5th Triennial International Fire and Cabin Safety Research Conference

The Use of Magnesium in Aircraft Interiors

Presented to: Session on Materials Fire Safety

By: Tim Marker, FAA Technical Center

Date: October 31, 2007

Use of Magnesium in Airplane Cabins

The FAA has had several recent inquiries regarding the use of magnesium in airplane cabins. Specifically, magnesium alloys have been suggested as substitute for aluminum alloys in seat structure. The FAA's central concern regarding the use of magnesium in the cabin is flammability. The current regulations do not address the potential for a flammable metal to be used in large quantities in the cabin. Therefore, if such a material were introduced to the cabin, the FAA would have to be convinced that the level of safety was not reduced. Special conditions may be required to establish appropriate criteria. While the FAA are aware that there have been changes in magnesium alloys over the years, magnesium remains a material that, once ignited, presents a fire hazard that is almost impossible to cope with. If there is widespread interest in assessing the potential requirements and data necessary to demonstrate that the level of safety is not reduced, the FAA will work with industry to do that. Both the post crash, as well as inflight, fire scenarios should be addressed. ~~At this point, the FAA does not have any research underway to address the use of magnesium in the cabin.~~

Magnesium Use in Aircraft Interiors

Possible Locations of Magnesium Use

seat components

overhead ducts

floor components, seat track

~~galley components~~

~~lavatory components~~

Magnesium Use in Aircraft Interiors

Potential Threats from Using Magnesium in Cabin

In-Flight

Electrical arc to magnesium component

Hidden fire adjacent to magnesium component

O_2 canister fire next to magnesium component

Intact components, or shavings?

Consider terroristic threat?

Magnesium Use in Aircraft Interiors

Potential Threats from Using Magnesium in Cabin

Postcrash

External fuel fire entering cabin

Primary concern – safety of passengers

Secondary concern – safety of firefighters?

Magnesium Use in Aircraft Interiors

How do we develop an appropriate test method?

Clearly define the threat(s)

Correlate with results of Full-scale testing

Develop appropriate Lab-scale test

Magnesium Use in Aircraft Interiors

Development of an appropriate Lab-Scale Test

In-Flight Test Considerations:

Electrical arc or combination radiant/small ignition source?

Size, power, of electrical arc?

Size, shape of test sample?

Pass/Fail criteria?

Magnesium Use in Aircraft Interiors

Development of an appropriate Lab-Scale Test

Postcrash Test Considerations:

Oil burner apparatus, what heat flux?

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

Size, shape of test sample?

Pass/Fail criteria?

Magnesium Use in Aircraft Interiors

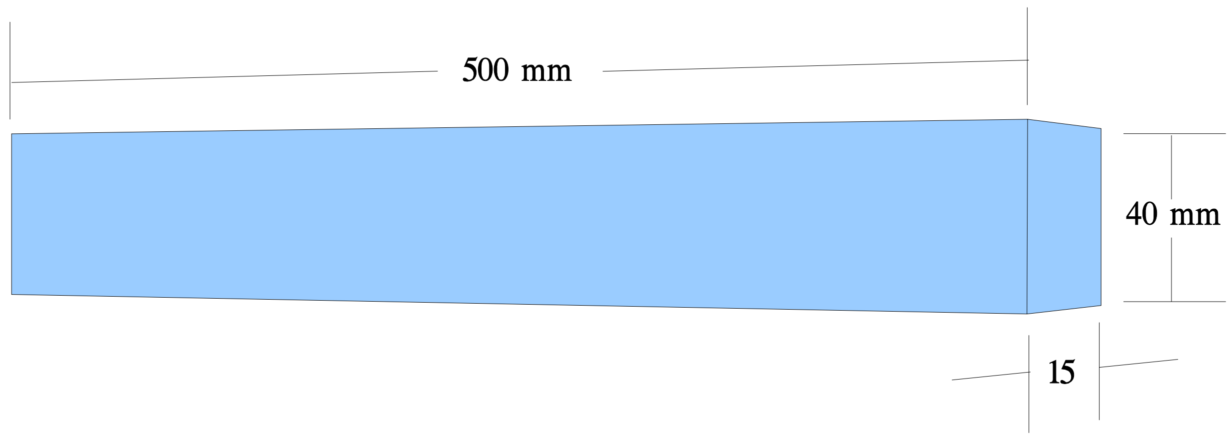
Summary of Task Group Discussion from March Meeting:

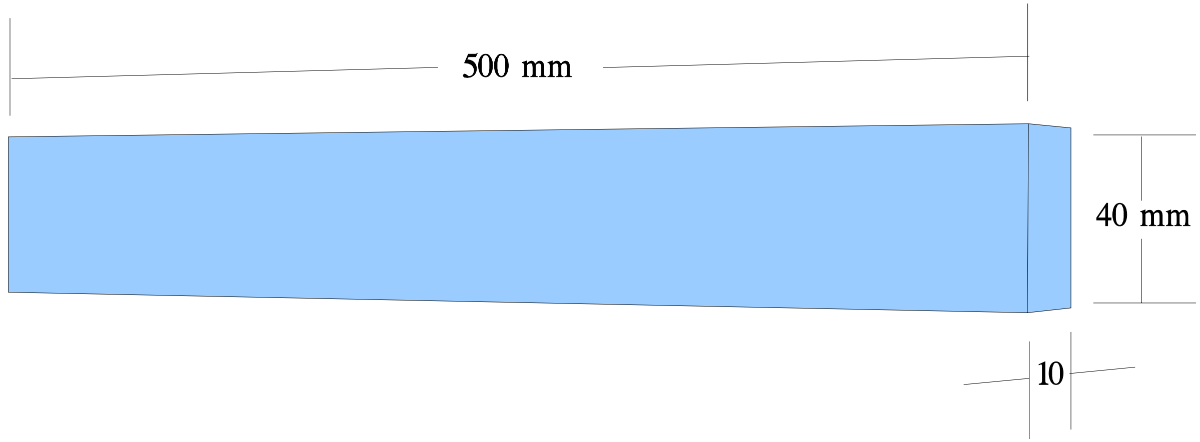
- FAATC agrees to run preliminary tests on magnesium bar, to provide initial characterization of flammability of various magnesium alloys

- Tests to utilize oil burner from existing seat cushion flammability test

- Informal program, with samples provided by Magnesium Elektron

Initial Magnesium Flammability Testing





Magnesium Alloy Samples Evaluated*

AZ31 – Most commonly used wrought magnesium, usually as plate or sheet

AZ80 – Extruded alloy, composition overlaps that of the most commonly used Magnesium High Pressure Die Casting (HPDC) alloy AZ91

