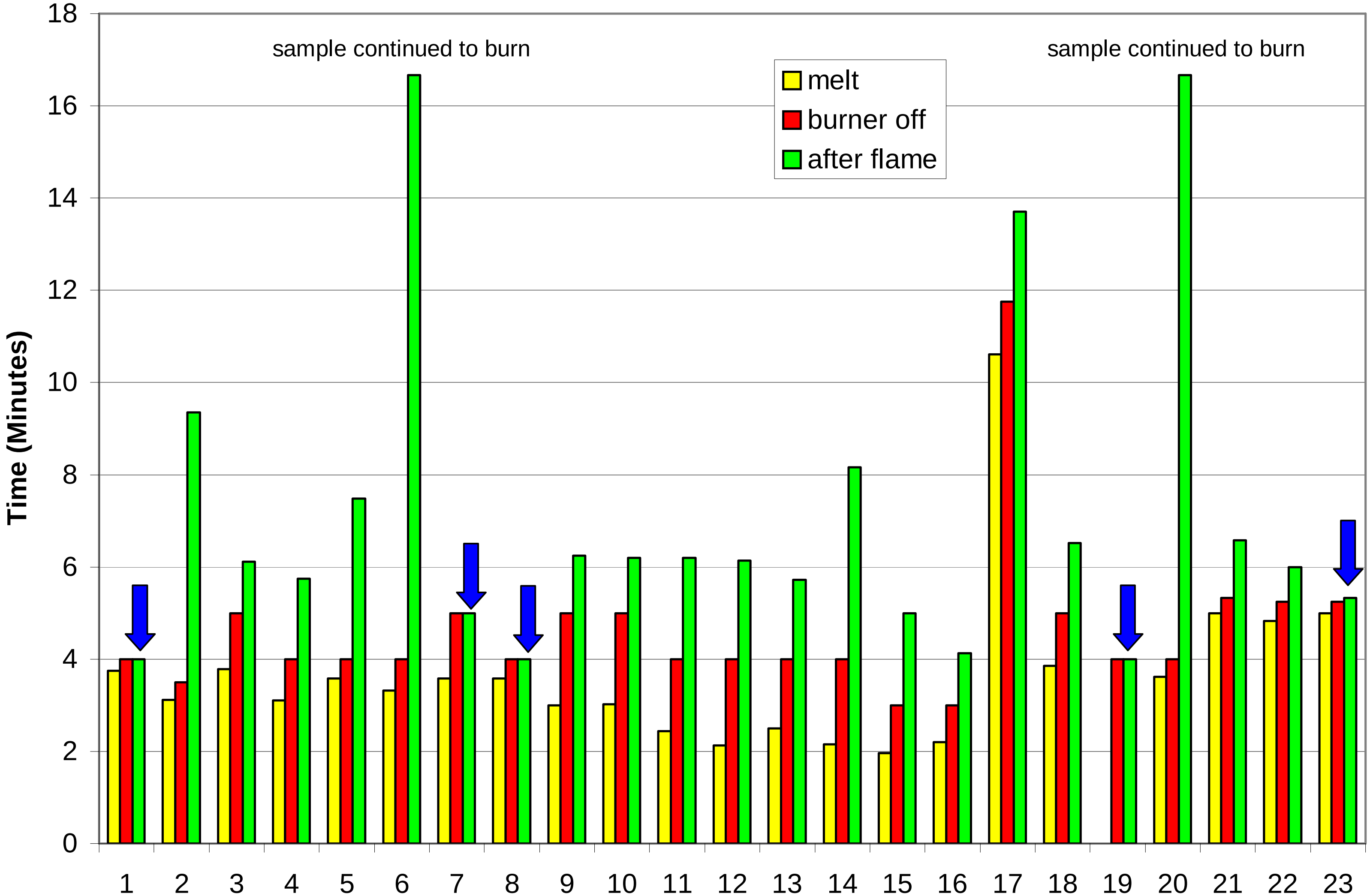
Initial Oil Burner Testing of Mag Alloy



Magnesium Burning After Burner Shut Off

*photo provided by Magnesium Elektron

Mag Alloy Test Results Using Oil Burner



Findings of Oil Burner Testing

None of the magnesium bar samples melted prior to 2 minutes

Extending exposure time beyond 2 min caused melting and ignition

78% of samples (18 of 23) continued to burn after burner flame removed

22% of samples (5 of 23) self extinguished within 5 seconds

Sample performance (i.e., flammability) largely dependent on alloy type and section thickness

