Federal Aviation Administration

International Aircraft Materials Fire Test Working Group

Update on Flammability Testing of Magnesium Alloy Components

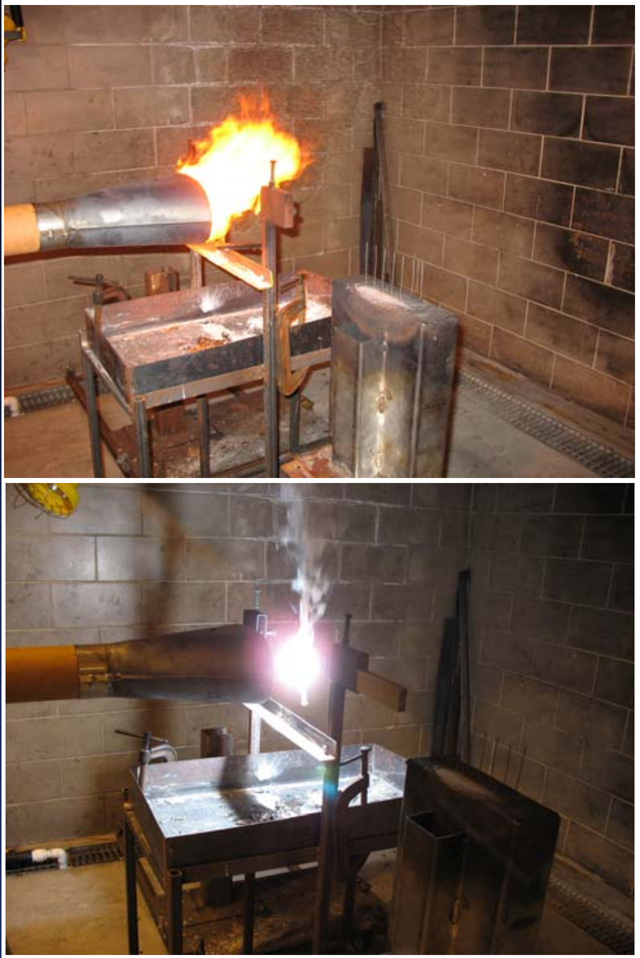
Presented to: IAMFT Working Group, Brazil

By: Tim Marker, FAA Technical Center

Date: March 4, 2008

Magnesium Alloy Flammability

- Background and Chronology
- Fire Threats
- Test Method Development
- Lab Testing Using Oil Burner
- Handheld Extinguishment Tests
- Proposed Full Scale Testing
- Closing



Magnesium Alloy Flammability

Background

- Growing popularity in automotive industry
- Renewed interest in commercial aviation
- Current SAE/FAA ban on use in seats
- SAE seat committee involvement

Magnesium Alloy Flammability

What are advantages and drawbacks?

Benefits

- Lightweight
- Machinability

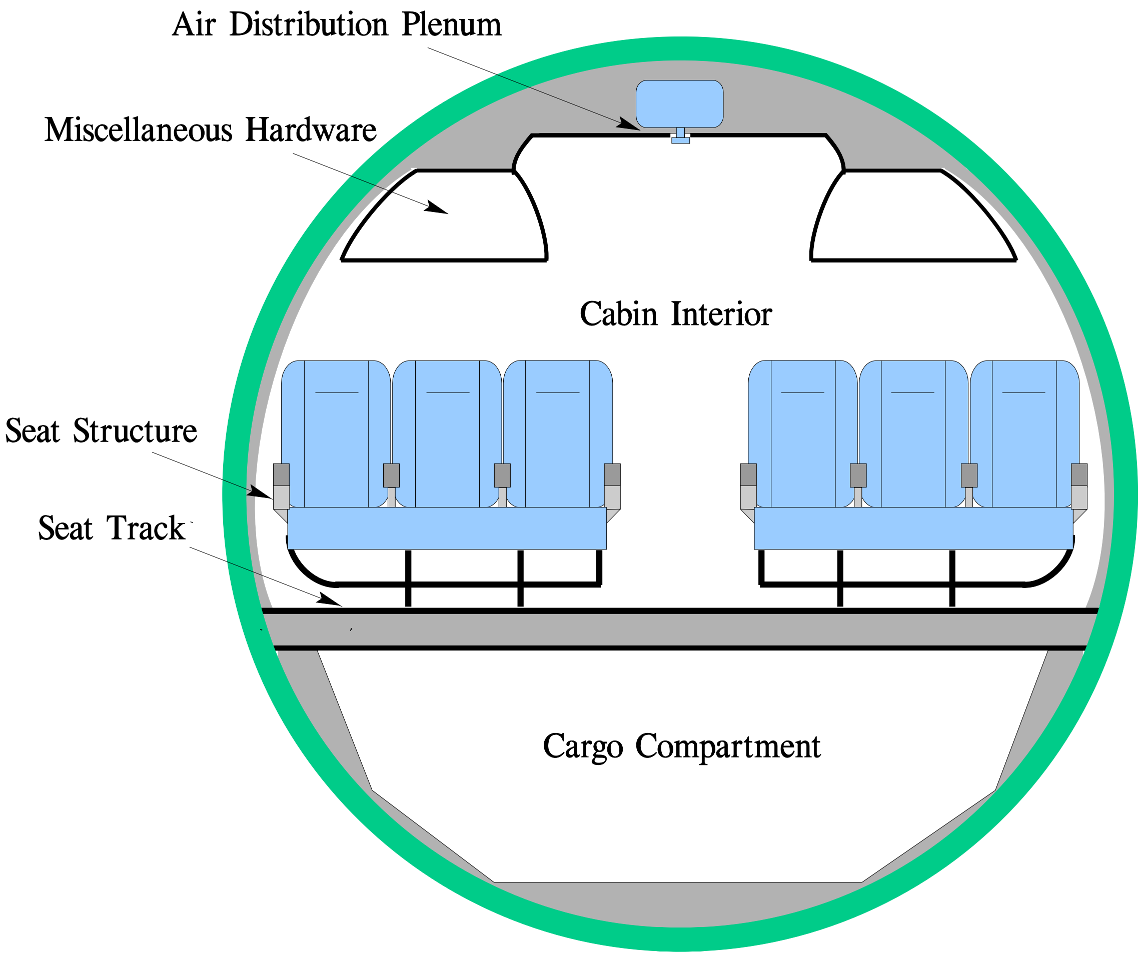
Magnesium Alloy Flammability

What are advantages and drawbacks?

Disadvantages

- Flammability
- Corrosion

Magnesium Alloy Flammability: Potential Use Locations



Magnesium Alloy Flammability

What are fire threats?

In-Flight Fire

Postcrash Fire

Magnesium Alloy Flammability

Potential <u>In-Flight</u> Fire Threats from Using Magnesium in Cabin

Electrical arc to magnesium component

Hidden fire adjacent to magnesium component

O_2 canister fire next to magnesium component

Consider terroristic threat from shavings?

Magnesium Alloy Flammability

Potential <u>Postcrash</u> Fire Threats from Using Magnesium in Cabin

External fuel fire entering cabin

Primary concern – safety of passengers

Secondary concern – safety of firefighters?

Magnesium Alloy Flammability

How do we develop an appropriate test method?

Clearly define the threat(s)

Correlate with results of full-scale testing

Magnesium Alloy Flammability

Development of an appropriate Lab-Scale <u>In-Flight</u> Test

Electrical arc or combination radiant/small ignition source?

Size, power, of electrical arc?

Size, shape of test sample?

Pass/Fail criteria?

Magnesium Alloy Flammability

Development of an appropriate Lab-Scale Postcrash Test

Oil burner apparatus, what heat flux?

Duration of test, 2-min or 5-min?

Size, shape of test sample?

Pass/Fail criteria?

Magnesium Alloy Flammability

What Has Been Done?