ZE41 – Most commonly used magnesium-zirconium sand cast alloy

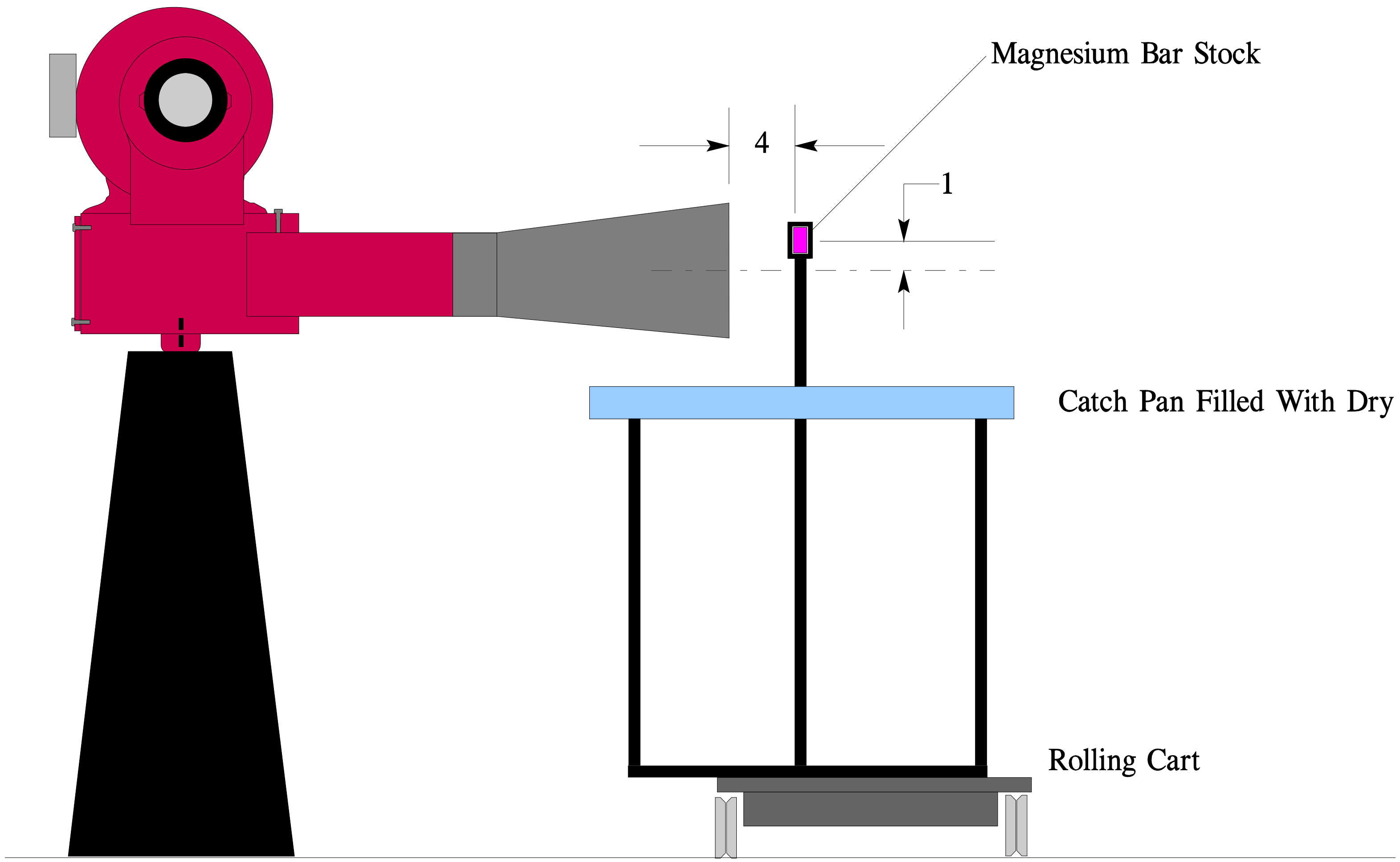
ZE10 – Sheet alloy with good formability. Low alloy content provides high melting point

WE43 – Sand cast and wrought alloy known to have good resistance to flammability

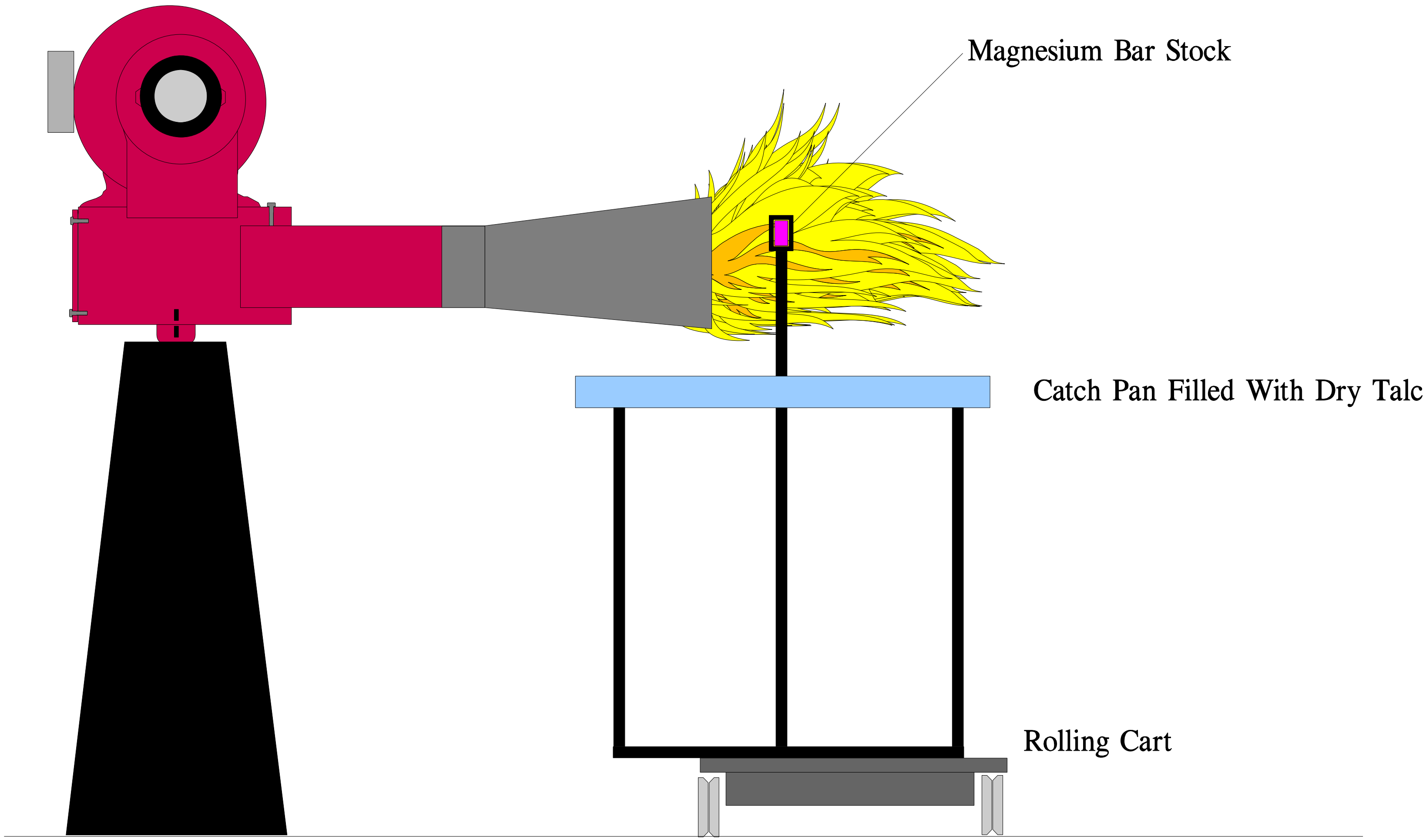
Elektron 21 – Sand casting alloy with good resistance to flammability