WE43, Elektron 21, and Elektron 675 more ignition resistant than other alloys

Vertical orientation of sample promoted continued burning

Use of intumescent coating increased time-to-melt substantially

Critical Elements of Postcrash Lab Test for Magnesium

Flame duration/exposure time

Size, shape, thickness of sample

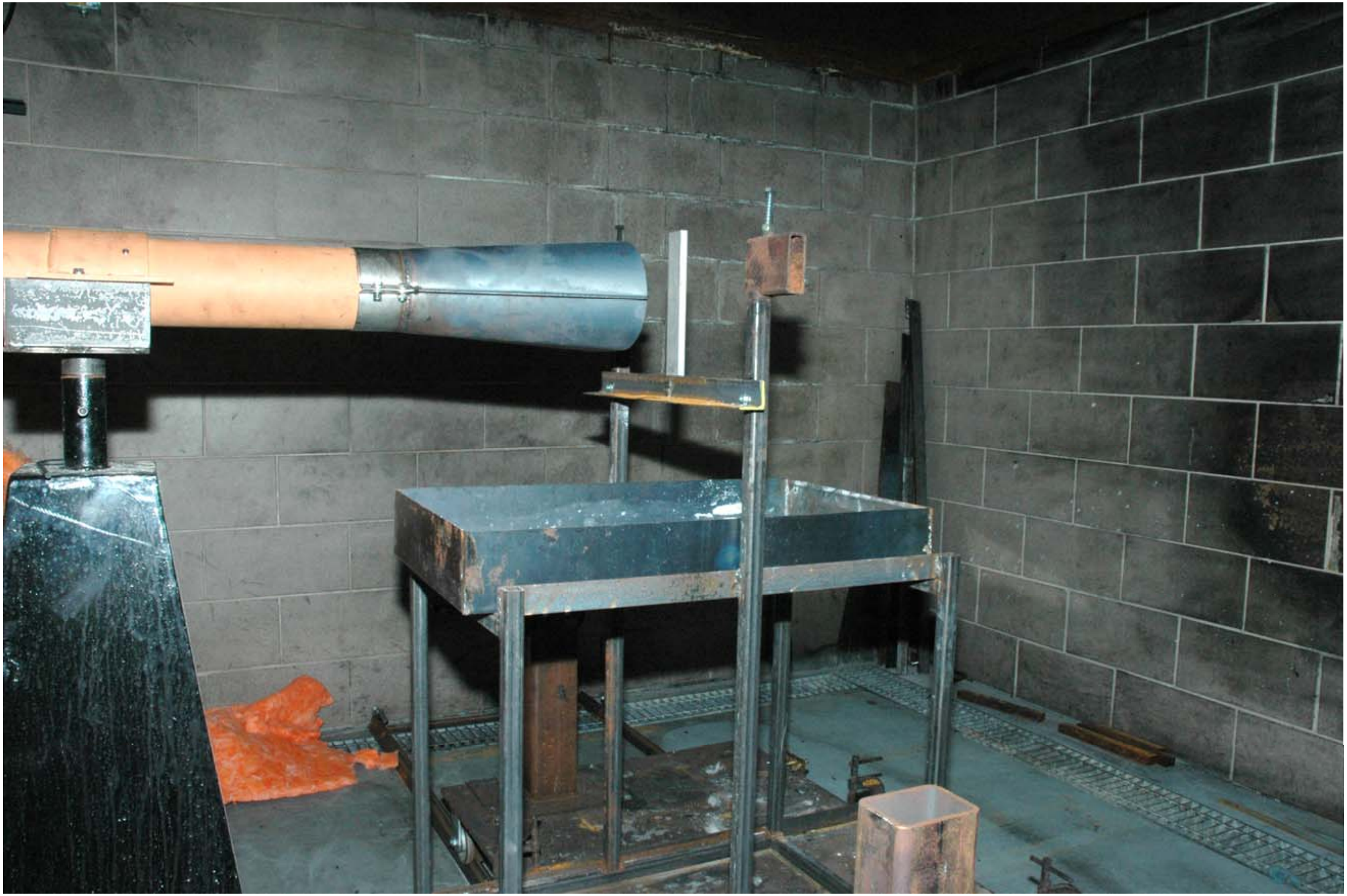
Orientation of sample

Time to reach melting

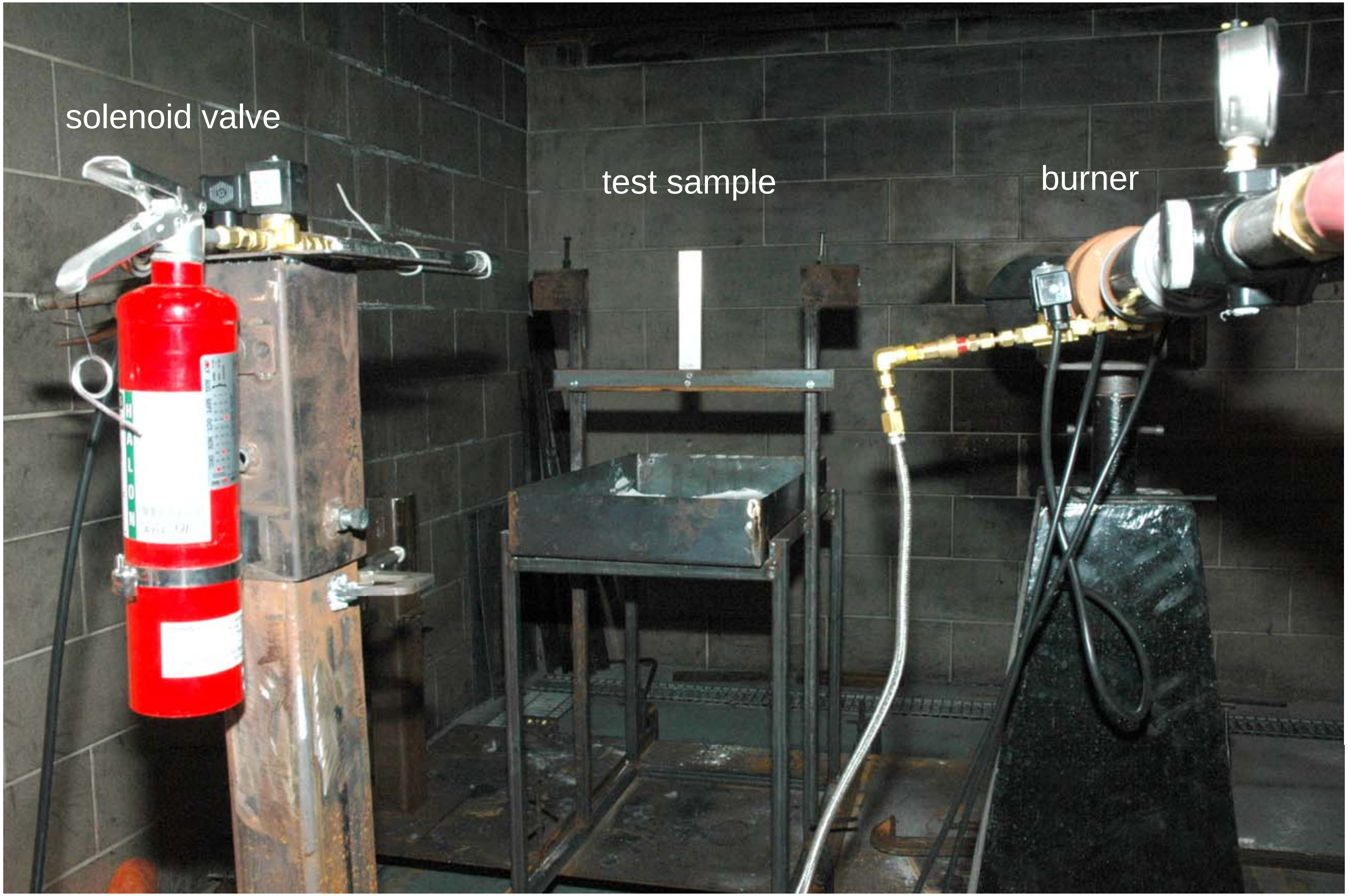
Ignition following melting (y/n)?