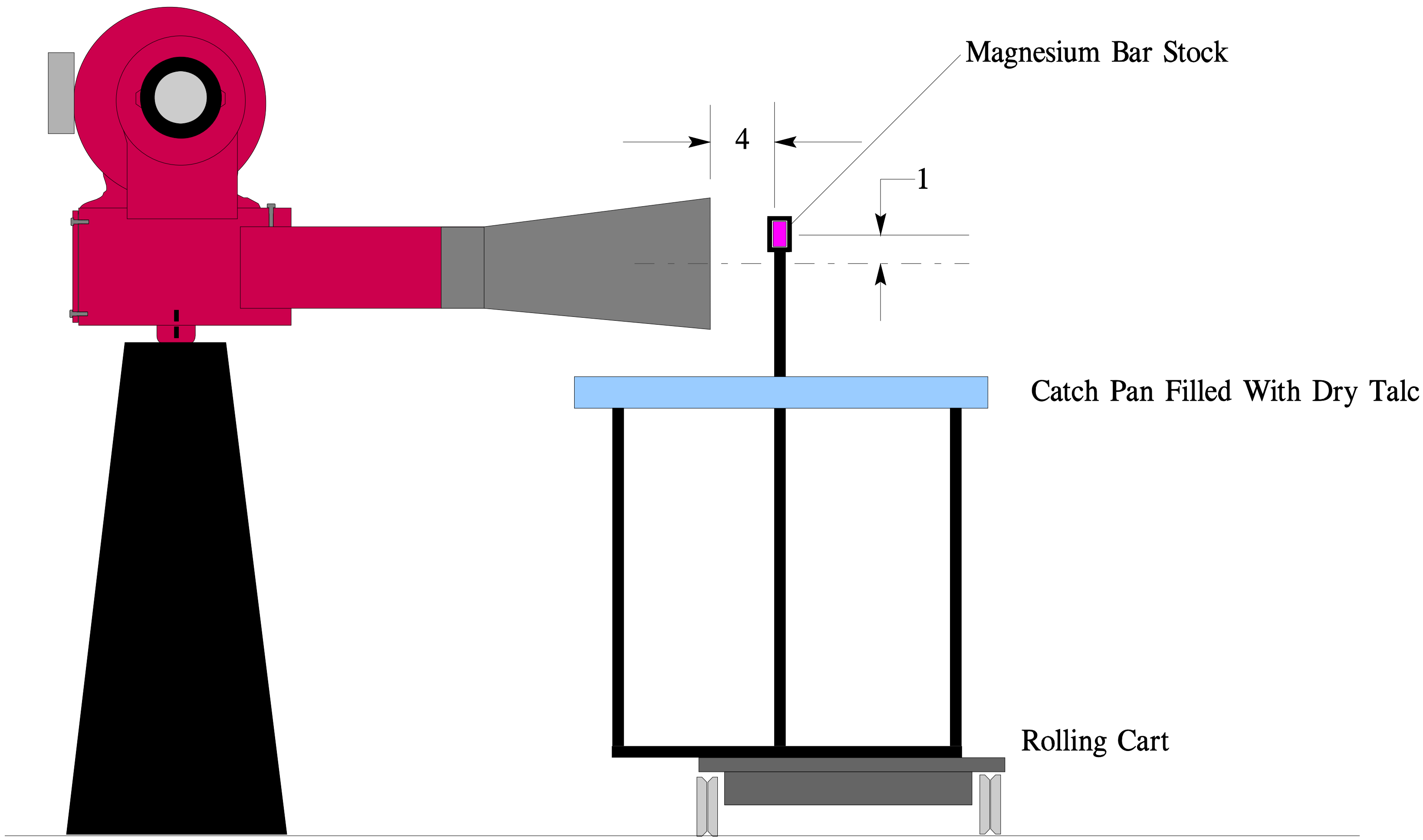
Initial Laboratory Scale “Fact-Finding” Experimentation

