MxV Rail on the Move

Kari Gonzales

President & CEO, MxV Rail (formerly TTCI)

Quality Assurance Conference
April 12, 2022

Moving Forward

MARCH 2021 — FRA names successor for TTC

APRIL 2021 — Buildings for HQ and labs acquired at Pueblo Industrial Park

JUNE 2021 — TTCI Board approves location for reimagined SERTC campus

SEPTEMBER 2021 — TTCI Board approves relocation of on-track testing services

FIRST QUARTER 2022 — TTCI breaks ground at PuebloPlex

MARCH 2022 — New company name **MxV Rail** debuts at AAR Research Review

SEPTEMBER 2022 — Operations to commence at new multi-campus facility at Pueblo and PuebloPlex sites

TTCI®

MxV

M x V RAIL

MxV RAIL

MxV Rail is a wholly owned subsidiary of the Association of American Railroads

OUR VALUES

Rigor

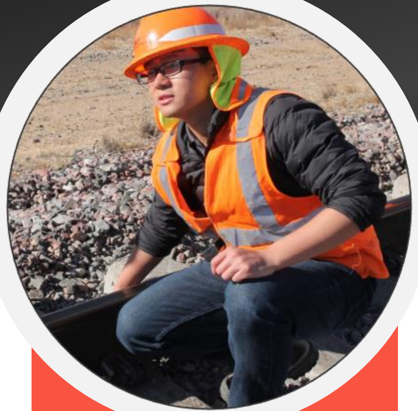
Purpose

Momentum

Insight

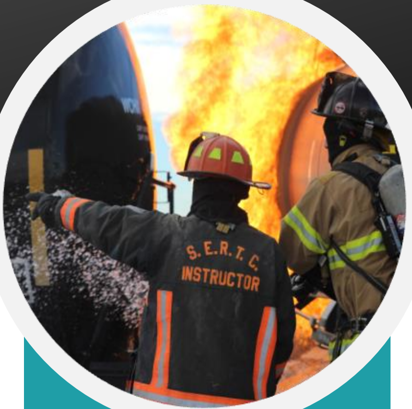
Teamwork

Team MxV Rail

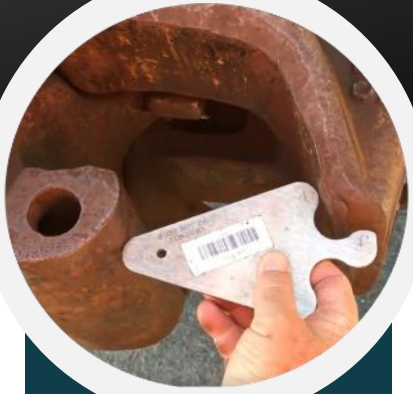


TESTING

CONSULTING



TRAINING



STANDARDS

RESEARCH

Industry-Owned, Independently Operated

ASSOCIATION OF AMERICAN RAILROADS

AMTRAK

APTA

BNSF RAILWAY

CN

CP

CSX

KANSAS CITY SOUTHERN Lines

M

NS NORFOLK SOUTHERN

UNION PACIFIC

Unlocking Momentum

M x V RAIL

Value Proposition

Team
Retaining top industry talent in engineering, operations, technical standards, and training

Focus on Industry Initiatives
Building on our legacy of excellence to provide insightful solutions to key industry challenges

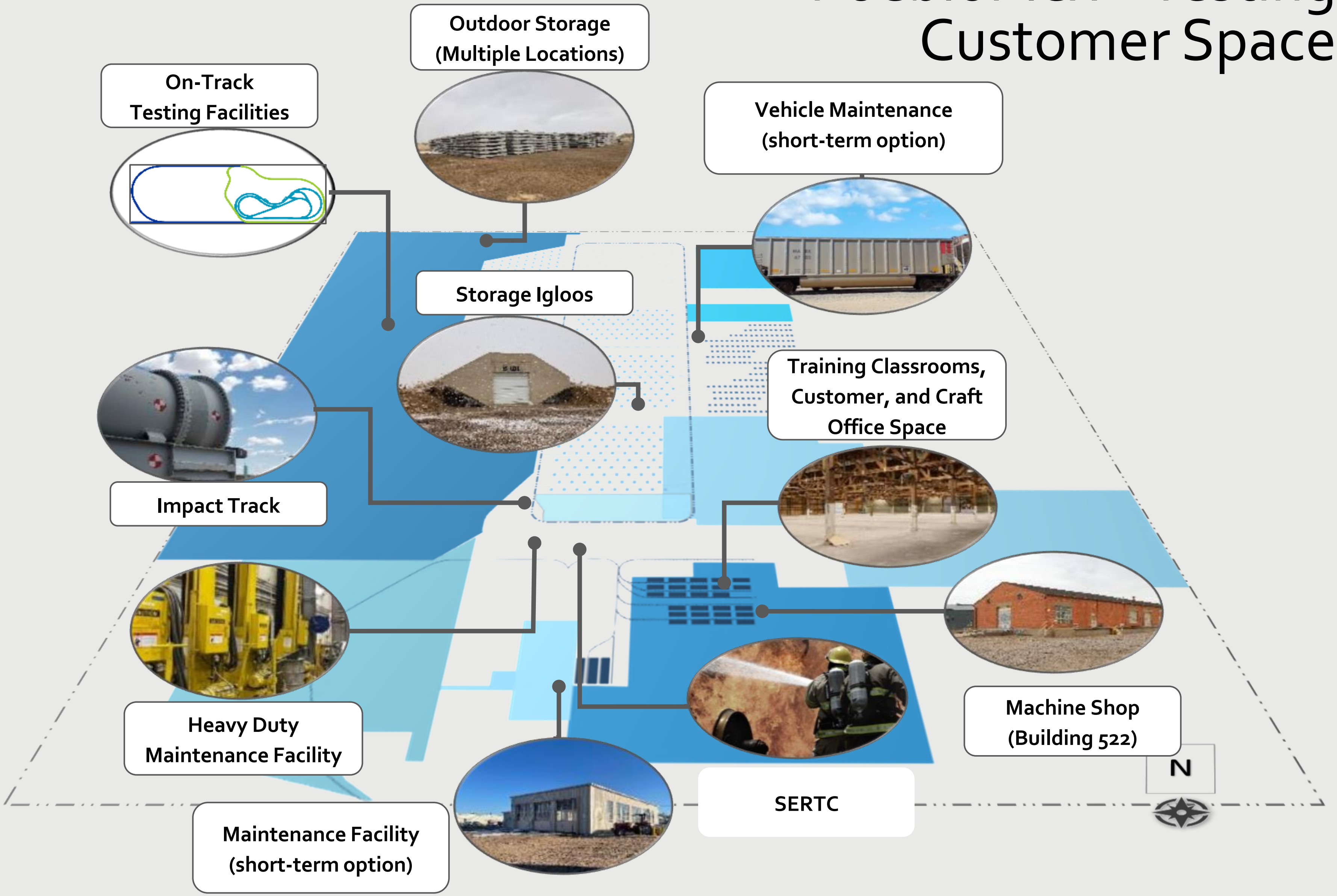
Independence
Ability to provide unbiased assessments of technology and performance
Secure environment, no third-party oversight, and ability to protect industry and client Intellectual Property and Confidentiality

Strategic Investments
Ability to prioritize and direct investments toward industry-impacting activities

Cost
New infrastructure combined with a smaller footprint results in more output for less cost

M x V RAIL

PuebloPlex – Testing Services, Customer Space & SERTC



M x V RAIL

PuebloPlex - Track Infrastructure

High Speed Loop

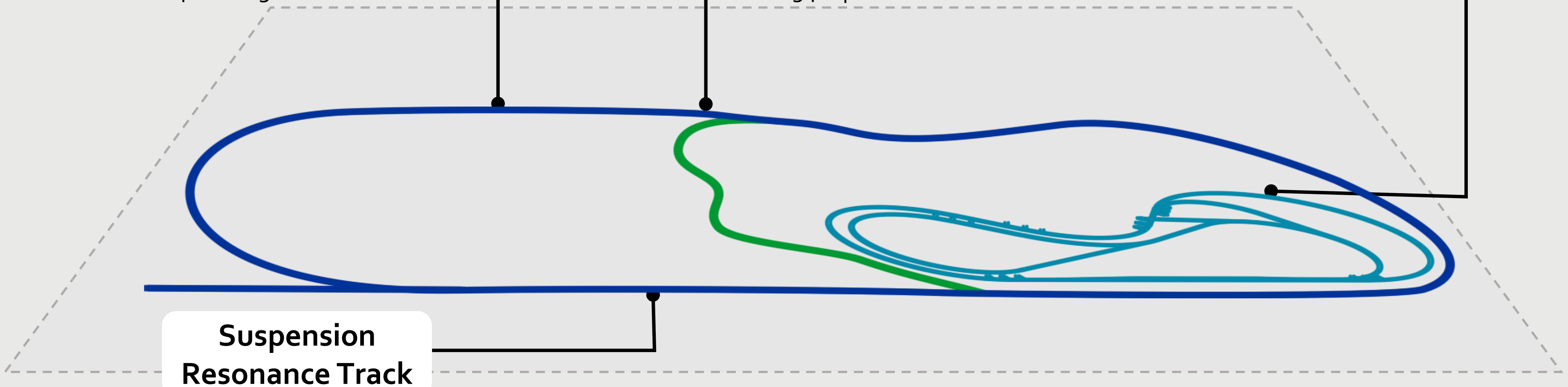
- 5.8 mi.
- Class 6 track
- 110 mph tangent
- 65-69 mph curves
- 6-in. superelevation
- 2° 41 ft. to 3°

Curving Performance Track

- 2.15 mi.
- Curves of 3, 4, 5, 7.5, 10, & 12 degrees
- 34 mph

FAST Loop

- 3.3 miles, 2.8 mi. main loop
- Self-contained
- Two loops:
  - Mainline outer loop
  - Mainline with bypass



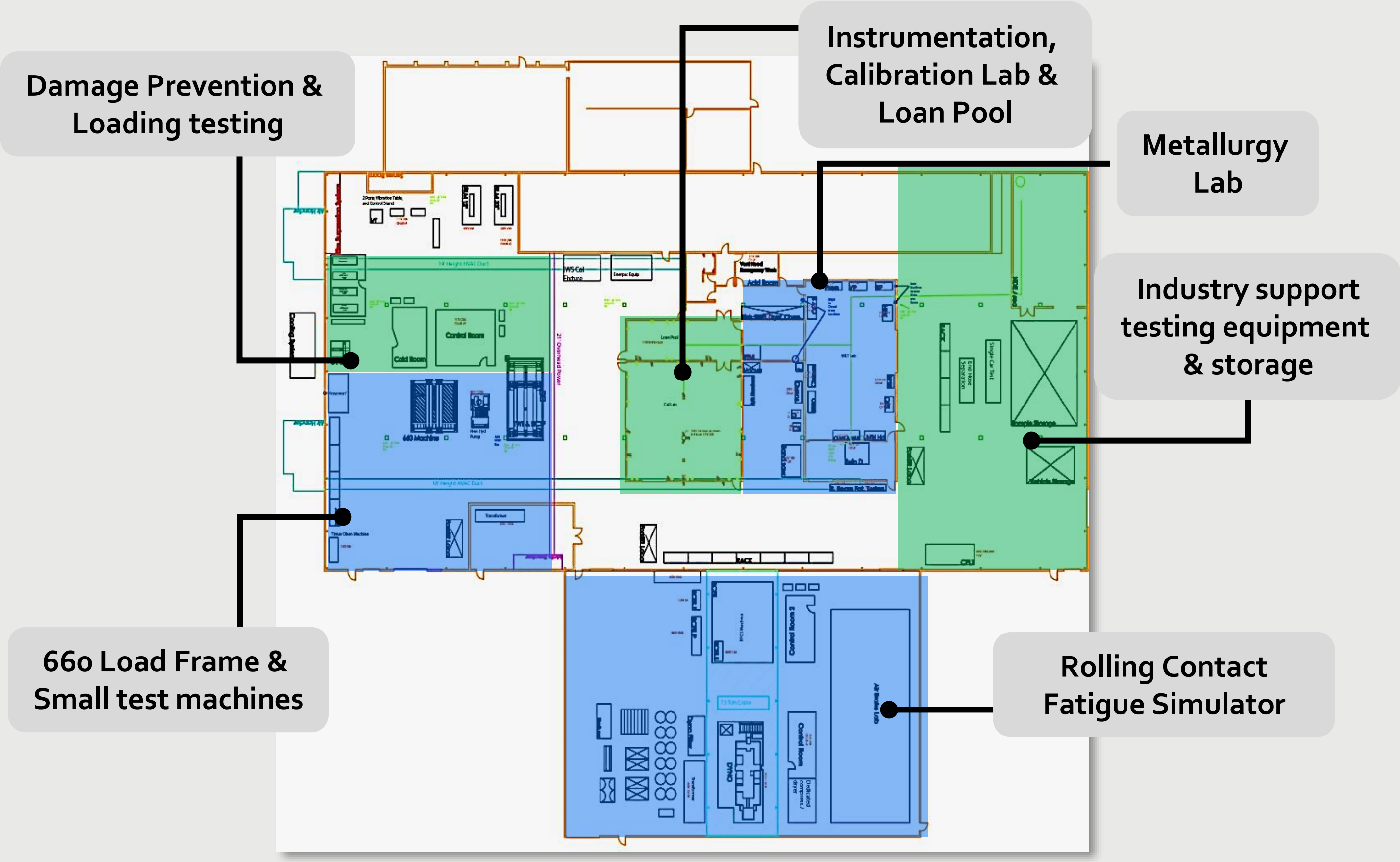
Suspension Resonance Track

- Siding to HSL
- 3.4 mi
- 75 mph through perturbed test zones
- Pitch & Bounce, Twist & Roll, Yaw & Sway

Laboratory and Headquarters

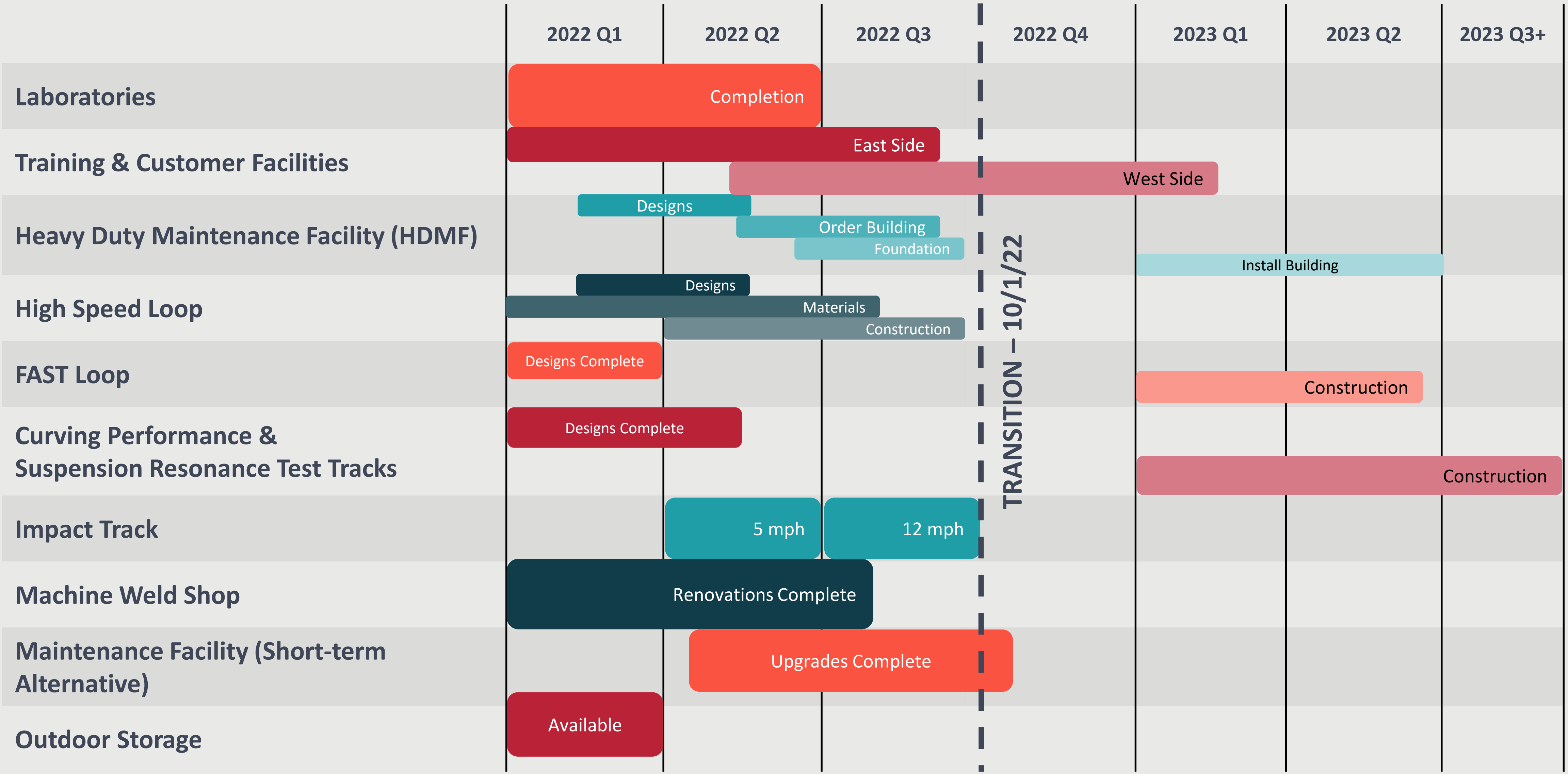
Headquarters (442 Keeler) – 45, 000 sq ft

Laboratory Facility (350 Keeler) – 70,000 sq ft.



M x V R A I L

Timeline



Research

AAR Strategic Research Initiative Program

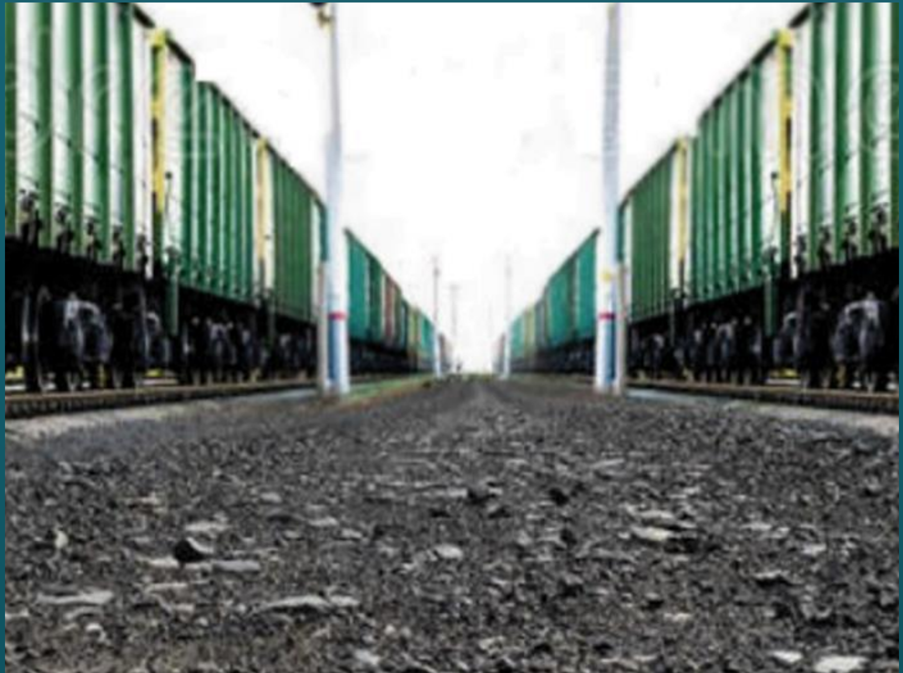
Build Exemplary Teams and Facilities

Empower Science-Based Solutions
- Identify and evaluate technologies
- Demonstrate understanding of root causes
- Support implementation
- Communicate findings

Safety
Reduce track and equipment-related derailments

Reliability
Reduce/eliminate service interruptions

Efficiency
Increase productivity, reduce costs



Program Design & Approval Process
- Driven by industry input
- Safety and operational trends considered
- Projects/budgets approved by:
  - AAR Research Committee
  - AAR Safety and Operations Management Committee (SOMC)
  - AAR Board of Directors

SRI Program Focus Areas

Infrastructure System Research

- Rail
- Welding
- Substructure
- Ties and fasteners
- Bridges
- Track buckling
- Special trackwork

Mechanical Systems Research

- Bearing
- Wheelsets
- Brake systems
- Draft & coupling systems
- Car & truck systems

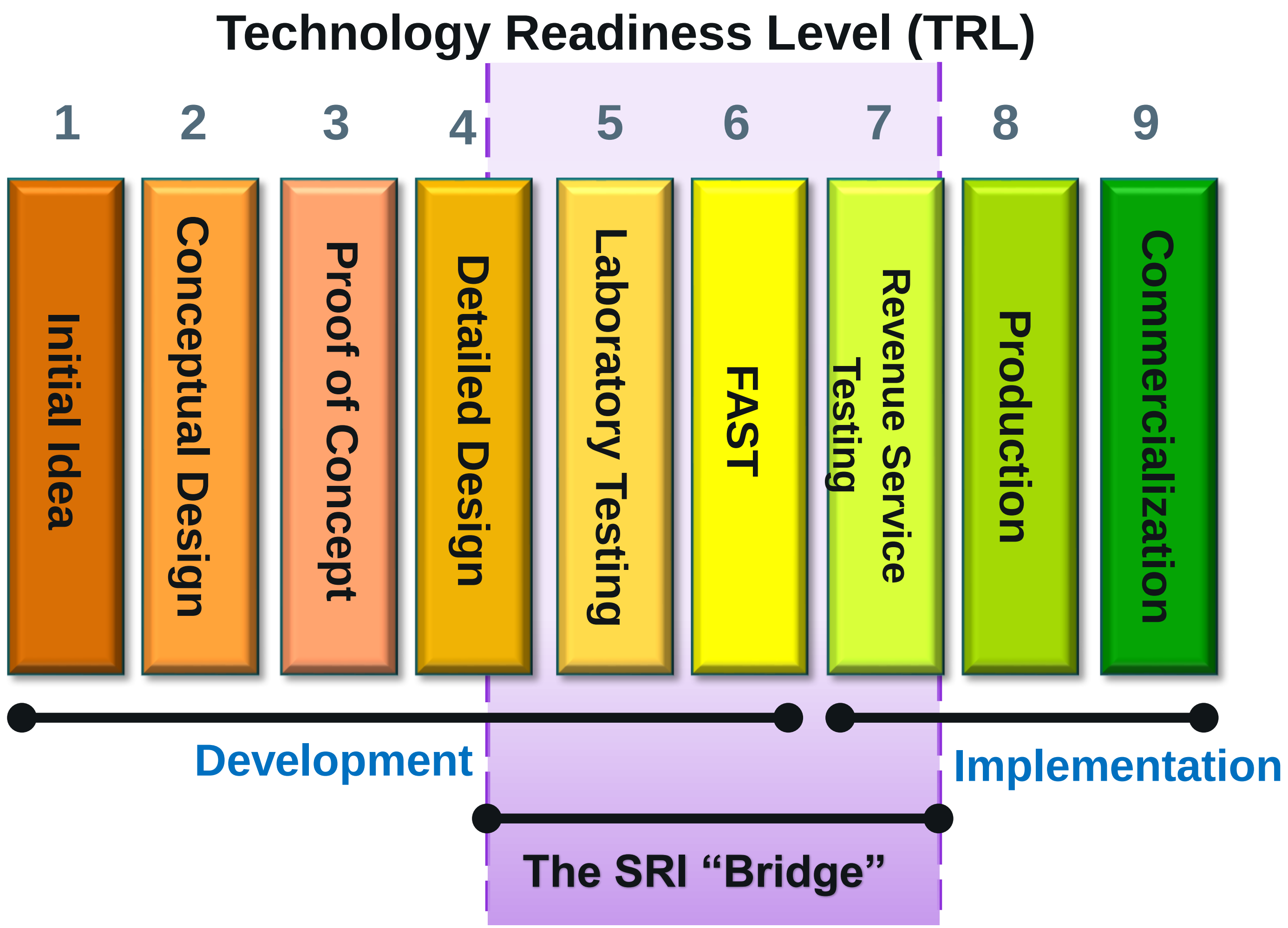
Operations Systems Research

- Train dynamics
- Train control
- Automated train operations
- Signaling systems
- Communication systems

