

3. APTA PR-CS-S-004-98 Rev. 1 Standard for Austenitic Stainless Steel for Railroad Passenger Equipment

Revision 1 Approved October 24, 2007
Reaffirmed June 14, 2006
Originally Approved March 26, 1998
APTA PRESS Task Force

Authorized March 17, 1999
APTA Commuter Rail Executive Committee

Abstract: This standard covers the minimum properties of austenitic stainless steels used in fabrication of passenger railroad equipment. Principal grades of austenitic stainless steels for railroad passenger equipment structural applications are the low carbon types 201L, 201LN and 301L, 301LN. Other austenitic stainless steels may be applied where justified by design considerations. This standard also includes requirements and precautions for forming, welding, and handling of the low carbon, austenitic stainless steel.

Keywords: austenitic stainless steel, structural materials, welding

Copyright © 1998 by
The American Public Transportation Association
1666 K Street, N. W.
Washington, DC, 20006, USA

No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of The American Public Transportation Association.

Introduction

This standard describes the minimum-acceptable properties of austenitic stainless steel sheet, plate, strip, bar, tubing, forgings, and castings to be used for structural parts in passenger railroad equipment. The described properties include chemical composition and mechanical properties.

This standard covers the common austenitic grades of stainless steel suitable for passenger railroad equipment structure. Several grades of austenitic stainless steels are referenced in this standard; however, this standard is not intended to specify the acceptable applications of the various grades in a structure. The latter would normally be prescribed by the procurement contract for new or refurbished equipment. Furthermore, the majority of existing stainless steel railroad vehicles which would have been subject to this standard, have been manufactured of AISI Type 201 or 301 austenitic grades, or low carbon variations thereof. Therefore, application of the various grades of austenitic stainless steel covered by this standard must be prescribed by the contract documents.

The standard also contains requirements for testing, forming, handling and welding, and material test reports and certifications.

The standard is intended to formalize the properties of austenitic stainless steels used for passenger railroad equipment for use by railroad vehicle builders, component fabricators and suppliers, railroad vehicle refurbishers, and passenger and commuter railroad operating authorities.

This standard makes extensive use of existing standards for stainless steels that are published by the American Society for Testing and Materials (ASTM).

Participants

The American Public Transportation Association greatly appreciates the contributions of the following individual(s), who provided the primary effort in the drafting of *the APTA- PR-CS-S 004-98 Standard for Austenitic Stainless Steel For Railroad Passenger Equipment*.

Nicole Paulus

John Pearson

At the time that this standard completed, the PRESS Construction & Structural Committee included the following members:

Ken Barnish, Chair

Al Bieber
 Harvey Boyd
 David Bremmer
 Barrie Bickle
 George Binns
 David Bremner
 George Brunner
 Ralph Buoniconti
 Gordon Campbell
 Gary Fairbanks
 Glen Gardener
 Kevin Hill
 Liz Grimes
 Michael Henderson
 Ken Hesser
 Bill Kleppinger
 Larry Kelterborn
 Steve Kokkins

Leroy Jones
 Thomas Kopec
 William Koran
 Wayne Krahn
 James Lamond
 Otto Masek
 Ron Mayville
 Frank Maldari
 James Michel
 Neil Mullaney
 Mike Nolan
 Nicole Paulus
 Alain Paquet
 Tom Peacock
 John Pearson
 Radovan Sarunac
 Harry Pool
 Ken Reed

Vinya Sharma
 Steven Roman
 Kris Severson
 Phil Strong
 David Tyrell
 Rich Shults
 Tom Simpson
 Valerie Block
 Richard Vadnal
 David VanHise
 Caroline VanIngen-
 Dunn
 Bill Verdeyen
 Gary Widell
 Clifford Woodbury
 Mike Wetherell

Table of Contents

| | |
|---|-----|
| 1. Overview..... | 3.4 |
| 1.1 Scope | 3.4 |
| 1.2 Purpose | 3.4 |
| 2. References..... | 3.4 |
| 3. Chemical Composition..... | 3.6 |
| 4. Mechanical Properties..... | 3.6 |
| 5. Manufacture | 3.7 |
| 5.1 Dimensional Tolerances | 3.7 |
| 5.2 Surface Finish..... | 3.7 |
| 5.3 Material Test Reports and Certifications..... | 3.7 |
| 5.4 Handling | 3.7 |
| 5.5 Forming | 3.7 |
| 5.6 Welding | 3.7 |
| 5.7 Pre- and Post Weld Heat Treatment | 3.8 |
| 5.8 Post Fabrication Cleaning..... | 3.8 |
| Annex A (informative) | 3.9 |

APTA PR-CS-S-004-98 Rev. 1

Standard for Austenitic Stainless Steel for Railroad Passenger Equipment

1. Overview

Some materials covered in this standard, because of their alloy content and specialized properties, may require special care in their fabrication and welding. Specific welding procedures are of fundamental importance, and it is presupposed that all parameters will be in accordance with approved methods capable of producing the desired properties in the finished fabrication.