Duration of after-flame following ignition

Handheld Extinguisher Testing of Mag Alloy Samples



Handheld Extinguisher Testing of Mag Alloy Samples



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Handheld Extinguisher Testing of Mag Alloy Samples

Summary

7 tests conducted on ignited mag-alloy samples (3 Halon-1211, 2 water, and 2 FE-36)

All extinguishing agent applications caused minor flare-up, sparking, and excitation of the burning samples, but no explosions or detonation

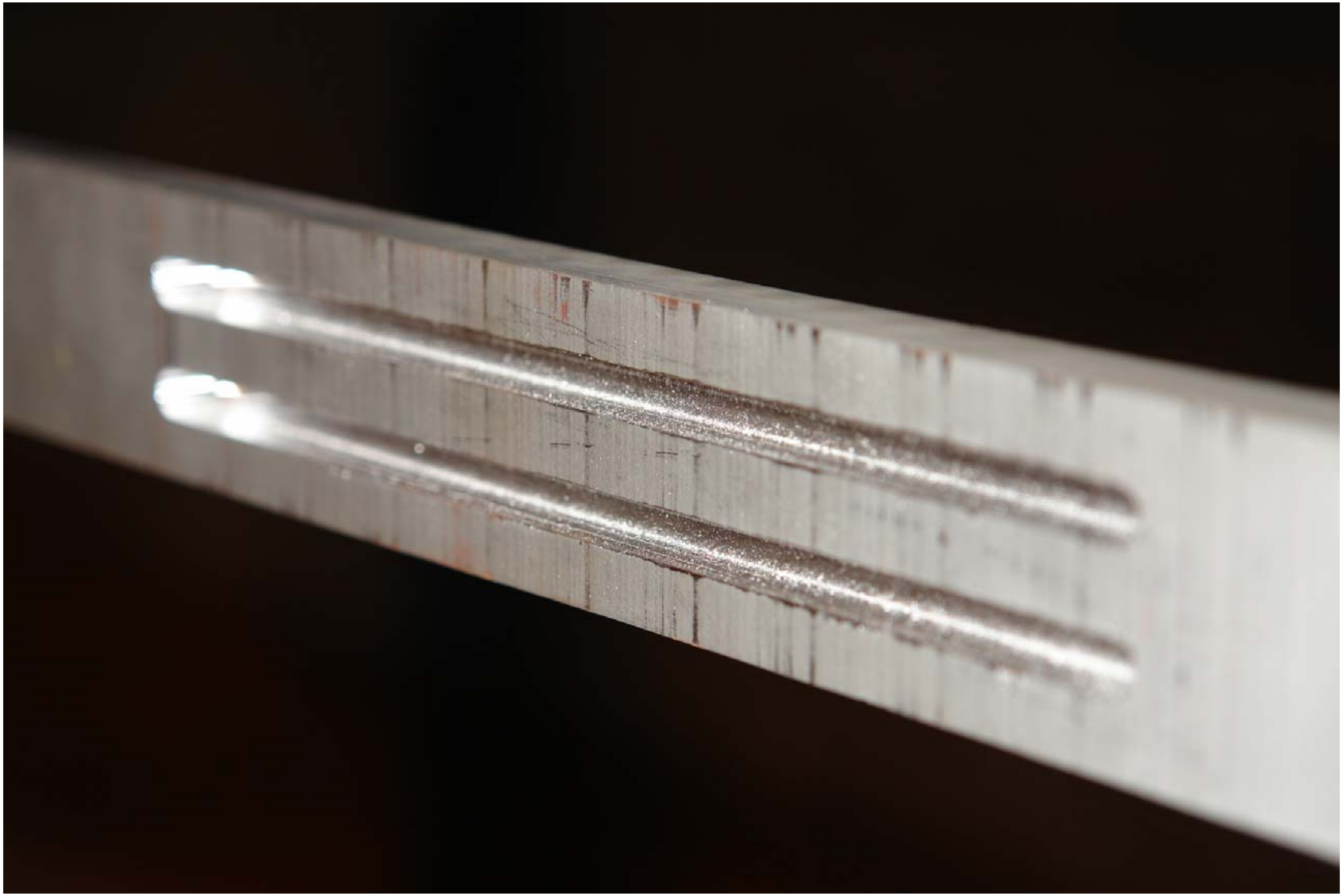
Halon-1211 least effective at extinguishing fire; water most effective