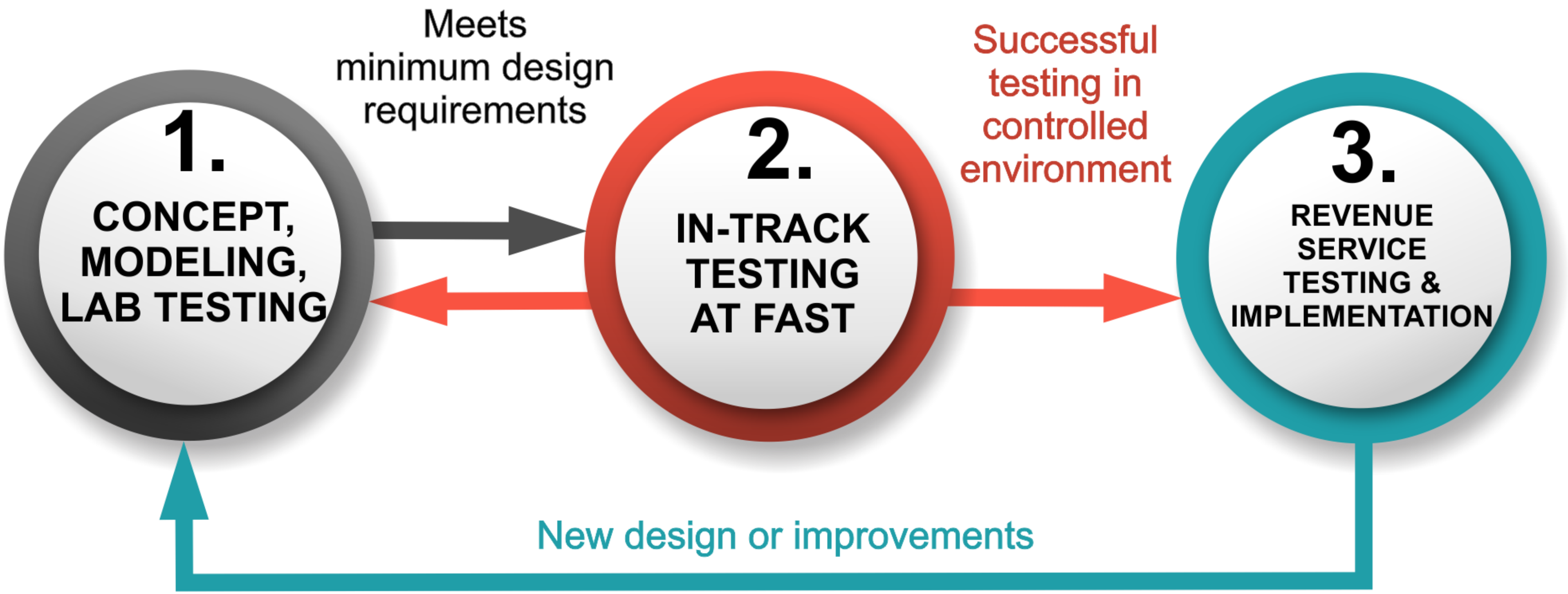
Cross Cutting Initiatives

- Facility for Accelerated Service Testing (FAST)
- Revenue service testing
- Inspection systems
- Mechanics & materials
- Predictive analytics
- University affiliated laboratories
- International cooperative research
- Technology transfer and safety data analysis

SRI Technology Assessment and Implementation



Revenue Service HAL Test Implementation



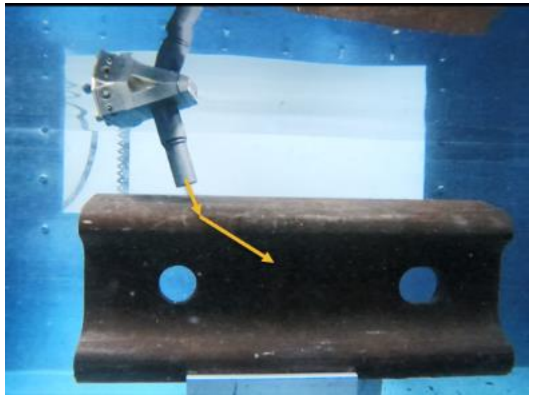
Research

Non-Destructive Evaluation

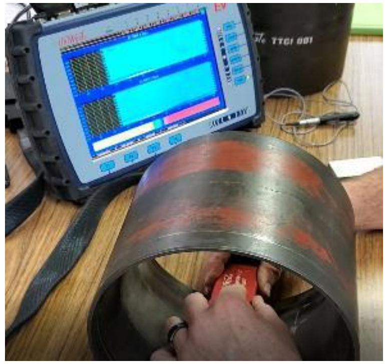
M x V RAIL

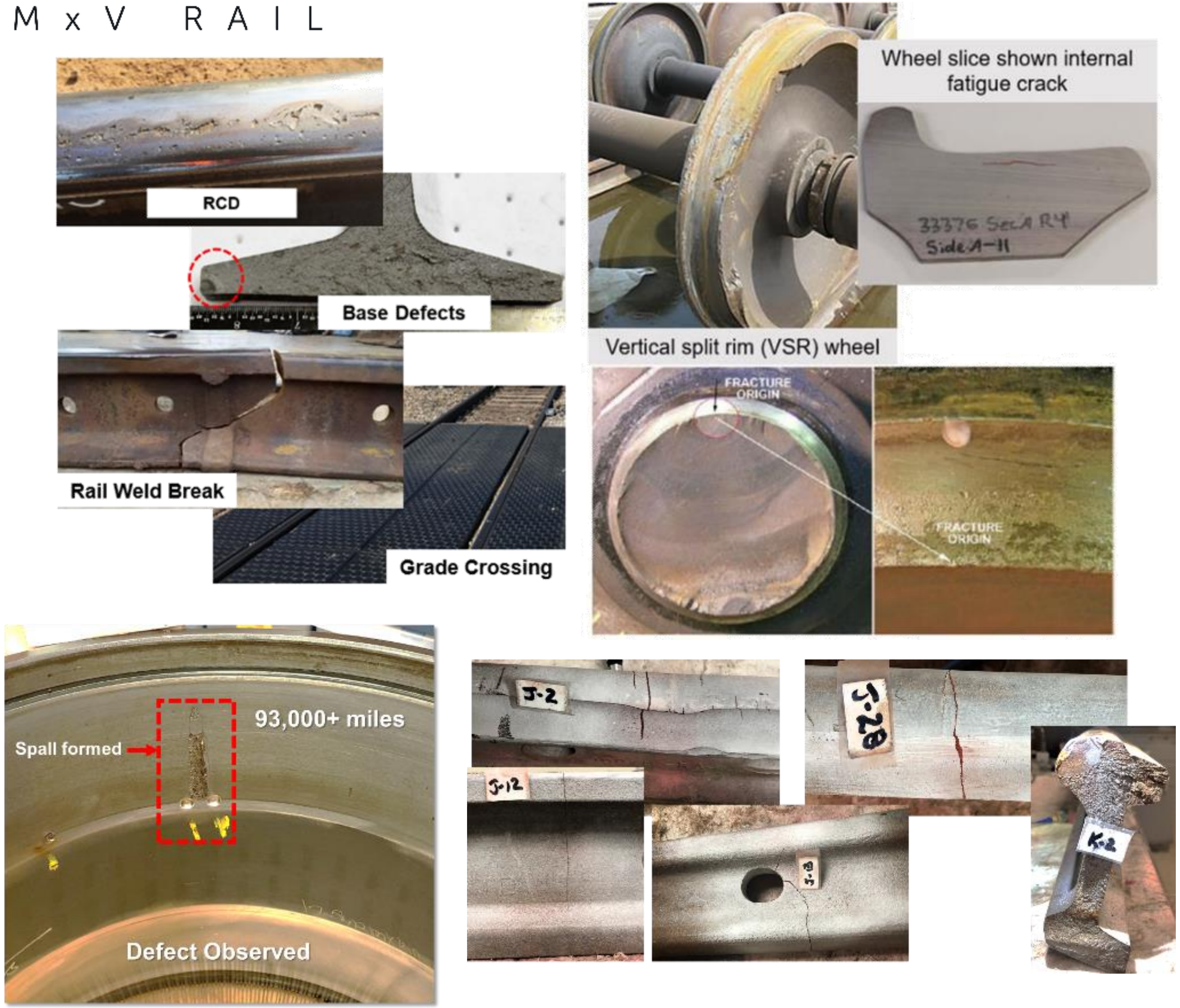
Overview

- **Track & Rolling Stock NDE Research**
  - Background
  - Rail NDE research
    - Electro-magnetic field imaging (EMFI)
    - Non-contact joint bar inspection
- **Wheel NDE research**
  - Defective wheel inspection technology
  - Cracked wheel inspection technology
- **Axle NDE research**
  - Eddy current cracked axle inspection
- **Bearing NDE research**
  - Eddy current array (ECA) bearing inspection





- **Zero broken rail, wheel, axle, and bearing-related derailments**
- **Flaw detection and characterization over wide range of conditions**
- **Facilitate development of validated next generation in-motion inspection & detection systems**

Communications & Train Control

The Evolution of Train Control

- **To support interoperable PTC, the industry has developed:**
  - A federated communications network
  - Standard messaging, data, and segment interfaces
  - A system that provides movement authority, bulletin, and speed limit enforcement
- **Opportunities to leverage these developments:**
  - Enhancements to increase capacity and reduce train delay
  - Foundation for development or integration of other technologies enhancing operational safety and efficiency

Communications & Train Control (C&TC) at MxV Rail

Research

Systems Engineering

Simulation & Modeling

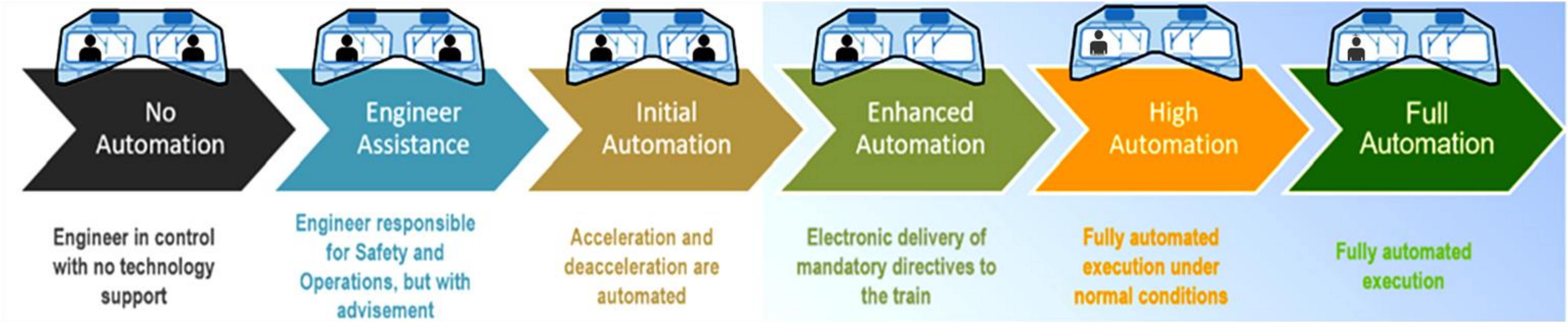
Testing

Projects and Capabilities

- Solving critical train control issues
- Train control performance analysis
- Interoperability testing
- RF communications design/analysis
- Requirement specification
- Lifecycle Management Support
- Development/testing of new technologies
- Railway capacity analysis
- RF Coordination
- Training

What is Automated Train Operation (ATO)?

Train automation is the fusion of multiple existing and emerging railway systems to automate train operation functions.



Train automation level is driven by capability of constituent systems

PTC Tools to Support New Technology

- **Evolution requires supporting infrastructure**
  - Lifecycle management
  - Monitoring and troubleshooting
  - Communications system planning
  - Analysis and testing of new features and functions
- **Interoperability requires joint industry tools and capabilities**
  - Enabler for successful evolution of train control technology

Emerging Technology

SwissPod Technologies

swisspod

Parallel Systems

Railway Supply Institute

Lee Verhey – Director of Regulatory & Industry Affairs

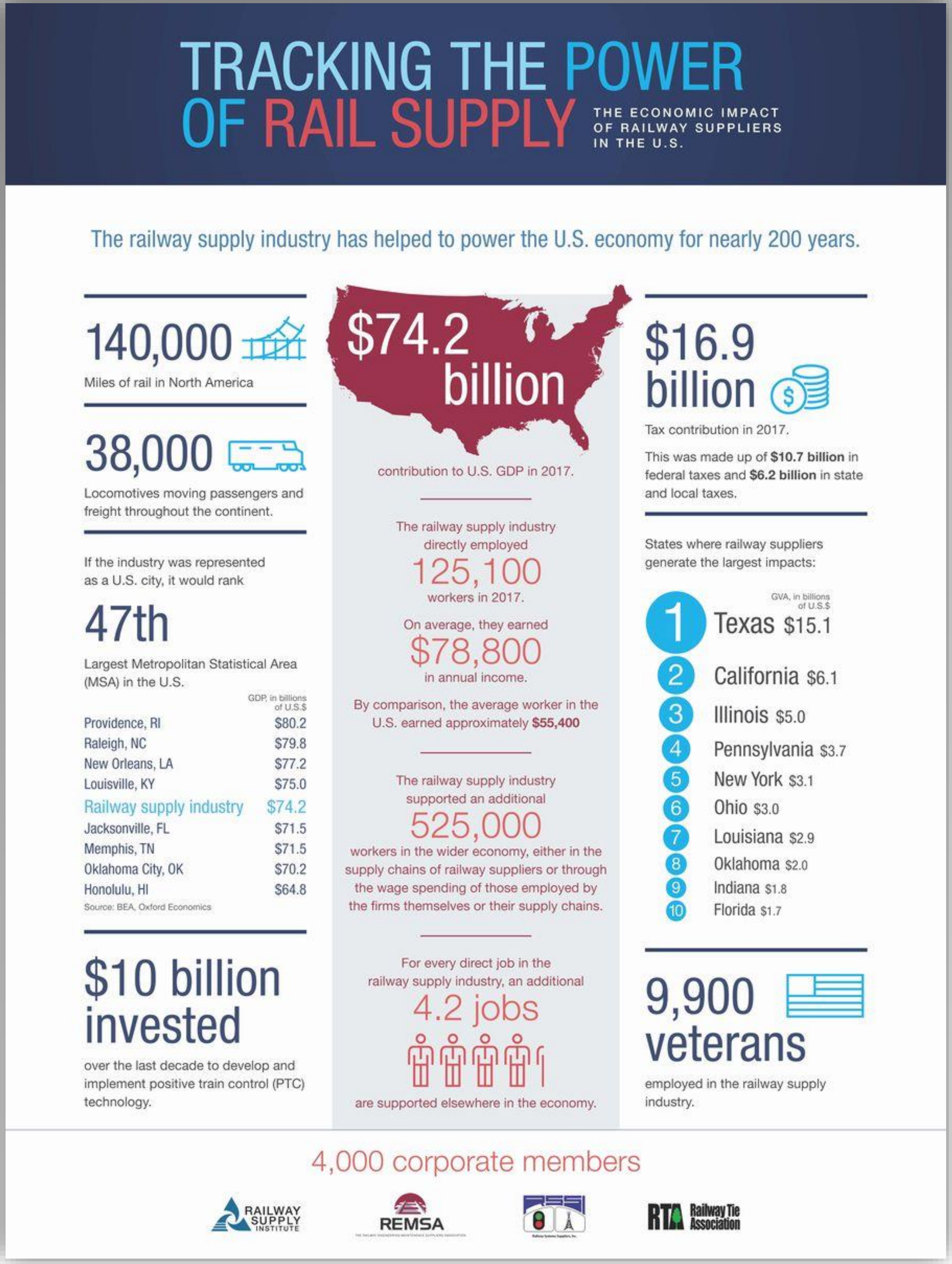
AAR Quality Assurance Auditor's Conference
April 12, 2022

RAILWAY SUPPLY INSTITUTE

Who We Are

Our 150+ member companies represent the broad span of the rail supply industry including:

- Locomotive & railcar builders and owners
- Component suppliers
- Maintenance of way equipment builders and suppliers
- Communications, signal & train control suppliers
- Advanced technology companies



Committees

Committee on Tank Cars

Bill Constantino, President of North American Leasing , UTLX – Chair
John Byrne, RSI Staff Consultant

- Executive Committee comprised of Executive Leadership of 7 RSI Companies in the railcar supply industry that built 95% of the tank cars in North America and own 73%.
- The RSI's Technical Subcommittee works with it Associate Members to advance industry standards that promote safety in the most efficient manner.
- Subcommittee members include technical and engineering leadership. There are 3 seats from CTC that sit on the AAR Tank Car Committee. This committee works closely with the AAR Executive Director of Tank Car Safety (Ken Dorsey) to advance engineering and design efforts to promote the advancement of tank car safety.

Committees

American Rail Car Institute

Kevin Poet, EVP, Operations & Support Services, Trinity Rail – Chair
Lee Verhey, RSI Staff Consultant

- Executive Committee comprised of executive leadership from the freight railcar manufacturers. Quarterly data on manufacturing including orders, backlog, and deliveries are available through annual licensing subscriptions.

- Engineering & Design Subcommittee
  - Subcommittee meets at least twice per year and works closely with the AAR Equipment Engineering Committee to address railcar design issues and improvements. Comprised mostly of railcar manufacturing and repair suppliers' engineering personnel. Additionally, supports edits and changes to the AAR MSRP's for technical design criteria and testing.

Committees

Equipment Leasing Committee

Terry Heidkamp, Vice President, Government and Industry Affairs, GATX Corporation - Chair
Lee Verhey, RSI Staff Consultant

- Leasing companies from railcar manufacturers, financial institutions (i.e. Wells Fargo, Mitsui, SMBC, etc.) and private rail car owners.
- Committee meets every other month to address industry and regulatory changes, rules, etc., that impact railcar operations and ownership. The committee works closely with the AAR and FRA to collaborate on important issues that impact the safe design and improvement of rail cars. Acts on behalf of car owners to communicate to Congressional committees concerns and issues related to the safe and efficient operation of railcars.

Committees

Quality Assurance Committee

Donna Jacobi, Manager, Quality Systems Amsted Rail Company, Inc. - Chair
Lee Verhey, RSI Staff Consultant

- Four Technical Advisory Groups (TAG's)
  - **Regulatory TAG** – Tom DeLafosse, Salco Products, Chair
    Works with AAR, FRA, industry leadership to address regulatory issues affecting the rail supply industry.
  - **Education TAG** – Dave Ronzani, AllTranstek, Chair
    Develops educational materials, presentations, modules, etc. for training online and at RSI Conferences.
  - **M-1003 TAG** – Collaborates with AAR QAC to review and create improvements to the AAR Quality Assurance Standard.
  - **Newsletter TAG** – Gary Alderson & Alfredo Ricardo, AllTransTek, Co-Chairs
    Coordinates with industry quality professionals to communicate current events affecting the railcar supply industry.

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Current Efforts

- Collaborating with the AAR QAC to rewrite M-1003
- Supporting and cost sharing “crude by rail” testing of a crude oil tank car (expected to be completed this year)
- Railcar weld joint testing (currently on hold to focus on crude by rail testing.
- Resumed the Freight Car Fatigue Task Force (FCFTF) efforts with AAR
- RSI-100 – Voluntary Industry Best Practice developed by a RSI-CTC task force to create a standard for the component certification of tank car products that do not have a required technical certification. Addresses FRA and industry concerns related to objective evidence of product compliance to quality assurance specification and design requirements.
- Preparing training content for workshops at the RSI Conference in Fort Worth, October 2022
- Complete rewrite of Appendix D of the AAR Field Manual. The rewrite includes new part qualification codes that will give repair shops and car owners more discreet data for tracking maintenance costs and component reliability. Appendix D will be referenced in the Field Manual when the new document is released and the full document content and associated part qualifier code tables will be available for download from Railinc.

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Current Efforts

- **Committee on Tank Cars –**

  - Last year the RSICTC TSC (RSI-Committee on Tank Cars, Technical Sub Committee) created a Technical Advisory Group consisting of subject matter experts in Inspection, Welding, Coatings and Materials.

  - The TAG is working on developing an industry best practice on how to determine the reliability and sensitivity of different nondestructive inspection performed on tank cars.

  - The TSC is also developing an industry best practice on how to perform product reliability analysis on tank car service equipment and coatings. This practice will include definitions, data collection requirements and guidelines on performing reliability analysis to support qualification intervals.

  - Other projects underway are focused on simplifying and streamlining DOT tank car tank and component design approvals.

RAILWAY SUPPLY INSTITUTE

RSI Collaboration

RSI today represents the “Voice of the Rail Supply Industry”. RSI leadership and its members strive to work hand in hand with the rail industry and regulatory leadership to promote the most safe and efficient transportation of goods by rail. RSI members include many of the industry railcar and rail car component design and technical experts. It is through these historical collaborative efforts that transportation by rail of goods remains the safest, most cost effective, and environmentally responsible mode of transportation today and in the future. RSI stands ready to work with the AAR and its staff to sustain and advance the future of rail transportation.

AAR Quality Auditors and Industry Conference

April 12-14, 2022

Fort Worth, Texas

Failure Modes and Effect Analysis

Tony Sultana

Tools Covered in the Presentation

- Failure Modes and Effect Analysis (FMEA)
  - What it is, when and how to use an FMEA

- Cause-and-Effect Diagram (aka Fishbone Diagram)
  - What it is and when and how to use one

- The FMEA and Fishbone diagram are typically used on a process, product or service (PPS)

Failure Modes and Effect Analysis

Failure Modes and Effect Analysis (FMEA)

- FMEA is a process to systematically identify potential problems before they occur.
  - Failure modes are the ways in which something might fail
  - Effect analysis is a study of the consequences of failures

- When to use an FMEA
  - Analyzing failures in an existing PPS (process, product, service)
  - Evaluating a containment plan as a temporary fix of a corrective action
  - A PPS is being designed or redesigned
  - Anytime a review of potential risks is desired

Steps for performing an FMEA

1. Review the PPS.
2. Determine the failure modes.
3. List one or more potential effects for each failure mode. Answer the question: “If the failure occurs, what are the consequences?
4. Identify potential causes of the failure modes.
5. List current controls to prevent or detect a failure mode.
6. Ranking each failure mode
   – Assign Severity, Occurrence, and Detection factors.
   – Calculate RPN. Prioritize RPNs from High to Low. Identify the top issues, those with high RPNs.
7. Determine preventive or remedial actions, especially for high-priority issues.
8. Recalculate RPN after actions have been implemented.

Process FMEA

Process Step	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes	OCC	Current Process Controls	DET	RPN
What is the process step?	In what ways can step go wrong? (Process fail to meet requirements)	What is the impact? customer requirements or internal requirements?	How Severe is effect to the customer?	What causes the step to go wrong? (How could the failure mode occur?)	How frequent is cause likely to Occur?	What are the existing controls that either prevent the failure mode from occurring or detect it should it occur?	How probable is Detection of cause?	Risk Priority # to rank order concerns

- For the step in the process with the failure, list the failure mode, its effects, potential causes and any controls currently in place
  - Note if a control is active, identify why the control did not prevent the current failure?

FMEA Ratings for Severity, Occurrence and Detectability

- Each of SEV, OCC and DET use values of 1 to 10 and multiply together for a range of 1 to 1000.
- Ratings apply to all types of FMEA's.

RATING	DEGREE OF SEVERITY	PROBABILITY OF OCCURRENCE		ABILITY TO DETECT	
			Frequency (1 in X)		Detection Certainty
1	Customer will not notice the adverse effect or it is insignificant	Likelihood of occurrence is remote	1,000,000	Sure that the potential failure will be found or prevented before reaching the next customer	100%
2	Customer will probably experience slight annoyance	Low failure rate with supporting documentation	20,000	Almost certain that the potential failure will be found or prevented before reaching the next customer	99%
3	Customer will experience annoyance due to the slight degradation of performance	Low failure rate without supporting documentation	5,000	Low likelihood that the potential failure will reach the next customer undetected	95
4	Customer dissatisfaction due to reduced performance	Occasional failures	2,000	Controls may detect or prevent the potential failure from reaching the next customer	90
5	Customer is made uncomfortable or their productivity is reduced by the continued degradation of the effect	Relatively moderate failure rate with supporting documentation	500	Moderate likelihood that the potential failure will reach the next customer	85
6	Warranty repair or significant manufacturing or assembly complaint	Moderate failure rate without supporting documentation	100	Controls are unlikely to detect or prevent the potential failure from reaching the next customer	80
7	High degree of customer dissatisfaction due to component failure without complete loss of function. Productivity impacted by high scrap or rework levels.	Relatively high failure rate with supporting documentation	50	Poor likelihood that the potential failure will be detected or prevented before reaching the next customer	70
8	Very high degree of dissatisfaction due to the loss of function without a negative impact on safety or governmental regulations	High failure rate without supporting documentation	20	Very poor likelihood that the potential failure will be detected or prevented before reaching the next customer	60
9	Customer endangered due to the adverse effect on safe system performance with warning before failure or violation of governmental regulations	Failure is almost certain based on warranty data or significant design verification (DV) testing	10	Current controls probably will not even detect the potential failure	50
10	Customer endangered due to the adverse effect on safe system performance without warning before failure or violation of governmental regulations	Assured of failure based on warranty data or significant DV testing	2	Absolute certainty that the current controls will not detect the potential failure	< 50

Design FMEA

Product Function	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes	OCC	Current Process Controls	DET	RPN
What is the process step?	In what ways can the Component, Subsystem or System potentially fail to meet the Design Intent ?	What is the impact on the step? customer requirements or internal requirements?	How Severe is effect to the customer?	List every conceivable failure and/or failure mechanism for each failure mode	How frequent is cause likely to Occur?	What are the Existing Controls & Procedures (Fail-Safe, Tests, Mathemat.Calcs) that prevent either the cause or the failure mode	How probable is Detection of cause?	Risk Priority # to rank order concerns

- The Design FMEA is structured the same, but the questions are specific to design instead of processes.

