10. APTA PR-CS-S-020-03 Standard for Passenger Rail Vehicle Structural Repair

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Abstract: This Safety Standard provides a standardized method for structural repairs to passenger rail vehicles. This Safety Standard emphasizes the proper methods, procedures and quality assurance processes to be used.

Key Words: passenger rail vehicles, structural repair, structural repair procedure, welding repair

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Standard for Passenger Rail Vehicle Structural Repair

1. Overview

1.1 Scope

This standard applies to repairs and modifications that concern structural integrity or crashworthiness of passenger cars or passenger locomotives. Repairs or modifications to equipment mounts for any piece of equipment weighing 150 pounds or more are covered by this standard. This standard does not cover repairs to trucks, motors, engines, HVAC systems, doors, wiring and piping, nor minor repairs, such as roof leaks or side sheet tears.

Although the cosmetic appearance of repaired passenger equipment is important, it is not within the scope of this standard. Limits on flatness, indentations, surfaces preparation prior to painting, etc. shall be established by mutual agreement between the contractor and the equipment owner.

1.2 Purpose

This document provides minimum repair guidelines for structural repairs of passenger rail vehicles performed to reproduce the strength of the vehicle as originally delivered by the original equipment manufacturer (OEM).

2. References

This standard shall be used in conjunction with the latest revision of the following publications.

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

APTA PR-CS-S-015-99, Standard for Aluminum and Aluminum Alloys for Passenger Car Body Construction.

APTA PR-CS-S-034-99, Standard for the Design and Construction of Passenger Railroad Rolling Stock.

ASTM C 1490 Standard Guide for the Selection, Training and Qualification of Nondestructive Assay (NDA) Personnel

ASTM D S67-A Handbook of Comparative World Steel Standards.

ASTM E 94 Method for Controlling Quality of Radiographic Testing

ASTM E 114-95 (2001) Standard Practice for Ultrasonic Pulse-Echo Straight-Beam Examination by the Contact Method

ASTM E 164 Standard Practice for Ultrasonic Contact Examination of Weldments

ASTM E 165 Standard Test Method for Liquid Penetrant Examination

ASTM E 390Standard Reference Radiographs for Steel Fusion Welds

ASTM E 709Standard Guide for Magnetic Particle Examination

ASTM E 1032Standard Test Method for Radiographic Examination of Weldments

ASTM E 1417Standard Practice for Liquid Penetrant Examination

ASTM E 1444 Standard Practice for Magnetic Particle Examination

ASTM E 1742Standard Practice for Radiographic Examination

ASTM E 1901 Standard Guide for Detection and Evaluation of Discontinuities by Contact Pulse-Echo Straight-Beam Ultrasonic Methods

AWS D1.1, Structural Welding Code – Steel.

AWS D1.2, Structural Welding Code – Aluminum.

AWS D1.3, Structural Welding Code – Sheet Steel.

AWS D1.6, Structural Welding Code - Stainless Steel.

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

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3. Definitions, abbreviations and acronyms

3.1 Definitions

3.1.1 hidden damage: Damage found after the repair work has started.

3.1.2 unseen but anticipated damage: Hidden damage that is expected based upon the assessment inspection of the damaged vehicle.

3.2 Abbreviations and acronyms

ASNT	The American Society for Nondestructive Testing
ASTM	ASTM International (formerly the American Society for Testing and Materials)
AWS	American Welding Society
APTA	American Public Transportation Association
LAHT	low-alloy high-tensile *Syn:* High-Strength Low Alloy
HSLA	High-Strength Low Alloy (steel) *Syn:* low-alloy high-tensile
MIL-HDBK	Department of Defense Military Handbook
NDT	non-destructive test
OEM	original equipment manufacturer

4. Repair facilities

All weld repairs shall be conducted by a qualified repair shop/maintenance facility whose processes, quality standards, equipment and welders comply in all respects with requirements of the appropriate American Welding Society (AWS) code for the materials used. Previous experience, as well as personnel, management and engineering shall be considered when selecting the repair shop/maintenance facility.

5. Inspection of repair area

Prior to beginning any work on damaged equipment, an assessment of the vehicle structure in the area where the repairs are to be made shall be performed to ensure that the car structure can be returned to the same level of structural integrity as when first manufactured. Removal of some components or members may be necessary to complete this assessment.

A report shall be made of the assessment, stating each item or member damaged, its location on the vehicle and the type and extent of damage, e.g., "Draft sill buckled, web torn, weld at web/bottom plate joint failed". The report shall indicate whether each part is to be repaired in place or replaced with a new one. Missing components shall also be noted in the report.

The report should address possible hidden damage and unseen but anticipated damage.

Depending on the extent of the damage, a second inspection should be performed after removal of all damaged parts, and any new information should be included in the inspection report.

