AEROSPACE INFORMATION REPORT

AIR6160

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Magnesium Alloys in Aircraft Seats - Developments in Magnesium Alloy Flammability Testing

RATIONALE

This SAE Aerospace Information Report (AIR) is offered to support the use of magnesium alloys in aircraft seat applications by removal of the restrictive paragraph in AS8049B, paragraph 3.3.3, 'magnesium alloys shall not be used.'

INTRODUCTION

In the interest of reducing the weight of civil and commercial aircraft for fuel economy and environmental reasons, aircraft seat producers would like to take advantage of the potential weight reduction benefits of magnesium alloys in seat structures. Current SAE standards and related FAA requirements do not allow magnesium for use in aircraft seat construction. This restriction of magnesium is presumed to be related to flammability and the possibility of an increased hazard level in an inflight or post-crash fire situation. Flammability testing by the FAA and others has demonstrated that the hazard level is not increased when magnesium alloys with certain chemistries are employed in this application. In order to consider the removal of the restrictions contained in AS8049, this report is offered as documentation of these evaluations and conclusions.

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1. SCOPE

This document provides informational background, rationale and a technical case to allow consideration of the removal of the magnesium alloy restriction in aircraft seat construction as contained in AS8049B. The foundation of this argument is flammability characterization work performed by the FAA at the William J. Hughes Technical Center (FAATC), Fire Safety Branch in Atlantic City, New Jersey, USA. The rationale and detailed testing results are presented along with flammability reports that have concluded that the use of specific types of magnesium alloys in aircraft seat construction does not increase the hazard level potential in the passenger cabin in a post-crash fire scenario. Further, the FAA has developed a lab scale test method, reference DOT/FAA/TC-13/52, to be used as a certification test, or method of compliance (MOC) to allow acceptability of the use of magnesium in the governing TSO-C127 and TSO-C39C.

Other flammability studies are also cited in the AIR document to substantiate the FAA findings.

2. APPLICABLE DOCUMENTS

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AS8049B Performance Standard for Seats in Civil Rotorcraft, Transport Aircraft, and General Aviation Aircraft

2.2 Code of Federal Regulations (CFR) Publications

Available electronically from FAA Regulatory and Guidance Library, http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgWebcomponents.nsf/HomeFrame?OpenFrameSet

Code of Federal Regulations 14 CFR Part 23 Airworthiness Standards: Normal, Utility, and Acrobatic Category Airplanes

Code of Federal Regulations 14 CFR Part 25 Airworthiness Standards: Transport Category Airplanes

Code of Federal Regulations 14 CFR Part 27 Airworthiness Standards: Normal Category Rotorcraft

Code of Federal Regulations 14 CFR Part 29 Airworthiness Standards: Transport Category Rotorcraft

2.3 Department of Transportation, Technical Standard Order (TSO) Publications

Available electronically from FAA Regulatory and Guidance Library, http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgWebcomponents.nsf/HomeFrame?OpenFrameSet

TSO-C127a Rotorcraft, Transport Airplane and Normal and Utility Airplane Seating Systems

TSO-C39c 9g Transport Airplane Seats Certified by Static Testing

2.4 FAA Publications

Available from the Federal Aviation Administration, William J. Hughes Technical Center, ANG-E21, Atlantic City International Airport, NJ 08405 http://www.fire.tc.faa.gov/cabin.stm

Position Statement Use of Magnesium in Airplane Cabins—Updated 10/07 (cited in this document)

Position Statement Use of Magnesium in Airplane Cabins—Updated 8/12 (cited in this document)

Minutes International Aircraft Materials Fire Test Working Group, June 19-20, 2013 Possible Process for Certifying the Use of Magnesium in Seat Frame Construction (i.e., Application for Special Conditions)

DOT/FAA/AR-00/12 Aircraft Materials Fire Test Handbook http://www.fire.tc.faa.gov/handbook.stm Report: DOT/FAA/AR-11/3, Evaluating the Flammability of Various Magnesium Alloys During Laboratory- and Full-Scale Aircraft Fire Tests http://www.fire.tc.faa.gov/pdf/AR11-13.pdf

Report DOT/FAA/TC-13/52, Development of a Laboratory-Scale Test for Magnesium Alloys Used in Aircraft Seat Structure http://www.fire.tc.faa.gov/pdf/TC-13-52.pdf

2.5 The Mineral, Metals & Materials Society (TMS) Publications

Available for purchase from TMS, http://www.tms.org/TMSHome.aspx.