The values stated are in English units. Metric units are provided for reference only. Metric units may be used by agreement between the railroad operating authority and the vehicle builder along with the steel mill.

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

1.1 Scope

This standard covers chromium-manganese-nickel, and chromium-nickel stainless steel sheet, plate, strip, bar, tubing, forgings and castings for welded fabrication of structural parts in passenger rail vehicles.

1.2 Purpose

This standard was developed to help ensure the quality of steel used in the fabrication of passenger rail equipment

2. References

This Standard shall be used in conjunction with the publications listed below. When the following publications are superseded by an approved revision, the revision shall apply.

American Iron and Steel Institute (AISI)

Steel Products Manual, Stainless and Heat Resisting Steels

American Society for Testing and Materials Standards (ASTM)

A 240/240M, Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels.

A 262, Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels.

A 276, Standard Specification for Stainless Steel Bars and Shapes.

A 370, Test Methods and Definitions for Mechanical Testing of Steel Products.

A 380, Standard Practice for Cleaning and Descaling of Stainless Steel Parts, Equipment, and Systems.

A 480/A 480M, Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip

A 484/A 484M, Specification for General Requirements for Stainless Steel Bars, Billets, and Forgings.

A 511, Standard Specification for Seamless Stainless Steel Mechanical Tubing.

A 666, Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.

A 743/A 743M, Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.

A 967, Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.

American Welding Society Standards (AWS)

A 4.2, Standard Procedures for Calibrating Magnetic Instruments, (Measure Delta Ferrite Content).

B 2.1, Standard for Welding Procedure and Performance Qualification.

C 1.1, Recommended Practices for Resistance Welding.

D 1.1, Structural Welding Code - Steel.

D 1.3, Structural Welding Code - Sheet Steel.

D 1.6 Structural Welding Code – Stainless Steel.

D 15.1, Railroad Welding Specification - Car and Locomotives.

D-17.2/ D 17.2M: 2007 Specification for Resistance Welding for Aerospace Applications

Military Specifications (NAVSEA Specifications)

NAVSEA S9074 AQ GIB -010/ 248, Requirements for Welding and Brazing Procedure and Performance Qualification.

American Society of Mechanical Engineers Code (ASME Code), Section IX, Welding and Brazing Qualification.

British Standards (BS) , BS 7608, 1993 Code of Practice for Fatigue Design and Assessment of Steel Structures.

3. Chemical Composition

Chemical composition of austenitic stainless steel sheet, strip and plate shall conform to the requirements in ASTM Specification A 240. Chemical compositions of the most frequently used austenitic stainless steels for rail vehicle structural applications are given in Table 1.

Where welded fabrication is required, only austenitic stainless steels with a carbon content below 0.030%, or with proven weldability that resists atmospheric corrosion (no sensitization in the weld heat-affected-zone) shall be used.

Chemical composition of austenitic stainless steel bar shall conform to the requirements of ASTM A 276.

Chemical composition of austenitic stainless steel forgings shall conform to the requirements of ASTM A 484/A 484M.

Chemical composition of stainless steel tubing shall conform to the requirements of ASTM A 511 for austenitic grades.

Chemical composition of stainless steel castings shall conform to the requirements of ASTM A 743 for austenitic grades.

4. Mechanical Properties

Mechanical properties of austenitic stainless steel sheet, strip and plate in annealed condition shall conform to the requirements of ASTM A 240. Table 2 lists mechanical properties of the most frequently used stainless steels in passenger rail vehicle structural applications.

Mechanical properties of austenitic stainless steel sheet in the cold rolled (temper rolled) condition shall conform to the requirements of ASTM A 666. Table 3 lists mechanical properties for tension tests of specimens taken in the transverse direction. Because cold worked stainless steel is highly anisotropic, properties taken in the longitudinal direction, or determined by compression testing can be significantly different and must be addressed by special agreement between the producer and purchaser. Also, adjustments of specific properties to meet formability requirements may be made by special agreement between the producer and purchaser.