Oil Burner Testing

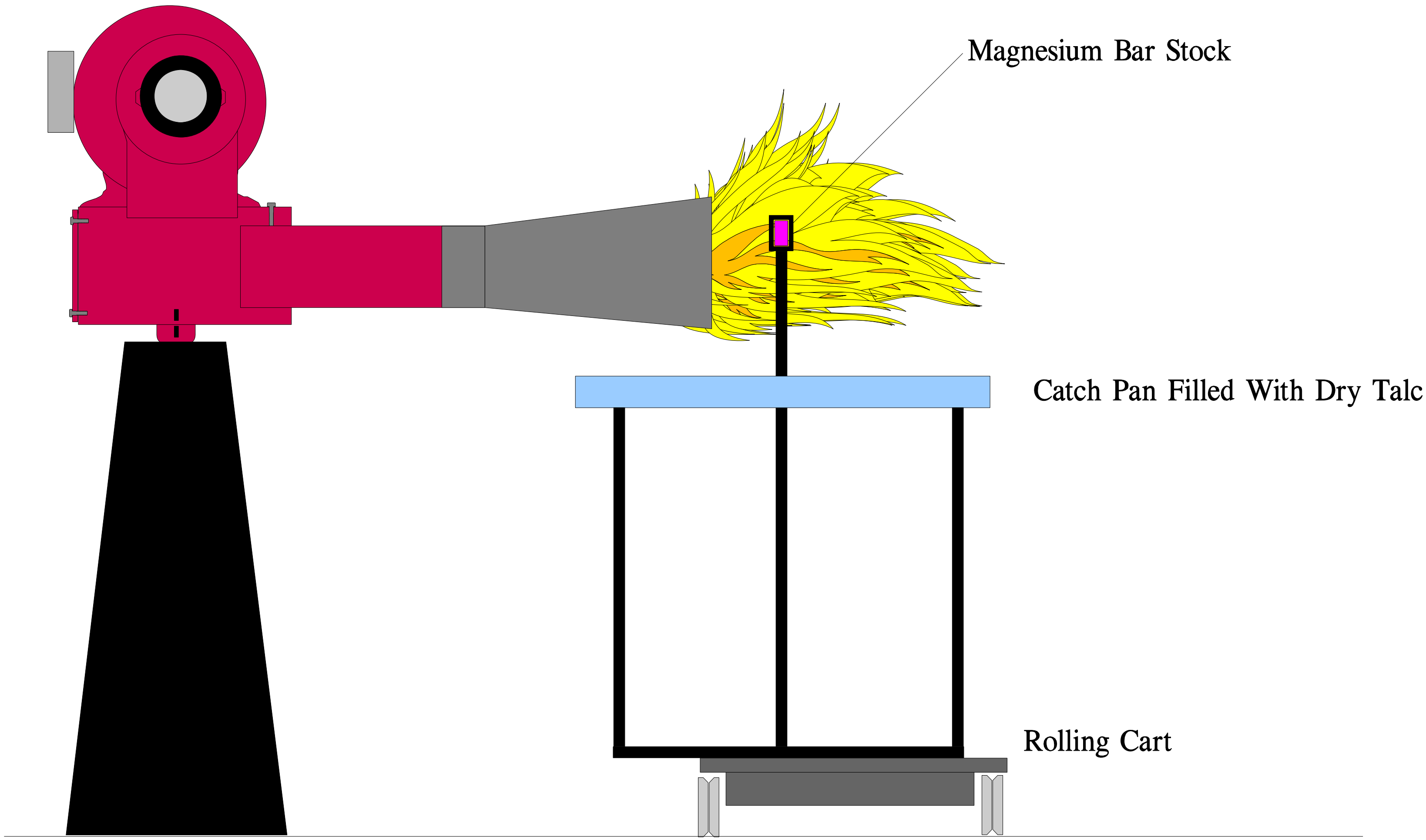
Handheld Extinguisher Testing

Miscellaneous “can-I-get-this-stuff-to-burn” Testing

Initial Oil Burner Testing of Mag Alloy



Initial Oil Burner Testing of Mag Alloy



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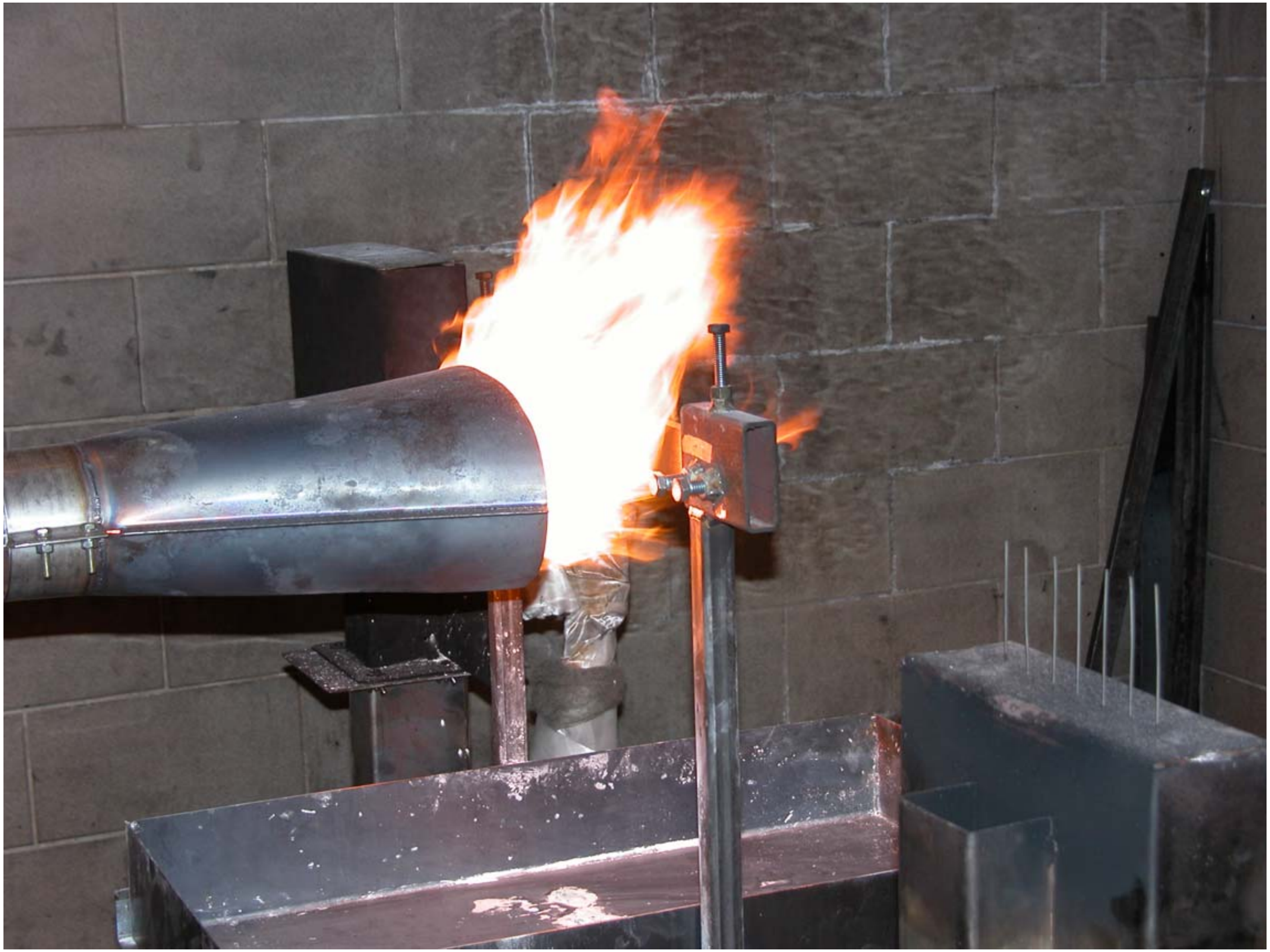

Initial Oil Burner Testing of Mag Alloy

*photo provided by Magnesium Elektron

Initial Oil Burner Testing of Mag Alloy

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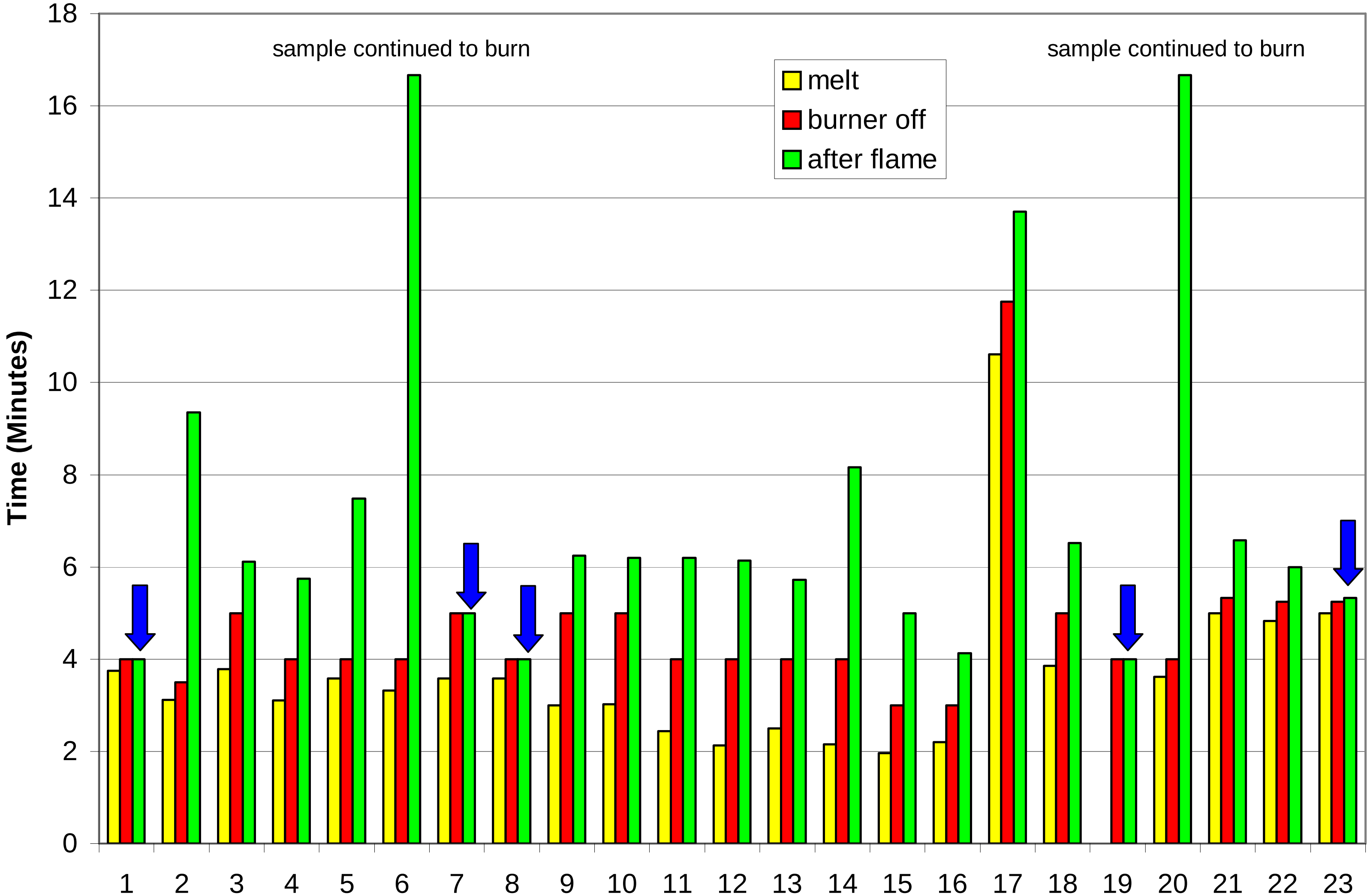
Initial Oil Burner Testing of Mag Alloy