6. Materials and design information

For all repairs, the original equipment manufacturer (OEM) drawings and/or specifications shall be consulted prior to beginning the repair in order to identify the base materials and to ensure the selection of the proper processes and procedures. Vehicle owners shall approve all material changes. All steel changes shall be in accordance with ASTM D S67-A Handbook of Comparative World Steel Standards. If available, vehicle owners shall make the OEM drawings and/or specifications available to the contractors for review. If not, inspection and analysis of the as-built structure and materials can suffice with the approval of the owner.

7. Preparation

Prior to beginning any repair, the vehicle shall undergo a thorough inspection to determine the best method of supporting the structure during the repair procedure. Where necessary, supports shall be located in a manner to minimize any sagging or distortion to any part of the undamaged vehicle when damaged areas are cut away. Supports shall be placed where contact with the structure will be at a place that has sufficient strength to carry the anticipated load. Timbers or other means shall be used to distribute the load when necessary.

The existing damaged material shall be removed by an appropriate method for the

material involved (plasma arc cutting, carbon arc cutting/gouging, oxyfuel cutting, saw, grinding, etc.), giving due consideration for how the damaged area will be rebuilt.

8. Repair plan

Based on the analysis, a repair plan shall be prepared that addresses each failed or damaged item or member with a general repair approach. The approach shall state whether the item will be repaired or replaced, and how. If a structural member is to be replaced, the plan shall include the removal and reinstallation techniques, whether the replacement is partial or entire, location of cutting, location of splices, material and welding information, including heat treatment.

The Repair Plan shall be reviewed with the vehicle owner before any further work is done. If drawings and/or sketches are required as part of the Repair Plan, see Section 11.1.

9. Repair strength

The goal of structural repairs shall be to restore the vehicle to its original configuration, strength level and crashworthiness, unless the equipment owner intends to modify the car or locomotive. The equipment owner and repair contractor shall agree on an allowance for corrosion. If the repair plan calls for replacing members in kind, i.e., with pieces of the same material (alloy, thickness, temper and finish), size, shape and connection details, no calculations shall be required. However, if any members are to be spliced, made of different material or assembled from components differently than the original, calculations shall be required to show that the original strength levels will be achieved.

Calculations shall take into account yield and ultimate strengths of materials applied as compared to original ones, shape factors, buckling strength, strength and stiffness of splices and connections, the effect of welding on strength, residual stresses and the service performance, collision loading, and crashworthiness. The original vehicle design calculations may be used where appropriate.

The calculations shall be submitted, for review, in a format acceptable to the equipment owner.

10. Workmanship and qualifications

All repairs shall be done in accordance with the written procedures specific to the application as indicated in Section 12 of this Standard and in accordance with the workmanship requirements of the applicable AWS ; D1.1, D1.2, D1.3, D1.6 and D15.1.

Welding procedures shall be either pre-qualified or test qualified in accordance with the requirements of the applicable AWS; D1.1, D1.2, D1.3, D1.6 and D15.1.Personnel performing any welding shall have valid AWS qualifications specific to the application, in accordance with the AWS; D1.1, D1.2, D1.3, D1.6 and D15.1.

Personnel inspecting welds shall be qualified in accordance with AWS Certified Welding Inspector program requirements. Personnel performing nondestructive testing of welds shall be qualified to ASTM International (ASTM) and/or American Society for

Nondestructive Testing (ASNT) standards for the non destructive testing (NDT) method applied.

11. Repair process

11.1 General

Process sheets or equivalent procedures for the repair shall be prepared by the contractor and approved by the owner. These sheets shall be based on the repair plan and shall include removal procedures and sequence, bracing and layout procedures and the installation of new members, including detailed welding and clamping procedures. Any deviations from the process sheets shall require approval by the owner.

11.2 Quality control

Prior to beginning any repair, a quality control Plan shall be prepared for the overall project and be specific to the tasks to be accomplished.

The repair operations shall be available for inspection by the equipment owner at all times. Process sheets for all work in progress shall be available at the work site. Welder qualification records shall be maintained at the work site or as agreed to by the owner. Material certifications shall be submitted to the owner prior to any fabrication.

11.3 Fabrication

Drawings and/or sketches shall be prepared for all parts to be fabricated, showing material, temper, thickness, bend radii, grain orientation (if necessary), size and shape.

Stainless steel shall be processed only on machines reserved for stainless steel or which have been completely cleaned of any carbon steel residue.

Aluminum alloys shall not be cut by thermal means, and stainless steel and aluminum alloys shall not be heated for fabrication, unless the specific process has been reviewed with and agreed to by the owner

Welds shall be made only where and as shown on drawings and process sheets.

Aluminum components shall not be heated for straightening, fit correction or any other purpose. Carbon steel and stainless steel components shall be heated only when the proposed heating process and temperature limits are specifically approved by the owner.