*alloy sample definitions provided by Magnesium Elektron

Initial Postcrash Test Configuration

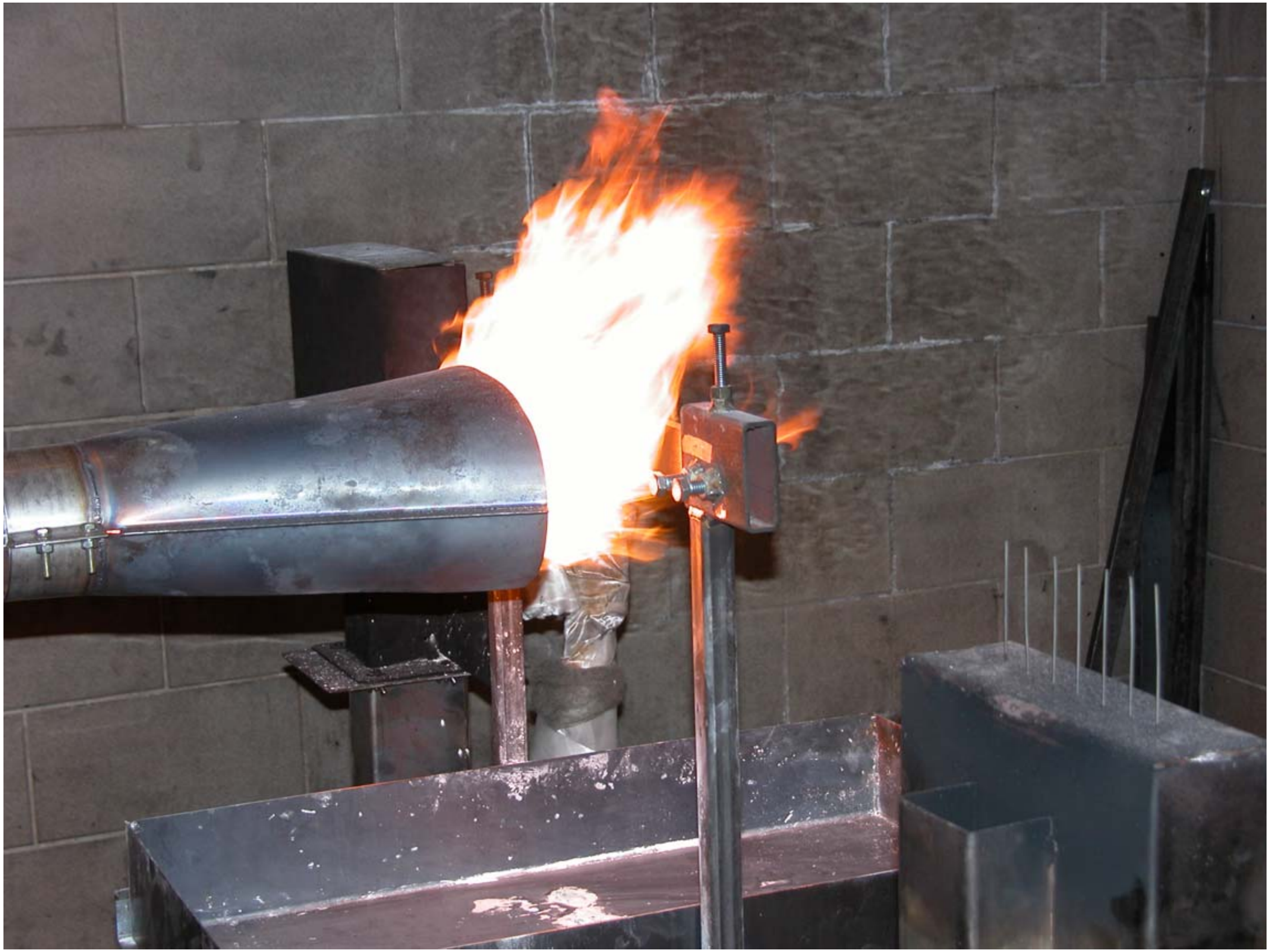


Initial Postcrash Test Configuration



Initial Postcrash Test Configuration

Initial Postcrash Test Configuration



Initial Postcrash Test Configuration

*photo provided by
Magnesium Elektron