*photo provided by
Magnesium Elektron

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

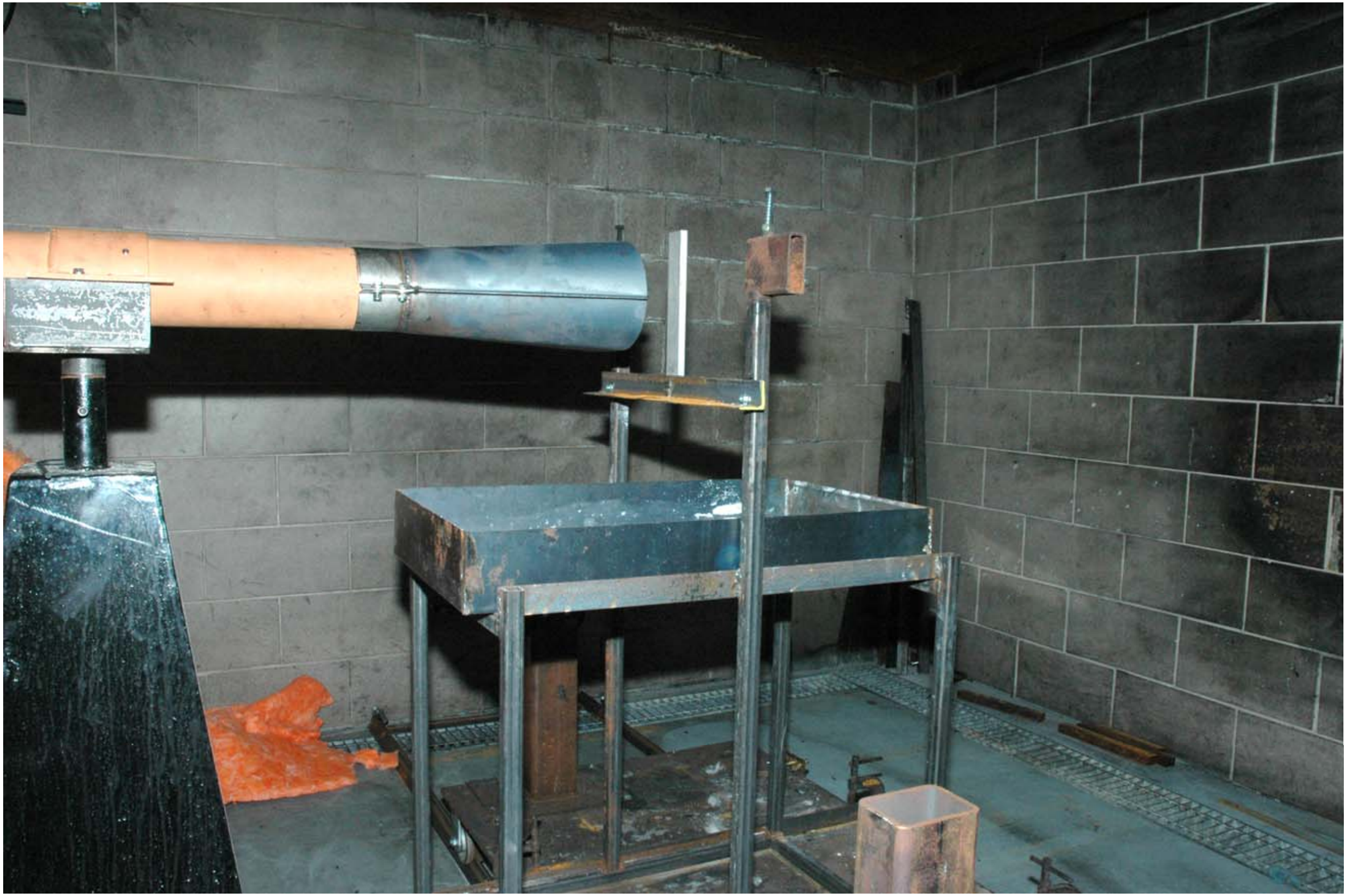
Time to reach melting

Ignition following melting (y/n)?

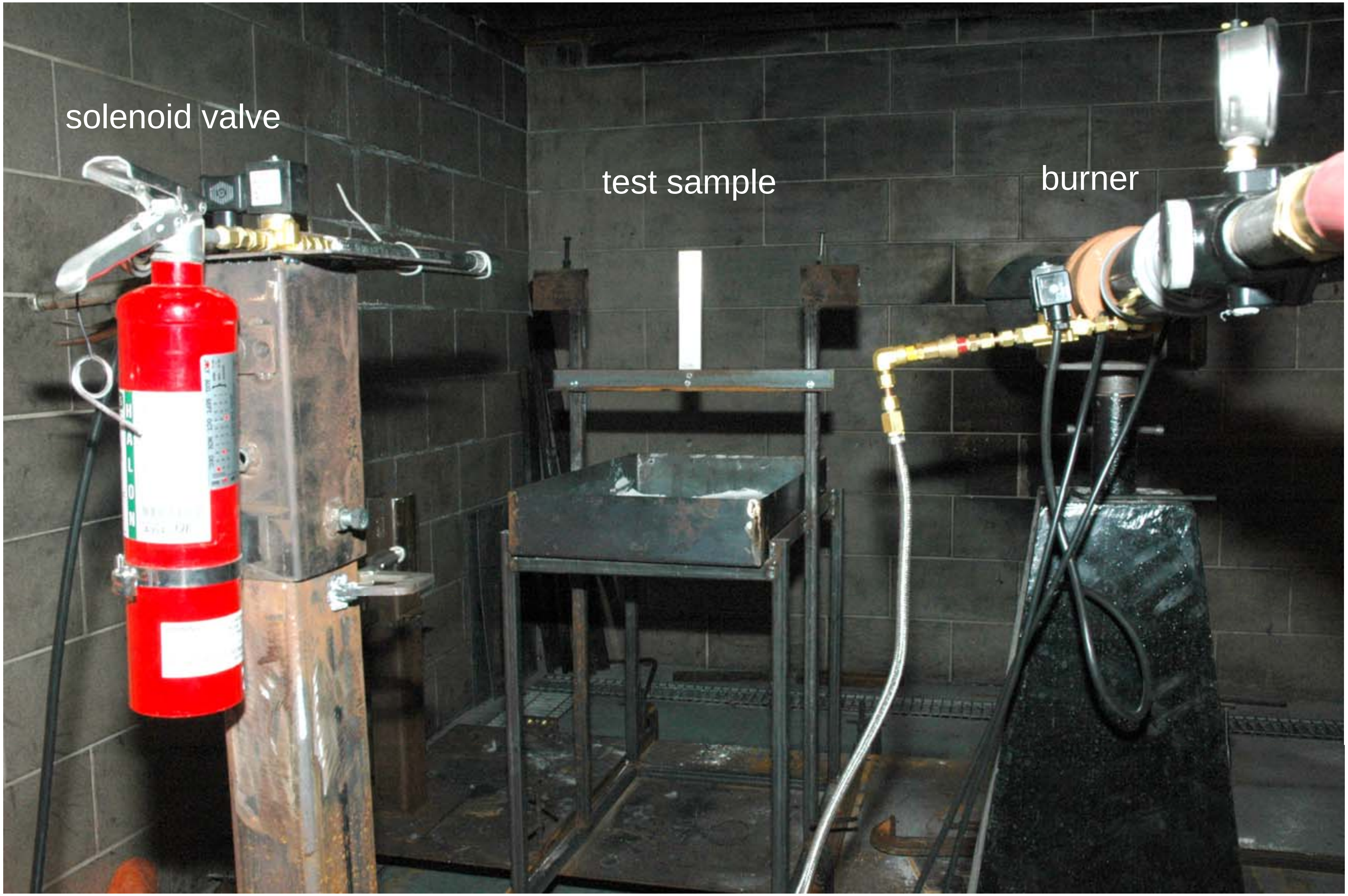
Duration of after-flame following ignition

Handheld Extinguisher Testing of Mag Alloy Samples

Handheld Extinguisher Testing of Mag Alloy Samples



Handheld Extinguisher Testing of Mag Alloy Samples



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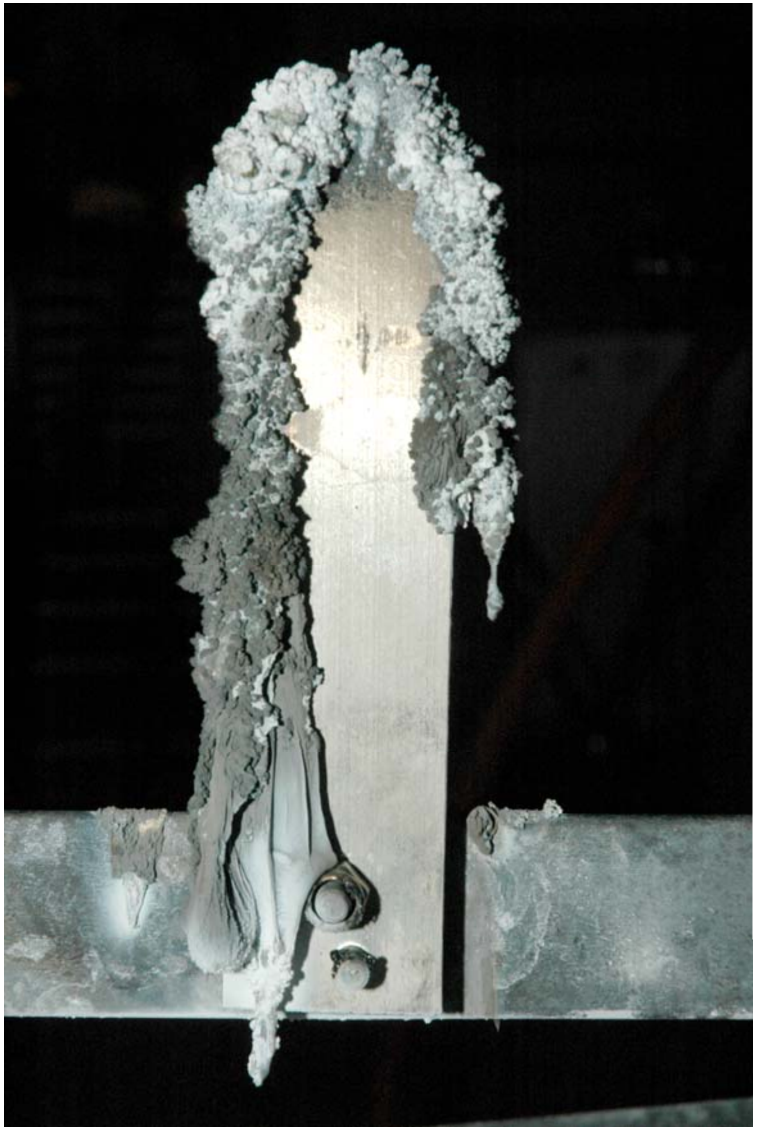