Mechanical properties of austenitic stainless steel bar shall conform to the requirements of ASTM A 276.

Mechanical properties of austenitic stainless steel forgings shall conform to the requirements of ASTM A 484.

Mechanical properties of austenitic stainless steel mechanical tubing shall conform to the requirements of ASTM A 511.

Mechanical properties of stainless steel castings shall conform to the requirements of ASTM A 743 for austenitic grades.

5. Manufacture

5.1 Dimensional Tolerances

The dimensional tolerances of stainless steel sheet, strip and plate shall be in accordance with ASTM A 480/A 480M, or as otherwise agreed to by the railroad operating authority and the vehicle builder along with the steel mill. It is recommended that rolled materials be held to the minimum-acceptable thickness within the allowable tolerance to the extent possible where it is desirable to minimize structure weight.

5.2 Surface Finish

Surface finish shall be in accordance with ASTM A-480/A 480M or as otherwise agreed to by the railroad operating authority and the vehicle builder along with the steel mill. Sheets and coils shall be produced in continuous passes, with surface finish within limits agreed to by the railroad operating authority and vehicle builder along with the steel mill.

5.3 Material Test Reports and Certifications

Material test reports and certifications shall be in accordance with ASTM A 480/A 480M. An intergranular corrosion test in accordance with ASTM A 262 shall be required for each heat of austenitic stainless steel. Following provisions of A 262, material may be accepted to Practice A of A 262. Material shall be rejected only by application of Practice E of A 262.

5.4 Handling

Austenitic stainless steel sheet and coil shall be packaged for shipment to protect the finished surface. Coils shall have paper or protective separator placed on the finished surface as the coil is wound. Recommended practices for handling and protection of stainless steel are discussed in Annex A.

5.5 Forming

Bending, forming and metal working shall be performed on tooling that has been cleaned and is free of iron particles and slivers. Formed parts shall have smooth radii, free of cracks, creases, or stretcher-strains, as demonstrated by visual inspection.

5.6 Welding

5.6.1. All fusion welding shall be performed by welders qualified to AWS B 2.1, D 1.1, D 1.3, D 1.6, or ASME Section IX requirements and in accordance with approved welding procedure

specifications that conform to AWS D 1.1, D 1.3, D 1.6, and D 15.1 requirements, or equivalent standards approved by the purchaser.

5.6.2. Fusion welding of austenitic stainless steels shall use 308 L or equivalent filler metal. Fusion welds in austenitic stainless steels shall have a ferrite number in the range of WRC 4 to 10, according to AWS A 4.2.

5.6.3 Fusion welding of stainless steels to carbon or LAHT (HSLA) steels shall use 309 L, or equivalent filler metal. The heat-affected-zone hardness shall not exceed 400 Vickers.

5.6.4 Resistance welding shall be in accordance with requirements of D-17.2/ D 17.2M, Class B for structural welds and Class C for non-structural welds. It is recommended that a more restrictive limit on indentation on visible structures than permitted by the standard be considered for improved appearance, as agreed to by the vehicle builder and railroad operating authority.

5.6.5 Fatigue design stresses in welded austenitic stainless steel structures shall be developed in accordance with the provisions of AWS D 1.1 Design Section for dynamically loaded structures, British Standard BS 7608, and the vehicle builder's design standards, or as otherwise agreed by the railroad operating authority and the vehicle builder.

5.6.6 Fusion welding of cold worked stainless steels tends to soften or anneal the weld heat-affected-zone (HAZ). The degree of loss of strength must be determined by testing.

5.7 Pre- and Post Weld Heat Treatment

Pre- and post-weld heat treatments are not typically applied to the austenitic stainless steels covered by this standard, and shall not be required, except as necessary for a particular approved application or approved welding procedure qualification.

5.8 Post Fabrication Cleaning

All surface contamination such as free iron, oil and crayon marks, as well as welding discoloration and weld spatter shall be removed before delivery of the fabricated stainless steel structure. The cleaning processes shall be in accordance with ASTM A 380 and A 967. Practice A, B or C of ASTM A 967, or other such similar procedure as agreed to by vehicle builder and railroad operating authority, should be used to demonstrate that the stainless steel is free of iron contamination.