Magnesium Bar Pre-Melt

*photo provided by
Magnesium Elektron

Magnesium Bar Melting

*photo provided by
Magnesium Elektron

Magnesium Burning After Burner Shut Off

*photo provided by
Magnesium Elektron

Molten Mag Sample After Burner Shut Off

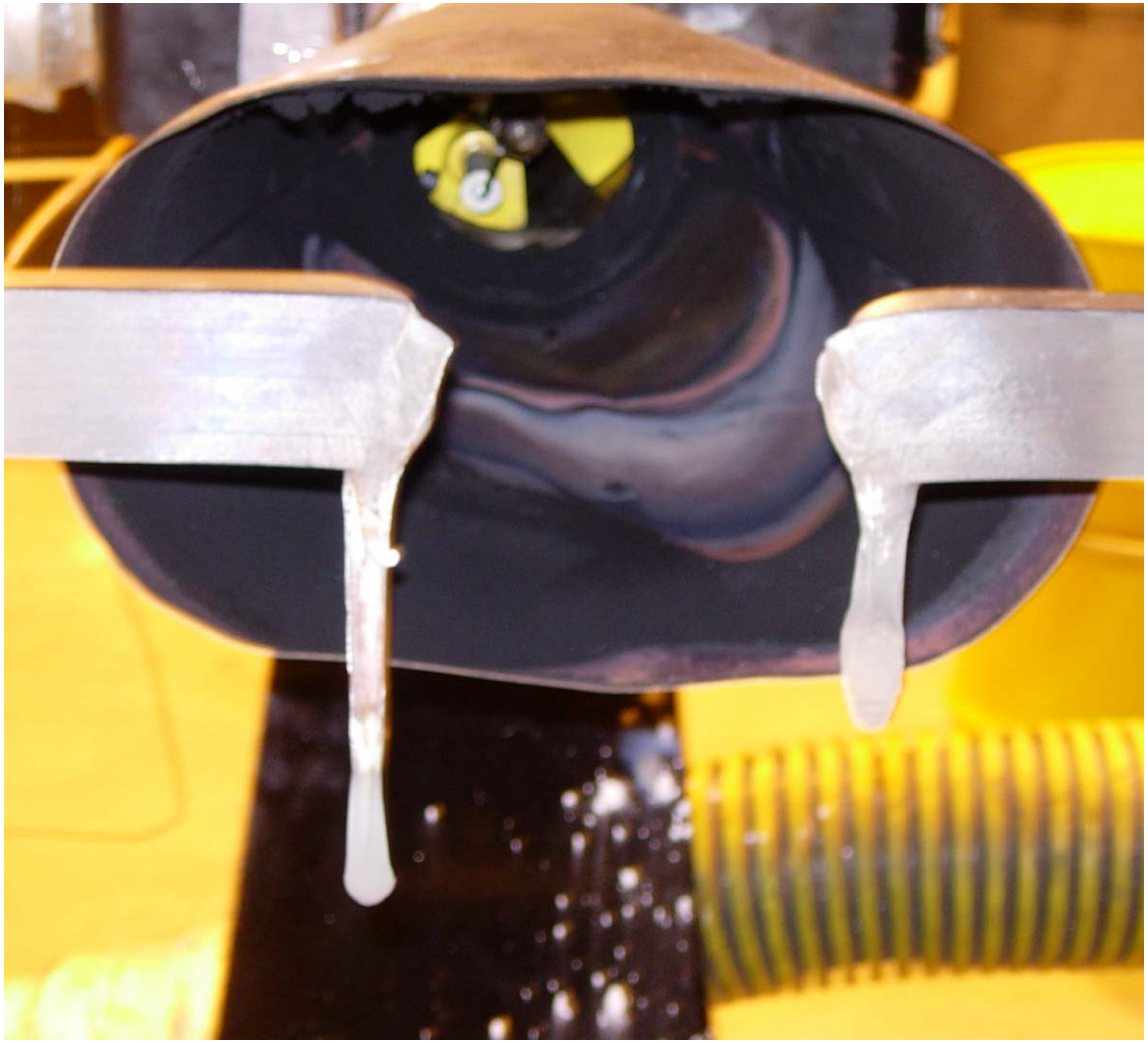
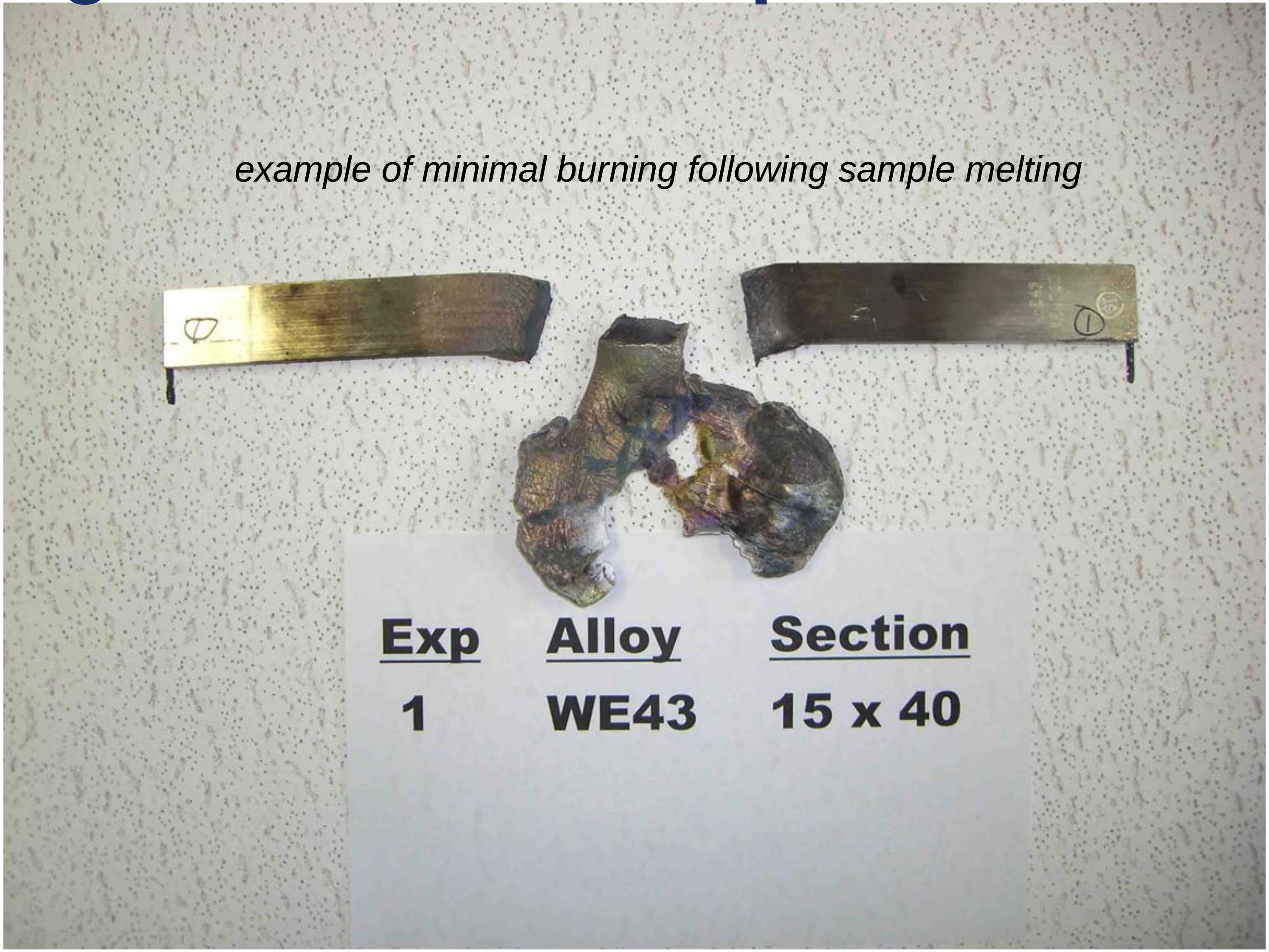