rapid oxidation of test sample
following FE-36 discharge

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

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

Proposed 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

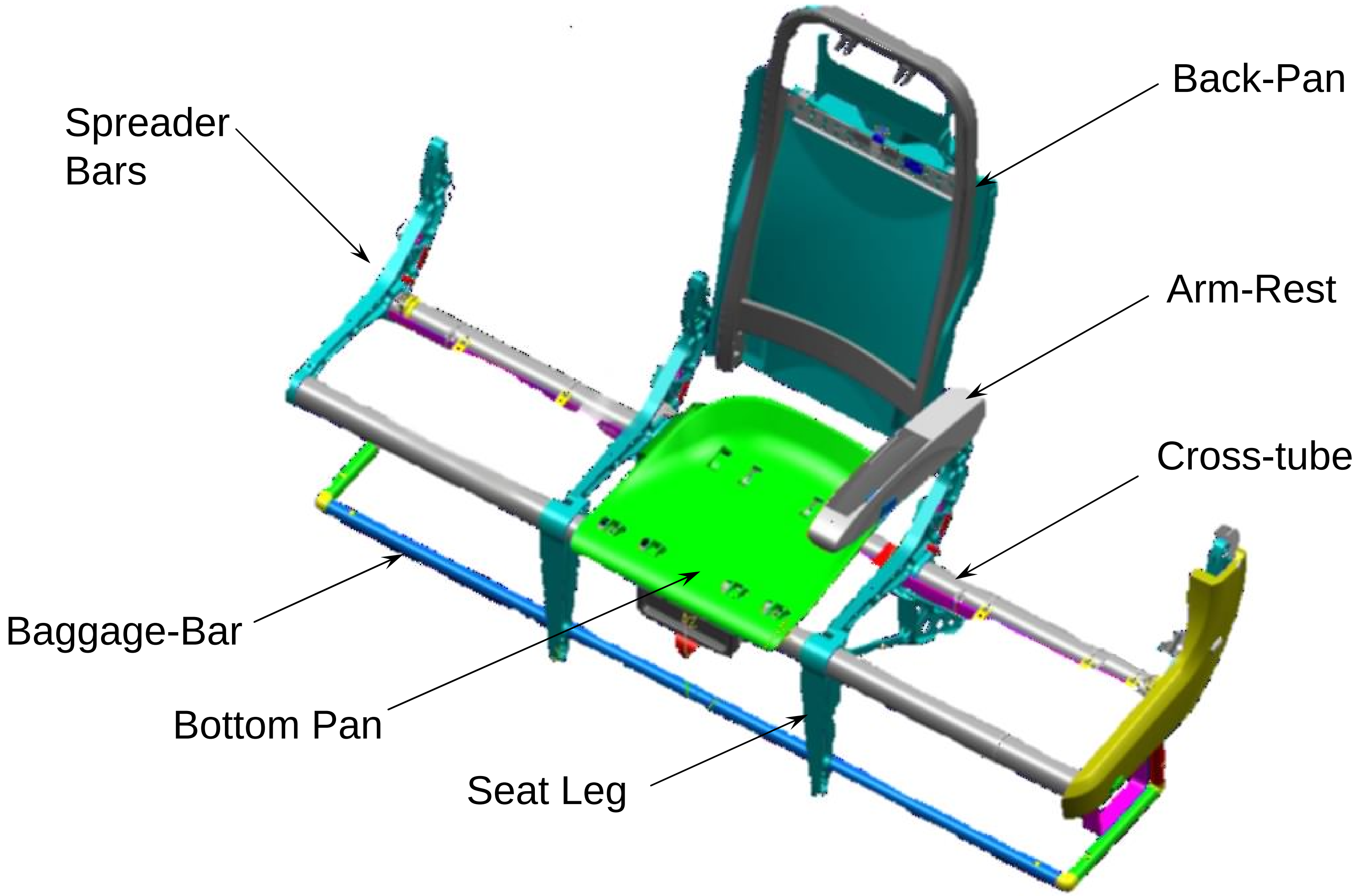
Determine if difference exists between mag alloys

Lab-Scale Test Development

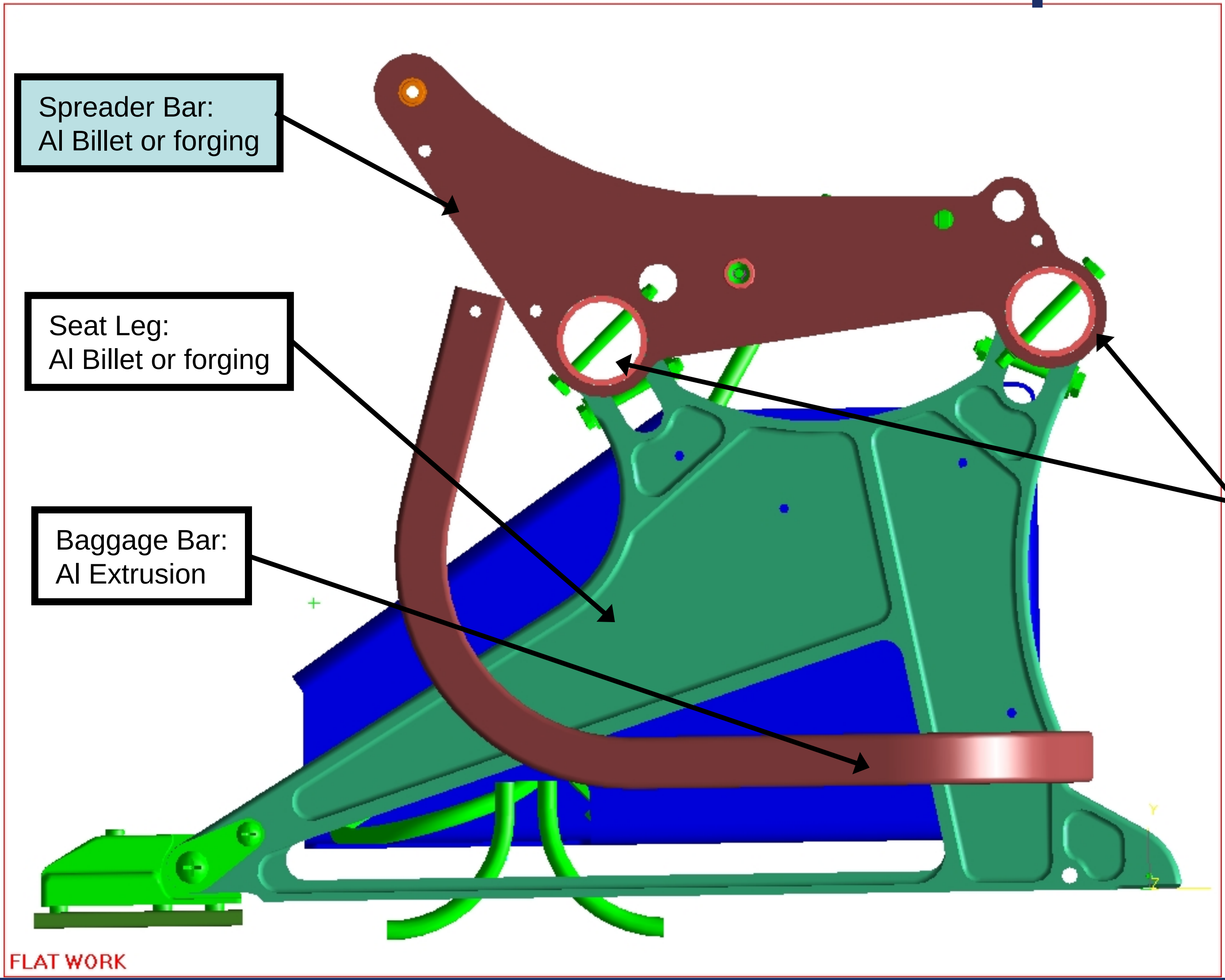
Results corollary to full-scale tests (i.e., consistent ranking of identical materials between full-scale and lab-scale)