Paper Magnesim Technology 2004 - Ignition Resistance of Various Magnesium Alloys, Authors - Blandin, Grosjean, Suery Kumar,Mebarki

2.6 Magnesium Elektron Publications

Available by written request from Magnesium Elektron, Magnesium Technology Centre, Rake Lane, Manchester, M27 8BF England.

Magnesium Elektron Technical Report. MR10/DATA/475 Flammability Testing of Magnesium Alloys at FAATC, Atlantic City, NJ, USA, Author – Lyon.

3. MAGNESIUM IN AIRCRAFT SEATS

CFR references can be considered valid across aircraft categories: 14 CFR Parts 23, 25, 27 and 29.

3.1 Current Status

Magnesium alloys are currently not allowed in aircraft seat construction. The magnesium ban is contained in AS8049B, under the paragraph 3.3 Materials and Workmanship Requirements, paragraph 3.3.3: Magnesium alloys shall not be used. The certification requirements for aircraft seats are contained in the DOT/FAA TSO-C127 and TSO-C39 that makes extensive reference to AS8049 and invokes specific sections including the aforementioned 3.3.3.

Magnesium alloys have been used in the aerospace industry in many applications external to the passenger cabin. These include helicopter transmission housings, gas turbine engine frames, sumps, power take off transmission housings, constant speed drive, integrated drive, generator housings and various other power converting applications. Magnesium alloys are 2/3 the mass relative to aluminum alloys and pose an unprecedented opportunity for weight reduction.

However, the weight reduction possibilities of magnesium in passenger aircraft cabin interiors has been precluded due to concerns with flammability and the possible impact on passenger safety. The magnesium ban does not extend to the cockpit area where it is regularly used for flight control components such as steering yokes, control columns and rudder pedals. The aircraft interior industry is now challenged to provide light weight products and mass reduction savings in order to improve fuel consumption efficiency and reduced CO_2 emissions. In this environment and considering the proven performance of magnesium alloys in other transportation industries, the magnesium restrictive standards must be reviewed. Flammability characteristics of magnesium alloys are now being characterized to determine where the material can safely be used without increased risk to the passenger.

Industry has approached the governing groups responsible for the restrictions expressing a desire to use the metal in various seat and other passenger cabin applications. The magnesium prohibiting statement of AS8049 was reportedly included as a result of concerns over flammability. However, there is no record of the evidence on which this conclusion was based. The flammability issue is the subject of extensive studies by the FAA. Flammability testing results have shown that the perceived threat of increased fire ignition and propagation are far less than originally feared.

3.2 Justification for the use of Magnesium Alloys in Aircraft Seats

The weight saving potential of magnesium in an aircraft is substantial. Using aircraft seating as an example, assuming a weight savings of 1.7 pounds (0.77 kg) per passenger seat using a conservative 20% reduction in weight when compared to aluminum[1], in a typical 200 passenger seat aircraft the savings would be 340 pounds (154.2 kg). The value of this weight savings is the subject of broad interpretation but studies seem to point to a fuel savings of approximately 20 gallons of fuel consumption per pound weight saved in an aircraft over the course of a year. This is equal to 6800 gallons of fuel savings per aircraft per year and at a value of $3.3/gallon the cost savings is $22,440/year or $561,000 over the 25 year life of an aircraft. In a fleet of 600 aircraft this equals $336.6m for a large carrier CO_2 emissions from fuel consumption is positively affected as well. Assuming a fleet of 600 aircraft and a weight saving of 340 pounds per aircraft, the potential annual CO_2 emission is estimated to be reduced by 40 000 tons.

The new generation magnesium alloys offer advantages that surpass the alloys of the past that are responsible for some of the attitudes and concerns that exist today in the potential fire hazard. The electronics and automotive industries have overcome these stigmas through better characterization of magnesium alloys, establishing the true facts and successfully utilizing the benefits of magnesium alloys as they were originally intended. Accomplishing the same understanding within the aircraft interiors and seat industries will result in an opportunity for designers of commercial aircraft products to reduce weight and take full potential to improve fuel efficiency and minimize aircraft emissions.

3.3 Governing Organizations

The custodial committee for AS8049 is the SAE Aircraft Seat Committee. The SAE Aircraft Seat Committee meets three times a year and is responsible for all revisions and modifications to the AS8049 standard and other SAE documents pertinent to aircraft seat construction and application.

The branch of the FAA responsible for conducting research on flammability matters in aircraft passenger cabins is the Fire Safety Branch, located at the William J. Hughes Technical Center, Atlantic City Airport, New Jersey, hereafter referred to as the FAATC. The FAATC host an industrial liaison group, the International Aircraft Materials Fire Test Working Group (IAMFTWG), which meets three times a year for the purpose of notification and negotiation of policies, regulations, test methods and certification of materials and components from a flammability standpoint.