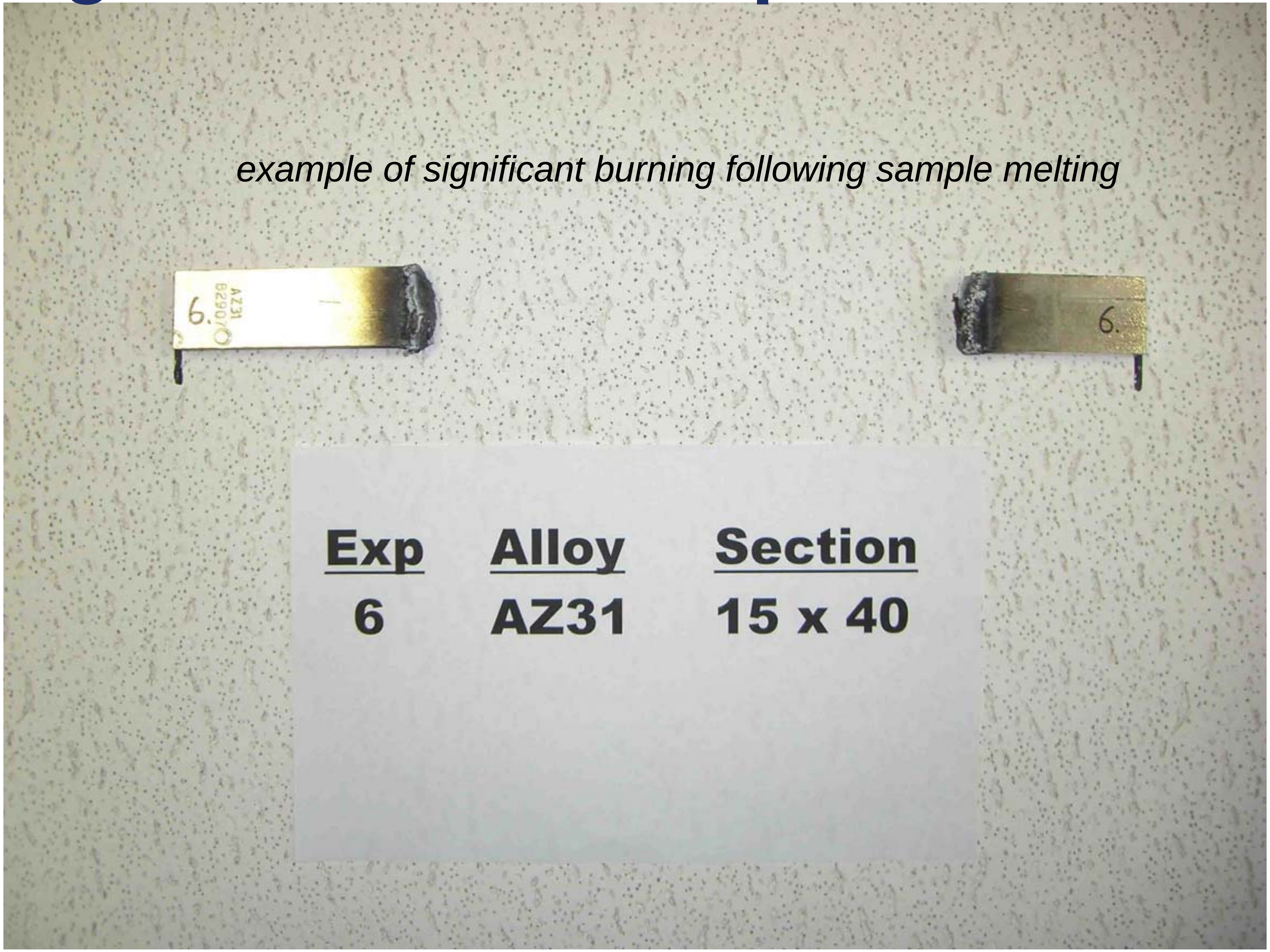
*photo provided by
Magnesium Elektron

Magnesium Bar Samples Post-Test

Magnesium Bar Samples Post-Test



Magnesium Bar Samples Post-Test



Magnesium Bar Sample Test Results

FAR 25 Appendix F Part 2 - Seat cushion flamability test - Imperial Version

Test No.	Alloy	Width	Thickness	Length	Flame On	Sample melted		Sample Continued to Burn	Sample Self Extinguished		Residue Burning	Comments
		Inches	Inches	Inches	Minutes	Mins	Secs		Mins	Secs		
1	WE43	0.6	1.6	19.7	4	3	45	**No**	n/a	n/a	**No**	
2	AZ80	0.6	1.6	19.7	3 1/2	3	7	Yes	9	21	Yes	
3	Elektron 21	0.6	1.6	19.7	5	3	47	Yes	6	7	**No**	
4	ZE41	0.6	1.5	19.7	4	3	6	Yes	5	45	**No**	
5	ZE10	0.6	1.6	19.7	4	3	35	Yes	7	29	Yes	
6	AZ31	0.5	1.6	19.7	4	3	19	Yes	Kept burning		Yes	
7	WE43	0.6	1.6	19.7	5	3	35	**No**	n/a	n/a	**No**	
8	Elektron 21	0.6	1.6	19.7	4	3	35	**No**	n/a	n/a	**No**	
9	AZ80	0.6	1.6	19.7	5	3	0	Yes	6	15	Yes	
10	AZ31	0.6	1.6	19.7	5	3	1	Yes	6	12	Yes	
11	WE43	0.4	1.6	19.7	4	2	26	Yes	6	12	Yes	
12	Elektron 21	0.4	1.6	19.7	4	2	8	Yes	6	8	**No**	
13	WE43	0.4	1.6	19.7	4	2	30	Yes	5	43	**No**	
14	AZ80	0.4	1.6	19.7	4	2	9	Yes	8	10	yes	
15	AZ80	0.4	1.6	19.7	3	1	58	Yes	5	0	Yes	
16	Elektron 21	0.4	1.6	19.7	3	2	12	Yes	4	8	**No**	
17	WE43	~0.4	~1.6	19.7	11 3/4	10	37	Yes	13	42	**No**	Intumescent paint coating
18	ZE41	0.6	1.6	19.7	5	3	51	Yes	6	31		90 degrees to vertical
19	ZE10	0.6	1.6	19.7	4	No melting		n/a	n/a		n/a	90 degrees to vertical
20	AZ31	0.4	1.6	19.7	4	3	37	Yes	>10	Kept burning		Bar orientation vertical