Typical Seat Assembly

Typical Seat Assembly



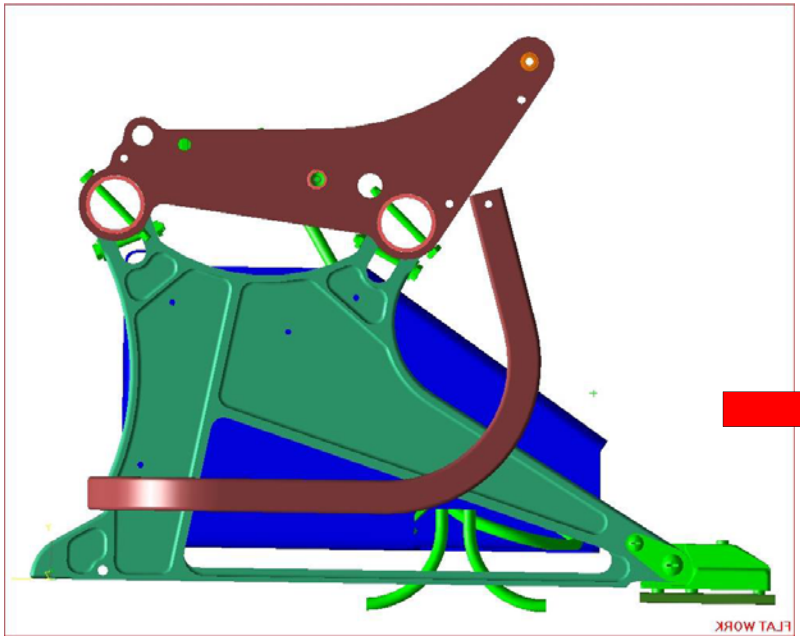
Billet and Extruded Seat Components



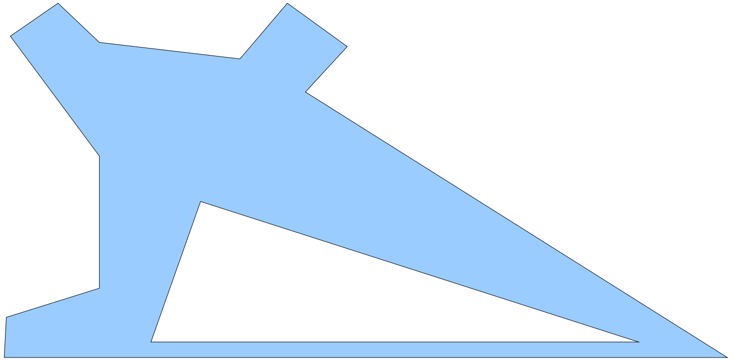
Proposed Simplified Mock-Up Seat for Full-Scale Tests

Construction of Major Components

Example, Leg – Simple flat plate pattern based on common designs



Actual forged component, costly to manufacture

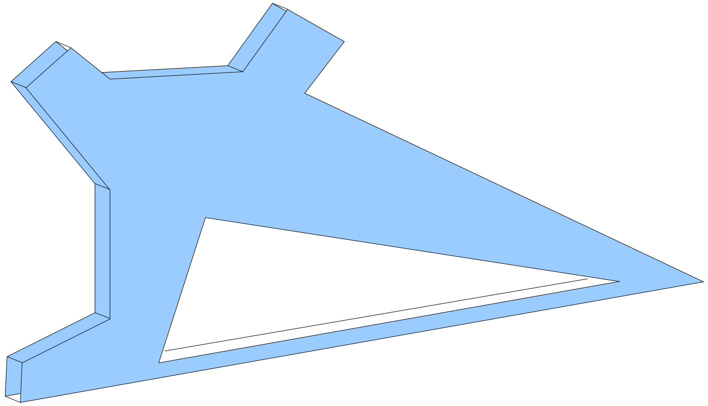


Representative component cut from flat sheet, less expensive to manufacture

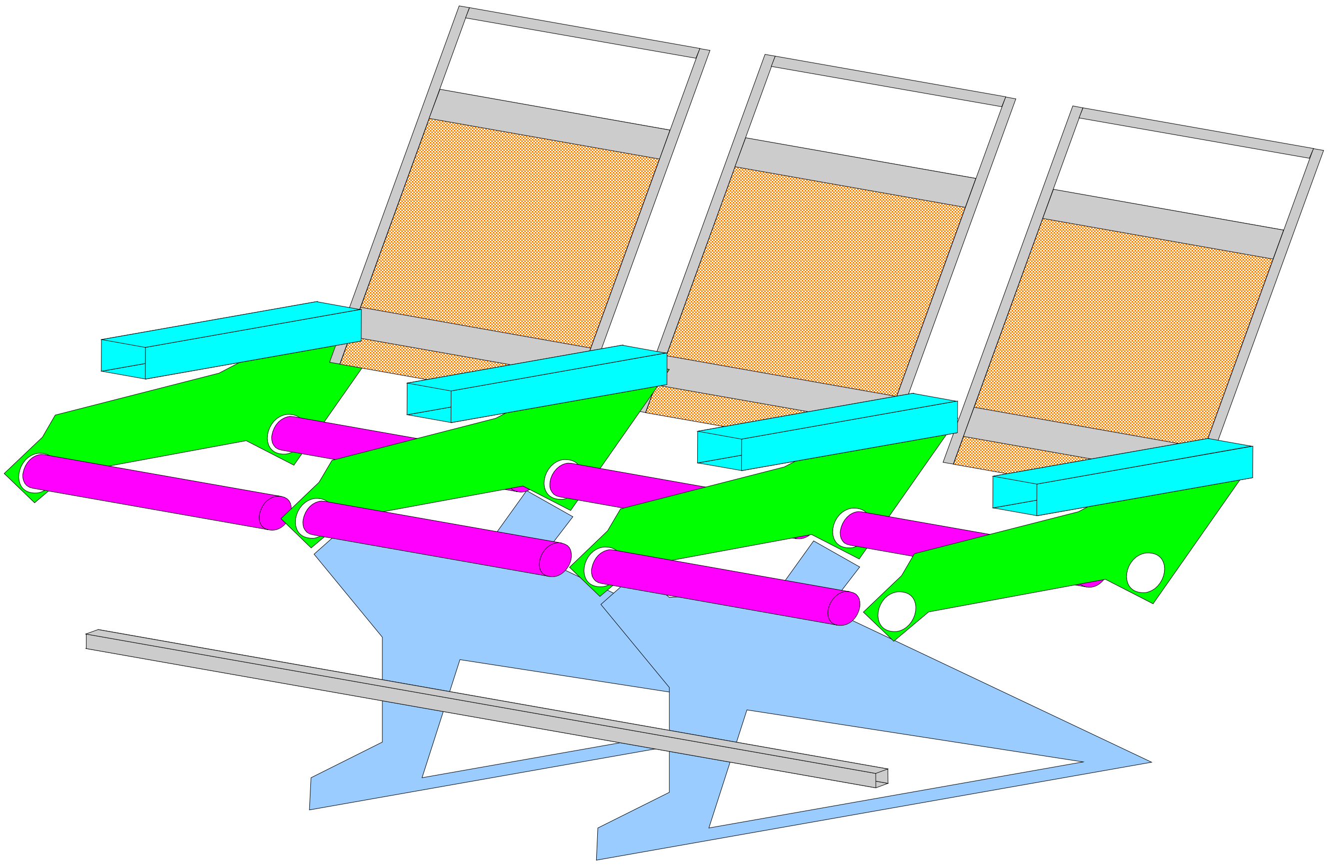
Proposed Mock-Up Seat for Full-Scale Tests

Construction of Major Components

Example, Leg – Simple flat plate pattern based on common designs



Proposed Mock-Up Seat for Full-Scale Tests



Interim Task Group Meeting @ FAATC

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

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

Consensus was that full-scale tests are obvious next step

New proposal to use an actual aircraft seat in full-scale testing

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 all components

Interim Task Group Meeting @ FAATC

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

Certification based on material type?