FE-36 caused rapid oxidation of burning samples

Additional Lab-Scale Flammability Testing of Mag Alloy Samples

Burner test of sample with modified cross section

Hemispherical grooves machined into test sample



Machining did not increase flammability of test sample

Vertically oriented machined test sample –no change

Flammability of turnings from lathe

Mag-alloy turnings ignited by torch

Burning mag-alloy turnings

Flammability of thin slice of mag-alloy

Flammability of thin slice of mag-alloy

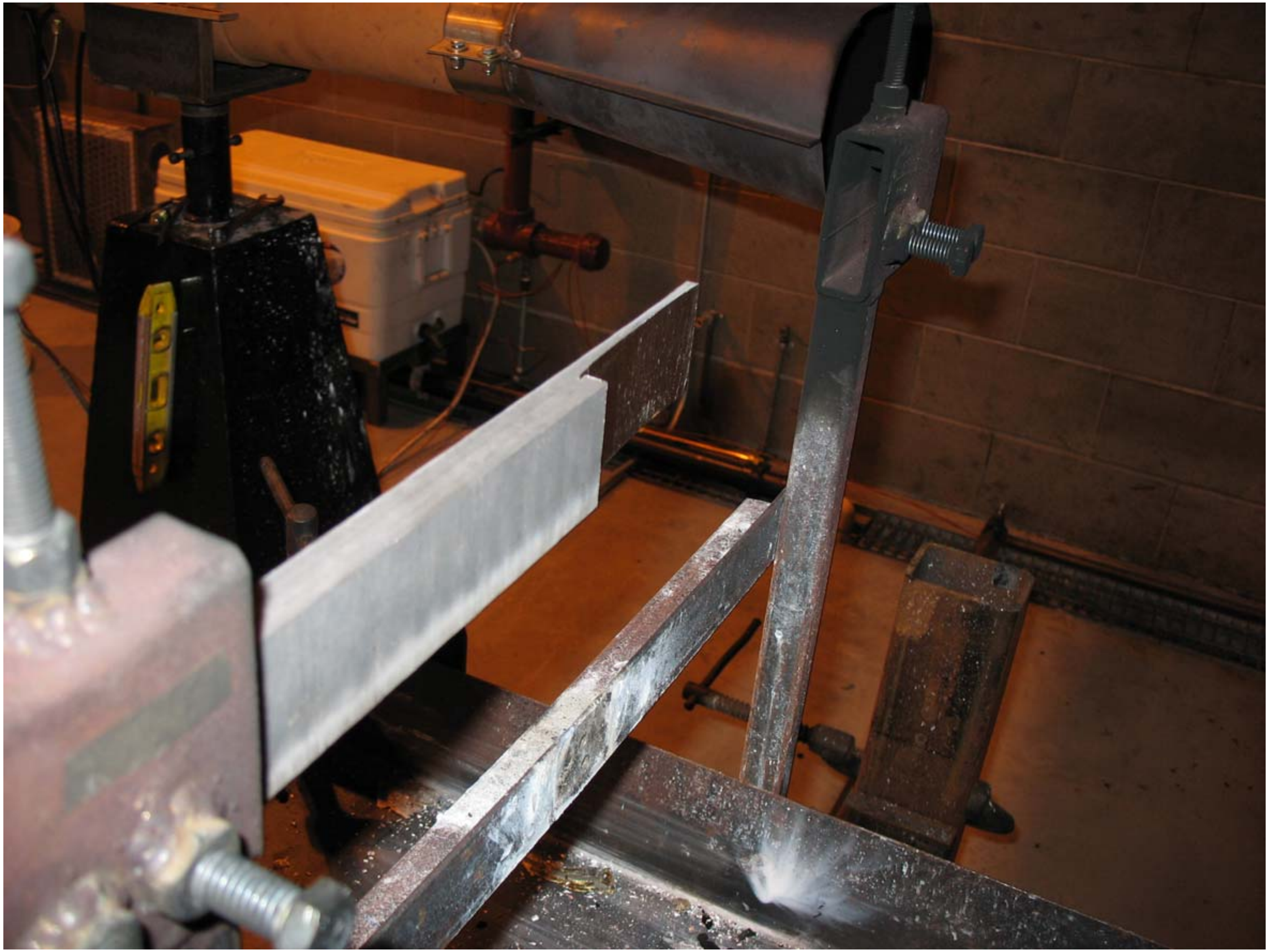