* Bare bar thickness could not be measured but was cut to nominal 0.4"

Magnesium Bar Sample Test Results

FAR 25 Appendix F Part 2 - Seat cushion flamability test - Imperial Version

Test No.	Alloy	Width	Thickness	Length	Flame On	Sample melted		Sample Continued to Burn	Sample Self Extinguished		Residue Burning	Comments
		Inches	Inches	Inches	Minutes	Mins	Secs		Mins	Secs		
1	WE43	0.6	1.6	19.7	4	3	45	**No**	n/a	n/a	**No**	
2	AZ80	0.6	1.6	19.7	3 1/2	3	7	Yes	9	21	Yes	
3	Elektron 21	0.6	1.6	19.7	5	3	47	Yes	6	7	**No**	
4	ZE41	0.6	1.5	19.7	4	3	6	Yes	5	45	**No**	
5	ZE10	0.6	1.6	19.7	4	3	35	Yes	7	29	Yes	
6	AZ31	0.5	1.6	19.7	4	3	19	Yes	Kept burning		Yes	
7	WE43	0.6	1.6	19.7	5	3	35	**No**	n/a	n/a	**No**	
8	Elektron 21	0.6	1.6	19.7	4	3	35	**No**	n/a	n/a	**No**	
9	AZ80	0.6	1.6	19.7	5	3	0	Yes	6	15	Yes	
10	AZ31	0.6	1.6	19.7	5	3	1	Yes	6	12	Yes	
11	WE43	0.4	1.6	19.7	4	2	26	Yes	6	12	Yes	
12	Elektron 21	0.4	1.6	19.7	4	2	8	Yes	6	8	**No**	
13	WE43	0.4	1.6	19.7	4	2	30	Yes	5	43	**No**	
14	AZ80	0.4	1.6	19.7	4	2	9	Yes	8	10	yes	
15	AZ80	0.4	1.6	19.7	3	1	58	Yes	5	0	Yes	
16	Elektron 21	0.4	1.6	19.7	3	2	12	Yes	4	8	**No**	
17	WE43	~0.4	~1.6	19.7	11 3/4	10	37	Yes	13	42	**No**	Intumescent paint coating
18	ZE41	0.6	1.6	19.7	5	3	51	Yes	6	31		90 degrees to vertical
19	ZE10	0.6	1.6	19.7	4	No melting		n/a	n/a		n/a	90 degrees to vertical
20	AZ31	0.4	1.6	19.7	4	3	37	Yes	>10	Kept burning		Bar orientation vertical

* Bare bar thickness could not be measured but was cut to nominal 0.4"