Process FMEA Example

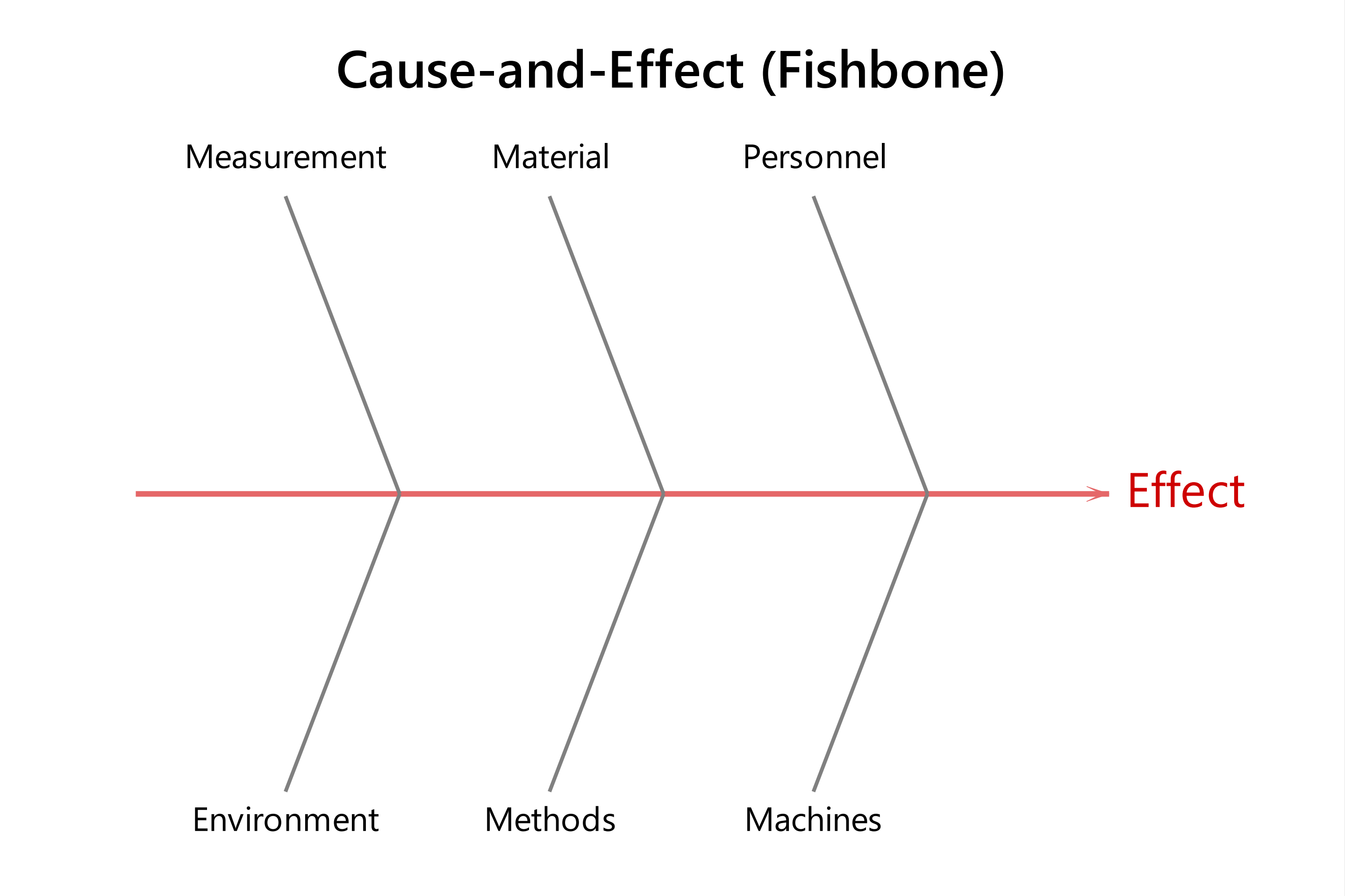
Process Step	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes	OCC	Current Process Controls	DET	RPN
What is the process step?	In what ways can step go wrong? (Process fail to meet requirements)	What is the impact? customer requirements or internal requirements?	How Severe is effect to the customer?	What causes the step to go wrong? (How could the failure mode occur?)	How frequent is cause likely to Occur?	What are the existing controls that either prevent the failure mode from occurring or detect it should it occur?	How probable is Detection of cause?	Risk Priority # to rank order concerns
	QA inspection missed low brinell hardness of part	Part fails MSRP requirements	8	Hardness not checked with each heat/ingot	3	Purity and temperature checks made during production	5	120

- For the step in the process with the failure, list the failure mode, its effects, potential causes and any controls currently in place
  - Note if a control is active, identify why the control did not prevent the current failure?

Cause-and-Effect Fishbone Diagram

Fishbone Diagram

- A brainstorming tool to identify all possible causes related to a problem or condition
- Advantages over an FMEA or process map
  - Easy layout
  - Focuses on “WHY” things happen, rather than on how the process operates
  - Drives toward root causes

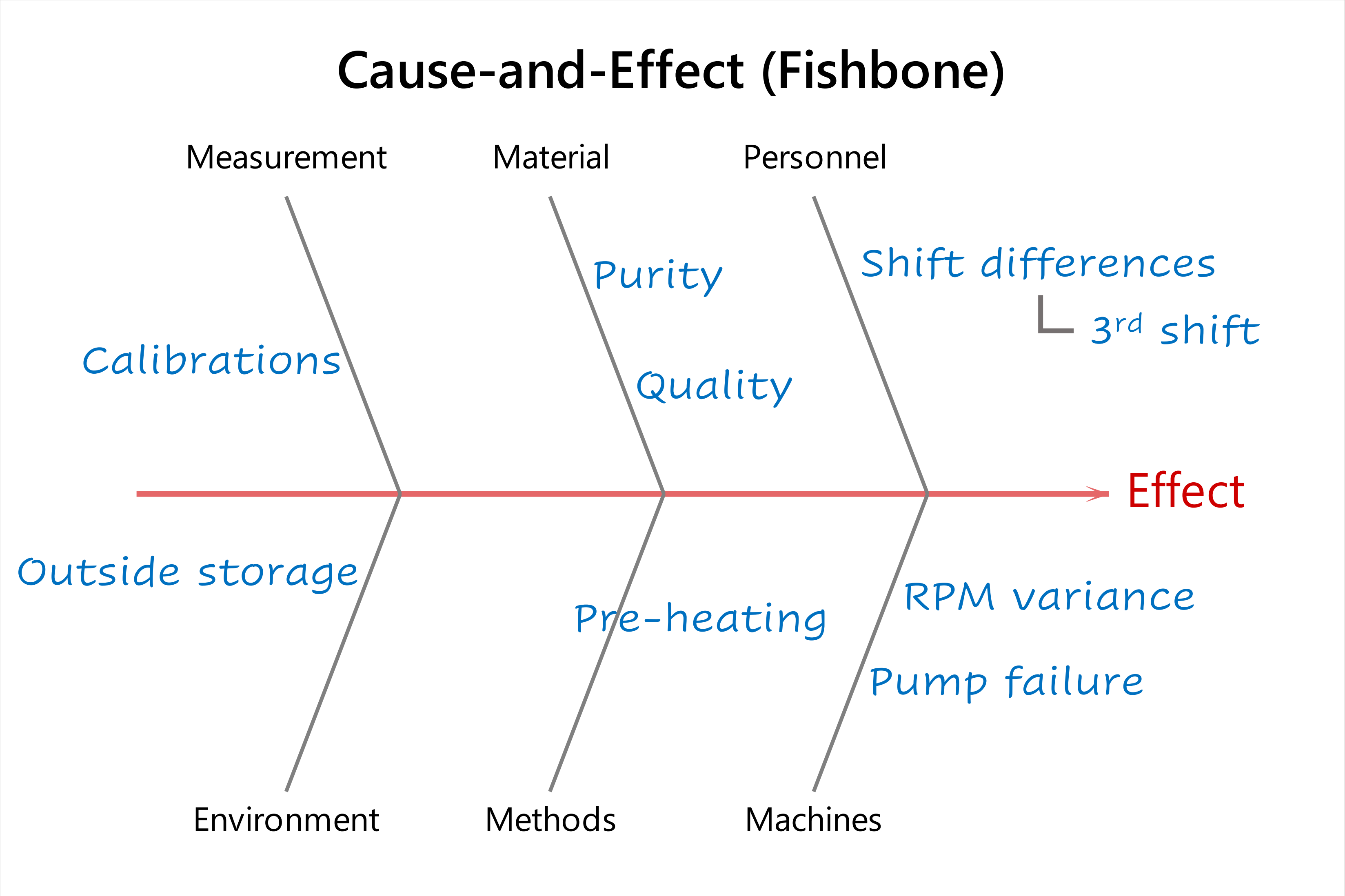


Using a Fishbone Diagram

- Build the basic tree with its six general potential causes
- Add sub-branches by asking “Why or how could this negatively affect the process or design?”
- Update the display of potential causes and consider other general causes or deeper sub-branches

- A fishbone diagram may identify a clear problem that may cause the effect
  - When a solution is not apparent, an FMEA, modeling, component testing, or experimental design may be needed.

Fishbone Diagram



Thank you!

AAR Quality Assurance
55500 DOT Road
Pueblo, Colorado 81001
www.aar.com

AAR Quality Auditors and Industry Conference

April 12-14, 2022

Fort Worth, Texas

AAR / TTCI Resources

Michael Anderson
Compliance Manager
BNSF Railway

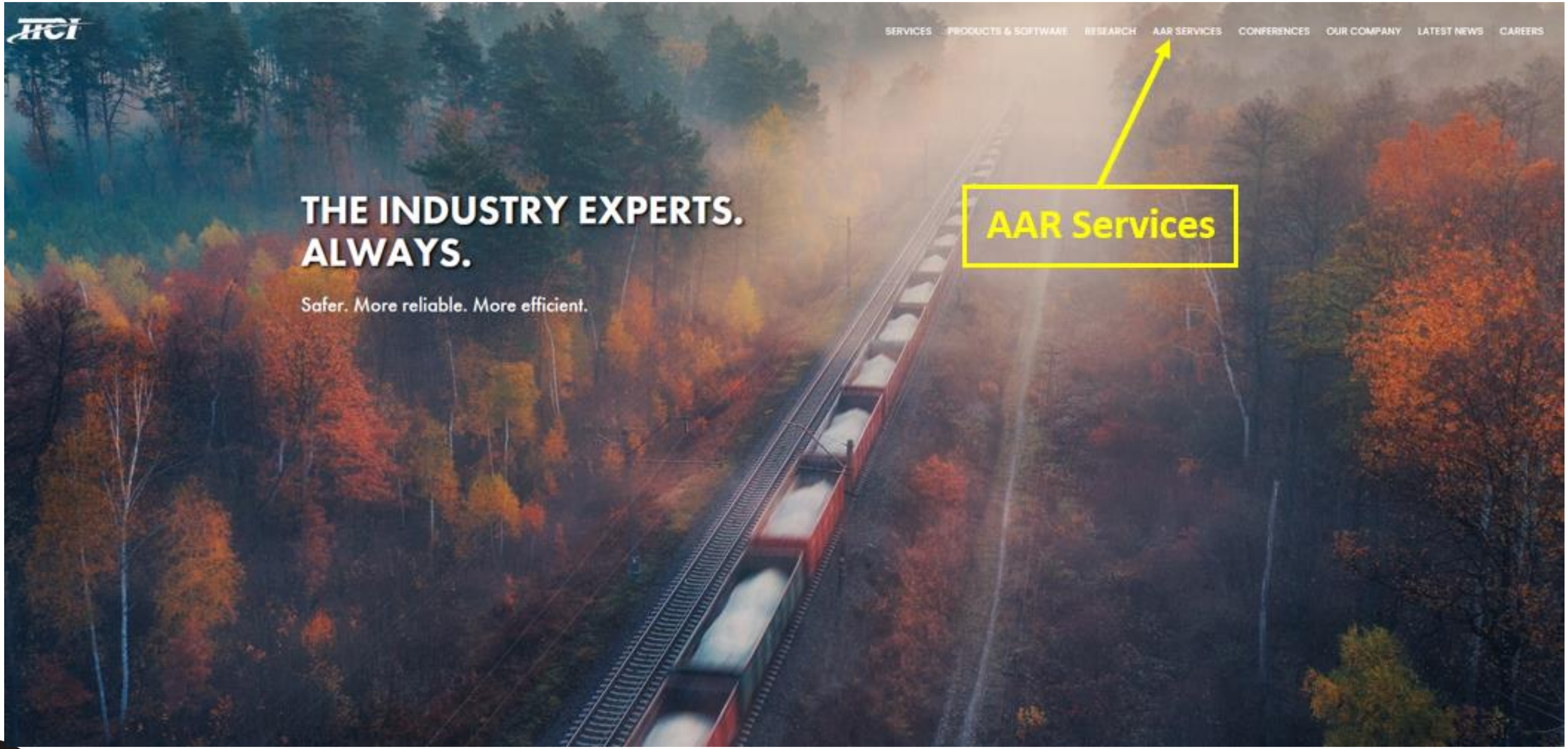
Agenda

AAR Technical Services & Resources

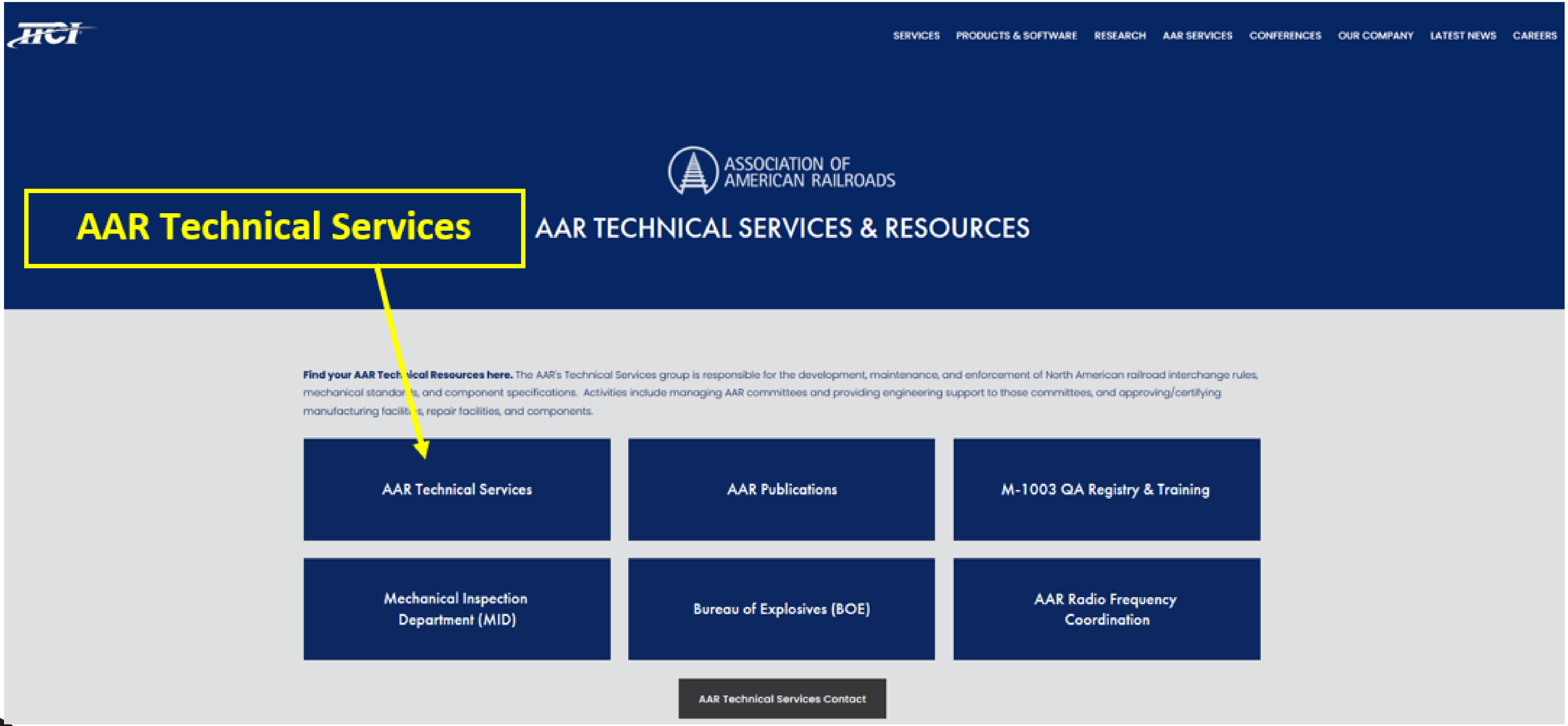
- Field Manual Gage Use Videos
- Field Manual Rule 1 Publications
- AAR Publications
  - MSRP's
  - Circular Letters
- Quality Assurance Committee Web Page
  - M-1003 QA Registry
  - Frequently Asked Questions (FAQ)
  - QAPE Link
  - Chapter 7 Nonconformance
  - Training
- AAR Contacts

AAR Technical Services & Resources

Main TTCI Weblink: https://www.ttci.tech/



https://www.ttci.tech/aar-services-overview



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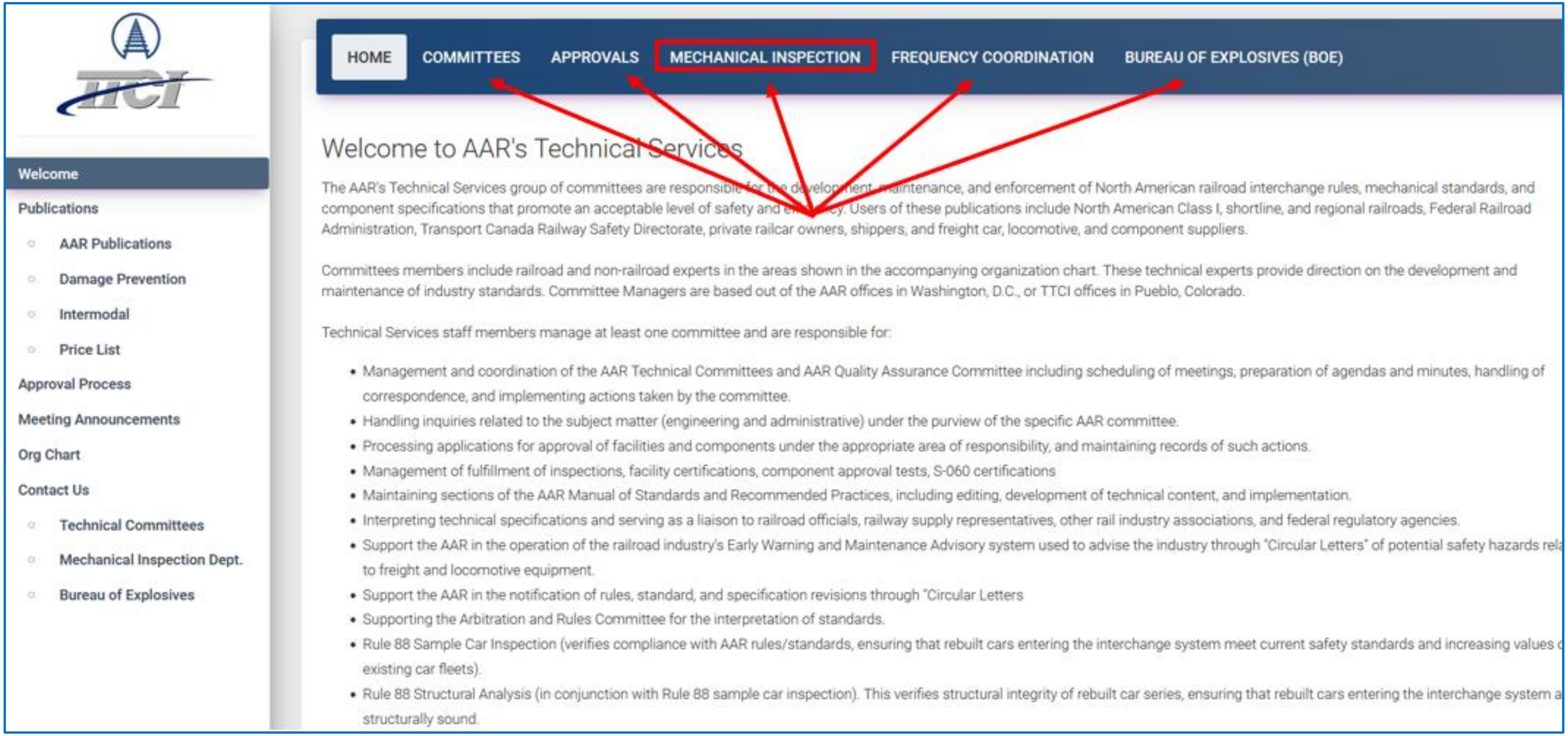


HOME | COMMITTEES | APPROVALS | MECHANICAL INSPECTION | FREQUENCY COORDINATION | BUREAU OF EXPLOSIVES (BOE)

- Welcome
- Publications
  - AAR Publications
  - Damage Prevention
  - Intermodal
  - Price List
- Approval Process
- Meeting Announcements
- Org Chart
- Contact Us
  - Technical Committees
  - Mechanical Inspection Dept.
  - Bureau of Explosives

Welcome to AAR's Technical Services

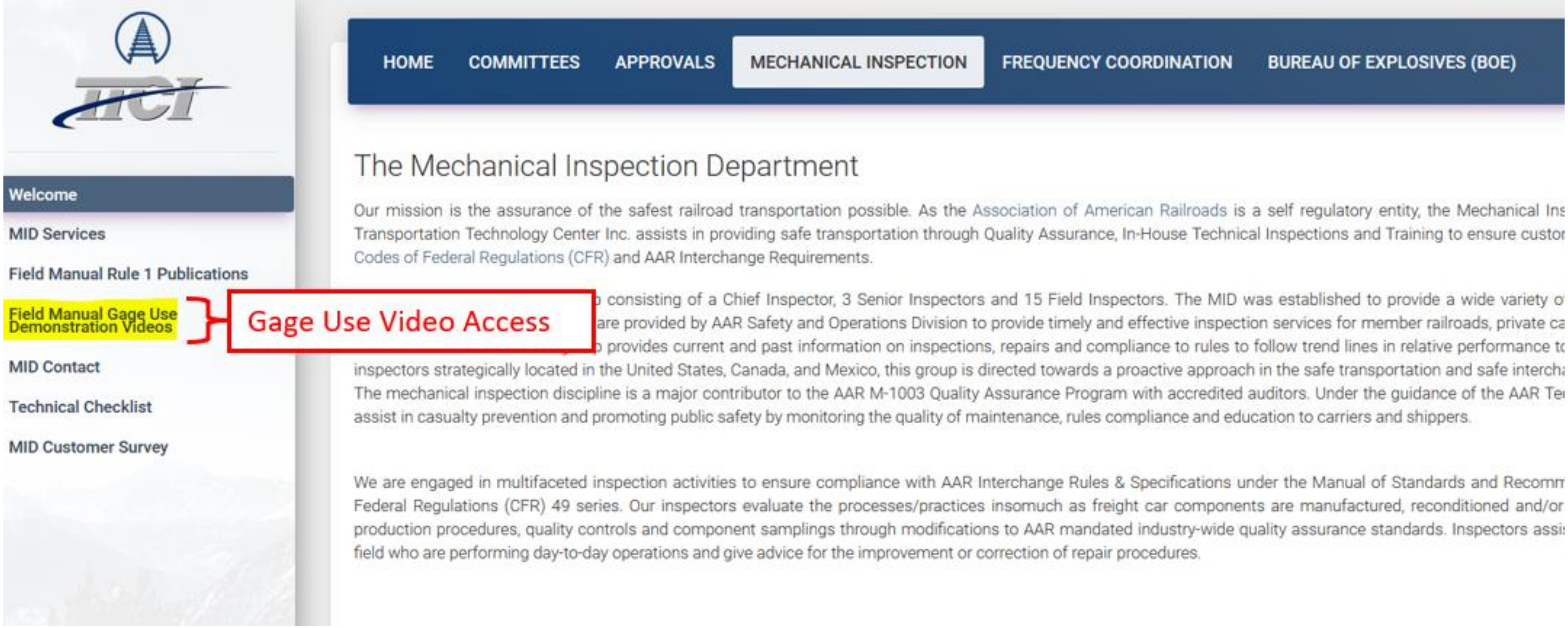
The AAR's Technical Services group of committees are responsible for the development, maintenance, and enforcement of North American railroad interchange rules, mechanical standards, and component specifications that promote an acceptable level of safety and efficiency. Users of these publications include North American Class I, shortline, and regional railroads, Federal Railroad Administration, Transport Canada Railway Safety Directorate, private railcar owners, shippers, and freight car, locomotive, and component suppliers.

Committees members include railroad and non-railroad experts in the areas shown in the accompanying organization chart. These technical experts provide direction on the development and maintenance of industry standards. Committee Managers are based out of the AAR offices in Washington, D.C., or TTCI offices in Pueblo, Colorado.

