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

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

Magnesium Bar Stock

Catch Pan Filled With Dry Talc

Rolling Cart
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

- **Melt**
- **Burner Off**
- **After Flame**

Sample continued to burn in samples 14, 16, and 18.

Time (Minutes)
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
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Halon 1211 discharge
Handheld Extinguisher Testing of Mag Alloy Samples
Handheld Extinguisher Testing of Mag Alloy Samples

burning mag alloy removed from talc
Handheld Extinguisher Testing of Mag Alloy Samples

burning mag alloy sprayed with 1211
Handheld Extinguisher Testing of Mag Alloy Samples

burning mag alloy sprayed with water
Handheld Extinguisher Testing of Mag Alloy Samples

burning mag alloy sprayed with FE-36 (HFC-236fa)
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

- Spreader Bars
- Back-Pan
- Arm-Rest
- Cross-tube
- Baggage-Bar
- Bottom Pan
- Seat Leg
Initial Planned Testing at FAA Tech Center

*Full-Scale Postcrash Fire Testing 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 all 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
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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

- FTIR Gas Analysis
- Continuous Gas Analysis
- Temperature
- Heat Flux
- Video Camera
- Smoke Meter

Heated Sampling Line
Temperature Control Line

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Seat Configuration & Location
Procurement of Seats for Full-Scale Testing
B/E Aerospace “990” Seats
B/E Aerospace “990” Seats
B/E Aerospace “990” Seats
B/E Aerospace “990” Seats
B/E Aerospace “990” Seats
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.