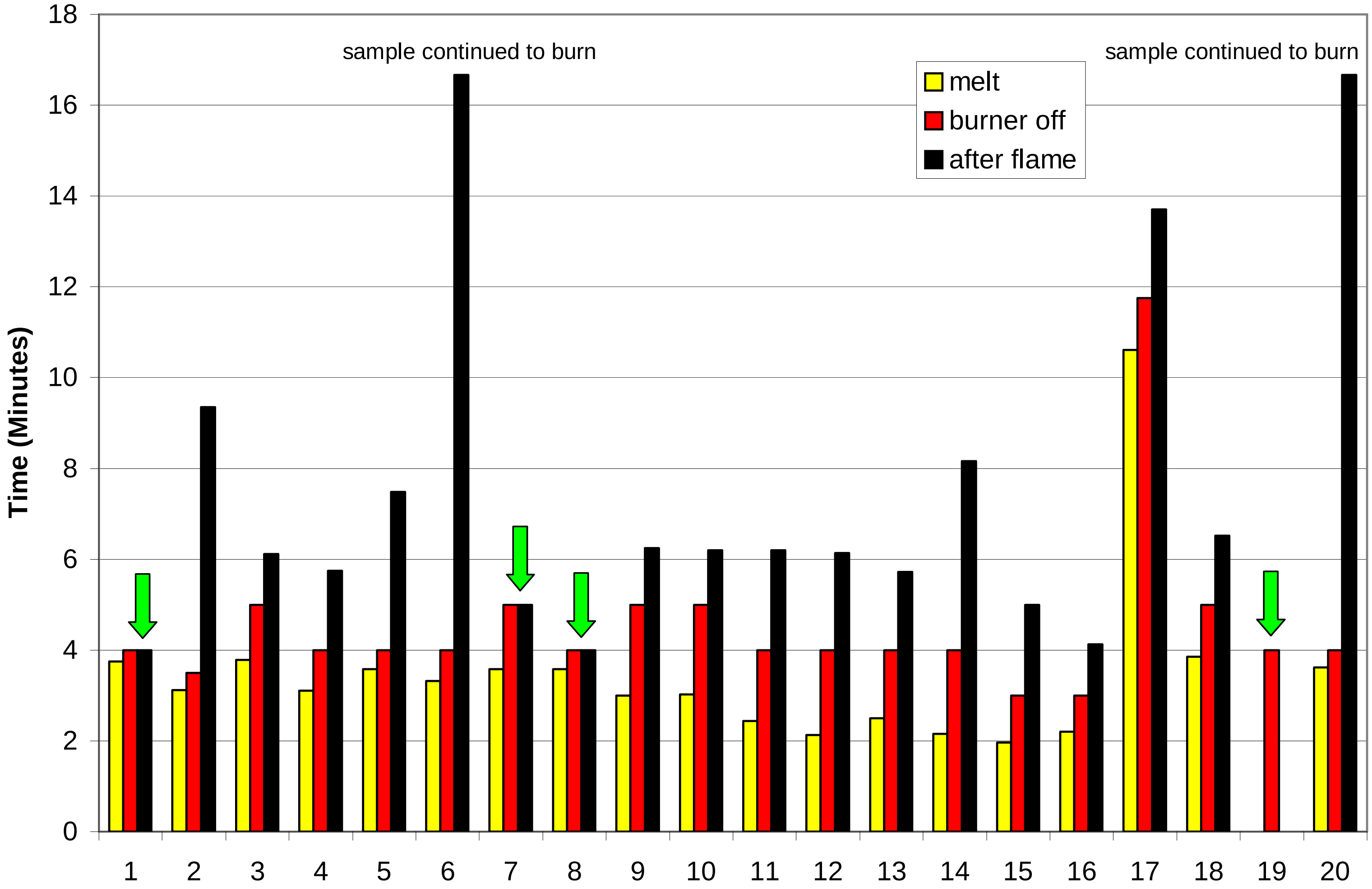
Video Clip of Good Performing Material

Video Deleted

Video Clip of Poor Performing Material

Video Deleted

Magnesium Alloy Test Results



Summary of Burner Test Results

None of the magnesium bar samples melted prior to 2 minutes

Extending exposure time beyond 2 min caused melting and ignition

80% of samples (16 of 20) continued to burn after burner flame removed

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

WE43 and Elektron 21 more ignition resistant than other alloys tested

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

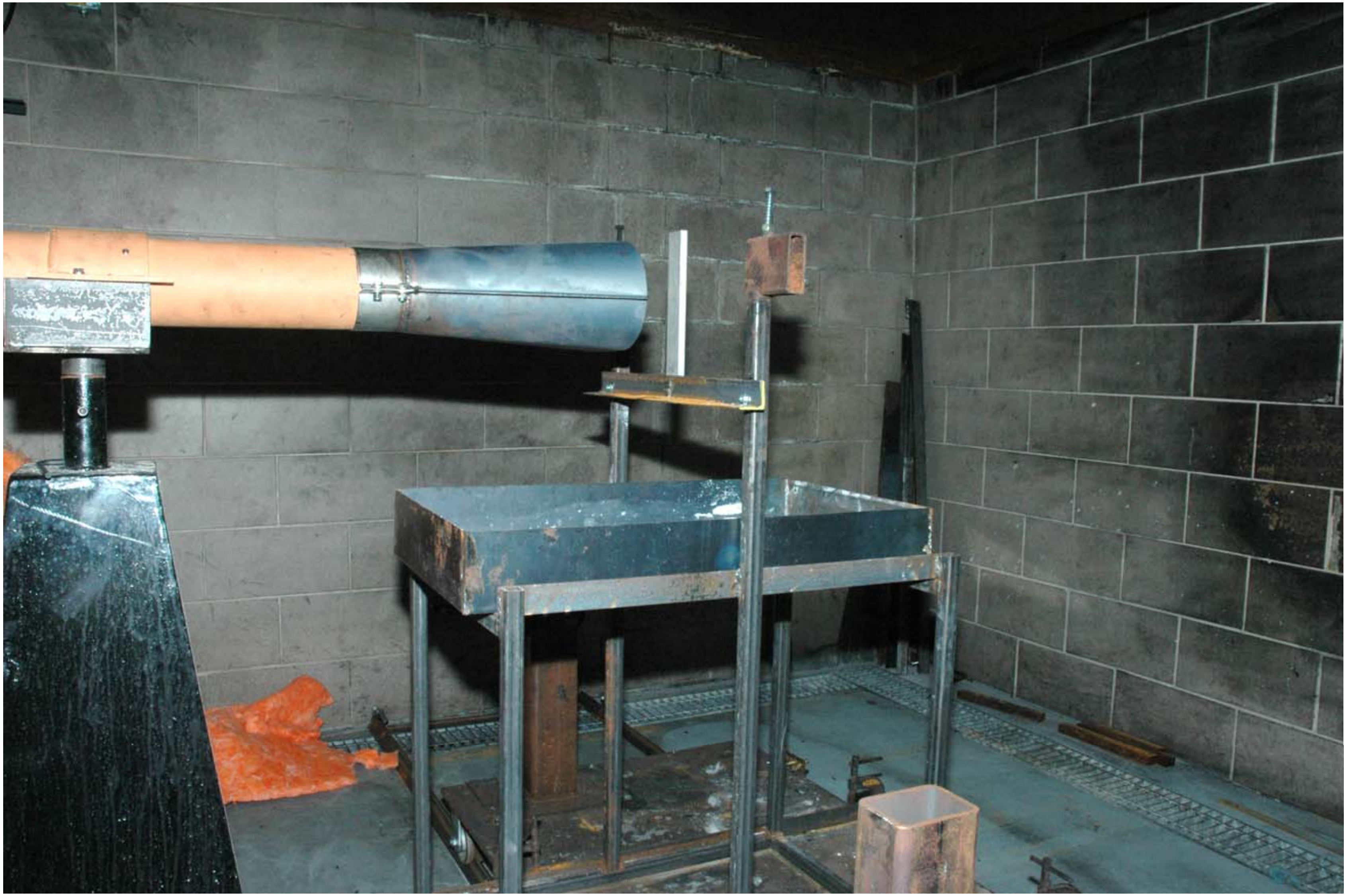
Time to reach melting

Ignition following melting (y/n)?