Annex A (informative)

Recommended Practice for the Handling of Austenitic Stainless Steel

- A1. Stainless steel should be stored off the ground by cribbing with wood, stacked to promote draining and to prevent damage and contamination.
- A2. When processing stainless steel, care should be taken to ensure that all working surfaces of the forming equipment, layout tables, and handling equipment are clean so that contamination of the stainless steel surface is avoided.
- A3. Plasma arc and laser cutting or gouging should be the only acceptable methods for thermal cutting. All arc-cut edges shall be ground to bright metal prior to welding.
- A4. All tools, such as wedges, lifting clamps, and wire brushes used in contact with stainless steel should be stainless steel or other non-contaminating metal or material. Abrasives used on stainless steel, such as grinding wheels, flapper wheels, and flexible abrasive disks, should not have been used previously on carbon steel.
- A5. In shipping fabricated components, care should be taken that ordinary steel chains, tie-downs, and banding do not come in contact with the stainless steel.

Table 1: Chemical Composition Requirements, wt. % (1)

Austenitic Stainless Steels

| UNS Designation | Common Name | Carbon | Manganese | Phosphorus | Sulfur | Silicon | Chromium | Nickel | Nitrogen | Other Elements |
|-----------------|-------------|--------|-----------|------------|--------|---------|-----------|----------|-----------|----------------|
| S20103 | 201L | 0.030 | 5.5-7.5 | 0.045 | 0.030 | 0.75 | 16.0-18.0 | 3.5-5.5 | 0.25 | *** |
| S20153 | 201LN | 0.030 | 6.4-7.5 | 0.045 | 0.015 | 0.75 | 16.0-17.5 | 4.0-5.0 | 0.10-0.25 | Cu 1.00 |
| S30103 | 301L | 0.030 | 2.00 | 0.045 | 0.030 | 1.00 | 16.0-18.0 | 6.0-8.0 | 0.20 | *** |
| S30153 | 301LN | 0.030 | 2.00 | 0.045 | 0.030 | 1.00 | 16.0-18.0 | 6.0-8.0 | 0.07-0.20 | *** |
| S30403 | 304L | 0.030 | 2.00 | 0.045 | 0.030 | 0.75 | 18.0-20.0 | 8.0-12.0 | 0.10 | *** |
| S30453 | 304LN | 0.030 | 2.00 | 0.045 | 0.030 | 0.75 | 18.0-20.0 | 8.0-12.0 | 0.10-0.16 | *** |

(1) Maximum, unless range or minimum is indicated.

Table 2: Mechanical Test Requirements
Solution Annealed, Wrought Stainless Steels

| UNS Designation | Common Name | Tensile Strength, min. | | Yield Strength, min. | | Elongation, in 2 inches min% | Hardness, Max. | |
|-----------------|-------------|------------------------|-----|----------------------|-----|------------------------------|----------------|------------|
| | | Ksi | MPa | Ksi | MPa | | Brinell | Rockwell B |
| S20103 | 201L | 95 | 655 | 38 | 260 | 40.0 | 217 | 95 |
| S20153 | 201LN | 95 | 655 | 45 | 310 | 45.0 | 241 | 100 |
| S30103 | 301L | 80 | 550 | 32 | 220 | 45.0 | 241 | 100 |
| S30153 | 301LN | 80 | 550 | 35 | 240 | 45.0 | 241 | 100 |
| S30403 | 304L | 70 | 485 | 25 | 170 | 40.0 | 201 | 92 |
| S30453 | 304LN | 75 | 515 | 30 | 205 | 40.0 | 217 | 95 |

Note: Direction of testing shall be transverse to rolling direction unless otherwise agreed to by purchaser and supplier.