Interaction of other materials (feedback)

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

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

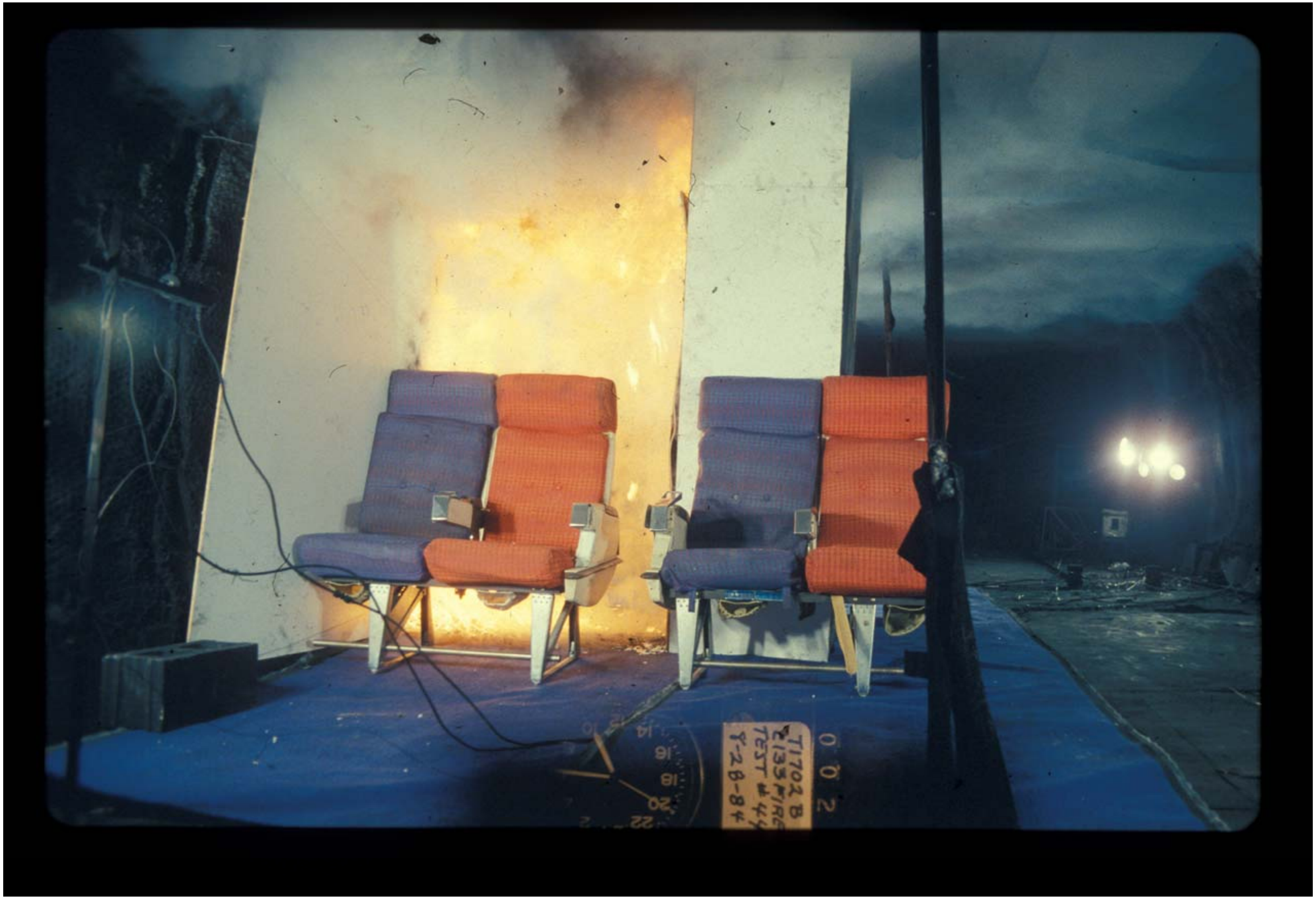
Propose AZ31 for poor performer, WE43 for good performer