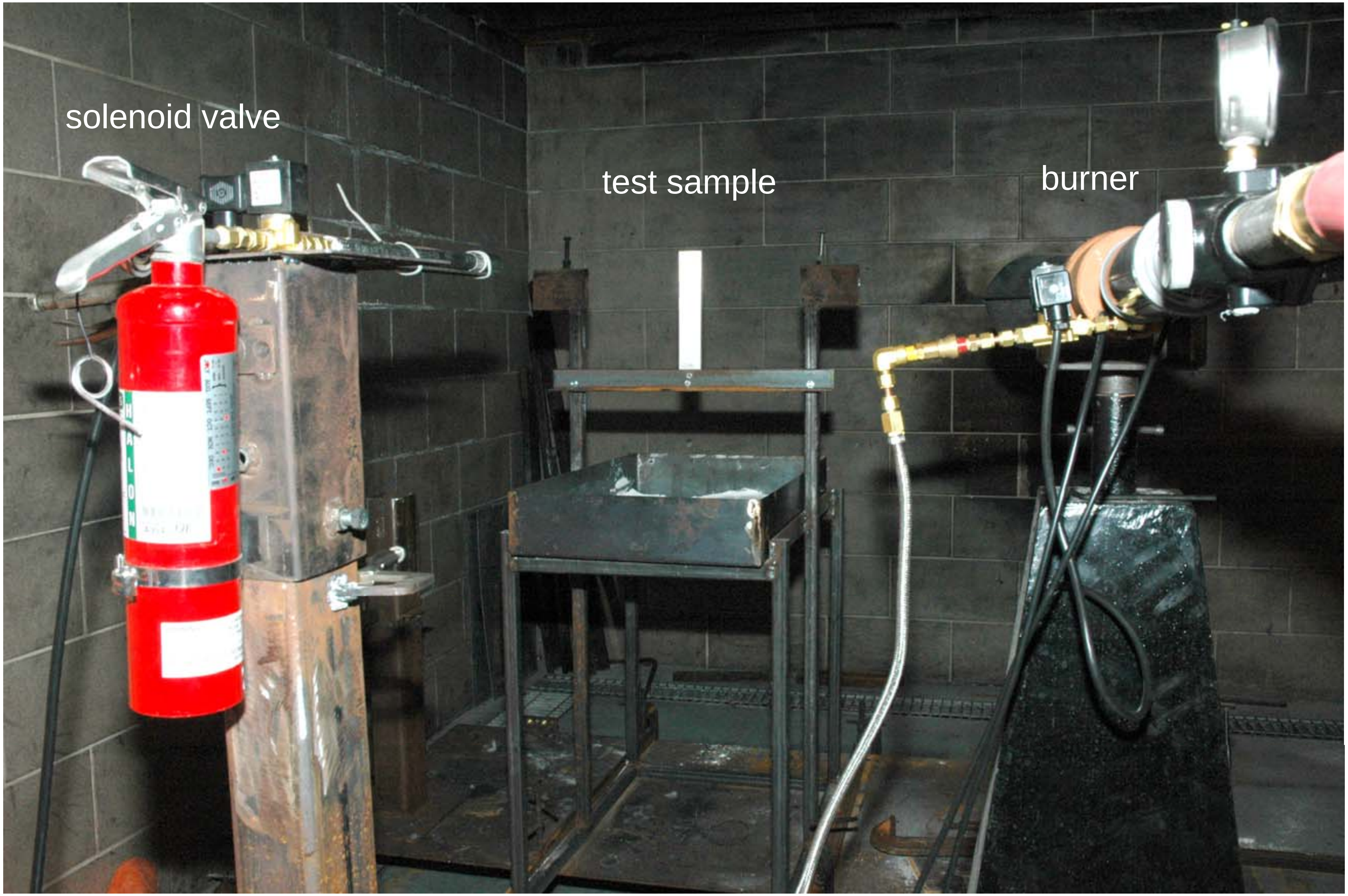
Duration of after-flame following ignition

Handheld Extinguisher Testing of Mag Alloy Samples

Handheld Extinguisher Testing of Mag Alloy Samples



Handheld Extinguisher Testing of Mag Alloy Samples



Handheld Extinguisher Testing of Mag Alloy Samples

Handheld Extinguisher Testing of Mag Alloy Samples

Handheld Extinguisher Testing of Mag Alloy Samples

Handheld Extinguisher Testing of Mag Alloy Samples

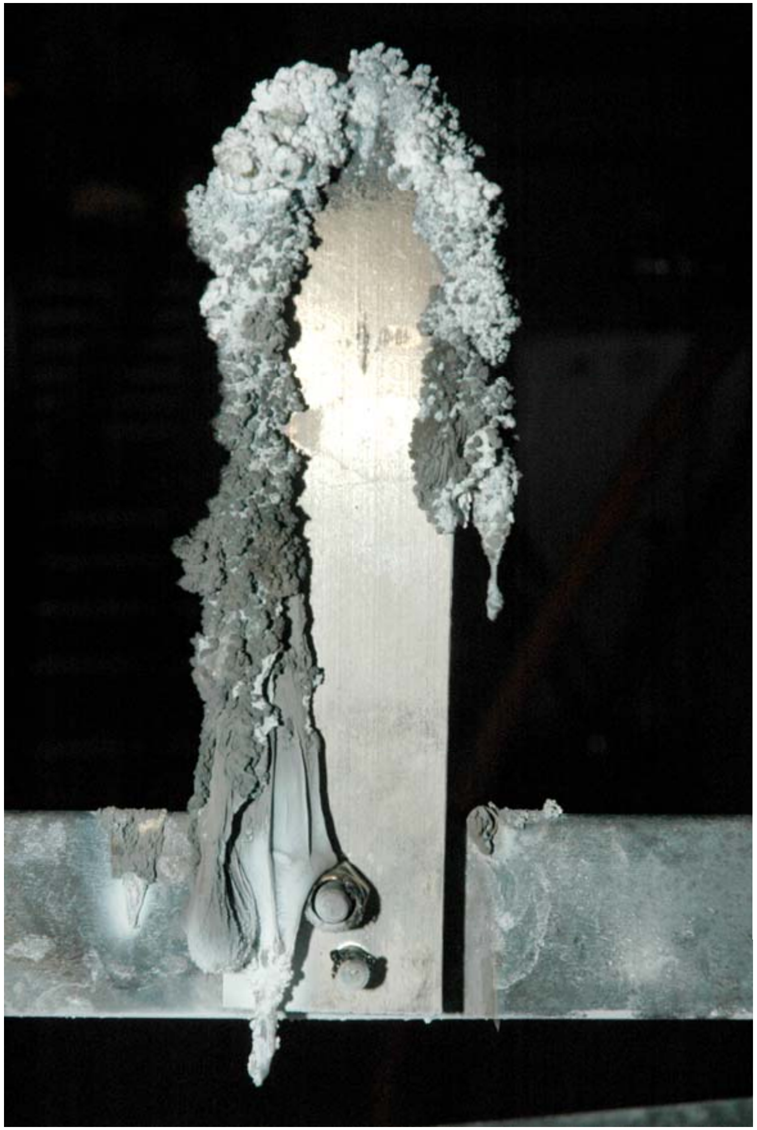
Handheld Extinguisher Testing of Mag Alloy Samples

Handheld Extinguisher Testing of Mag Alloy Samples

Handheld Extinguisher Testing of Mag Alloy Samples

Handheld Extinguisher Testing of Mag Alloy Samples

Handheld Extinguisher Testing of Mag Alloy Samples



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

Future Considerations

Full-Scale Postcrash FireTesting

- 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 at all 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)

Future Considerations

Full-Scale In-flight Fire Testing (hidden areas)

Baseline using flaming-block-of-foam adjacent to aluminum ductwork above cabin ceiling

Substitute poor-performing mag-alloy ducting for aluminum ductwork

Substitute good-performing mag-alloy ducting for aluminum ductwork

Determine differences in various materials, if any

Lab-Scale Test Development

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

Future Considerations

Full-Scale In-flight Extinguisher Testing on Seats

Baseline using accelerant on FB seat w/OEM aluminum frame inside cabin

Toxicity measurements taken inside cabin?

Substitute poor-performing mag-alloy for aluminum OEM frame

Substitute good-performing mag-alloy for aluminum OEM frame

Determine differences in various materials, if any

How do we ignite mag-ally without "unrealistic" fire source??

How do we ignite mag-ally without "unrealistic" fire source??

How do we ignite mag-ally without "unrealistic" fire source??

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.