Technical Services staff members manage at least one committee and are responsible for:

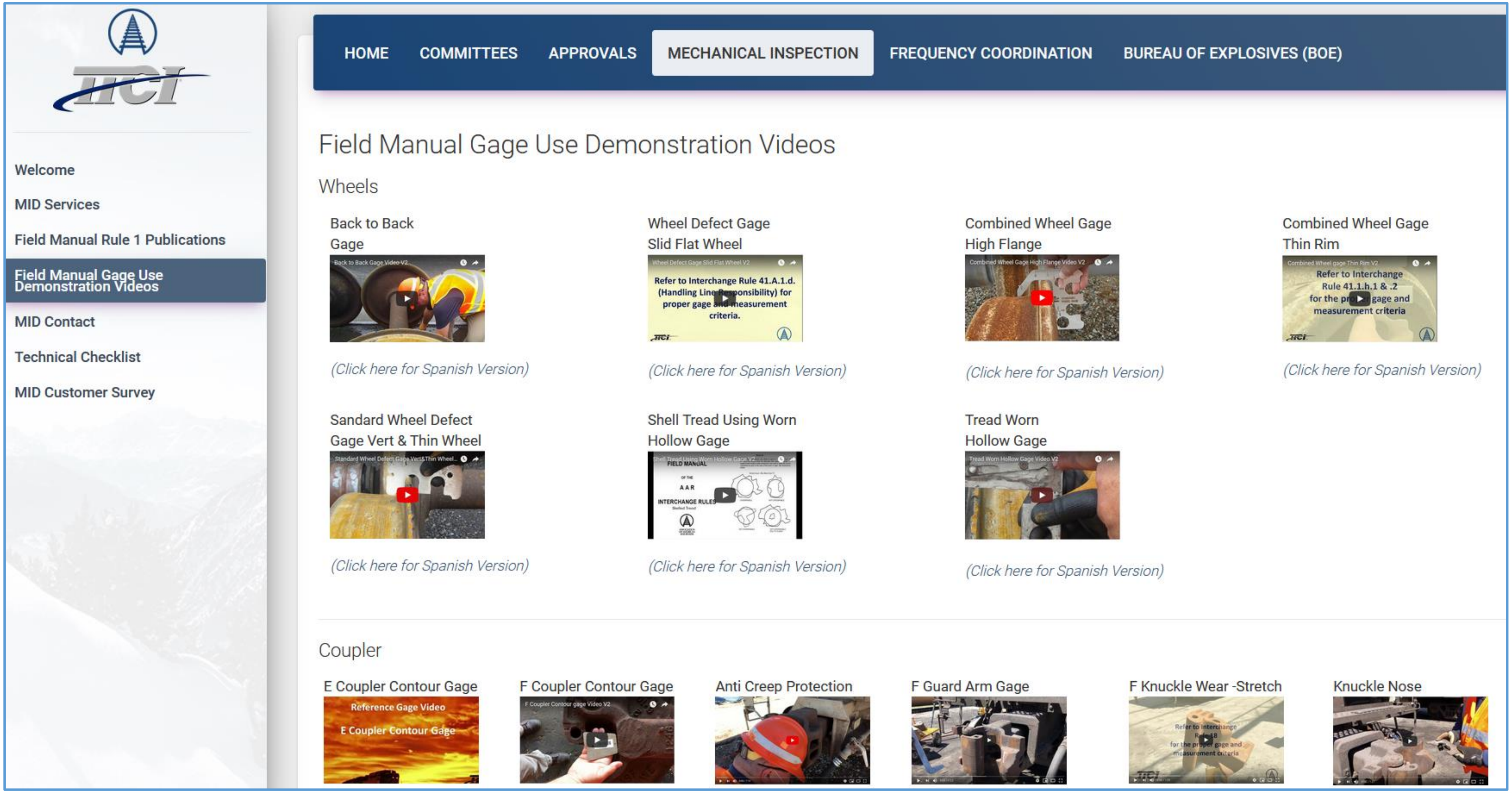
- Management and coordination of the AAR Technical Committees and AAR Quality Assurance Committee including scheduling of meetings, preparation of agendas and minutes, handling of correspondence, and implementing actions taken by the committee.
- Handling inquiries related to the subject matter (engineering and administrative) under the purview of the specific AAR committee.
- Processing applications for approval of facilities and components under the appropriate area of responsibility, and maintaining records of such actions.
- Management of fulfillment of inspections, facility certifications, component approval tests, S-060 certifications
- Maintaining sections of the AAR Manual of Standards and Recommended Practices, including editing, development of technical content, and implementation.
- Interpreting technical specifications and serving as a liaison to railroad officials, railway supply representatives, other rail industry associations, and federal regulatory agencies.
- Support the AAR in the operation of the railroad industry's Early Warning and Maintenance Advisory system used to advise the industry through "Circular Letters" of potential safety hazards rela to freight and locomotive equipment.
- Support the AAR in the notification of rules, standard, and specification revisions through "Circular Letters
- Supporting the Arbitration and Rules Committee for the interpretation of standards.
- Rule 88 Sample Car Inspection (verifies compliance with AAR rules/standards, ensuring that rebuilt cars entering the interchange system meet current safety standards and increasing values c existing car fleets).
- Rule 88 Structural Analysis (in conjunction with Rule 88 sample car inspection). This verifies structural integrity of rebuilt car series, ensuring that rebuilt cars entering the interchange system a structurally sound.

https://aar.com/standards/mid-index.html



Field Manual Gage Use Videos

- https://aar.com/standards/Field_Manual_Gage_Use_Demonstration_Videos.html



https://aar.com/standards/mid-index.html

Field Manual Rule 1 Publications

- https://aar.com/standards/mid-field_manual.htm

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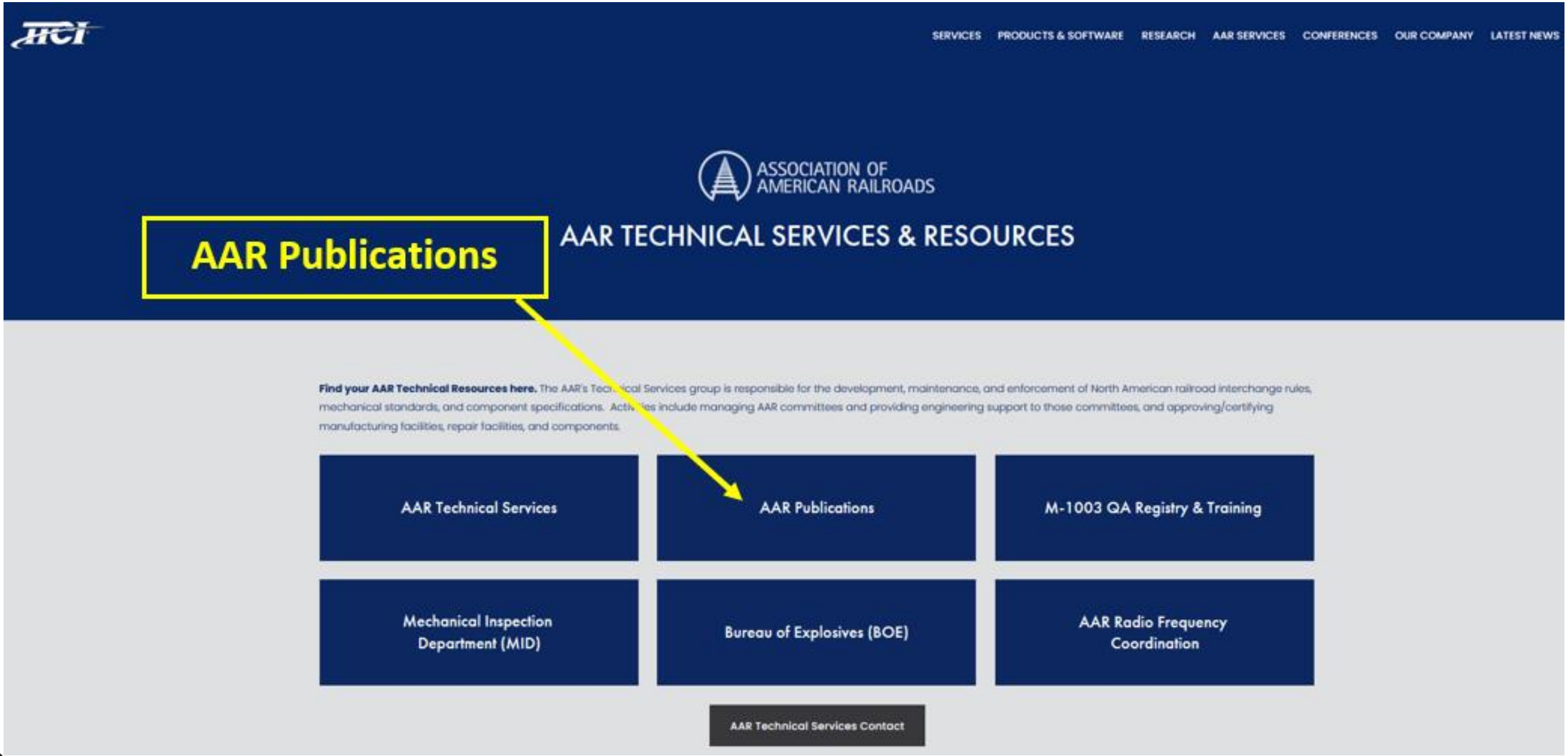
- Welcome
- MID Services
- Field Manual Rule 1 Publications
- Field Manual Gage Use Demonstration Videos
- MID Contact
- Technical Checklist
- MID Customer Survey

Field Manual of the AAR Interchange Rules

Publication	Hard Copy Revision Date	Comment/Link
Field Manual of the AAR Interchange Rules	January 2022	Available through the AAR Publications.
Code of Air Brake System Tests for Freight Brake Equipment (AAR Standard S-486)	August 2018	The current MSRP Section E is available through the Transportation Technology Center Inc.
Instruction Leaflet No. 2391 Sup. 1, Repair Track Maintenance, Freight Brake Equipments "AB" Type	April 1991	2391, S.1
Repair Track Maintenance, Freight Brake Equipment DB-60 and DB-60L Control Valves	December 2019	IP-175.pdf
Repair Track Maintenance, Freight Brake Equipment ABDX and ABDXL Control Valves	September 2004	2391, S5
CFR 49, Part 215, Rilroad Freight Car Safety Standards (FRA)	July 2021	Electronic Code of Federal Regulations - 49CFR, Part 215
CFR 49, Part 224, Reflectorization of Rail Freight Rolling Stock (FRA)	July 2021	Electronic Code of Federal Regulations, CFR 49, Part 224
CFR 49, Part 231, Railroad Safety Appliance Standards (FRA)	July 2021	Electronic Code of Federal Regulations - 49CFR, Part 231
CFR 49, Part 232, Brake Systems Safety Standards for Freight and Other Non-Passenger Trains and Equipment; End-of-Train-Devices (FRA)	July 2021	Electronic Code of Federal Regulations - 49CFR, Part 232
AAR Form MD-11, Roller Bearing Hot Box and Shop Inspection Report	Electronic Version	https://www.railinc.com/md11/ * You must have SSO ID for Railinc and permission to/for this MD reporting ** For RailInc access information go to https://www.railinc.com/rportal/mrr

https://www.ttci.tech/aar-services-overview



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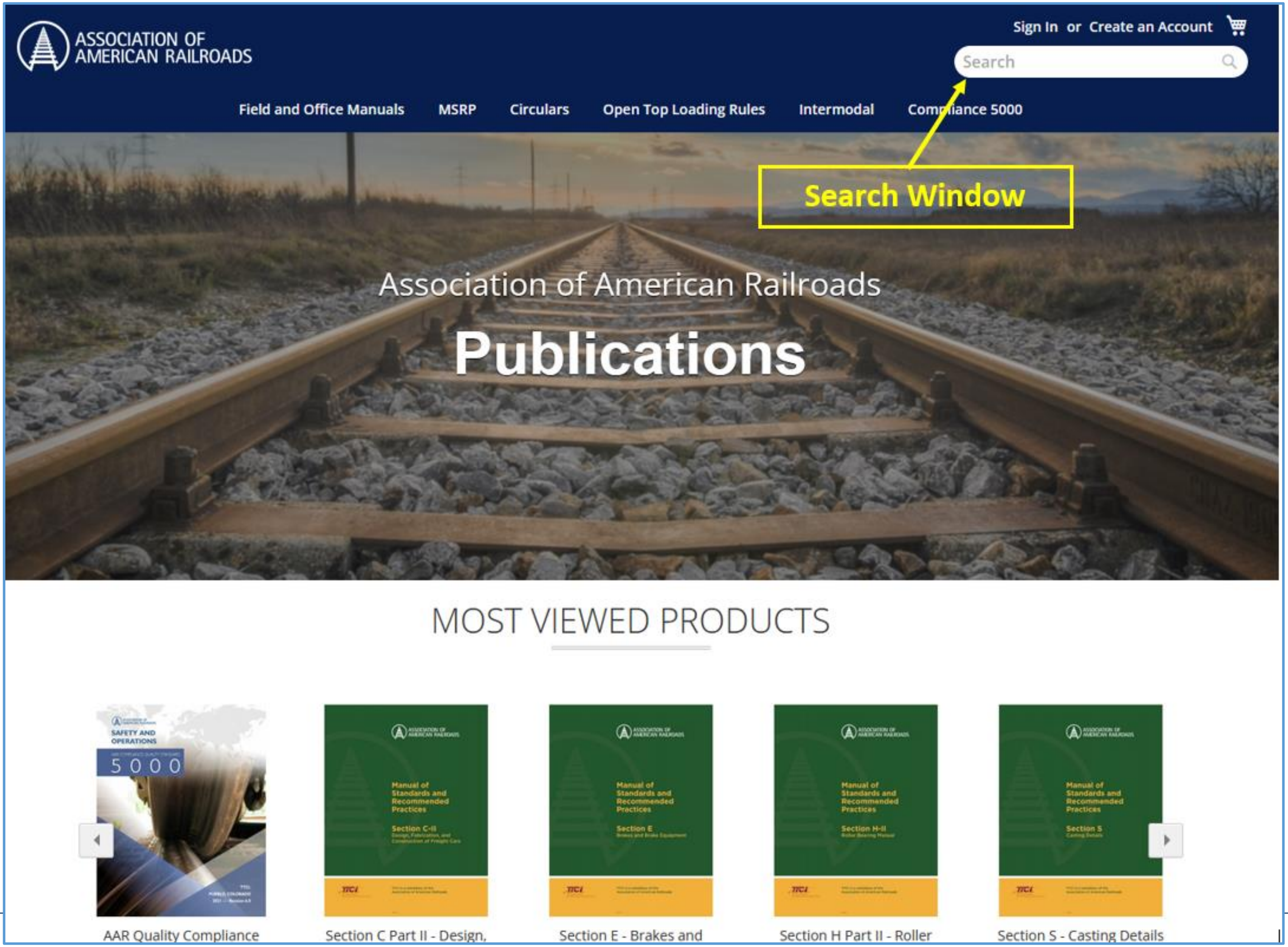

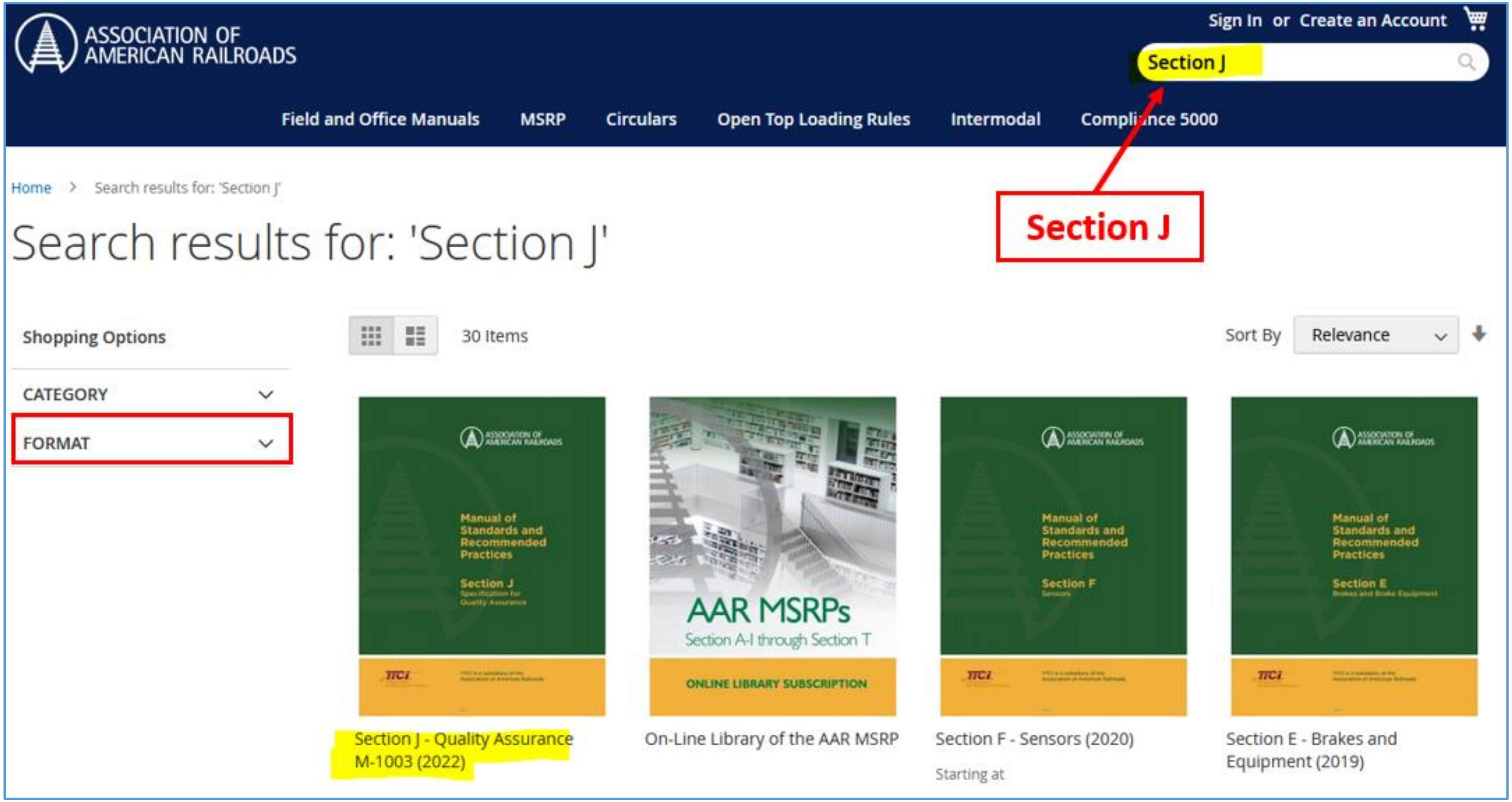
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Starting at
Section E - Brakes and Equipment (2019)

https://aarpublications.com/

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Home > Circulars

Circulars

Please note: MSRP volumes are republished frequently, approximately every 2 years. New or amended standards between publications are announced via AAR Circular Letters. Therefore, to ensure compliance to the latest AAR standards, AAR Circular Letters must be monitored. The AAR Circular Letter system emails notices to all subscribers.

1 Item

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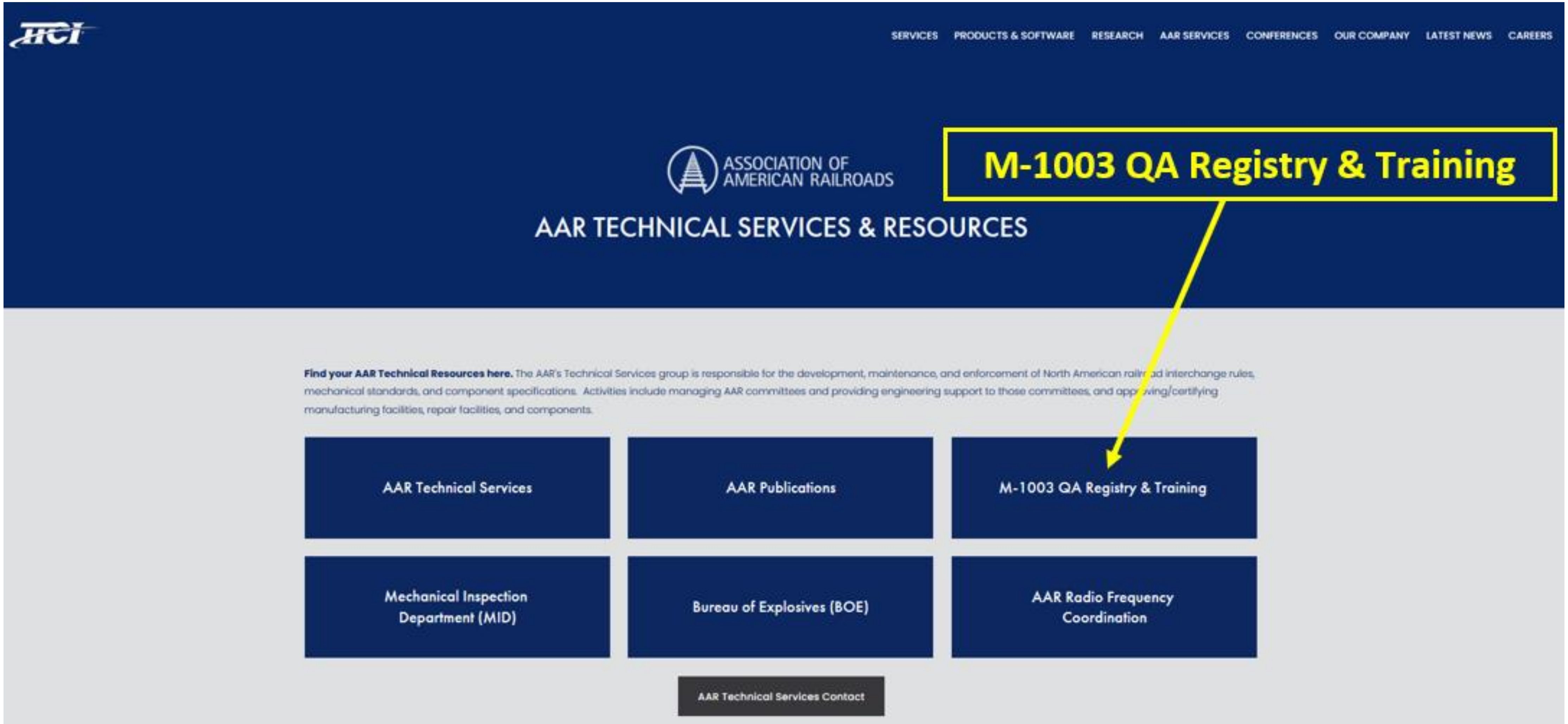
Circulars Subscription

$750.00

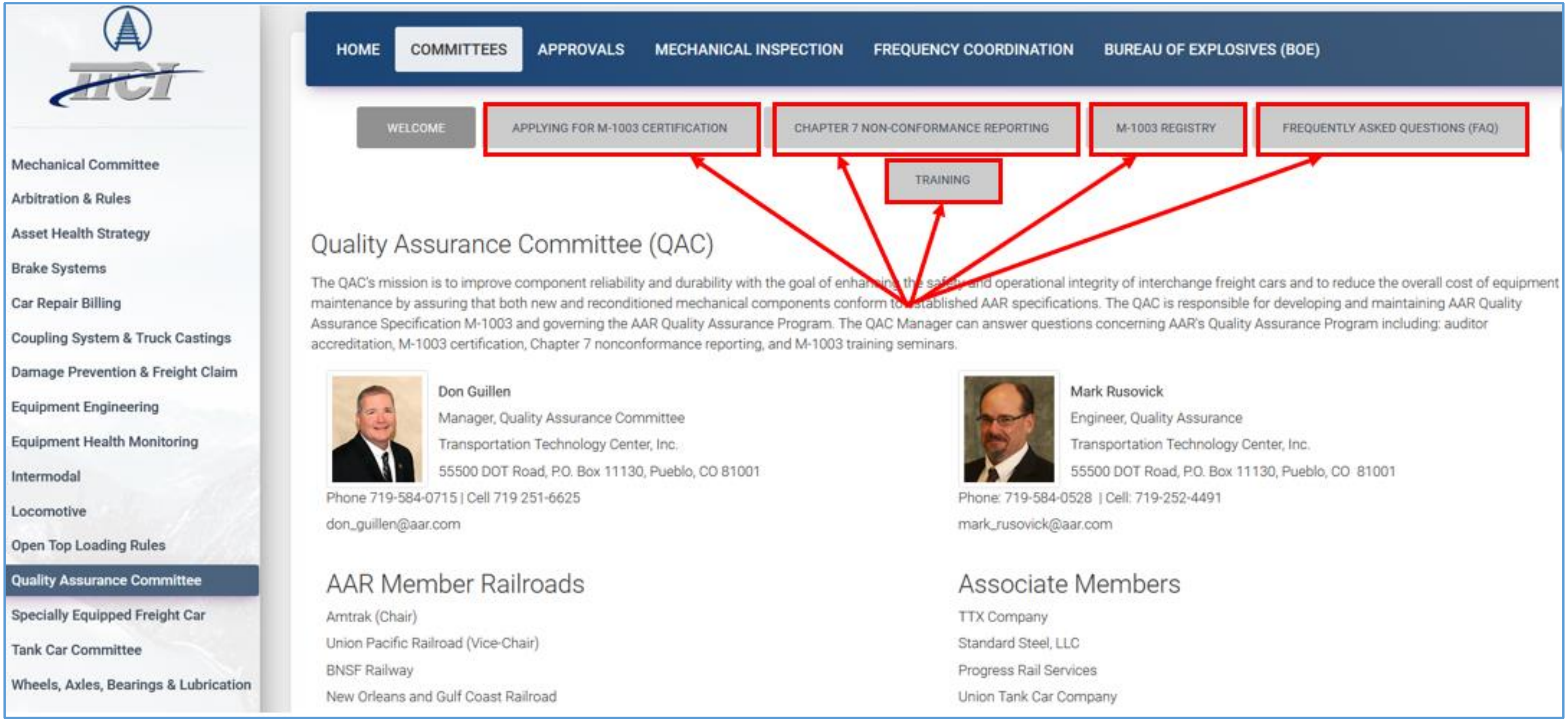
Add to Cart

Per section 2.3.5 of M-1003 (Section J), M-1003 Certified Facilities are required to maintain a current subscription to AAR Circular Letters.

https://www.ttci.tech/aar-services-overview



https://aar.com/standards/qa.html



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Specially Equipped Freight Car
Tank Car Committee
Wheels, Axles, Bearings & Lubrication

Quality Assurance Committee (QAC)

The QAC's mission is to improve component reliability and durability with the goal of enhancing the safety and operational integrity of interchange freight cars and to reduce the overall cost of equipment maintenance by assuring that both new and reconditioned mechanical components conform to established AAR specifications. The QAC is responsible for developing and maintaining AAR Quality Assurance Specification M-1003 and governing the AAR Quality Assurance Program. The QAC Manager can answer questions concerning AAR's Quality Assurance Program including: auditor accreditation, M-1003 certification, Chapter 7 nonconformance reporting, and M-1003 training seminars.