Baseline test could be performed by June 2008

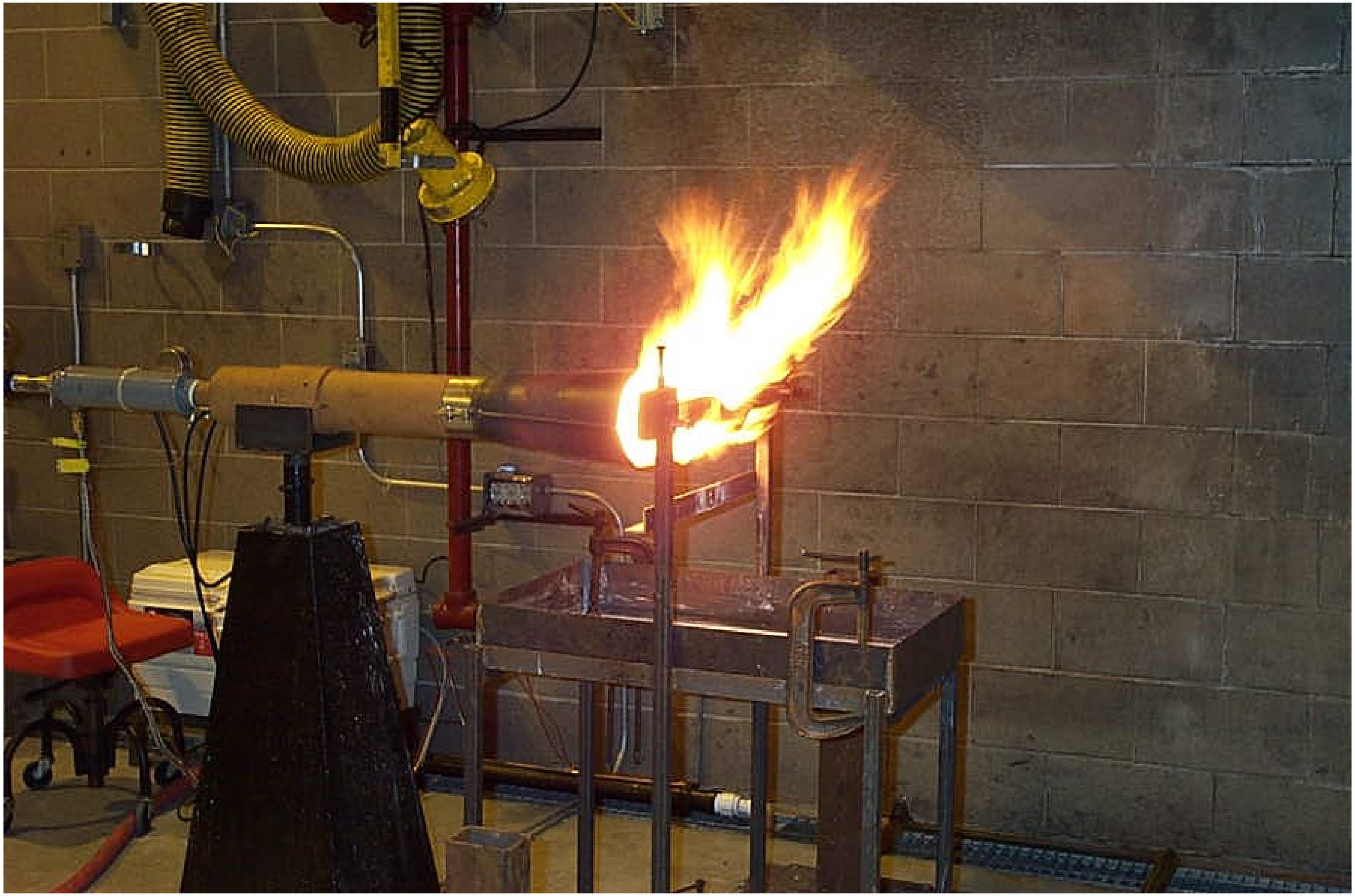
Future Considerations

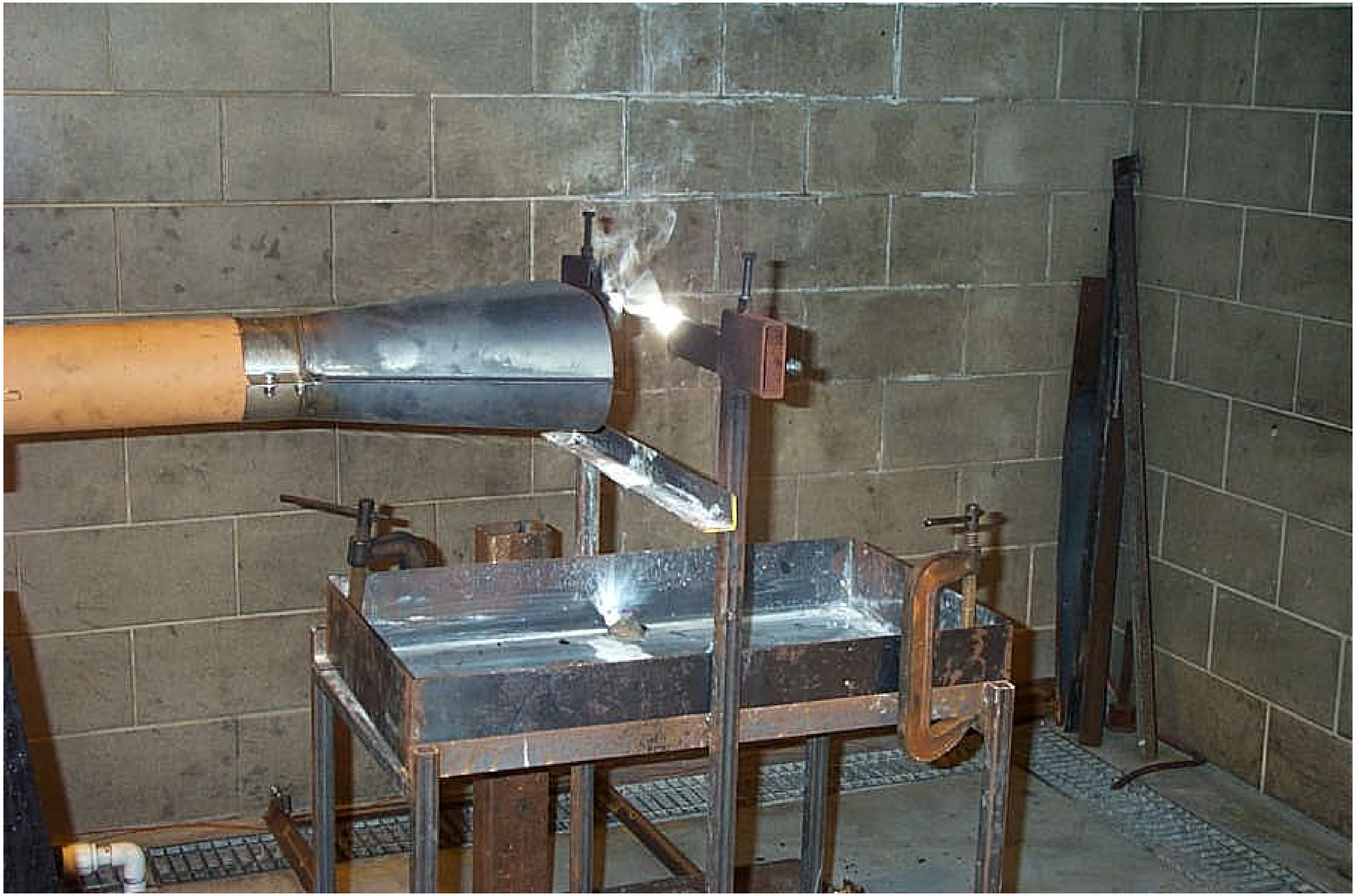
All full-scale test results would help define an appropriate lab-scale test method or methods, which is the primary goal of the research.

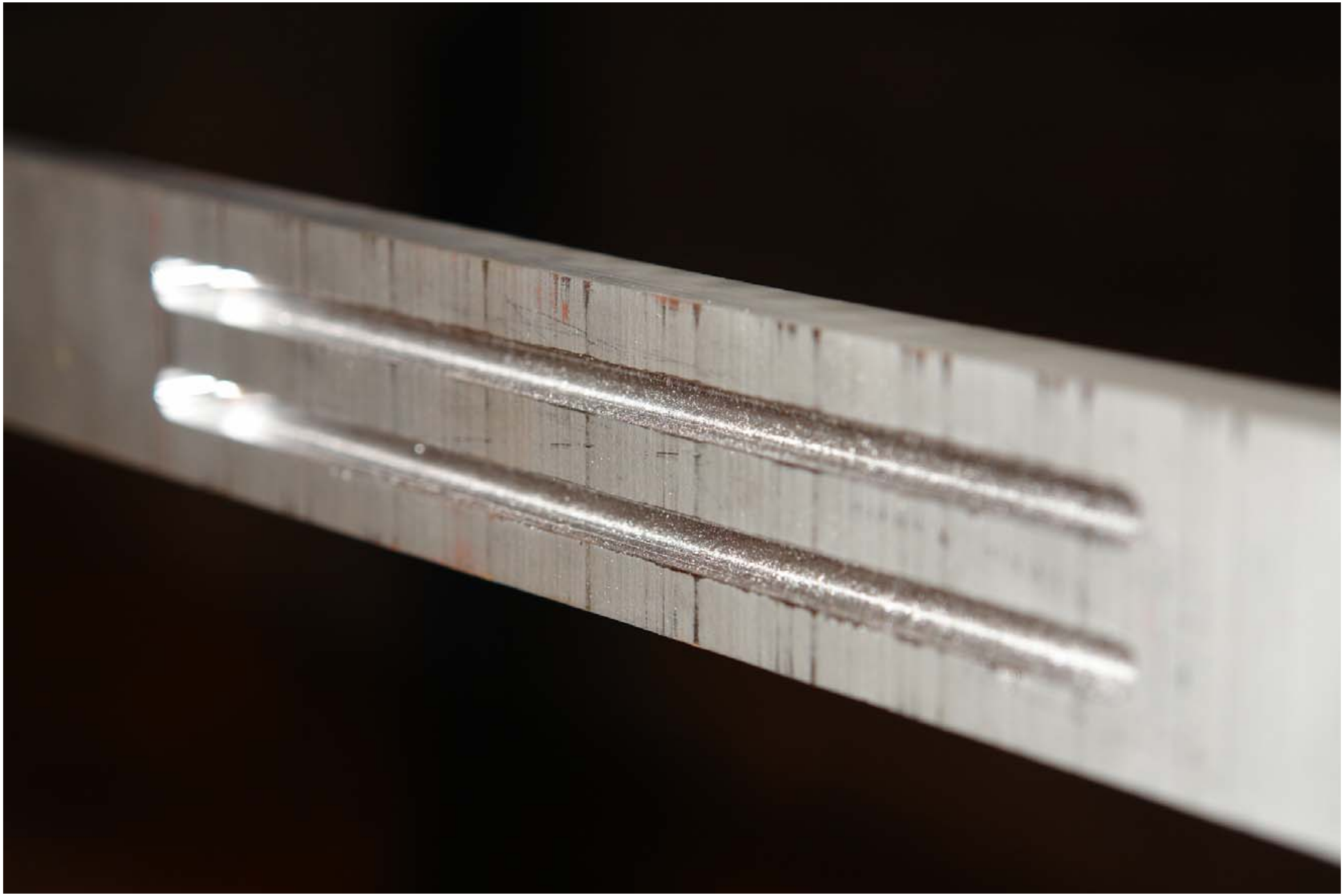
Manufacturer's perspective necessary to determine value of developing new test methodology.



Additional Small-Scale Flammability Testing of Mag Alloy Samples





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