Table 3: Mechanical Test Requirements, Cold Rolled Austenitic Stainless Steel

| UNS Designation | Common Name | Tensile Strength, min. | | Yield Strength, min. | | Elongation in 2 in., min. % | | |
|-------------------------|-------------|------------------------|------|----------------------|-----|-----------------------------|------------------|-----------|
| | | Ksi. | MPa | Ksi | MPa | <0.015 in | 0.015 - 0.030 in | >0.030 in |
| <u>1/16 Hard</u> | | | | | | | | |
| S20103 | 201L | 100 | 690 | 50 | 345 | 40 | 40 | 40 |
| S20153 | 201LN | 100 | 690 | 50 | 345 | 40 | 40 | 40 |
| S30103 | 301L | 100 | 690 | 50 | 345 | 40 | 40 | 40 |
| S30153 | 301LN | 100 | 690 | 50 | 345 | 40 | 40 | 40 |
| S30403 | 304L | 80 | 550 | 45 | 310 | 40 | 40 | 40 |
| S30453 | 304LN | 90 | 620 | 45 | 310 | 40 | 40 | 40 |
| <u>1/8 Hard</u> | | | | | | | | |
| S20103 | 201L | 105 | 725 | 55 | 380 | 35 | 35 | 35 |
| S20153 | 201LN | 110 | 760 | 60 | 415 | 35 | 35 | 35 |
| S30103 | 301L | 110 | 760 | 60 | 415 | 35 | 35 | 35 |
| S30153 | 301LN | 110 | 760 | 60 | 415 | 35 | 35 | 35 |
| S30403 | 304L | 100 | 690 | 55 | 380 | 30 | 30 | 30 |
| S30453 | 304LN | 100 | 690 | 55 | 380 | 33 | 33 | 33 |
| <u>1/4 Hard</u> | | | | | | | | |
| S20103 | 201L | 120 | 825 | 75 | 515 | 25 | 25 | 25 |
| S20153 | 201LN | 120 | 825 | 75 | 515 | 25 | 25 | 25 |
| S30103 | 301L | 120 | 825 | 75 | 515 | 25 | 25 | 25 |
| S30153 | 301LN | 120 | 825 | 75 | 515 | 25 | 25 | 25 |
| S30403 | 304L | 125 | 860 | 75 | 515 | 8 | 8 | 10 |
| S30453 | 304LN | 125 | 860 | 75 | 515 | 10 | 10 | 12 |
| <u>1/2 Hard</u> | | | | | | | | |
| S20103 | 201L | 135 | 930 | 100 | 690 | 22 | 22 | 22 |
| S20153 | 201LN | 135 | 930 | 100 | 690 | 22 | 22 | 22 |
| S30103 | 301L | 135 | 930 | 100 | 690 | 20 | 20 | 20 |
| S30153 | 301LN | 135 | 930 | 100 | 690 | 20 | 20 | 20 |
| S30403 | 304L | 150 | 1035 | 110 | 760 | 5 | 6 | 6 |
| S30453 | 304LN | 150 | 1035 | 110 | 760 | 6 | 7 | 7 |

Note: Direction of testing shall be transverse to rolling direction unless otherwise agreed to by purchaser and supplier.

Table 3: (Continued)
Free Bend Requirements

| UNS Designation | Common Name | Thickness, t#0.050 in. | | Thickness, t> 0.050 to < 0.1874 in. | |
|---|-------------|------------------------|------------------|-------------------------------------|---------------------|
| | | Included Bend Angle, E | Min. Bend Radius | Included Bend Angle, E | Minimum Bend Radius |
| <u>Annealed, 1/16 and 1/8 Hard</u> | | | | | |
| S20103 | 201L | 180 | 1t | 180 | 1t |
| S20153 | 201LN | 180 | 1t | 180 | 1t |
| S30103 | 301L | 180 | 1t | 180 | 1t |
| S30153 | 301LN | 180 | 1t | 180 | 1t |
| S30403 | 304L | 180 | 1t | 180 | 2t |
| S30453 | 304LN | 180 | 1t | 180 | 2t |
| <u>1/4 Hard</u> | | | | | |
| S20103 | 201L | 180 | 1.5t | 135 | 1.5t |
| S20153 | 201LN | 180 | 1.5t | 135 | 1.5t |
| S30103 | 301L | 180 | 1.5t | 90 | 1.5t |
| S30153 | 301LN | 180 | 1.5t | 90 | 1.5t |
| S30403 | 304L | 180 | 2t | 90 | 3t |
| S30453 | 304LN | 180 | 2t | 90 | 3t |
| <u>2 Hard</u> | | | | | |
| S20103 | 201L | 180 | 2t | 135 | 2t |
| S20153 | 201LN | 180 | 2t | 135 | 2t |
| S30103 | 301L | 180 | 2t | 90 | 2t |
| S30153 | 301LN | 180 | 2t | 90 | 2t |
| S30403 | 304L | 180 | 3t | 90 | 2t |
| S30453 | 304LN | 180 | 3t | 90 | 3t |

Note: Direction of testing shall be transverse to rolling direction unless otherwise agreed to by purchaser and supplier.