Don Guillen
Manager, Quality Assurance Committee
Transportation Technology Center, Inc.
55500 DOT Road, P.O. Box 11130, Pueblo, CO 81001
Phone 719-584-0715 | Cell 719 251-6625
don_guillen@aar.com

Mark Rusovick
Engineer, Quality Assurance
Transportation Technology Center, Inc.
55500 DOT Road, P.O. Box 11130, Pueblo, CO 81001
Phone: 719-584-0528 | Cell: 719-252-4491
mark_rusovick@aar.com

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Link to M-1003 Registry Page

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AAR Registry of M-1003 Certified Facilities

Commonly referred to as "the Registry" or "the M-1003 Registry", this live, searchable database contains the most current listing of M-1003-certified facilities and the activities (products c covered by their M-1003 certification. It is a public database designed to inform AAR member railroads, suppliers, and others of all facilities that are certified to the M-1003 Quality Assura Specification.

CLICK HERE TO ACCESS THE M-1003 REGISTRY

Important: The Registry contains the most up-to-date information regarding a facility's certification status. If a facility is listed in the Registry, they have received initial M-1003 certificatio M-1003 certification is current.

Registry Link

Tips for searching the registry:

- You can export the Registry as a .csv file by clicking Code column. Keep in mind that because the Registry is a live database, exporting only snapshot of the data at any given time.
- Each column in the registry provides typical spreadsheet functionality.
- To SORT the values in a given column by ascending or descending order, simply click the column header.

If you have further questions, please see the Frequently Asked Questions Page, or email QA@aar.com.

AAR Registry of M-1003 Certified Facilities

AAR Registry of M-1003 Certified Facilities

Searchable Fields

Important Note: If a facility is listed in the Registry, its M-1003 Certification is current even if the facility's ce

From time to time, the renewal of a facility's certification becomes delayed for reasons beyond the facility's control and in that case the certification is considered current.

Export Registry

Export

QA Code	Facility Name	Facility Location	Activity Description
CPNE	Crane CP&E	Cincinnati, Ohio	C4a - Assemble and Qualification of Tank Car Service Equipment
STLN	A Stucki Company - Lincoln	Lincoln, Ne	B33-2B - Approved roller bearing repair shop-freight and Amtrak passenger car B33-2G - Cone face grinding
AKKS	A&K Railroad Materials, Inc.	Kansas City, KS	VOL - Manufacturer and supplier of new and relay rail, track components and special trackwork.
STKI	A. Stucki Company	Sharon, PA	B29 - Manufacturer of Brake Beams VOL - Manufacturer of Side Bearings; Friction Elements; Manufacturer and Reconditioner of Hydraulic Stabilizers
ABXCL	ABTREX Industries. Inc.	Cleveland, TX	C10 - Repair of Interior Linings and Coatings in Tank Cars C7 - Removal of Interior Linings and Coatings in Tank Cars C8 - Installation of Interior Linings and Coatings in Tank Cars
ACMX	ACEROMEX SA DE CV	Ciénega de Flores, , N.L.	A22 - Manufacturer of Freight Car Major Subassemblies
AIDF	Acoforja Industria de Forjados S.A.	Santa Luzia City, Minas Gerais	A15 - Manufacturer of Axles
ADM	ADM Railcar Repair	Decatur, IL	B24 - Tank Car Repair Facility B25 - Repair Shop (Facility)/Repair Track Engaged in Heavy Repairs B26 - Repair Shop (Facility)/Repair Track Engaged in Office Manual Rule 88.C Activity B81 - Qualification of Tank Cars B89 - Maintenance, Modification, and Qualification of Safety Systems B90 - Maintenance, Alteration, and Qualification of Fuel Tanks of Tank Car Stub Sills C10 - Repair of Interior Linings and Coatings in Tank Cars C5 - Recondition/Repair and Qualification of Tank Car Service Equipment C6r - Remove and Replace Tank Car Service Equipment, Including Gaskets, Leakage Test, and Modifications C7 - Removal of Interior Linings and Coatings in Tank Cars C8 - Installation of Interior Linings and Coatings in Tank Cars

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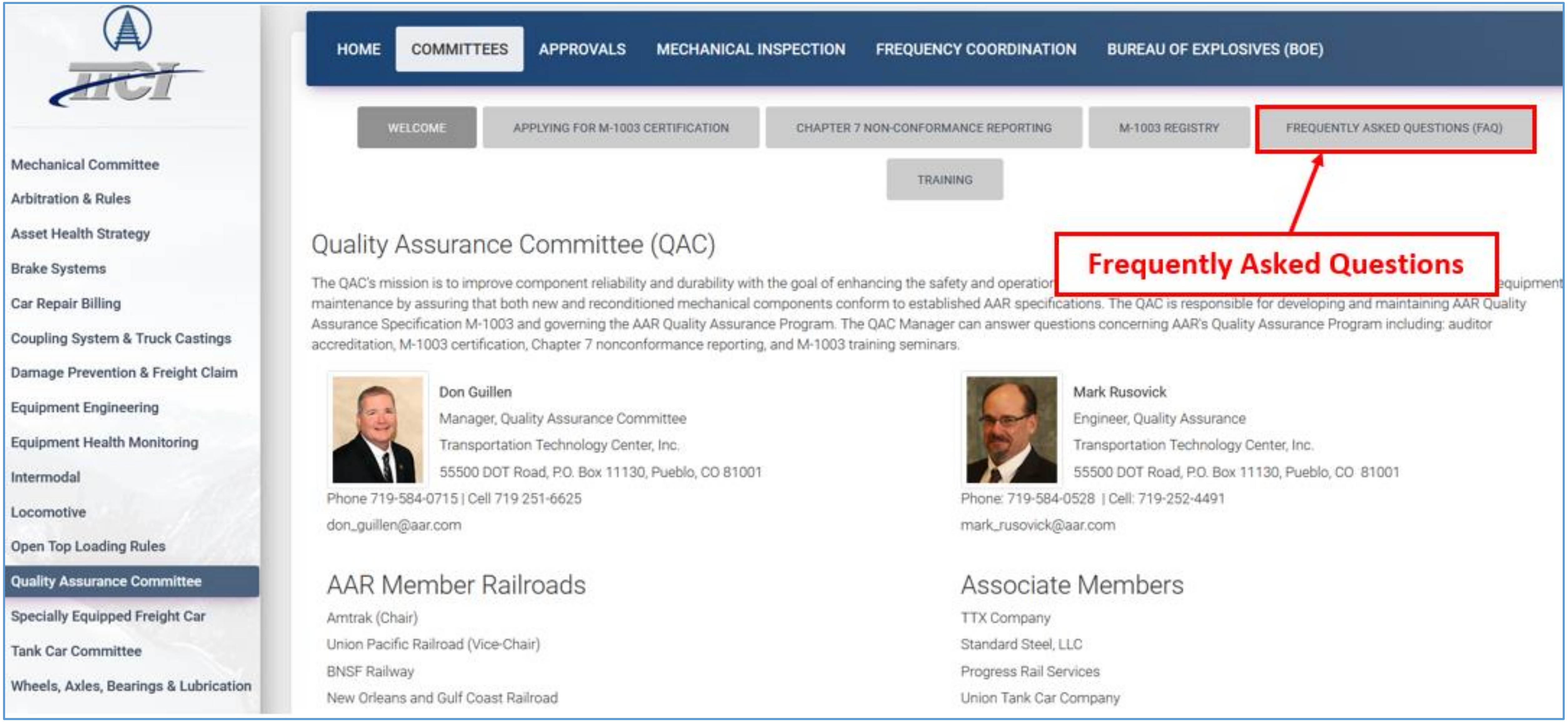
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Manager, Quality Assurance Committee
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55500 DOT Road, P.O. Box 11130, Pueblo, CO 81001
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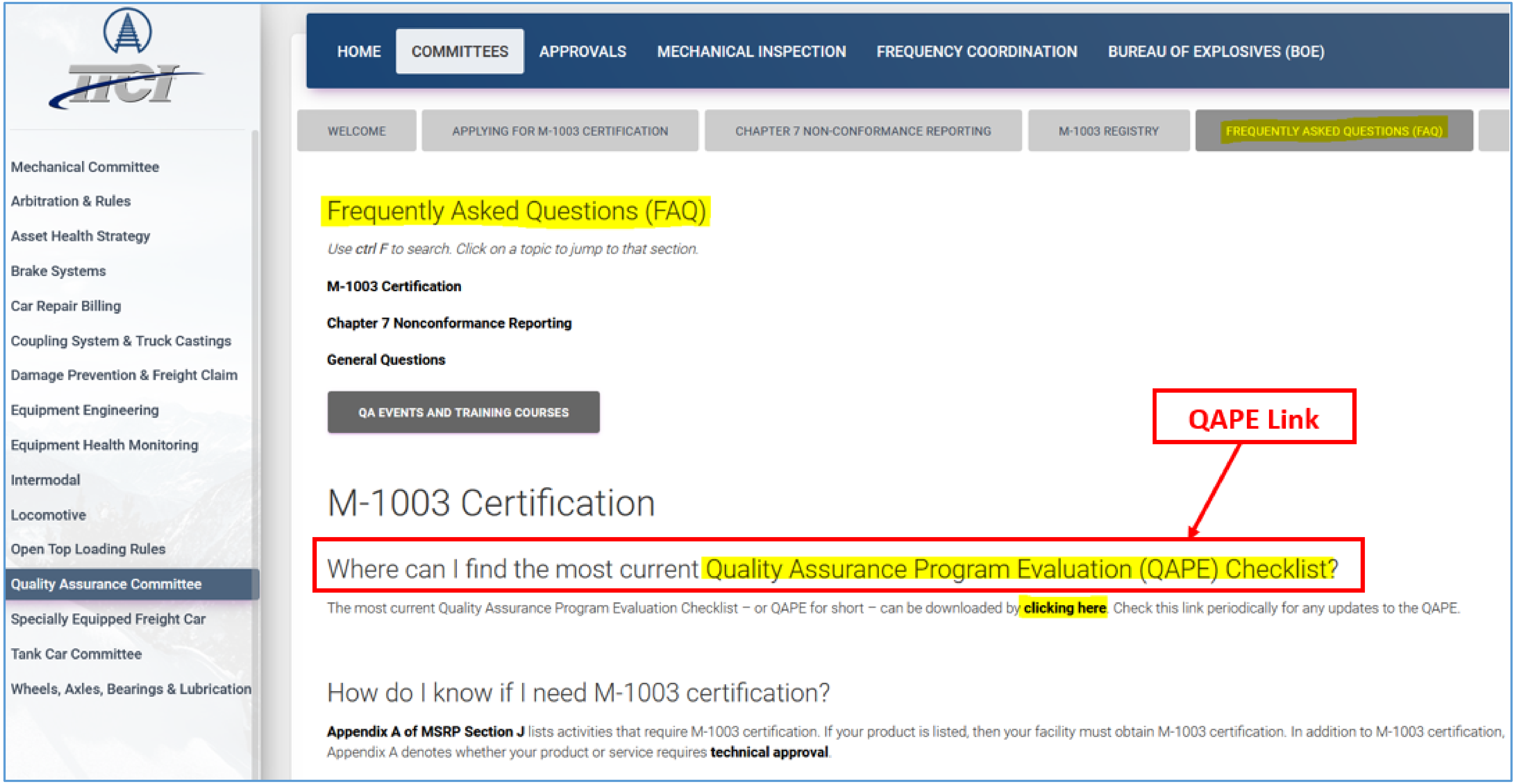
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Frequently Asked Questions (FAQ)

Use ctrl F to search. Click on a topic to jump to that section.

M-1003 Certification

Chapter 7 Nonconformance Reporting

General Questions

QA EVENTS AND TRAINING COURSES

QAPE Link

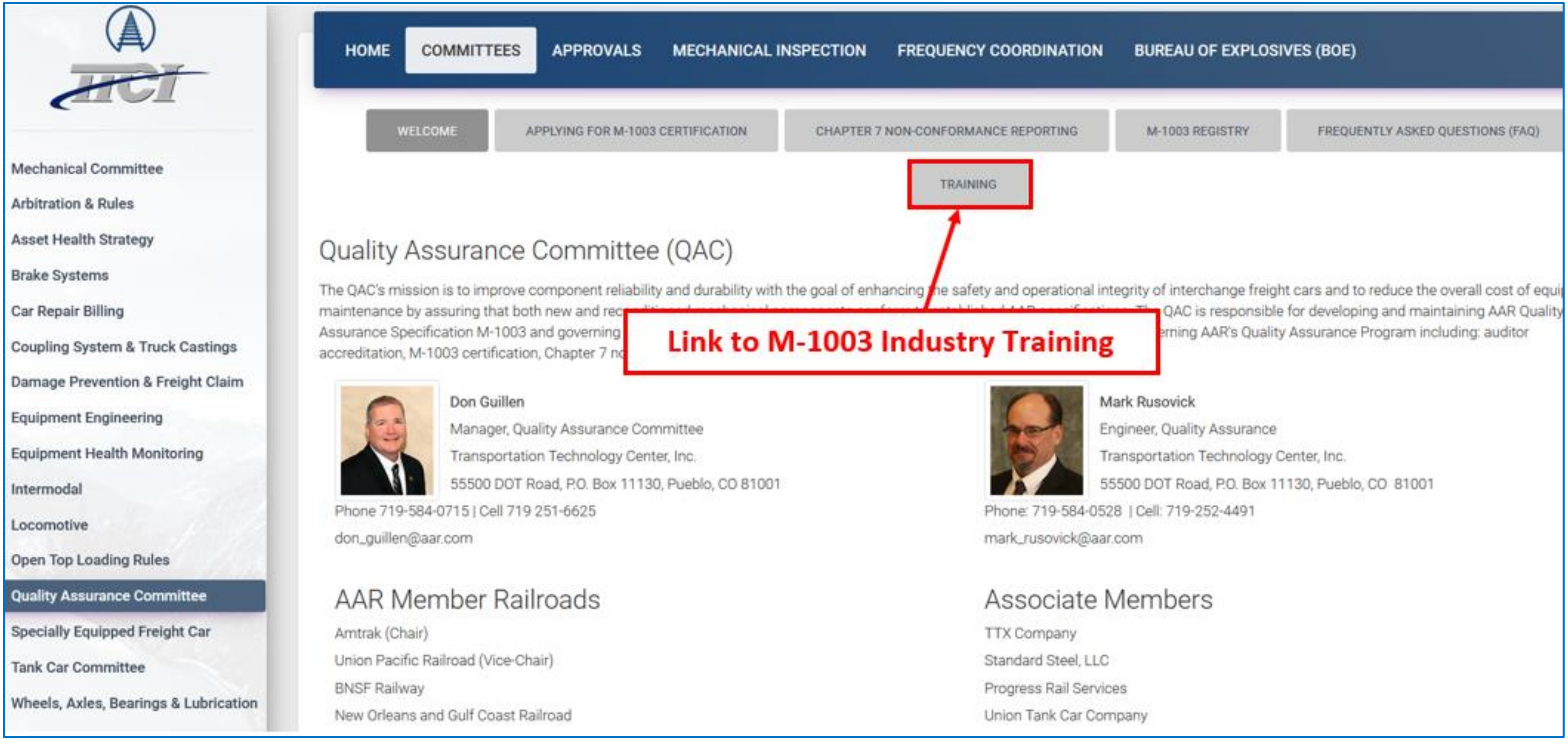
M-1003 Certification

Where can I find the most current Quality Assurance Program Evaluation (QAPE) Checklist?

The most current Quality Assurance Program Evaluation Checklist – or QAPE for short – can be downloaded by **clicking here**. Check this link periodically for any updates to the QAPE.

How do I know if I need M-1003 certification?

Appendix A of MSRP Section J lists activities that require M-1003 certification. If your product is listed, then your facility must obtain M-1003 certification. In addition to M-1003 certification, Appendix A denotes whether your product or service requires **technical approval**.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rning AAR's Quality Assurance Program including: auditor
accreditation, M-1003 certification, Chapter 7 n
Link to M-1003 Industry Training
Don Guillen
Manager, Quality Assurance Committee
Transportation Technology Center, Inc.
55500 DOT Road, P.O. Box 11130, Pueblo, CO 81001
Phone 719-584-0715 | Cell 719 251-6625
don_guillen@aar.com
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Engineer, Quality Assurance
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QA Events and Training Courses

2022 AAR M-1003 Quality Assurance Training Schedule			
Course	**Date**	**Location**	**Registration**
AAR Quality Auditor and Industry Conference	April 12-14, 2022	Fort Worth, TX	Open
Basic Auditor Training Class	April 26-28	Virginia Beach, VA	Open
	June 7-9	Kansas City, KS	Open
	July 12-14	Nashville, TN	Open
	September 20-22	Puerto Vallarta, MX	Open
	November 15-17	San Diego, CA	Open
Advanced Auditor Training Class	May 17-19	Tlaxcala, MX	Open
	July 26-28	Greenville, SC	Open
	August 23-25	Dallas, TX	Open
	October 25-27	Dallas, TX	Open
Root Cause & Corrective Action Class	June 21-22	Chicago, IL	Open
	December 6-7	Fort Worth, TX	Open

Registration Links:

Basic Auditor Training, April 26-28 in Virginia Beach, VA

Basic Auditor Training, June 7-9 in Kansas City, KS

Basic Auditor Training, July 12-14 in Nashville, TN

Basic Auditor Training, September 20-22 in Puerto Vallarta, MX

Basic Auditor Training, November 15-17 in San Diego, CA

ed Auditor Training Class –

ed Auditor Training Seminar is arties seeking in-depth training in ce Program auditing techniques and s must have attended the AAR Basic inar. The attendee must have ne internal or external audit prior to ar. The course will include: case d quality assurance manual review klist, and various role-playing experience is obtained though n-site compliance audit. Personal t (PPE) is required for this class including hard hats, safety glasses, hearing protection, and steel toe shoes.

Cost $1,200.

Registration Links:

Advanced Auditor Training, May 17-19 in Tlaxcala, MX

Advanced Auditor Training, July 26-28 in Greenville, SC

Advanced Auditor Training, August 23-25 in Dallas, TX

Advanced Auditor Training, October 25-27 in Dallas, TX

Root Cause & Corrective Action Class - In-person:

The Root Cause Analysis and Corrective Action course is an interactive two-day training program and is designed to improve the problem-solving skills of employees by promoting the understanding of the processes and techniques used for effective root cause analysis and corrective action implementation. The intent is to enhance awareness of the underlying causes of problems that negatively impact many organizations' operations, quality, and profitability. Instructors will utilize lectures, group discussions, hands-on exercises, and other interactive activities to develop the knowledge and skills of the attendees.

Cost $860.

Registration Links:

Advanced Root Cause Analysis Training, June 21-22 in Chicago, IL

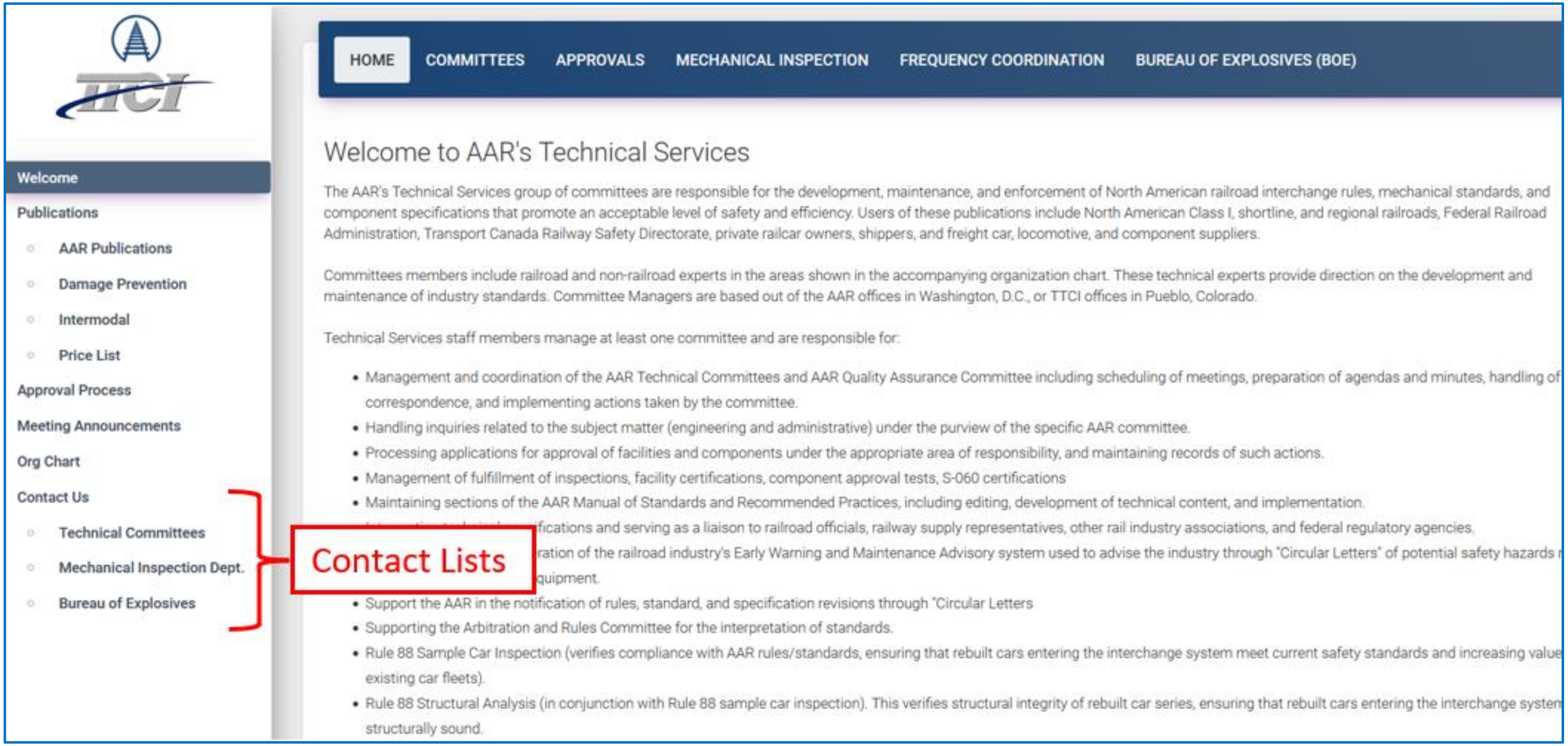
Advanced Root Cause Analysis Training, December 6-7 in Fort Worth, TX

2021 QA Conference Presentations

2020 QA Conference Presentations

2019 QA Conference Presentations

https://aar.com/standards/contact.html



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- Meeting Announcements
- Org Chart
- Contact Us
  - Technical Committees
  - Mechanical Inspection Dept.
  - Bureau of Explosives

Ron Hynes | AAR Washington, D.C.
Assistant Vice President Technical Services
Mechanical Committee Committee
rhynes@aar.org

Nichole Fimple | AAR Washington, D.C.
Executive Director Rules and Standards
Arbitration & Rules Committee
nfimple@aar.org

Karen Carriere | Winnipeg, Manitoba
AVP Technical Services
Karen_Carriere@aar.com

Tom Feltault | TTCI Pueblo, CO
Director, Damage Prevention Engineering
Damage Prevention & Loading Services
tom_feltault@aar.com

Greg Deibler | AAR Washington, D.C.
Director – Asset Health
Asset Health Strategy Committee
Equipment Health Monitoring Committee
GDeibler@aar.org

Jon Hannafious | TTCI Pueblo, CO
Director Technical Standards, EEC Manager
jon_hannafious@aar.com

Mike Fore | AAR Washington, D.C.
Director, Technical Services
Locomotive Committee

Shay Callahan | TTCI Pueblo, CO
Principal Economist
Car Repair Billing Committee

Daniel Carter | TTCI Pueblo, CO
Manager, Wheel, Axle, Bearing, and Lubrication Committee
Intermodal Committee

Thank you!

