8. APTA SS-C&S-015-99 Standard for Aluminum and Aluminum Alloys for Passenger Equipment Car Body Construction

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Abstract: This Standard provides a guide for the selection of appropriate aluminum alloys for rail passenger equipment used in fabrication of passenger railroad equipment. In addition to basic information on the grades of aluminum alloys and their designations, this standard also includes precautions for selecting, welding, and handling the aluminum alloys.

Key Words: aluminum, aluminum alloys, rail car construction

Introduction

This Standard is limited to the application of aluminum alloys for construction of passenger rail equipment car bodies. This Standard makes specific recommendations for alloys that are suitable for this application, and provides specific cautions against the use of unsuitable alloys.

These standards are based on conservative industry practices.

This Standard references other industry/trade association standards that are currently valid. There are other valuable sources of design information that were published by aluminum smelting and manufacturing companies, but most of these publications are now out of print.

Participants

The American Public Transportation Association greatly appreciates the contributions of the following individual, who provided the primary effort in the drafting of the Standard for Aluminum and Aluminum Alloys for Passenger Equipment Car Body Construction.

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Standard for Aluminum and Aluminum Alloys for Passenger Equipment Car Body Construction

1. Overview

This Standard covers heat treatable or work hardenable aluminum alloys in sheet, plate, extrusion, forging, casting and bar form for use in mechanically or weld-assembled structural elements of passenger rail vehicles.

Of the 150 or more alloys that are recognized by the Aluminum Association, some are more suitable for specific applications than others. Alloys to be avoided for specific applications will be listed. The end user should ascertain the commercial availability of the proposed alloys in their specific commodity format. The fact that an alloy is registered does not necessarily guarantee its availability.

Aluminum products and test methods may be fully described in traditional English units or in S.I. units, in ASTM and Aluminum Association standards and data documentation.

In case of conflict between this standard and a referenced specification, the more stringent requirement shall prevail.

1.1 Scope

This standard applies to aluminum and aluminum alloys used in passenger equipment car body construction.

1.2 Purpose

This standard developed to help ensure the quality of aluminum and aluminum alloys used in the fabrication of passenger equipment car bodies.

2. References

This Standard refers to the following publications, at the latest date of issue:

2.1 Aluminum Association

“Aluminum Standards and Data”

“Specifications and Guidelines for Aluminum Structures”

2.2 American Society for Testing and Material Standards (ASTM)

B209, B209M, "Specification for Aluminum and Aluminum-Alloy Sheet and Plate"

B211, B211M, "Specification for Aluminum-Alloy Bars, Rod and Wire"

B221, B221M, "Specification for Aluminum-Alloy, Extruded Bars, Rods, Wires, Shapes and Tubes"

B26, "Specification for Aluminum-Alloy Sand Castings"

B308, "Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles"

2.3 American National Standards Institute (ANSI)

H35.1, "Alloy and Temper Designation Systems for Aluminum"

H35.2, "Standard Dimensional Tolerance for Aluminum Mill Products"

2.4 American Society of Civil Engineers (A.S.C.E.)

"Suggested Specification for Structures of Aluminum Alloys 6061T6 and 6062T6"

2.5 American Welding Society (AWS)

D1.2, "Structural Welding Code, Aluminum"

D15.1, "Railroad Welding Specification – Cars and Locomotives"

2.6 Aluminum Corporation of America (Alcoa)

Technical Report No. 524, "Specification Covering Use of Aluminum in Passenger Carrying Railway Vehicle"

2.7 American Society for Metals

Metals Handbook, Vol. 2, "Properties and Selection: Nonferrous Alloys and Pure Metals"

3. Alloy Specifications

3.1 Standards for Purchasing Raw Material

The chemical and physical properties of recognized alloys are listed in the ASTM Standards referenced in Section 2.2, and in the Aluminum Association publications referenced in Section 2.1. Use of the ASTM standards is preferred for ordering raw material in mill run quantities, because these standards include information that facilitates procurement. Examples are guides to product marking quality control, testing, source inspection, certification and guides for rejection and retesting.

The relevant ASTM Standards are listed below in Section 3.1.1 for convenience.

3.1.1 Reference 2.1, ASTM Standards

B26 for Sand Castings

B209 for Flat Wrought Products

B221 for Extrusions

B221 for Wrought Shapes

B308 for Structural Shapes

3.2 Alloy Designations

The basic wrought commercial alloys are defined by the Aluminum Association with a 4-digit designation in which the first digit indicates the principal alloy components. Cast alloys have a similar 3-digit designation:

Principal Alloy Materials	Wrought Alloys	Cast Alloys
Aluminum, essentially pure	1xxx	
Copper	2xxx	2xx.x
Manganese	3xxx	
Silicon	4xxx	3xx.x, 4xx.x
Magnesium	5xxx	5xx.x
Silicon/Manganese	6xxx	
Zinc	7xxx	7xx.x

The mechanical properties of the aluminum alloys are further defined by a letter/number suffix designating the temper of the alloy. Complete details of this system are contained in Reference 2.3. The basic classifications are listed in the table below.

Designation	Type of Treatment
F	As fabricated
O	Annealed
H	Strain hardened/cold worked
W	Solution heat treated
T	Heat treated to tempers other than F, O, or H

All the designations other than "F" may or must be followed by one or more numbers that give additional information about the specific treatments.

The temper designation is an integral part of the ordering information for all aluminum alloys.

4. Mechanical Data/Applications

1xxx is too soft for structural applications.

2xxx is susceptible to corrosion in saline environments. It is not used in the rail car transportation industry.

3xxx is suitable for secondary structure, e.g. roof skins.

4xxx is used for welding electrodes and in architectural anodizing applications.

5xxx is the most versatile alloy for sheet and plate. These 5000 series alloys are available in different amounts of cold work hardening, as denoted by the suffix "H" temper. Cold working increases the strength but the trade-off is a reduction in ductility. The alloys in this series lose proportionally the least amount of strength in the welded condition. This series is difficult to extrude and generally is not available in the extruded form.

6xxx is a heat treatable alloy series is available in a number of ranges of mechanical strengths. The two basic tempers are the T4 (naturally aged) and T6 (artificially aged) tempers. 6xxx alloys are available in nearly every commodity. 6061-T6 products outsell all other alloys combined. It has good corrosion resistance and can be easily welded, albeit with a considerable decrease in strength. This loss of strength can be recovered by reheat treating, on smaller parts.

The 7xxx is generally considered to be aircraft alloys. It is substantially more expensive than 6000 group alloys; however, the 7xxx alloys can be heat treated to the highest strength of all the aluminum alloys.

5. Product Tolerances

Product physical tolerances shall be per ANSI H35.2. (see Section 2.3).

6. Procurement Specifications

The Purchaser may specify the applicability of any of the relevant portions of the ASTM specifications that are quoted in Section 2.2 of this Standard.

7. Welding

Welding processes, weld and welder qualification, quality assurance and inspection, and workmanship practices shall be per Reference 2.5.

Structural design of welds for statically and dynamically loaded structures shall be per Reference 2.1.

8. Supplementary References

Supplementary references to other topics relating to aluminum design and construction are found in Reference 2.1.2 Part III, “Design Guide”.