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: Potential Use Locations
Use of Magnesium in Airplane Cabins—Updated 10/07

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, as well as other applications, due to the potential for weight savings.

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. Different magnesium alloys have different susceptibility to ignition, however, magnesium remains a material that, once ignited, is very challenging to cope with using fire extinguishers currently available on aircraft.

The use of magnesium is currently the subject of a task group of the International Aircraft Materials Fire Test Working Group. Depending on the outcome of the task group’s work, the FAA may support additional research in this area, to the extent industry can supply materials. This would likely include full-scale testing should the initial assessments suggest there is some potential for acceptable installations. Both the post crash, as well as in-flight, fire scenarios need to be addressed.
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
Initial Oil Burner Testing of Mag Alloy

*photo provided by Magnesium Elektron*
Handheld Extinguisher Testing of Mag Alloy Samples

- solenoid valve
- test sample
- burner
Handheld Extinguisher Testing of Mag Alloy Samples

Halon 1211 discharge
Handheld Extinguisher Testing of Mag Alloy Samples

burning mag alloy sprayed with 1211
Additional Lab-Scale Flammability Testing of Mag Alloy Samples
Flammability of turnings from lathe

Burning mag-alloy turnings
Ignition of thin slice of mag-alloy
Burner test of sample with modified cross section
Ignition of sample with modified cross section
Magnesium Alloy Flammability

- Preliminary lab scale oil burner testing
- Handheld extinguisher testing
- Additional lab-scale flammability experimentation
- Identify 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

Update on Flammability Testing of Magnesium Alloy Components
October 21, 2008
Proposed Mag-Alloy Testing at FAA Tech Center

Conduct 4 full-scale tests, postcrash fire scenario

Baseline using OEM aluminum frames, FB seat cushions
Substitute poor-performing mag alloy in primary structural components
Substitute good-performing mag alloy in primary structural components
Substitute good-performing mag alloy in all structural components

Expected Outcomes

Determine if any additional hazard results
Determine if any difference exists between mag alloys
Procurement of Seats for Full-Scale Testing
B/E Aerospace “990” Seats
B/E Aerospace “990” Seats
Seats Fully Dressed, Ready for Testing
Full Scale Testing Update
Test Rig Being Prepared
Test Rig Being Prepared
Full-Scale Test Apparatus

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

Heated Sampling Line
Temperature Control Line
Seat Configuration & Location

= Thermocouples in Seat Frames
Full-Scale Test Apparatus
Full-Scale Test Apparatus
Full-Scale Test Apparatus
Full-Scale Test Apparatus
Full-Scale Test Apparatus
Full-Scale Test Apparatus
Full-Scale Test Apparatus
Full-Scale Test Apparatus
Forward Cabin Temperatures

Temperature (°F) vs Time (Seconds)

- FWD Tree 1'
- FWD Tree 2'
- FWD Tree 3'
- FWD Tree 4'
- FWD Tree 5'
- FWD Tree 6'
- FWD Tree 7'

Temperature and time data for various forward cabin trees is shown in the graph.
Mid Cabin Temperatures

Time (Seconds)

Temperature (°F)

MID Tree 1'
MID Tree 2'
MID Tree 3'
MID Tree 4'
MID Tree 5'
MID Tree 6'
MID Tree 7'

Update on Flammability Testing of Magnesium Alloy Components
October 21, 2008
Mid Smoke Levels

Light Transmission (%)

Time (Seconds)

- MID Smoke Top
- MID Smoke Middle
- MID Smoke Bottom
Update on Flammability Testing of Magnesium Alloy Components

October 21, 2008

Carbon Dioxide Levels

<table>
<thead>
<tr>
<th>Time (Seconds)</th>
<th>CO2 Mid 5'6&quot;</th>
<th>CO2 Mid 3'6&quot;</th>
<th>CO2 Fwd 5'6&quot;</th>
<th>CO2 Fwd 3'6&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>120</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>240</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>360</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>480</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Federal Aviation Administration

47 of 56
Oxygen Levels

- O2 Mid 5'6"
- O2 Mid 3'6"
- O2 Fwd 5'6"
- O2 Fwd 3'6"

Time (Seconds)

Oxygen (%)

0 60 120 180 240 300 360 420

Update on Flammability Testing of Magnesium Alloy Components
October 21, 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.

Although post crash full-scale test results will help in determining the safe application of magnesium in seat frames, other scenarios and testing will also be used.

If magnesium alloys are determined safe for use in seat frames, a lab test/tests will be developed.
Next Steps

Conduct additional baseline test with zero wind condition

Determine which baseline result is appropriate

Continue with good-performing mag-alloy test using chosen condition

If good-performing mag-alloy results in elevated hazard level:

Terminate?

If good-performing mag-alloy does not result in elevated hazard level:

Proceed with test of poor-performing mag-alloy
Disassembly/Reassembly with Mag-Alloy Parts
Baseline Seat Test Conducted on Oct 7, 2008