AAR Quality Assurance
55500 DOT Road
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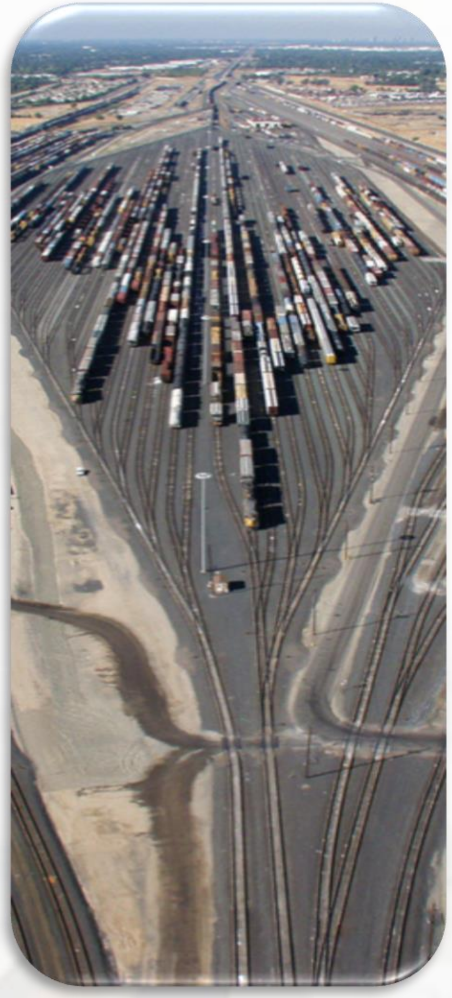

DESIGN CONTROL

FRA EXPECTATIONS

LEARNING OBJECTIVES

- DOT Safety Policy;
- FRA Expectations;
- Where Facility Design Control Begins;
- Relevant Definitions;
- Examples;
- Analysis v. Performance;
- Summary.

U.S. Department of Transportation

Federal Railroad Administration

DOT SAFETY POLICY

POLICY STATEMENT ON SAFETY 2011

In carrying out our transportation mission, safety is our highest priority. Every life is precious, and we must strive to ensure the safety of every user of our transportation systems, as well as all who are affected by those systems. Injuries and loss of life are unacceptable in the efficient and effective transportation of goods and people, and we must take every practical action to prevent those tragedies from happening.

The American public has entrusted us with the responsibility of assuring the safety of our transportation systems. We will hold ourselves accountable, measure our performance, and continuously act to make our transportation systems safer. We expect no less from our transportation partners. Our guidance, oversight, and regulatory decisions will emphasize safety and be timely, fair, reasonable, and necessary. We can and should be a change agent by exemplifying and promoting a safety culture in which the values, actions, and behaviors of our employees reflect this priority.

Safety begins within our own Department, and the ability to carry out our statutory responsibilities is directly tied to the health and wellbeing of our workforce. The safety of our own employees is paramount. Each of our employees should be provided with a safe working environment, and know how to respond to emergencies and avoid unnecessary risks. We also expect supervisors and managers to provide our employees with an environment that promotes the open sharing of safety concerns, without fear of reprisal, as well as processes to assure those concerns are addressed. It is the responsibility of all DOT employees to conduct themselves in a way that does not pose unnecessary risks, or put themselves or others in danger.

Everyone within the Department is expected to exercise effective leadership in support of this policy, which shall be posted throughout the Department, clearly visible and accessible to all employees.

Ray LaHood

FRA EXPECTATIONS

- Paper Must Match Car!
- Car Must Match Paper!

U.S. Department of Transportation
Federal Railroad Administration

WHERE FACILITY DESIGN CONTROL BEGINS

- Design Control begins with facilities that:
  - Design, redesign, manufacture, modify, maintain, or qualify tank cars (T/C) and components;
  - Review contracts to ensure the facility can design, redesign, manufacture, modify, maintain, or qualify T/C and components per owner acceptance criteria and contract requirements.

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WHERE FACILITY DESIGN CONTROL BEGINS

- Document verbally transmitted orders;
- Resolve differences between order and acceptance; document the resolution;
- Identify how contract amendments/revisions are reviewed, accepted, and transmitted to designated facility personnel and the review documented.

WHERE FACILITY DESIGN CONTROL BEGINS

- Ensure customer requirements (design inputs) are provided to relevant personnel;
- Ensure design documents/drawings are provided to relevant personnel;
- Ensure subcontracted materials, products, and services are correctly ordered and verified;
- Ensure critical characteristics are identified and verified;

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WHERE FACILITY DESIGN CONTROL BEGINS

- Identify and ensure design outputs meet design inputs, including acceptance criteria – "*paper must match car, car must match paper*"
- Ensure servicing, if specified, meets contract & reporting requirements, and accept. criteria;
- **Have written procedures covering the afore-mentioned activities.**

RELEVANT DEFINITIONS

- Alteration (AAR) – A change in tank or *service equipment* that does not change the specification but that does change the Certificate of Construction (CoC) (Form AAR 4-2);
- Conversion (AAR) - A change in tank or *service equipment* that changes the specification;
- Modification (AAR) - Any change to a *tank car* that affects the CoC including an alteration or conversion.

U.S. Department of Transportation
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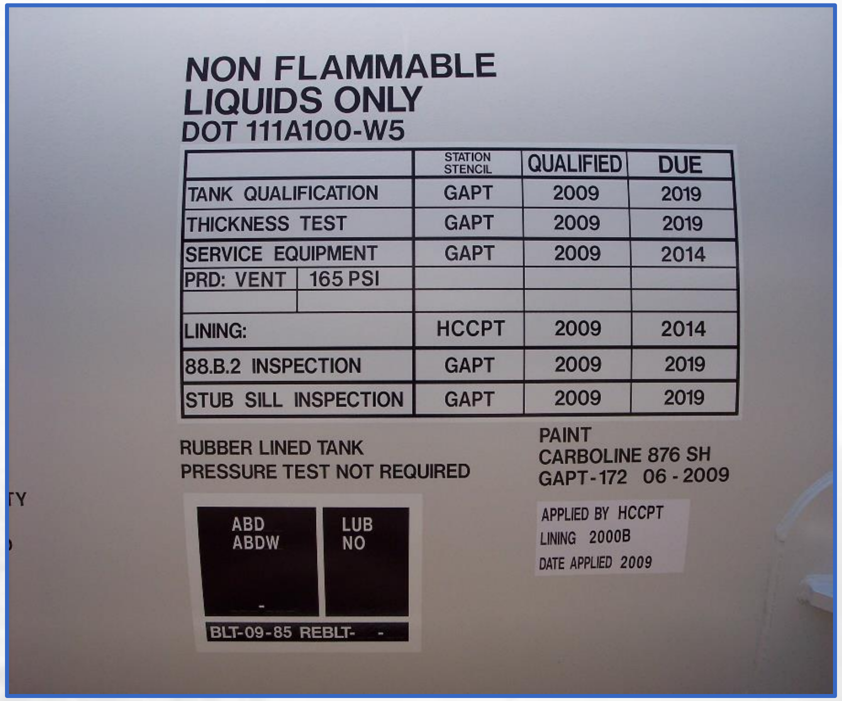
RELEVANT DEFINITIONS

- Reliability (FRA) - The quantified ability of an item or structure to operate without failure for the specified period of its design life or until its next qualification.
- Design level of reliability and safety (FRA) - The level of reliability and safety built into the *tank car inherent* in its specification, design, manufacture;
- Service reliability assessment (AAR) - An analysis of an item based on systematically collected in-service data to verify an item’s railworthiness.

RELEVANT DEFINITIONS

- Railworthy – The tank, service equipment, interior coatings/linings, safety systems, and all other components covered by Subpart F conform to the HMR and are suitable and capable of performing their intended function until the next qualification.



U.S. Department of Transportation
Federal Railroad Administration

RELEVANT DEFINITIONS

- Verification (AAR) – Confirmation that an *activity*, condition, or control conforms to requirements specified in documents such as contracts, codes, standards, drawings, specifications, system function descriptions, and procedures.
  <u>Ensuring all requirements are included in the design.</u>

<u>Paper Matches Car!</u>

RELEVANT DEFINITIONS

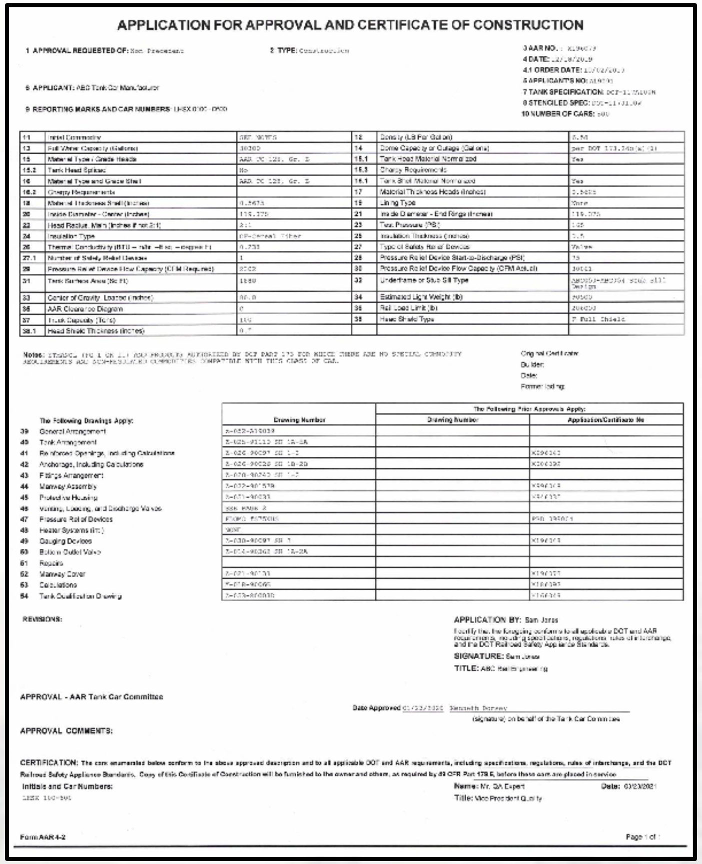
- Validation (ASQ) – Confirmation, using objective evidence, that the requirements which define an intended use or application have been met. Whenever all requirements have been met, a *validated status* is achieved.
  <u>Ensuring the design can be produced and perform its intended function(s).</u>

<u>Car Matches Paper!</u>

EXAMPLE #1

- M-1002 Chapter 1.3.6.5 (AAR) - In addition to valve and/or closure approval requirements, the fittings arrangement on the *tank car* also requires approval. The fittings arrangement drawing is listed on the CoC (AAR 4-2) and is approved as part of the *tank car* design. If the fittings arrangement is altered, the alteration must be approved. The alteration of the fittings arrangement must be submitted using the AAR 4-2 and approved drawing(s).

EXAMPLE #1



APPLICATION FOR APPROVAL AND CERTIFICATE OF CONSTRUCTION

1 APPROVAL REQUESTED OF: [illegible]
2 TYPE: Construction
3 AAR NO.: [illegible]
4 DATE: [illegible]
4.1 ORDER DATE: [illegible]
5 APPLICANT'S NO: [illegible]
6 APPLICANT: ABC Tank Car Manufacturer
7 TANK SPECIFICATION: [illegible]
8 STENCILED SPEC: [illegible]
9 REPORTING MARKS AND CAR NUMBERS: [illegible]
10 NUMBER OF CARS: [illegible]

11	Initial Commodity	[illegible]	12	Density (LB Per Gallon)	[illegible]
13	Full Water Capacity (Gallons)	[illegible]	14	Dome Capacity or Outage (Gallons)	[illegible]
15	Material Type / Grade Heads	AAR TC 128, Gr. B	15.1	Tank Head Material Normalized	Yes
15.2	Tank Head Spliced	No	15.3	Charpy Requirements	
16	Material Type and Grade Shell	AAR TC 128, Gr. B	16.1	Tank Shell Material Normalized	Yes
16.2	Charpy Requirements		17	Material Thickness Heads (Inches)	[illegible]
18	Material Thickness Shell (Inches)	[illegible]	19	Lining Type	None
20	Inside Diameter - Center (Inches)	[illegible]	21	Inside Diameter - End Rings (Inches)	[illegible]
22	Head Radius, Main (Inches if not 2:1)	2:1	23	Test Pressure (PSI)	[illegible]
24	Insulation Type	[illegible]	25	Insulation Thickness (Inches)	[illegible]
26	Thermal Conductivity (BTU – in/hr – ft sq – degree F)	[illegible]	27	Type of Safety Relief Devices	Valves
27.1	Number of Safety Relief Devices	1	28	Pressure Relief Device Start-to-Discharge (PSI)	[illegible]
29	Pressure Relief Device Flow Capacity (CFM Required)	[illegible]	30	Pressure Relief Device Flow Capacity (CFM Actual)	[illegible]
31	Tank Surface Area (Sq Ft)	[illegible]	32	Underframe or Stub Sill Type	[illegible]
33	Center of Gravity, Loaded (Inches)	[illegible]	34	Estimated Light Weight (lb)	[illegible]
35	AAR Clearance Diagram	C	36	Rail Load Limit (lb)	[illegible]
37	Truck Capacity (Tons)	[illegible]	38	Head Shield Type	[illegible]
38.1	Head Shield Thickness (Inches)	[illegible]			

Notes: [illegible]

Original Certificate:
Builder:
Date:
Former lading:

The Following Drawings Apply:	Drawing Number	The Following Prior Approvals Apply: Drawing Number	Application/Certificate No
39 General Arrangement	[illegible]		
40 Tank Arrangement	[illegible]		
41 Reinforced Openings, including Calculations	[illegible]		[illegible]
42 Anchorage, Including Calculations	[illegible]		[illegible]
43 Fittings Arrangement	[illegible]		
44 Manway Assembly	[illegible]		[illegible]
45 Protective Housing	[illegible]		[illegible]
46 Venting, Loading, and Discharge Valves	[illegible]		
47 Pressure Relief Devices	[illegible]		[illegible]
48 Heater Systems (int.)	[illegible]		
49 Gauging Devices	[illegible]		[illegible]
50 Bottom Outlet Valve	[illegible]		
51 Repairs			
52 Manway Cover	[illegible]		[illegible]
53 Calculations	[illegible]		[illegible]
54 Tank Qualification Drawing	[illegible]		[illegible]

REVISIONS:

APPLICATION BY: Sam Jones
I certify that the foregoing conforms to all applicable DOT and AAR requirements, including specifications, regulations, rules of interchange, and the DOT Railroad Safety Appliance Standards.
SIGNATURE: Sam Jones
TITLE: ABC Rail Engineering

APPROVAL - AAR Tank Car Committee

Date Approved [illegible] [illegible]
(signature) on behalf of the Tank Car Committee

APPROVAL COMMENTS:

CERTIFICATION: The cars enumerated below conform to the above approved description and to all applicable DOT and AAR requirements, including specifications, regulations, rules of interchange, and the DOT Railroad Safety Appliance Standards. Copy of this Certificate of Construction will be furnished to the owner and others, as required by 49 CFR Part 179.5, before these cars are placed in service.

Initials and Car Numbers:
[illegible]

Name: Mr. QA Expert
Date: 03/23/2021
Title: Vice President Quality

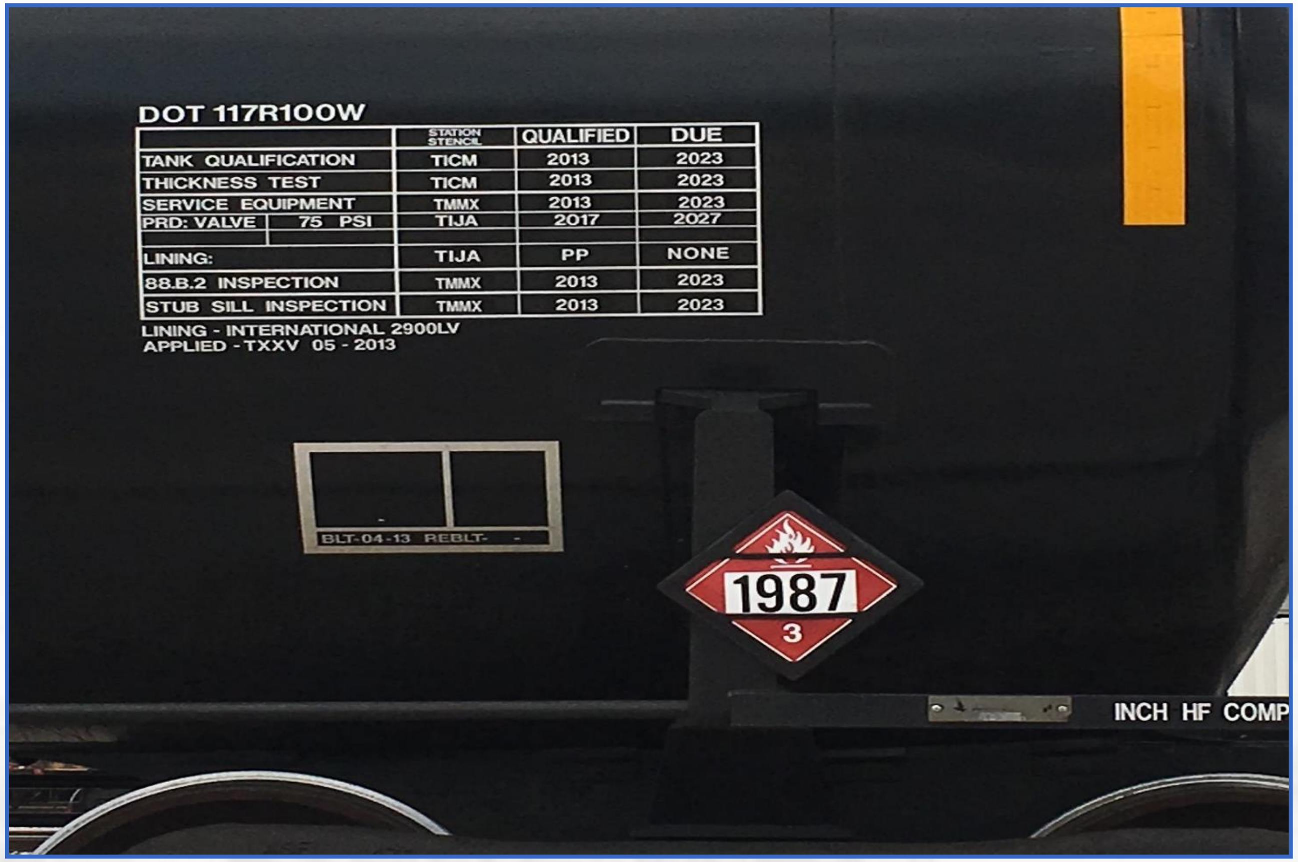
Form AAR 4-2
Page 1 of 1

U.S. Department of Transportation
Federal Railroad Administration

EXAMPLE #2

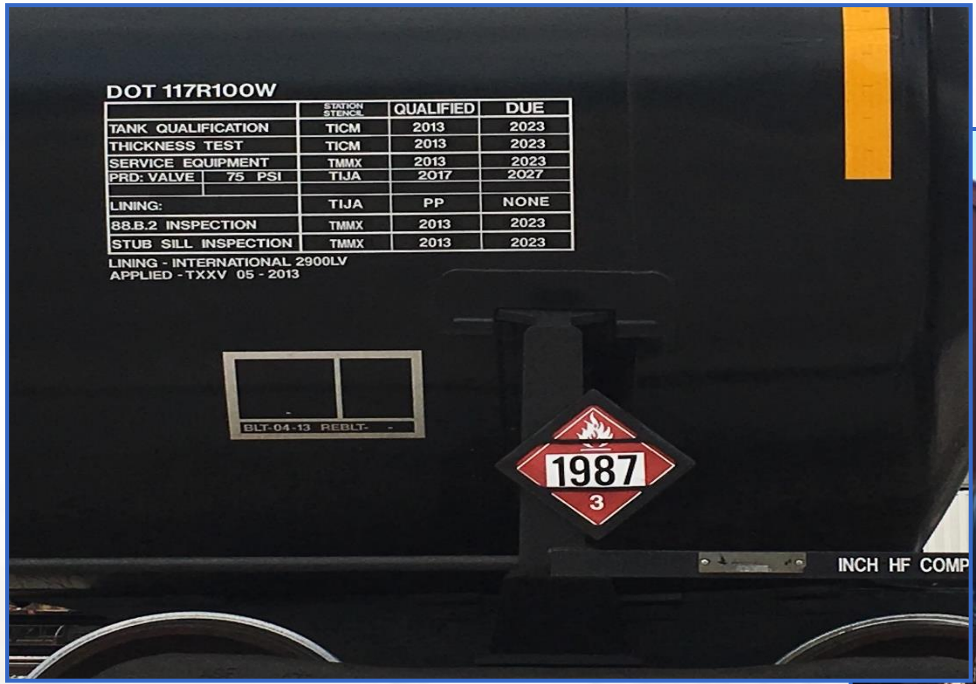
49CFR Part180.509(1)(e)(iii) - The tank shell butt welds within 60.96 cm (2 feet) of the bottom longitudinal centerline, unless the tank car owner can determine by analysis (e.g., finite element analysis, damage-tolerance analysis, or service reliability assessment) that the structure will not develop defects that reduce the design level of reliability and safety or fail within its operational life or prior to the next required inspection.

EXAMPLE #2



DOT 117R100W
STATION STENCIL
QUALIFIED
DUE
TANK QUALIFICATION
TICM
2013
2023
THICKNESS TEST
TICM
2013
2023
SERVICE EQUIPMENT
TMMX
2013
2023
PRD: VALVE
75 PSI
TIJA
2017
2027
LINING:
TIJA
PP
NONE
88.B.2 INSPECTION
TMMX
2013
2023
STUB SILL INSPECTION
TMMX
2013
2023
LINING - INTERNATIONAL 2900LV
APPLIED - TXXV 05 - 2013
BLT-04-13 REBLT-
1987
3
INCH HF COMP

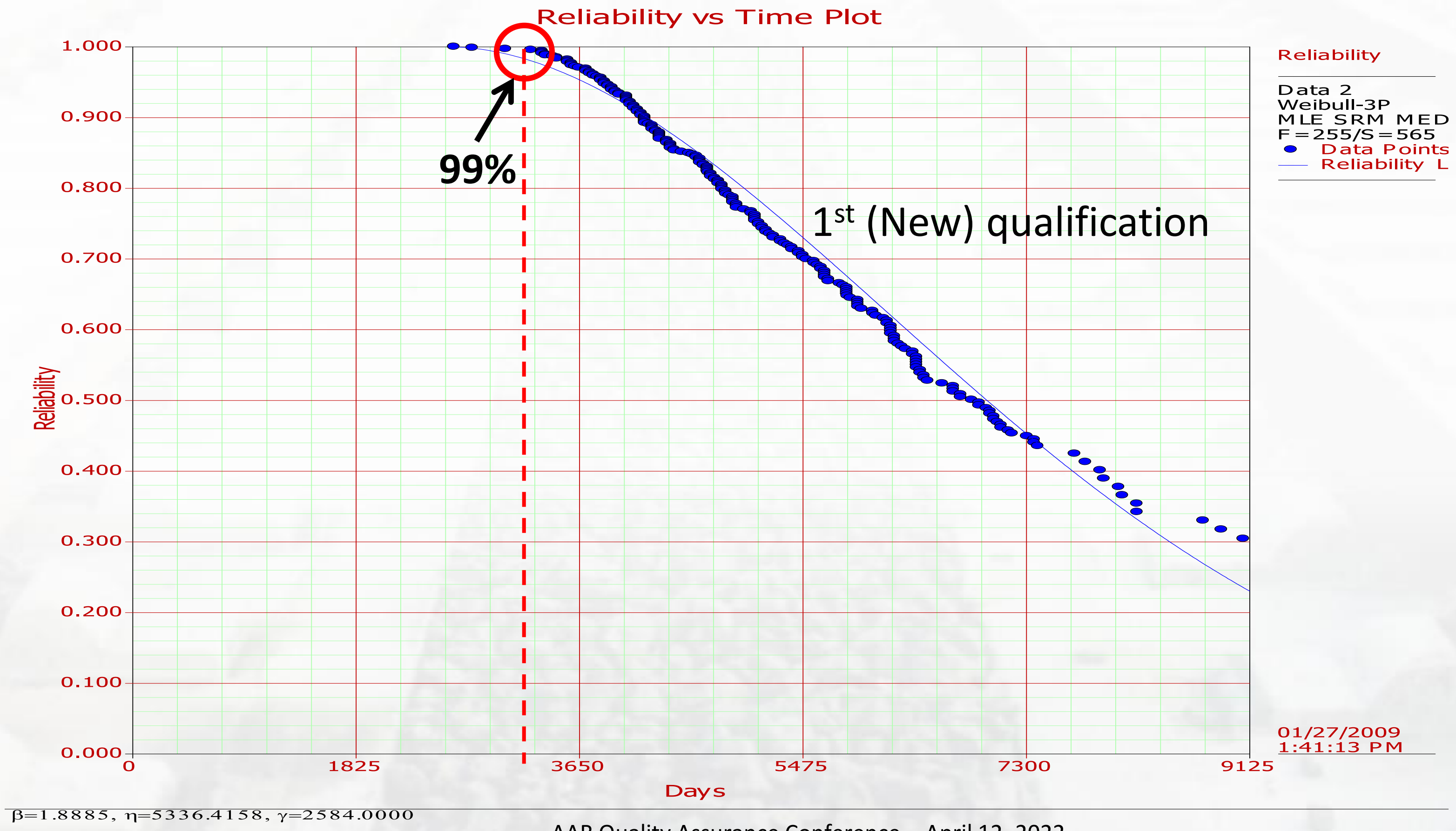
EXAMPLE #2


DOT 117R100W
STATION STENCIL
QUALIFIED
DUE
TANK QUALIFICATION TICM 2013 2023
THICKNESS TEST TICM 2013 2023
SERVICE EQUIPMENT TMMX 2013 2023
PRD: VALVE 75 PSI TIJA 2017 2027
LINING: TIJA PP NONE
88.B.2 INSPECTION TMMX 2013 2023
STUB SILL INSPECTION TMMX 2013 2023
LINING - INTERNATIONAL 2900LV
APPLIED - TXXV 05 - 2013
1987
3
INCH HF COMP