Ignition of thin slice of mag-alloy

Flammability of thin slice using burner

Flammability of thin slice using burner

Thin slice not ignited using burner

Burner test of sample with modified cross section



Burner test of sample with modified cross section

Ignition of sample with modified cross section

Magnesium Alloy Flammability

Preliminary lab scale fact-finding testing

Handheld extinguisher testing

Define critical elements of preliminary testing

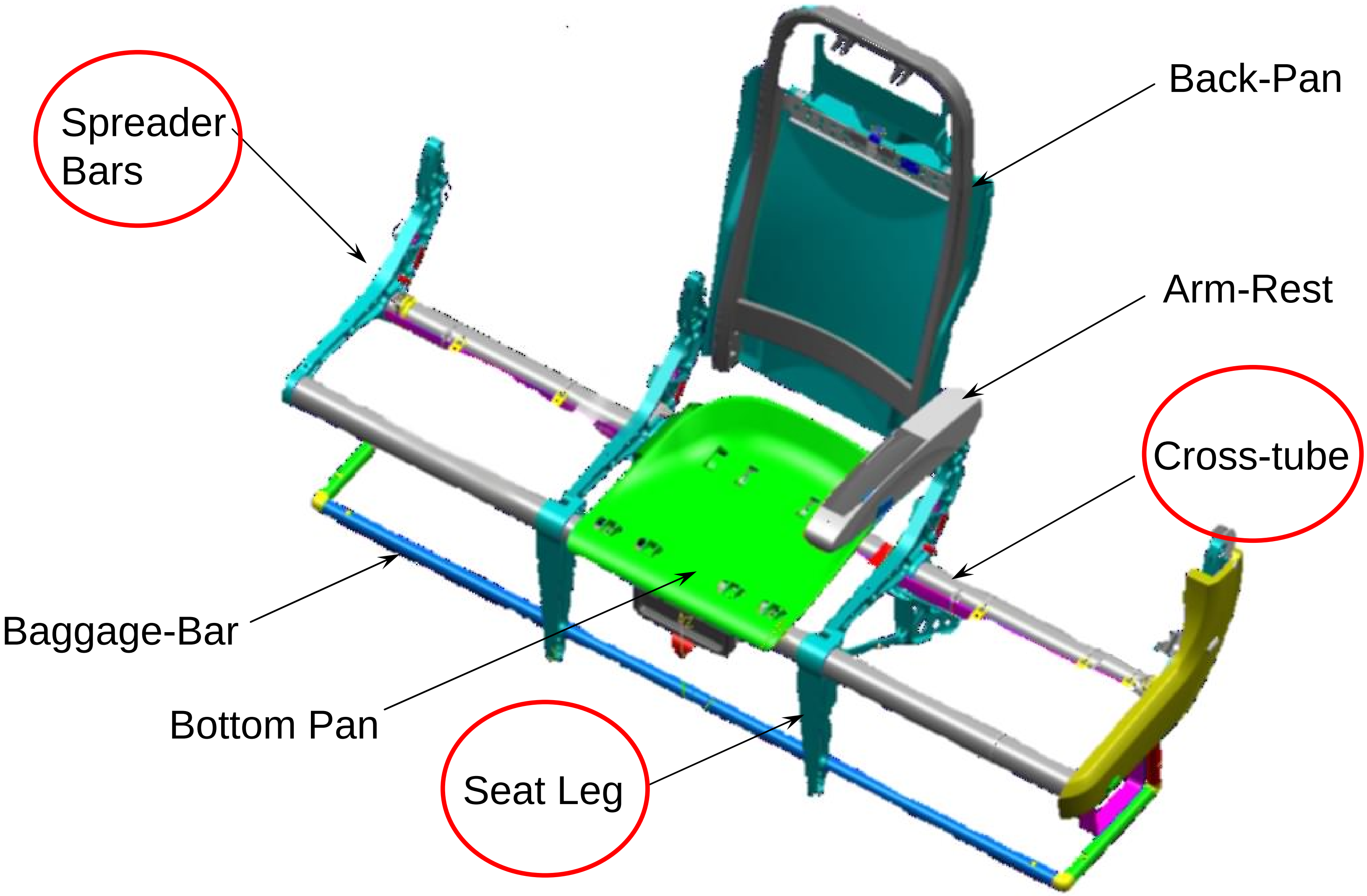
Conduct full scale test using mag-alloy seat frames