FAA Transport Airplane Directorate (ANM-100) governs transport airplane regulations and FAATC activities 14 CFR Part 25.

FAA Small Plane Directorate (ACE-100) governs 14 CFR Part 23

FAA Rotorcraft Directorate (ASW-100) governs 14 CFR Parts 27 & 29

FAA Aircraft Engineering Division (AIR-120) governs TSO-C127 and TSO-C39

[1] Magnesium alloys do not have the same mechanical properties as corresponding aluminum alloys so we will not use the theoretical 30% weight savings volume/volume and assume a conservative 20% weight savings for a seat engineered for magnesium.

3.3.1 FAATC

The FAA Transport Airplane Directorate (TAD) requested that the FAATC establish a Task Group to investigate magnesium in aircraft cabins, which was to be made up of industry and FAATC persons. The activity has been limited to the consideration of magnesium use in aircraft seats before any other cabin applications of magnesium use would be considered. Potential hazards were identified in both post-crash and inflight fire situations. The Task Group requested that the FAATC perform preliminary testing of magnesium alloy bars, using the oil burner, to establish an initial understanding of flammability characteristics and to develop a baseline for potential future testing. Preliminary testing is described in 3.4.

Preliminary test results were encouraging to the extent that in January 2008 the FAATC recommended full-scale testing for a more comprehensive understanding of magnesium alloy performance in an actual aircraft fire situation.

A program was established to conduct a full-scale test of aluminum structure seats to establish baseline data. This baseline data will be used for comparison to later magnesium alloy seat structure full-scale tests. Selection of magnesium alloys for full-scale testing was based on preliminary testing establishing a poor performing alloy and good performing alloy. Full OEM off-the-aircraft seats were used for the baseline tests. The magnesium tests substitute magnesium alloy for aluminum alloy in primary structures (leg assemblies, spreader bars and cross tubes) initially and subsequently additional magnesium alloy substitution in seat backs and baggage bars. The original schedule of tests included one baseline and three magnesium alloy tests: (1) one good performing, (2) one poor performing and (3) one good performing including seat backs and baggage bars.

Tests were conducted commencing October 2008 and finishing May 2010. A total of seven full-scale tests were ultimately performed, three aluminum alloy baselines, one good magnesium alloy, one poor magnesium alloy and two more good magnesium alloy with added magnesium alloy components.

The results showed the magnesium alloys had minimal impact on the survivability during the first 5 minutes of the test compared to the baseline aluminum alloy seat structures.

Flammability work with the FAA was continued. Results were positive in favor of magnesium alloy resistance to ignition in the first critical minutes of a fire event. A Task Group was established in June 2010 to develop a laboratory scale flammability test for seat components for the purpose that magnesium alloys can be certified for use in aircraft seat structure. This work was concluded mid-2013 with the development of laboratory scale test and results issued in a report describing the method development process and method specification. The method is to be inserted into the Aircraft Materials Fire Test Handbook.

3.3.2 SAE Aircraft Seat Committee

There is no supportive data included with the magnesium prohibition paragraph contained in AS8049, which is controlled by the SAE Aircraft Seat Committee. However, the current committee members concur that 3.3.3 was inserted due to flammability concerns.

The SAE Aircraft Seat Committee has formed a Magnesium working group to review changes to the magnesium paragraph as part of the five-year review of AS8049. This document (AIR6160) was requested by the Committee to support any changes.

3.3.3 DOT/FAA

The general use of magnesium or magnesium alloys in passenger cabins is discussed on the FAA Fire Safety Branch's website. The FAA has a position statement that expresses their concerns as follows:

> *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.*

Following the full-scale testing performed and initial development of a laboratory scale test the FAA position statement was updated in August 2012 to read:

> *Use of Magnesium in Airplane Cabins—Updated 8/12*
>
> *Based on requests from industry, and considering the absence of recent research data, the FAA has worked extensively with industry to evaluate the potential use of magnesium alloys in airplane cabins. Specifically, magnesium alloys have been evaluated as 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, the FAA and industry research has focused on identifying the large scale performance of different magnesium alloys under realistic fire threats, and characterizing that behavior in a laboratory scale test method.*
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> *The work has progressed to the point where it appears that certain magnesium alloys may have flammability properties acceptable to be used in aircraft seat structure. Special conditions will likely be required to establish appropriate criteria. The development of a laboratory-scale test method is progressing and could be defined near the end of the year.*
>
> *The use of magnesium is still 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 entertain requests for approval using the special condition process.*