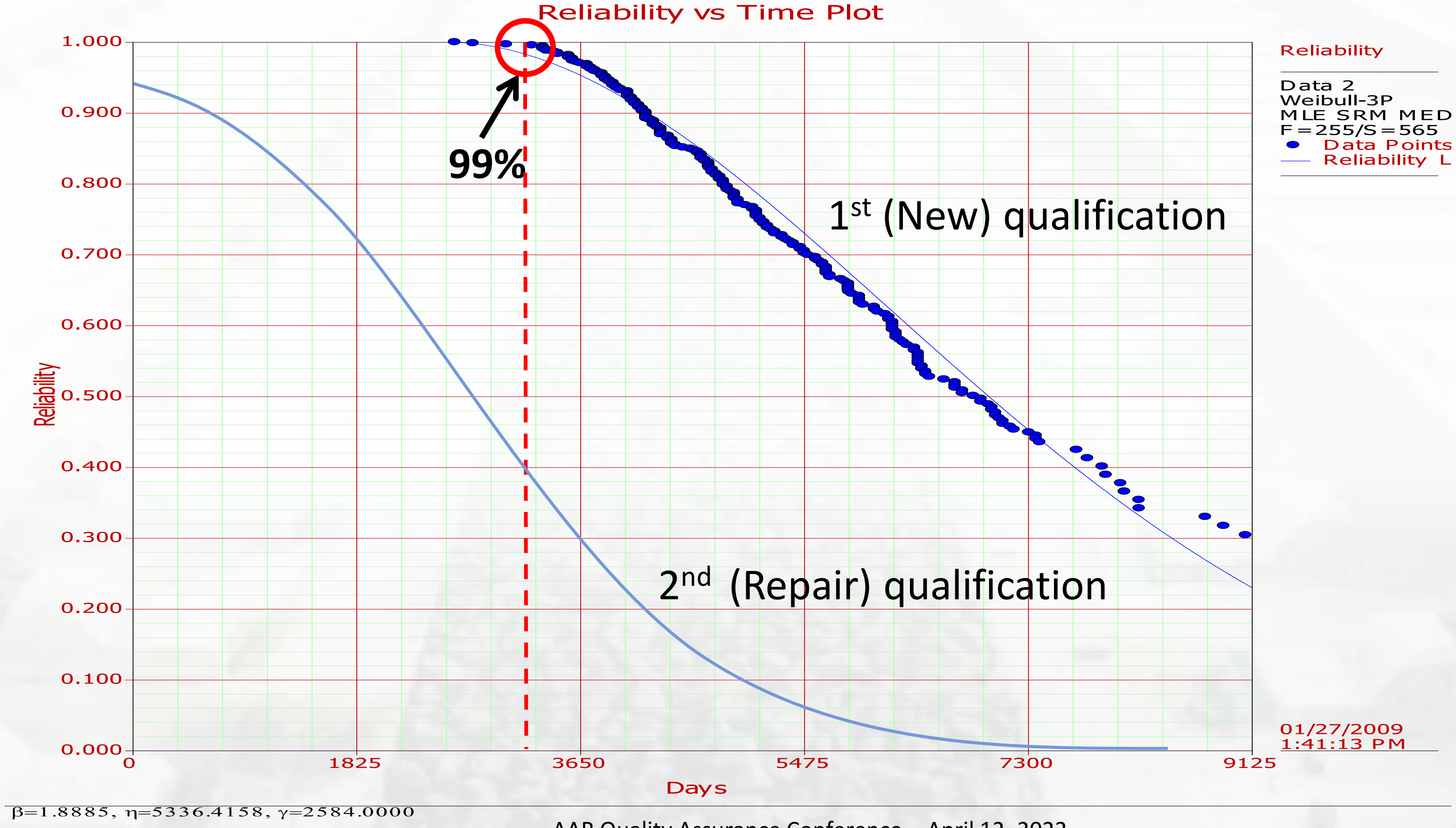

LRS 2397
CGRX
579219
SULFURIC ACID

U.S. Department of Transportation
Federal Railroad Administration

EXAMPLE #2



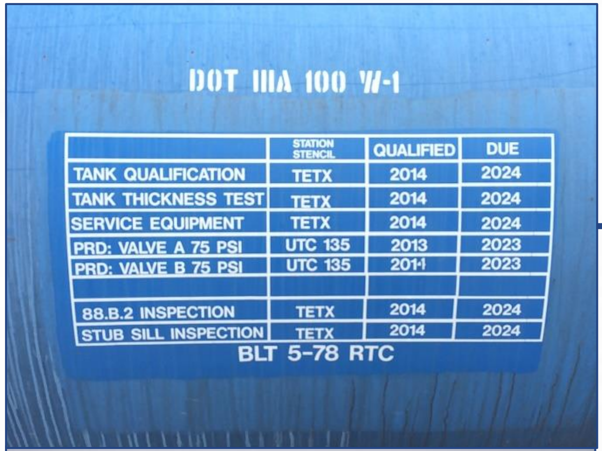
EXAMPLE #2


Reliability vs Time Plot
Reliability
Data 2
Weibull-3P
MLE SRM MED
F=255/S=565
Data Points
Reliability L
99%
1st (New) qualification
2nd (Repair) qualification
Reliability
Days
0
1825
3650
5475
7300
9125
1.000
0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
01/27/2009
1:41:13 PM
β=1.8885, η=5336.4158, γ=2584.0000

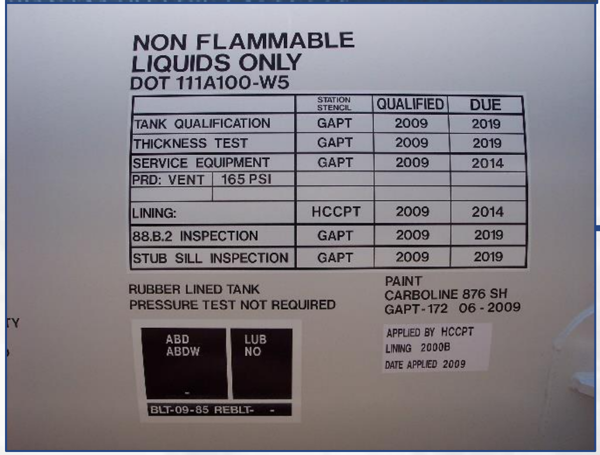
EXAMPLE #2

Note: Owners may use 10-year intervals ***only if*** validated by data collection and analysis!

ANALYSIS v. PERFORMANCE



VS.



VS.

SUMMARY

Federal regulations require that marking a tank car as qualified and railworthy means the tank car meets all FRA regulations, AAR specifications, and owner acceptance criteria according to documented procedures and the tank car matches documented records.

Paper Matches Car!
Car Matches Paper!

THOUGHTS???

AAR Quality Assurance Auditor and Industry Conference

April 12-14, 2022

Fort Worth, Texas

Audit Quality Task Force (AQTF) Update

Karen Carriere
AVP Technical Services
MxV Rail

Audit Quality Task Force

Background

AQTF – W5

- Why was the AQTF formed?
- Who is the AQTF?
- What progress has been made?
- Where does it go from here?
- When will the industry see the changes as a result of AQTF?

Why was the AQTF formed?

- Industry identified differences in AAR philosophies between committees.
  - Tank Car Committee uses a combined audit & requires demonstrations for all activity codes.
  - Other Technical Committees separate the QA audit & and technical audit/inspection for activity codes.

- Goal to encourage consistency across technical committees as well as standards & specifications

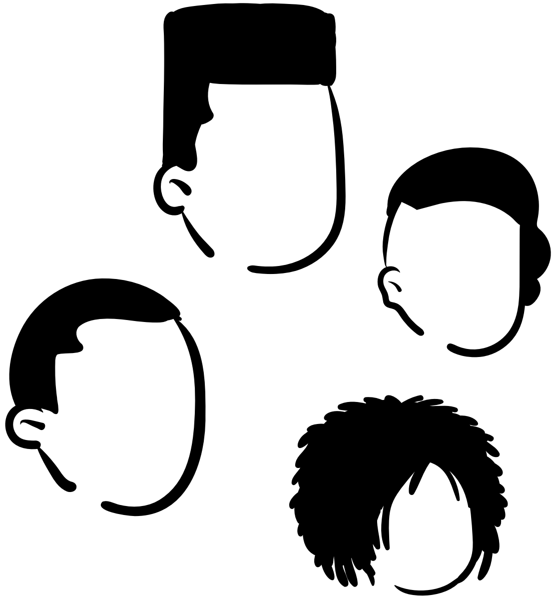
Who is the AQTF?

Main Task Force

- 24 professionals from railroads, AAR technical committees, manufacturing and repair facilities, private car owners, auditors, and quality assurance specialists.
    - ➢ Definitions sub-taskforce examined commonly used terms in connection with facility audits.
    - ➢ Root Cause Analysis sub-taskforce reviewed the different types of audits (system, process, product).

Mini Task Force

- Resulted in Communications Task Force
    - ➢ Representatives from Technical Committees
    - ➢ QAC
    - ➢ AAR Staff



What progress has been made by the AQTF?

Recommendation made and Mechanical Committee approved:

> *"For all Activity Codes, the AAR considers M-1003 Quality Assurance Program Audits and Technical Approvals as distinct committee responsibilities (QA Committee and appropriate technical committee respectively)."*

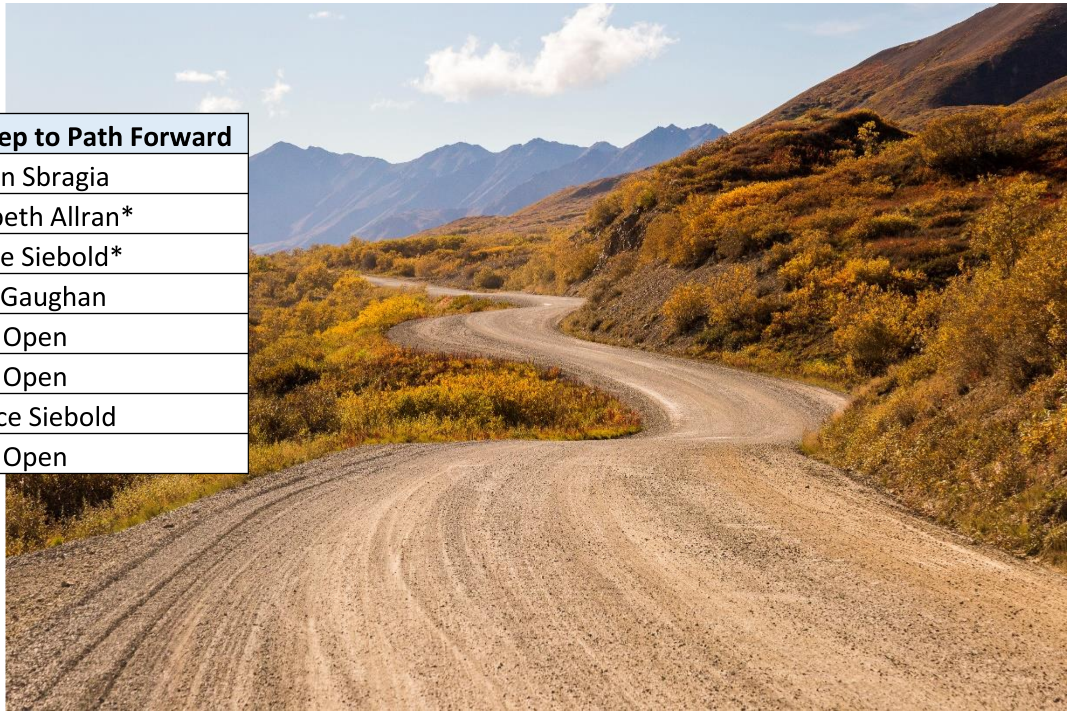
<u>Path Forward</u>: Further, the AQTF identified the path forward to considering the QA audits and technical approvals as distinct responsibilities as stated in the recommendation.

- Path forward has been delivered to each of the Technical Committees.
- Audit review and approval process should be more transparent and, if needed, improved.

Where does it go from here?

AQTF Communications TF Leads

Abrev.	AAR Committee	Committee Manager	Committee Rep to Path Forward
EEC	Equipment Engineering Committee	Jon Hannafious*	John Sbragia
WABL	Wheels, Axles, Bearings & Lubrication Committee	Dan Carter	Elizabeth Allran*
CSTCC	Coupling System & Truck Castings Committee	Dan Gutscher	Bruce Siebold*
BSC	Brake Systems Committee	Heath Bushell	Ed Gaughan
LC	Locomotive Committee	Mike Fore	Open
QAC	Quality Assurance Committee	Don Guillen*	Open
TCC	Tank Car Committee	Ken Dorsey	Bruce Siebold
SEFCC	Special Equipment Freight Car Committee	David Hendrixon	Open



	AAR Committee	Committee Manager
AAR	Mechanical Committee / AQTF	Ron Hynes
TTCI	Technical Standards / AQTF Communication TF	Karen Carriere*

* AQTF Communications TF Members

- Technical committees will create a standing docket to:
  - review their activity codes,
  - align activities with the technical MSRP's, and
  - review the committee's level of oversight for the auditing and approval processes.

When will the industry see the changes?

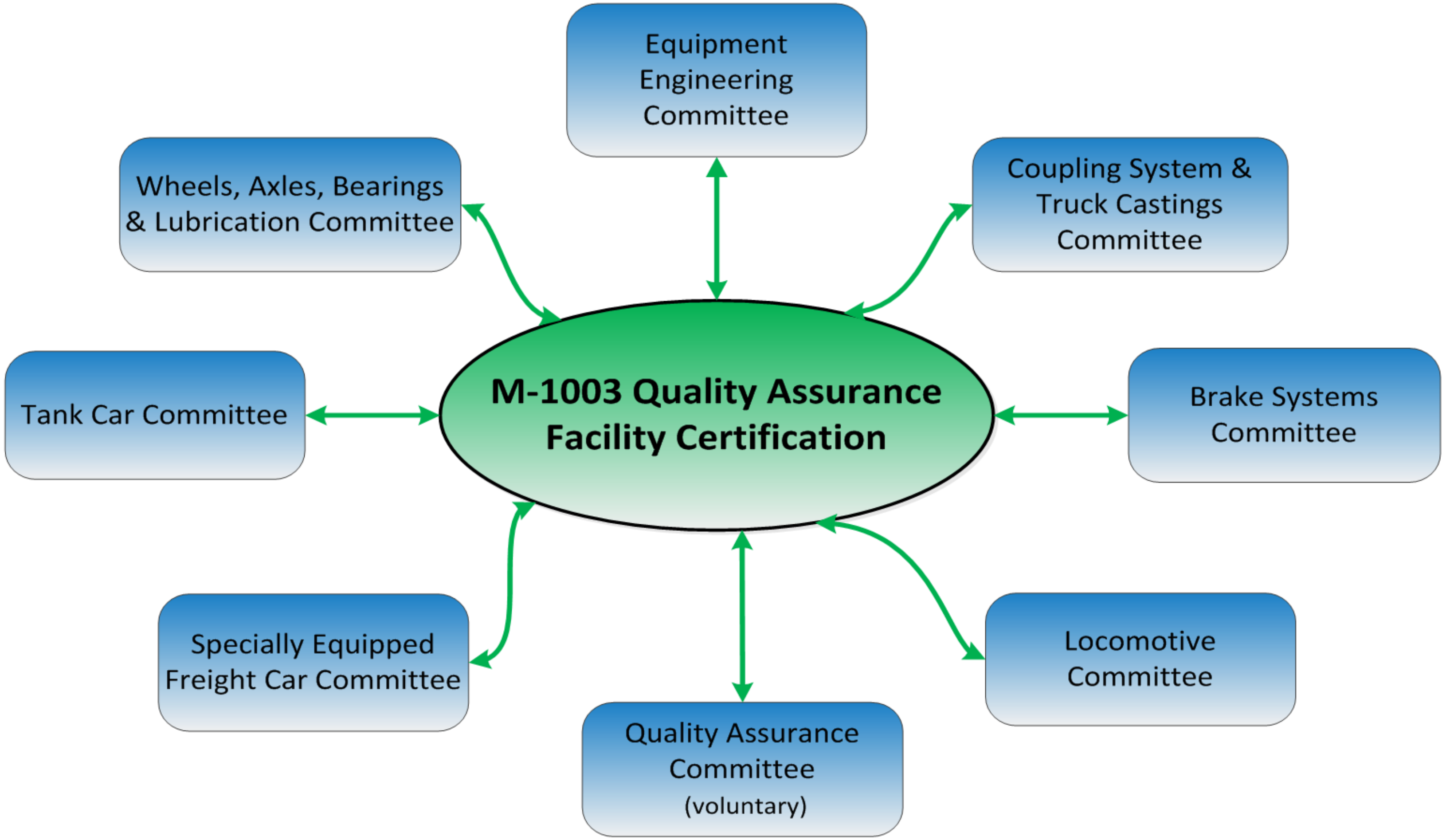
The work has begun!

Technical Committees have been delivered the “Path Forward” instruction package.

Executing the Path Forward

Technical Committees

The Quality Relationship



The Quality Relationship

APPENDIX A
REFERENCE GUIDE

Shown below is a listing of materials, products, and services (activities) that require M-1003 certification, the AAR *Field Manual* rule and/or circular letter that added the materials, products, or services (activities) to the M-1003 program, and the number of the standard or specification that requires technical approval in addition to M-1003 certification.

Activity Group A

Activity Code	Activity Description	AAR *Field Manual* Rule Reference	AAR Circular Reference	AAR Circular Date	Technical Approval Required
A1	Manufacturer of Journal Roller Bearings	36	C-7081/ C-8306	9/10/85– 1/31/95	M-934
A2	Blank				
A3	Manufacturer of Freight Couplers	16, 17, 18	C-7144	10/20/86	M-211 or M-215
A4	Manufacturer of Locomotive Couplers		C-8306	1/31/95	
A5	Manufacturer of Freight Knuckles	16, 17, 18	C-7144	10/20/86	M-211 or M-215
A6	Manufacturer of Locomotive Knuckles		C-8306	1/31/95	
A7	Manufacturer of Freight Yokes	19, 20	C-7144	10/20/86	M-211 or M-215
A8	Manufacturer of Locomotive Yokes		C-8306	1/31/95	
A9	Manufacturer of Freight Side Frames and Bolsters	47, 48	C-7144	10/20/86	M-210
A10	Manufacturer of Locomotive Truck Frames and Bolsters		C-8306	1/31/95	
A11	Manufacturer of Freight Cushioning Devices	59	C-7196	6/10/87	M-921/ M-921G
A12	Blank				
A13	Manufacturer of Wheels	41, 43	C-7149/ C-8306	11/10/86– 1/31/95	M-107/ 208
A14	Blank				
A15	Manufacturer of Axles	41, 43	C-7149/ C-8306	11/10/86– 1/31/95	M-101
A16	Manufacturer of Journal Roller Bearing Adapters		C-10535	6/12/07	M-924
A17	Manufacturer of Freight Brake Valves	4	C-7504	5/21/90	S-462
A18	Manufacturer of Locomotive Brake Valves		C-8306	1/31/95	
A19	Construction of Tank Cars by Manufacturing		CPC-1338	10/24/18	S-2034/ M-1002
A20	Manufacturer of Freight Cars		C-8233	7/20/94	S-2034
A21	Manufacturer of Locomotives		C-8279	11/21/94	
A22	Manufacturer of Freight Car Major Subassemblies		C-8174	4/29/94	S-2034
A23	Manufacturer of AEI Tags	63	C-9866	6/18/04	
A24	Manufacturer of Draft Sill End Castings		C-7144	10/20/96	

Activity Group B (Page 1 of 4)

Activity Code	Activity Description	AAR Field Manual Rule Reference	AAR Circular Reference	AAR Circular Date	Technical Approval Required
B1	Manufacturer of Roller Bearing Grease	26	C-7332	11/30/88	M-942
B2	Manufacturer of Freight Truck Springs	50	C-7144	10/20/86	
B3	Manufacturer of Locomotive Truck Springs		C-8331	3/31/95	
B4	Manufacturer of Center Plates	60	C-7149	11/10/86	
B5	Manufacturer of Freight Draft Gear	21	C-7149	11/10/86	M-901
B6	Reconditioner of Freight Draft Gear	21	C-7149	11/10/86	M-901B
B7	Manufacturer of Locomotive Draft Gear		C-8306	1/31/95	
B8	Reconditioner of Locomotive Draft Gear		C-8547	5/10/96	
B9	Manufacturer of Brake Hoses	5	C-7504	5/21/90	M-601/ M-618
B10	Manufacturer of Rubber Goods, Including Gaskets, Packing Cups and Diaphragms	4	C-7504	5/21/90	S-4001
B11	Manufacturers of Repair Kits	4	C-7504	5/21/90	S-4001
B12	Reconditioner of Freight Couplers	16, 17, 18	C-7145	10/20/86	M-212
B13	Reconditioner of Locomotive Couplers		C-8547	5/10/96	
B14	Blank				
B15	Blank				
B16	Reconditioner of Freight Yokes	16, 17, 18	C-7145	10/20/86	M-212
B17	Reconditioner of Locomotive Yokes		C-8547	5/10/96	
B18	Reconditioner of Freight Side Frames and Bolsters	47, 48	C-7833	4/30/92	M-214
B19	Reconditioner of Locomotive Truck Frames and Bolsters		C-8547	5/10/96	
B20	Reconditioner of Freight Cushioning Devices	59	C-7197	6/20/87	M-921C/G
B21	Manufacturer of Freight Car Brake Shoes	12	C-9951	11/3/04	M-926/ M-997
B22	Recondition Freight Car Hand Brakes	13	C-11360	12/21/10	
B23	Reconditioner of Locomotive Journal Roller Bearings		C-8547	5/10/96	H-II
B24	Maintenance and Modification of Tank Car Tanks		CPC-1338	10/24/18	M-1002
B25	Repair Shop (Facility)/Repair Track Engaged in Heavy Repairs	88	C-8405	9/11/95	
B26	Repair Shop (Facility)/Repair Track Engaged in Office Manual Rule 88.C Activity	88	C-8168	4/11/94	
B27	Facility Performing M-970 Certifications/Recertifications	88	C-8168	4/11/94	M-970
B28	Designated Satellite Shop Repairs	88	C-8168	4/11/94	M-992
B29	Manufacturer of Brake Beams	10	C-7504	5/21/90	S-344
B30	Reconditioner of Brake Beams	10	C-7505	5/21/90	M-300
B31	Freight Air Brake Repair Facility	4	C-7505	5/21/90	S-477
B32	Locomotive Air Brake Repair Facility		C-8547	5/10/96	

Executing the Path Forward - Key Definitions

Technical Approval - means design approval, product approval, and facility approval as required by the AAR technical committee with oversight for the activity.

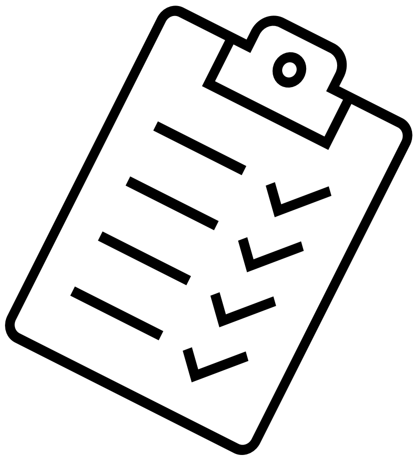
> **Design Approval -** Technical Committee approval of engineering documentation, analyses and physical testing (i.e. fatigue, mechanical, microstructural, dimensional, gauging).
>
> **Product Approval** – monitoring and continued evaluation of a design in interchange service (i.e. field trials, service trials, conditional approval and allotments), up to and including unconditional approval.
>
> **Facility Approval -** Demonstrated compliance to technical requirements associated with an activity code in the MSRP(s).