Develop lab scale test based on full-scale results

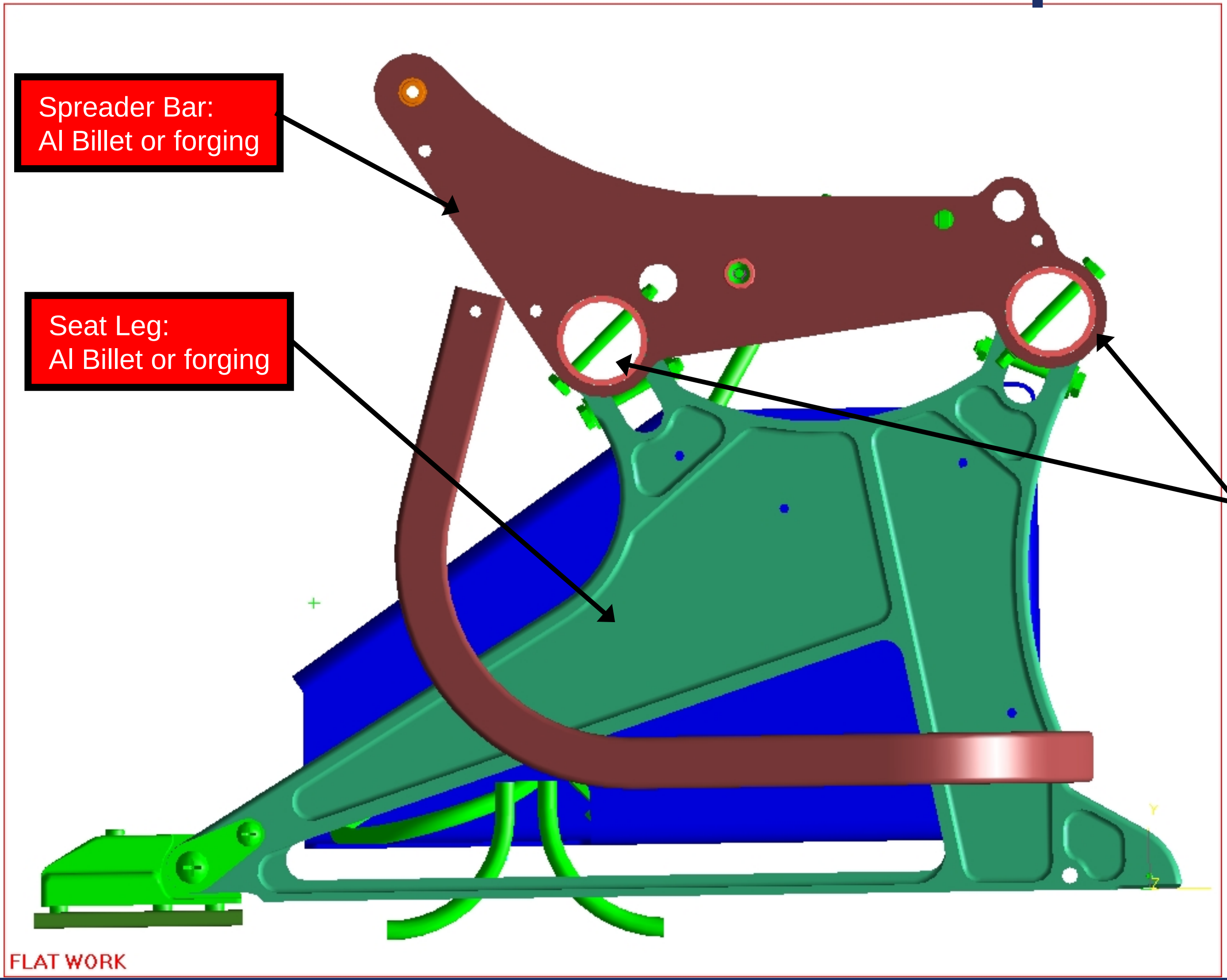
How Should a Full Scale Seat Test Be Conducted?

Typical Seat Assembly

Typical Seat Assembly



Billet and Extruded Seat Components



<u>Initial</u> Planned Testing at FAA Tech Center

Full-Scale Postcrash FireTesting i.e., 3 tests

Baseline using OEM aluminum frames, FB seat cushions

Substitute poor-performing mag alloy for aluminum frames

Substitute good-performing mag alloy for aluminum frames

Outcomes

Determine if any difference exists between 3 scenarios

Determine if difference exists between mag alloys

Interim Task Group Meeting @ FAATC 2/21/08

Attended by representatives from seat manufacturers, airframers, and mag-alloy supplier

Consensus was that full-scale tests are obvious next step

Discussed proposed mock-up seat, advantages, drawbacks, how realistic is it?

Consensus to use actual aircraft seats in full-scale testing, not mock-up

Conduct 4 full-scale tests:

- aluminum baseline test
- poor performing mag-alloy used in primary components
- good performing mag-alloy used in primary components
- good performing mag-alloy used in <u>all</u> components

Interim Task Group Meeting @ FAATC 2/21/08

Additional Points of Discussion

Considering “good” performing mag-alloy, which alloy should be used?

Considering “bad” performing mag-alloy, which alloy should be used?

Interaction of other materials (feedback)?

Effect of fire blocked seats vs. fire hardened foam (unblocked)?

Impact of using water on burning mag-alloy seats? Impact on CFR crews?