Before welding is started, all parts to be joined shall be properly cleaned of coatings and films such as paint, zinc, rust, oxides, mill scale, oil, grease, and other foreign materials. Cleaning materials and processes shall be approved by the equipment owner.

11.4 Welding procedure

All welding processes and procedures shall comply with applicable AWS codes specified in Section 2 of this document. As required by the owner, a detailed Welding Procedure Specification Form (Data Sheet) specific to the application shall be completed prior to performing the weld repair.

The owner shall have the right to require the making of test welds to settle any question that may arise as to the suitability of any welding method or procedure used during production. AWS codes shall be followed in the making of tests and the settlement of other questions that may arise regarding welding practice.

All welding consumables shall be purchased to conform to applicable AWS specifications, in packages of convenient size, which shall be marked with the manufacturer's name and the specification, classification, diameter, net weight and other characteristics of the material. The consumables shall be stored conforming to the applicable AWS codes so as to protect it from damage, and so that it can be easily identified. Material shall be issued and handled in such a way as to prevent it from being mixed with that of another specification.

Joint welding procedures that are to be employed shall be qualified by conforming to AWS standards above. When the procedure is required to be qualified by test, a written procedure qualification record shall be prepared in accordance with the applicable AWS codes. When the appropriate AWS standard listed in Section 2 above allows the use of pre-qualified joints, these joints shall conform in all respects to the provisions of the applicable AWS codes in order to be exempt from testing.

All parts to be joined by welding shall be adequately supported or held in their proper position by appropriate tables, jigs, and/or fixtures. The method of depositing weld metal shall be chosen to minimize warp age. Complete penetration welds shall be used for all structural welds. All complete penetration welds made from one side without backing or back gouging shall be qualified by test using production welding techniques and welders. Where partial penetration welds are proposed, the contractor shall provide design calculations supporting the weld size desired and conduct tests to prove that production welding shall achieve the required penetration with an acceptable margin of safety.

Finished welds shall present a clean appearance and quality consistent with the AWS standards referenced in Section 2 of this specification. Grinding of welds and surface restorations such as paint, buffing of stainless steel, etc. shall be consistent with the owner's specifications and directives.

Heat treatment or stress relief, if required, shall be performed in accordance with the applicable AWS codes and ASTM specification for the material involved, or the recommendations of the material manufacturer.

Plug welds shall only be permitted with extra low carbon stainless steel and shall not be used in aluminum alloys. Ring welds are acceptable in both stainless steels and aluminum alloys.

If spot welds are used, they shall be in accordance with AWS C1.1 and MIL-W-5868.

The extent to which these referenced publications are applied shall be in accordance with the original fabrication configuration or as agreed upon between repair contractor and owner.

12. Materials

12.1 General

If OEM material specifications are not available, a metallurgical analysis shall be made of a material sample taken from the damaged part or from structure adjacent to the area to be repaired. Care shall be taken to ensure that excessive heat or corrosion has not compromised the sample characteristics. Materials selected for repair shall equal or exceed the characteristics determined by analysis regarding their yield and ultimate strength, ductility and chemistry.

12.2 HSLA and low-carbon steel

HSLA and low-carbon steel shall be per APTA PR-CS-S-034-99, Standard for the Design and Construction of Passenger Railroad Rolling Stock or an equivalent approved by the owner.

12.3 Stainless steel

Stainless steel shall be per APTA PR-CS-S-004-98, Standard for Austenitic Stainless Steel for Railroad Passenger Equipment or an equivalent approved by the owner.

12.4 Aluminum

Aluminum shall be per APTA PR-CS-S-015-99, Standard for Aluminum and Aluminum Alloys for Passenger Car Body Construction or an equivalent approved by the owner.

13. Inspection

After completing the repair, a thorough inspection of welds shall be performed by authorized personnel in accordance with the requirements of the applicable AWS standard and under the supervision of an AWS-certified welding inspector. All welds shall be visually inspected. In addition, welds in critical (highly stressed) areas shall be inspected using appropriate NDT methods. The repair procedure shall specify critical areas, and NDT methods for specific welds. Welds not meeting the inspection acceptance criteria specified in the referenced AWS documents shall be repaired and re-inspected.

The following industrial standards and specifications are recommended for inspection of welds:

Visual Examination

AWS D 1.1, Part C (Use criteria for cyclically loaded structures.)

Dye Penetrant Examination

ASTM E 165, E 1417

Magnetic Particle Examination

ASTM E 709, E 1444

Radiographic Examination

ASTM E 94, E 390, E 1032, E 1742

AWS D 1.1-2002, Part E

Ultrasonic Examination

ASTM E 114, E 164, E 1901

AWS D 1.1-2002, Part F or Annex K

Qualification of NDT Personnel

ASTM C 1490