Propose AZ31 for poor performer, WE43 for good performer

Baseline test could be performed by June 2008

Full Scale Testing Update

Previous Test Configuration in 707

Previous Test Configuration in 707

Previous Test Configuration in 707

View Into Fire Door in 707

Full-Scale Test Parameters

Test Article

B707 fuselage, fully fire hardened interior

Instrumentation

Continuous gas analysis at 2 locations, 2 heights + FTIR at locations

Temperature measurement: 3 thermocouple trees + additional seat thermocouples

Smoke measurement: smoke-meters at 2 locations, 3 heights each

4 interior video cameras, 2 external

Interior Materials

0.25-Inch thick crushed-core Nomex honeycomb panels, meets 65/65

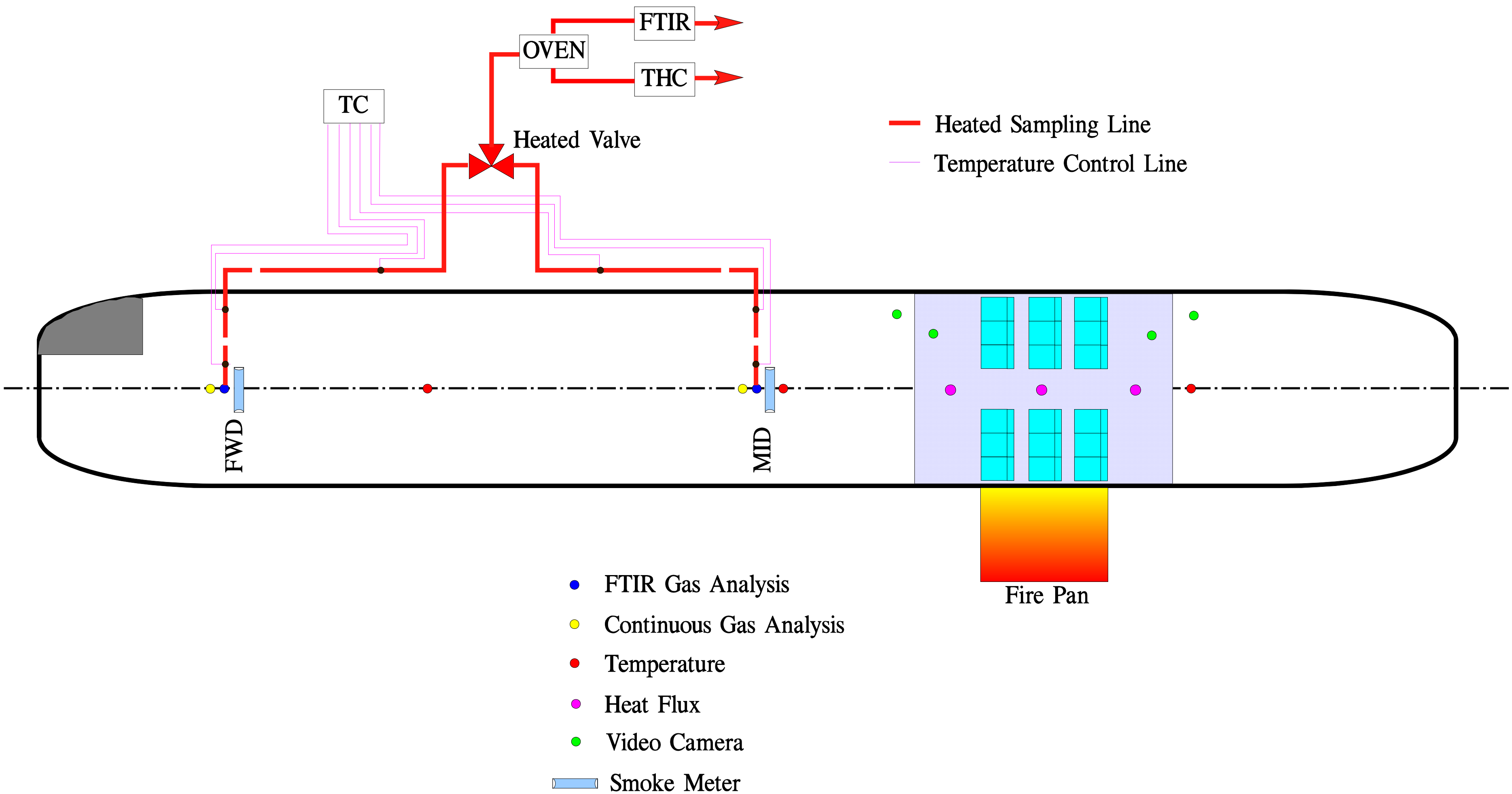
Aircraft-grade carpet, meets VBB

Test Execution

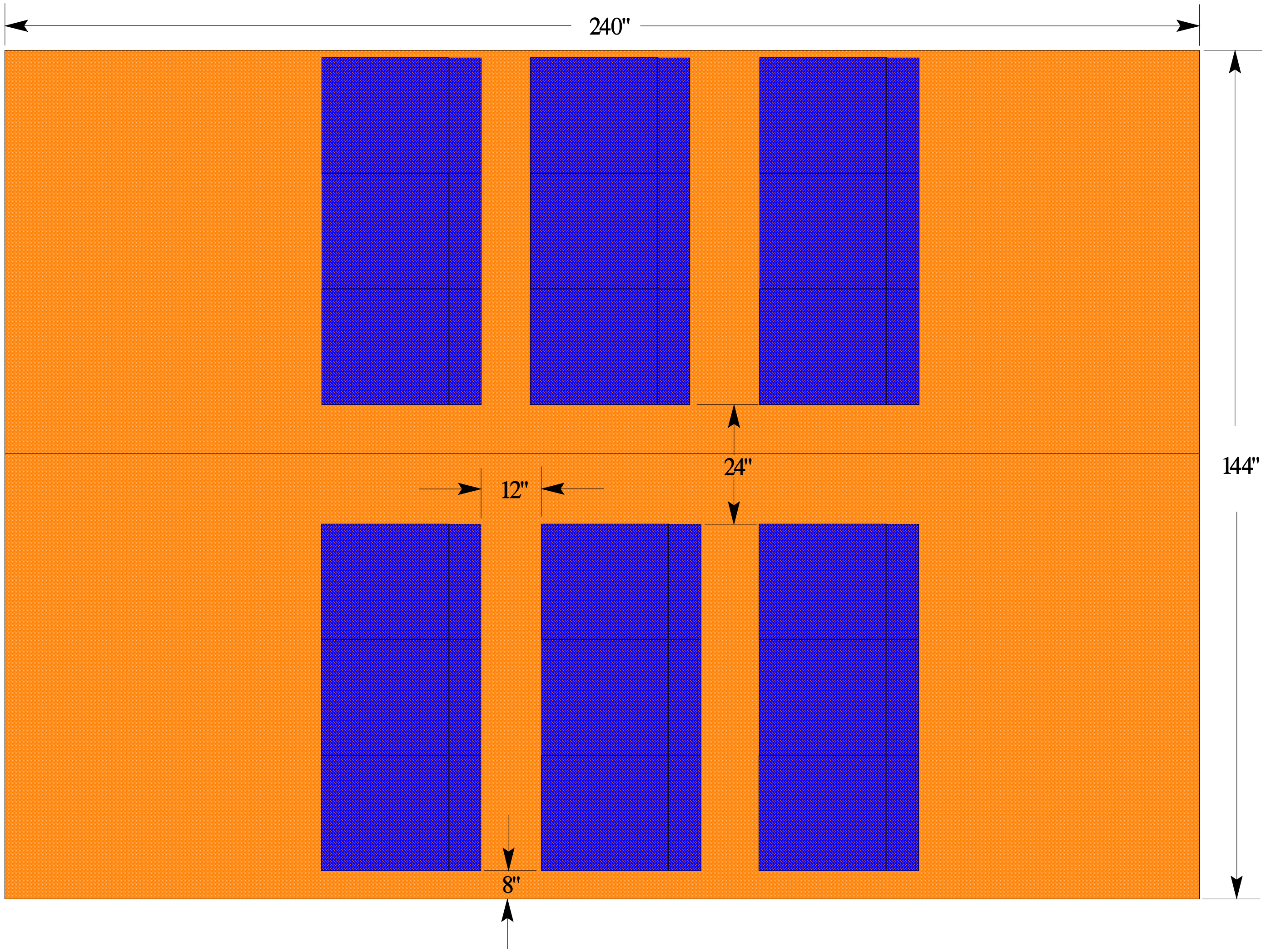
55 gallon JP8 fuel fire in 8’ by 10’ pan adjacent to fuselage

External fuel fire extinguished following noticeable flashover

Full-Scale Test Apparatus

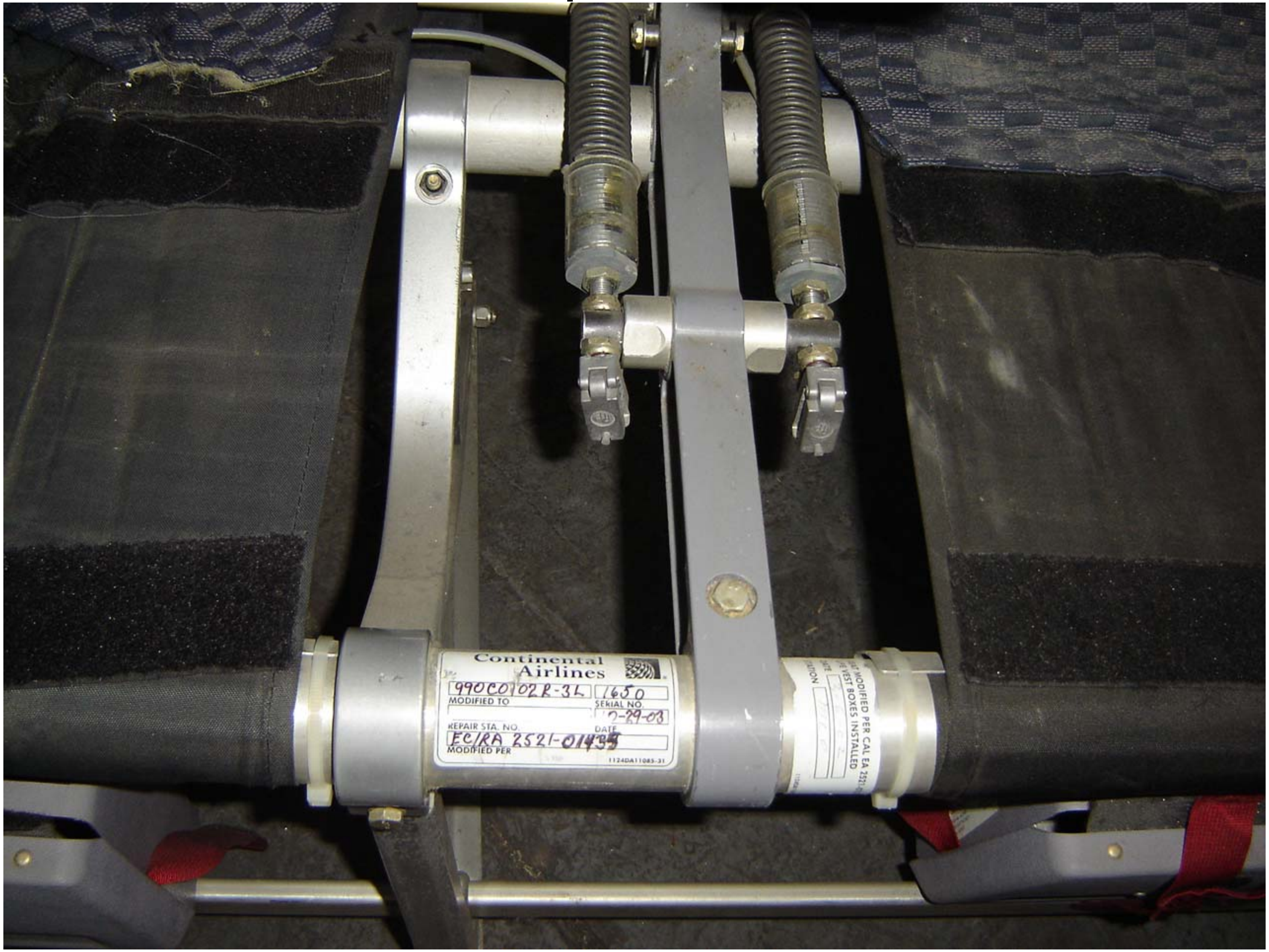


Seat Configuration & Location



Procurement of Seats for Full-Scale Testing

B/E Aerospace "990" Seats



B/E Aerospace “990” Seats

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Seat Disassembly

Cross Tube Assembly

Spreader Assembly

Leg Assembly

Future Considerations

All full-scale test results would help define an appropriate lab-scale test method or methods, which is the primary goal of the research.

Manufacturer's perspective necessary to determine value of developing new test methodology.