Activity Codes by Committee

- 129 Activity Codes
- Minimum of 33 Standards/ Specifications

Committee	Number of Activitiy Codes	Level of Technical Approval Oversight
Quality Assurance	1	Facility Approval
Special Equipped Freight Car	2	Facility Approval
Coupling Systems & Truck Castings	8	Design, Product, Facility Approval
Brake Systems	11	Design, Product, Facility Approval
Equipment Engineering	13	Design, Product, Facility Approval
Tank Car	18	Design, Product, Facility Approval
Wheels, Axles, Bearings	26	Design, Product, Facility Approval
Locomotive	50	None

Executing the Path Forward – Dockets



- MSRP Review
- Consistency
- Standard language
- Identify responsibility of QAC and/or Technical Committee
- Identify responsible auditing agency
- State Level of Auditing Oversight
- Published check lists/minimum requirements
- Identify auditor training and/or experience requirements
- Standardization of Adverse Audit Finding Reporting

Executing the Path Forward
Activity Code Review & Alignment Workbook

			Activity Code Review and Alignment Exercise															
Coupling System & Truck Castings Committee (CSTCC) Committee Manager: daniel_gutscher@aar.com			Objective 1a						Objective 1b (SEE "STEP 5" TAB)						Objective 1c	Objective 1d	Objective 1e	
Activity Code	Activity Description	AAR Committee	STEP 1 & 2 Applicable Specification (note the Activity Code)	STEP 3a Assess Level of Oversight (Design, Product, and/or Facility)	STEP 3b Review usage of Terms Technical Approval vs Certification	STEP 3c - Does Technical MSRP specify an M-1003 QA Program?	STEP 4a Technical Approval - Minimum Requirements	STEP 4b - COMPLETE OBJECTVE 2	STEP 5a Design Approval	STEP 5b Product Approval	Step 5c Facility Approval	STEP 5d - COMPLETE OBJECTVE 3a	STEP 5e - COMPLETE OBJECTVE 3b	STEP 5f - COMPLETE OBJECTVE 3c	STEP 6 - COMPLETE Joint Review with QAC	STEP 7 - Consider QA Program Report Routing	STEP 8 - Technical Audit Report Requirements	STEP 9 - AAR Administrative Process
A3	A3 - Manufacturer of Freight Couplers	CSTCC																
A5	A5 - Manufacturer of Freight Knuckles	CSTCC																
A7	A7 - Manufacturer of Freight Yokes	CSTCC																
A9	A9 - Manufacturer of Freight Side Frames and Bolsters	CSTCC																
A24	A24 - Manufacturer of Draft Sill End Castings	CSTCC																
B12	B12 - Reconditioner of Freight Couplers	CSTCC																
B16	B16 - Reconditioner of Freight Yokes	CSTCC																
B18	B18 - Reconditioner of Freight Side Frames and Bolsters	CSTCC																
B4	B4 - Manufacturer of Center Plates	CSTCC																

After the Path Forward

Quality Auditors

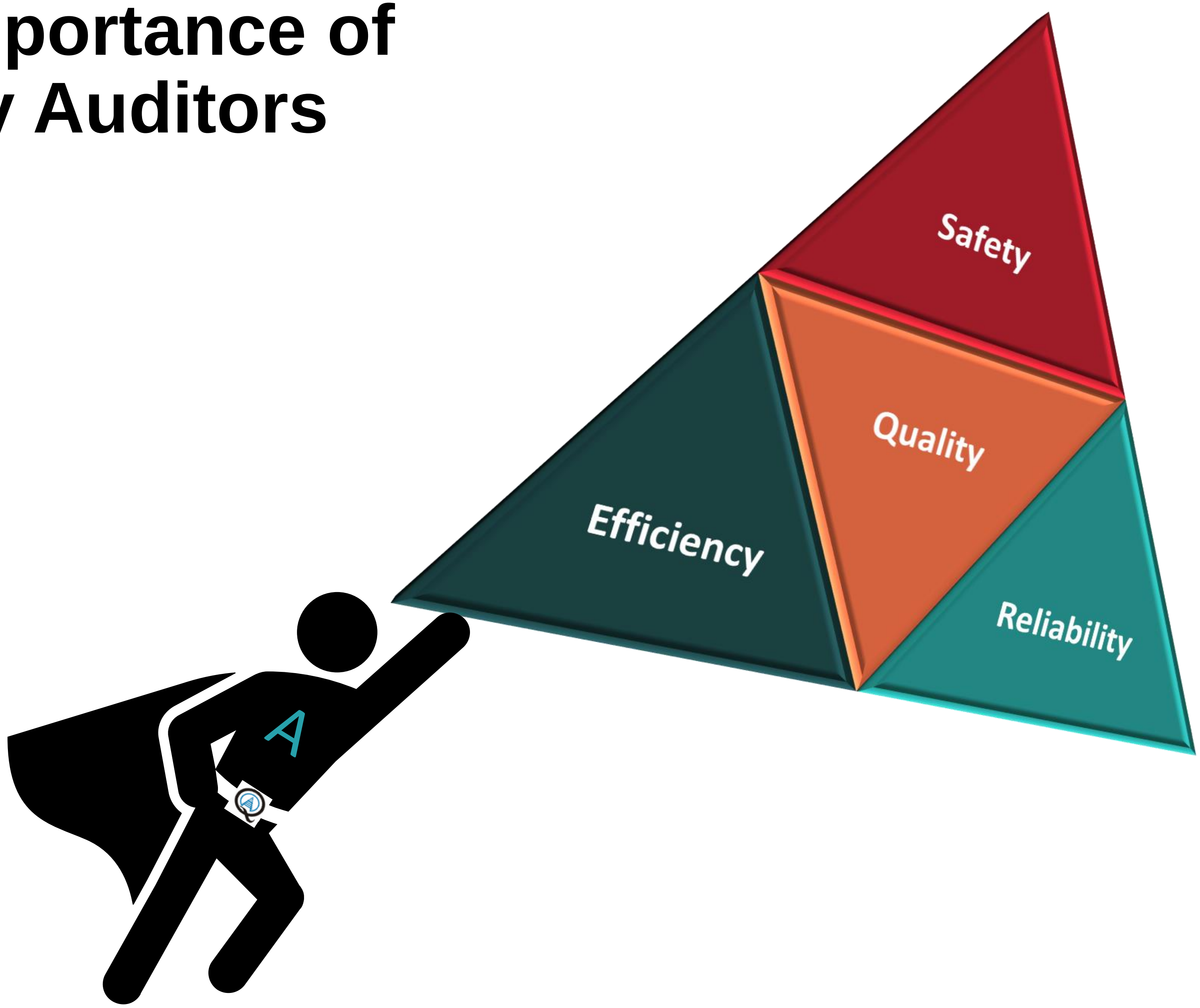
The Importance of Quality Audits

Ensuring the quality of workmanship for manufacturing, reconditioning, repairs, and processes

Ensuring compliance of the industry to AAR standards & specifications

Ensuring the safe transport of goods across our nation's rail network

The Importance of Quality Auditors



Thank you!

AAR Quality Assurance
55500 DOT Road
Pueblo, Colorado 81001
www.aar.com

AAR Quality Assurance Auditor and Industry Conference

April 12-14, 2022

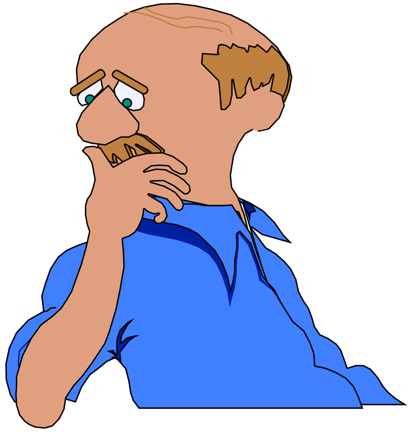
Fort Worth, Texas

Auditing Reminders

<u>Presented by:</u>

Brad Purcell – Acting as Auditor

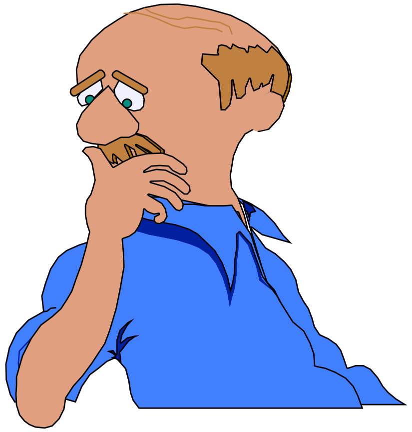
Steve Berkshire – Acting as Facility



Opening Meeting

Use checklist / build repour / review schedule / review last year findings / Purpose / sign-in sheet / Confidential / Objective evidence / Profile sheet / Safety

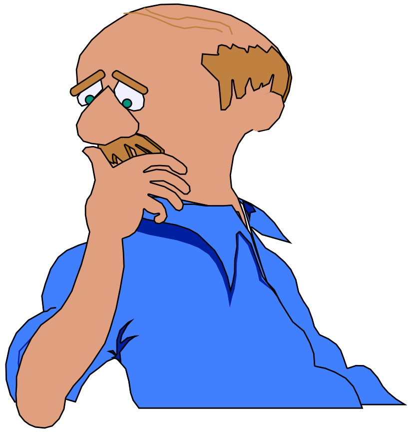
Did we get everything done / everyone ready / gauges calibrated / documents up to date / He likes to Fish



On The Shop Floor

Safety while on floor / how does shop look / Non-con area / Tags / areas marked – incoming – shipping / Take good notes

He likes to Fish / Documents are good !!/ Please don't talk to Doug or Don



The Interview – Doug

Hi – I am performing an audit
today …. Good notes

Hi my name is Doug Dart /
winner winner Chicken Dinner

The Interview – Don

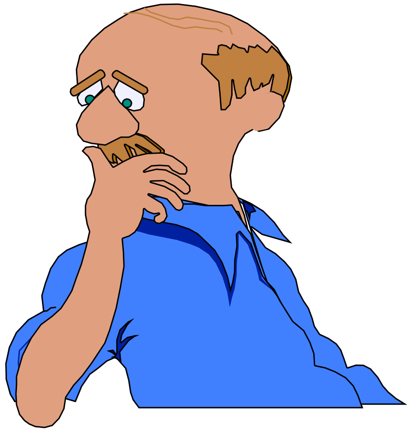
Hi – I am performing an audit today … good notes

Hi – I am Don Dorado / Great here goes an hour

Closing Meeting

Use checklist / go over findings/ make sure they are understood / close out past findings / say something good about audit

Talk him out of any findings / get things fixed and back to work



Thank you!

Transportation Technology Center, Inc.
Mechanical Inspection Department
www.aar.com/standards

AAR Quality Assurance Auditor and Industry Conference

April 12-14, 2022

Fort Worth, Texas

Auditing Methods for IT Systems – AAR M-1003

Document Control –Sec. 2.7
Quality Records – Sec. 2.17

Richard A. Sena
Vaquero Canyon Advisors, LLC

Key Audit Enhancements for Non-Paper/System Support for ERP Records & Documentation

Approach for today's Review:

1. Provide Key Areas / Topics for M-1003 Auditing of an AAR Supplier's "**System**" Support & Controls for Chap.'s 7 & 17

2. Include some detailed question topics for you to review the Facility's
IT Area's systemic Methods & SOPs

AAR M-1003's Document Control Chap. 7 & "The System"

- **First ….**
- **Chap. 2.7 Document Control**
  –"IT needs to realize" 2.7 applies to both
  Paper & the IT System's Virtual Records, Screens & Reports

This includes…

- **IT Control & Change Authorizations** for screen format & data content, report designs, etc.
  - Procedures/Methods to confirm the "IT/Software change From & To" screen AND its code history
- **Support controls** exist for **Standards in a library**
- **Product Design Software Control -** for Drawings and SOPs
  - Are there "authorized persons SOPs" for Approval and Release? …

AAR M-1003 Calls for Document Control Chap. 7

- **Does IT have documented SOPs/Training Records** that apply IT Staff and cover…
  - Record Keeping & Document/Screen/Software controls
  - AAR's methods to assess activity … requiring Objective Evidence?
  - Have they been giving training on any SOP for doing the "System Backup & Back-up Results Report Reviews"

- <u>Do we ask</u>….
- Who has been trained on the IT procedures to:
  - Set-up running the Back-up of the System & Library Doc's??
  - Relating to Work Instructions –the SOP for saving documents on an Individual's PC or Laptop drive?
  - SOP that identifies that Doc's X, Y or Z are Controlled by whom?
  - Authorized persons enter a Testing Device or QC inspection screen and make a change?

AAR M-1003 Calls for Document Control Chap. 7

- **Regarding "Saving & Back-up" of the System?**
  - Is saving the System on "media X?" in an in-house device or local location?
  - Or Does the IT team save AAR Documents "**in The Cloud**"

- Does IT have **retrieving ability for Code Version/Revision Change History**
  - Any SOP for Screen the "System" Contents or Report Printout Control &/or sign-off authorizations

    including "Touching" the soft-ware/code on the system (ERP) itself ?
    Or SOPs – or QC Inspection Report Screens?

- **Any Level 3 Work Instructions for Key-strokes to Access/Use Screens**
  - Are there SOPs within the ERP System data files that are being backed up?

- **Are there Access Privileges SOPs**? for screen formats? for revisions/history?

AAR M-1003 Calls for Document Control Chap. 7

Change Control….. For the IT Systems …

Are there SOPs for "System Screens/Reports" Changes calling for **a written Software Change Request / Review / Approval protocol**?

- Is there an "Authorized persons list" of who can make/approve Software/Code changes?
- Can their IT team trace actions if accuracy was **checked/validated?**

Ref. the Archiving process …..

Saving to the On-facility archive "system" with internal control? Or save to "The Cloud" ??

- Is there a set-up SOP to officially backup documents or reports into a type of archive?
- And Who Reviews "Backup Report" activity for a confirmation of a 100% accurate Backup?
  or an automatic report review identifying/confirming "No Data Lost"

AAR M-1003 Quality Records - Chap.17

In the Facility / Operating Department areas….

How is IT dealing with a Non-paper documents' archive?

- **Is there Printing & Saving the stored paper records … to Go where**?

……Are reports being Scanned & saved .. Within the ERP system?

Or saved into External File Boxes?

- So, looking into more closely saving records……..
  - Operations/QA/QC activities with manual data reports and related Inspection Report Records –

Does paperwork go from "Paper to an "IT" media …

….like a scanned PDF & thus are "on the system" with "System" "records"

AAR M-1003 Quality Records Chap. 2.17

- **First Step Reminder– include the IT team to the audit**
  IT should attend the Kick-Off meeting with their other facility departments
  - Highlight their role in Chap. 7 & Chap.17 overall for the IT "system"

Formerly "Records" were made and printed on paper …….
- Now it is a high percent of virtual or maybe all virtual per the "computer's System software"

…. We need to remind companies they need to maintain documents and access them in a timely manner ….

AAR M-1003 Quality Records 2.17

How are “Records / Data / Report templates /PDF being kept?

M-1003 in 2.17.1.2 calls for “records” include all areas – such as:

- Personnel records
- Procedures and related “computer report screens”
- Equipment info – testing devices data records
- Training records –
- Suppliers –reports at any & all locations
- Inspection results –ex. from machining centers
- Drawings - Etc., Etc.
- **& Who can Access and/or Modify these “System” contained records**

AAR M-1003 Quality Records - Retention 2.17.3.4

“Virtual” Recordkeeping…How do we keep Records?…

How Does IT do it? With an SOP?

- Manage Electronic Records per **any retention period**? & in a protected environment?

Steps to check at the facility …

- **Who is Monitoring the “Backed-up file” process for integrity of “the backup”..**
  Does anyone get &/or review the “End of “Back-up / Download” reports?

- **Do they Monitor & Identify any environment malfunctions/ “down” events?**

AAR M-1003 Quality Records 2.17

Regarding "**The System" and the IT support staff** ? **And their Records**? Etc. ?

- **Is there an in-house IT team?**
  Any qualifications records / training on M-1003 record?
- OR does the Supplier work with external support group or person?

- **Do they develop or modify text?** Or just setup then go to….
- Is there traceable Contractor support?

- **Do Lab Areas have Test Equipment with electronic data reports with IT access?**
  - Does it operate with its own "computer device?
    - or with an Internal LAP-top PC?
    - How are test data reports saved? … For how long?
      - Do these have any sustaining internal facility IT service desk support?

AAR M-1003 Quality Records 2.17

The software itself – is there one key operating package?

- What is the age, years in use? When was a recent update?
- Any revision levels since first bought?
- **Do revisions work right the first time? Are Tests Recorded?**
- **<u>Is there a Log for the Software updates history?</u>**

- Where does data go temporarily during a fix?
- Modules utilization – are there Features/ Modules not be used”
- Are all “system software functions” at x% “smooth?
- **Are there any “<u>Support Requests” History & tracking </u>for any Key functions?**
- **Ever have any Hacker Event & a Breach from the outside?**

AAR M-1003 Quality Records 2.17

- **Data / "System" backups** .....
  - **<u>Any IT SOP for</u>** <u>"Setting up and doing and checking results"</u>
  - Includes documented SOP for:
    - Backup schedule
    - Reports on "system data losses"
    - Show a copy of a printed recent "Before & After" screen
    - Any System events of being "in a loop" scenarios

    - Is Storage Noted in the SOP – is it kept internally, or does it go the **"The Cloud"** external storage service?
    - How long does it take for a backup dump?

IT Change Management for software

- **Are Requests for IT Changes submitted in writing?**
  - Is there an example or model presented?
- With notation of any impact/contact to the software code?
  - For Aesthetic Changes ….on Screens or Report formats?

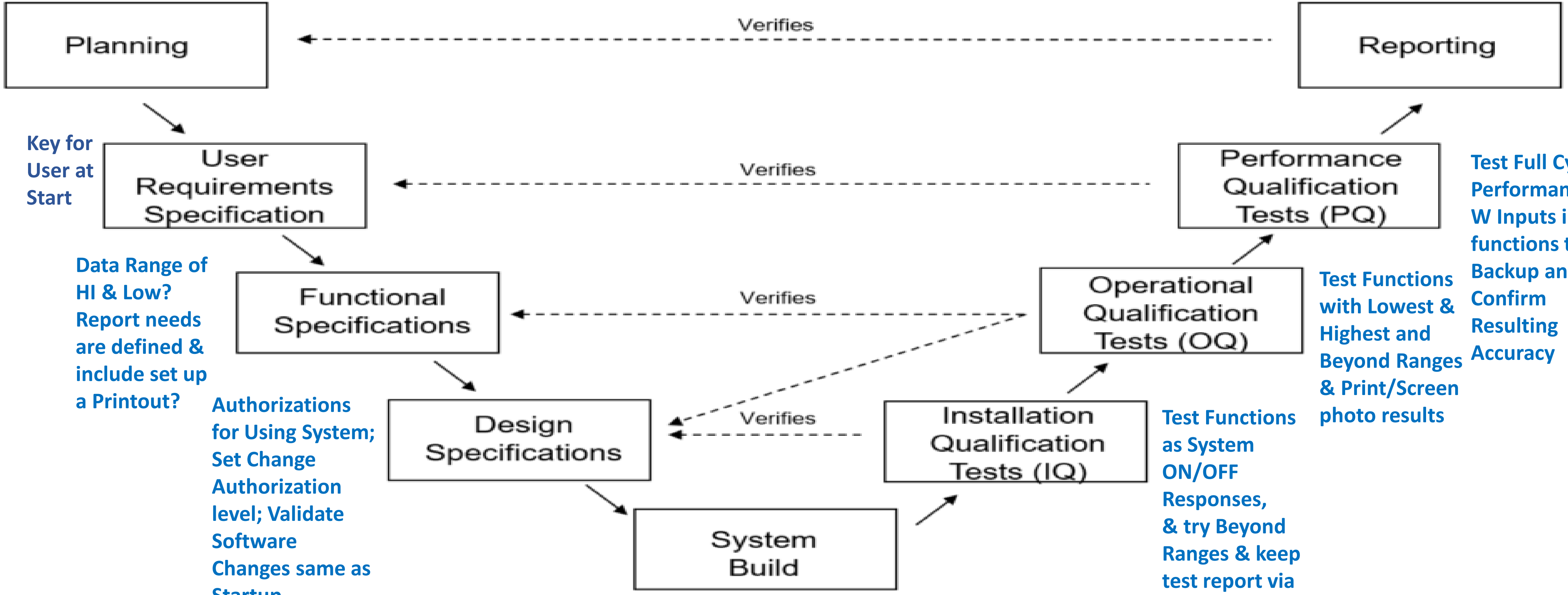
- **Function Changes** – is a request is written?
  - **Are results Verified by requestor?**

- **Is IT Testing the changes –??? –is it done By IT <u>and</u> Also <u>By the End User</u>?**
  - Verification (testing and show example at max and min)
  - Validation testing and results reported? Any Validation step Testing by users?

  - **Do Changes get Signed off by? IT? QA/QC? Requestor? …. Per the SOP?**
    - Can it be printed? Is the history saved? Shown on a screen or be printed?

Review and Confirm Documented IT SOPs/Guidance for "New" or "Changes"

For your Reference…These Major Validation Process Steps can be used to Review the Facilities' New "System" when installed, or Changes/Upgrades that are being set up / implemented



Key for User at Start

Data Range of HI & Low? Report needs are defined & include set up a Printout?

Authorizations for Using System; Set Change Authorization level; Validate Software Changes same as Startup

Test Functions as System ON/OFF Responses, & try Beyond Ranges & keep test report via Print/Screen photo of results

Test Functions with Lowest & Highest and Beyond Ranges & Print/Screen photo results

Test Full Cycle Performance W Inputs in all functions then Backup and Confirm Resulting Accuracy

FOR YOUR REFERENCE …. Five IT Related points to "Ask" about regarding how "The System" is being managed ….

Identify the Name of the ERP/MRP/"The System" per the "maker/developer…

Confirm M-1003 compliance related software functions (excluding Ops/Acctg activity)

- Review from Sales Order Entry to Bill of Lading & identify their Owner
- View if any Test Reports on "screen usability" or

  and when printed were they confirmed to meet the intended "operational user" needs
- Confirm Closure/Approval includes signatures? (Electronic? By Hand?)
- Applies to new software AND screen/software changes/modifications ?

Review as objective evidence the "paper document" requirements

for assessing if System printed report outputs are available.

Check printed reports/screen-shots…

Do they meet the M-1003 needs and the facility's "the user needs" and
Was it 100% accepted with no requested changes?

Points to "Ask About" / check as part of "IT's validation" (cont.)

Confirm special or particular key records requirements or reporting functions

can constantly be performed without errors or issues effecting users.

- Review the IT "support requests/tickets" for help with "x, y, or z…any trends?

Does the overall ERP/MRP software:

– Always and consistently able to provide report/data quickly & perform without errors?

Ref: "backup" is performed

- on schedule
- always being reviewed for data loss
- and is performing with "no data losses" 100% of the time?
    - Any Objective Evidence?

IT Support for Chapter 7 – Responses Support Info

- Chap. 7 - Nonconformances Reporting System includes:
  - Objective Evidence Among all it’s 5 Steps –
    Historical Data and reports are needed –… ? IT’s Readiness?
  - Can the System report on all possible facility’s locations?
  - **IT’s Role then becomes Key to Search AND Collect/Save/Print** “from the System” **on a timely basis** for
    - Incoming Supplier Materials information
    - Test Reports Data
    - Production Process Data
    - Final Inspection Report Documentation & Data
    - and of Course … Shipping information reports

IT Support for Chapter 7 – "System/Reporting" Readiness?

IT's role is Key - are they "prepared" and capable internally or with external support - ?
ie Supporting Records & Documents that are needed to be "collected & saved" and often "needed to be printed" on a timely schedule… for example…

- Incoming Material Inspection/testing or saved PDF Certificates
- Production work Order History including Lot Codes/Quantities
- Inventory on-hand and "Recent Released / In-transit"
- Shipping Report with Customer's Data, & Parts info & Lot # - both listing and
- printing saved "System" Shipping documents

Special Note …. At an Audit visit –
Ask for a Chap 7 "Response" Demonstration for Part # X123 for Lot C04122

- **What is their Response for a listing for parts being recalled? …. You might be advised …. "OK we will go and Print the data?" … Or… "we need to create a Report Inquiry for the system?**

In Closing …. Thank you - and Remember:

- **Include IT Management & their key staff persons or Service Provider!**
- **Look for IT's Objective Evidence – Systemic ERP &/or Software O/Ps**

-- Ask for demonstrations to confirm performance …

And …Ask "the users" about the software & their screens as you go around and visit various departments…

– *Dick Sena*, **Vaquero Canyon Advisors, LLC,   AAR Q Conf. - 4/12/2022**

……. Contact us any time for support and/or facility needed assistance

……. We have current & pending certified manufacturing support in the USA, South Korea, Italy, Canada

Thank you!

AAR Quality Assurance
55500 DOT Road
Pueblo, Colorado 81001
www.aar.com

2022 AAR Quality Assurance Auditor & Industry Conference

April 12- 14, 2022 | Fort Worth, TX

Performance Based Standards

Jason Riggs

Vice President of Technical Standards – Marmon Rail

Performance Based Standards

Performance Based Standards do not specify how to do the work, they specify what the end result should be, whereas current **Prescriptive Standards** are recipes that provide step by step instructions or specifies how, what and when.

Performance Based Standards

- Promoted by Clinton, Bush and Obama Administration as Regulatory Basis for rule making.
- Adopted by World Trade Organization as "favored regulation".
- Adopted in regulatory framework for USA, Canada, Mexico, UK, New Zealand and Australia.
- Used in other high reliability industries.

Examples

Example 1:

A prescriptive standard would specify what size motor is required to power a vacuum cleaner

A performance standard would only specify how much suction is required.

Example 2:

A prescriptive standard would specify the grade of steel.

A performance standard would specify the physical properties. A step further would be to specify how the part made from the steel should behave in-service.

Examples Continued…

Example 3:

A prescriptive city fire code requires smoke detectors in a public building to be 30’ apart.

A performance standard based fire code requires detection of smoke within 30 seconds.

Example 4:

A prescriptive standard may specify the specific type of tool, instrument or equipment to use. In some cases, even the manufacturer or model.

A performance standard would specify what the accuracy, reliability or what the item must accomplish (based on data and science).

Challenges of Prescriptive Standards

Places a ceiling on product quality and reliability.

Prohibits innovation and technology.

Reduces competition by keeping new suppliers that are more competitive or have “better ways of doing things” out of the industry.

Guidelines for Performance Based Standards

Companies must assume commercial & legal ownership.

Must be defined, measured and monitored.

How “loose” or “tight” the standard is should be based on a Risk Assessment.

Companies must demonstrate how “an equivalent level of safety” is accomplished.

Example of a successful performance-based standards in the Rail Industry

Transport Canada requires a certain size void be found in thermal protection but does not specify the method or technology.

9.5.10.1 Acceptable Level of Defects in Thermal Protection Systems

a. The maximum permissible void size or total void area is described in the following table:

Maximum Allowable Void Size for Thermal Protection

Void	Size/Area	Condition
Single isolated void	Maximum allowable void is 48 in. on the longitudinal axis of the tank by 16 in. on the circumferential axis (1.2 X 0.4 m).	Voids must be separated from other voids by more than one half of the largest dimension or must be considered a single void.

Next Steps

- Consider Performance Based Standards throughout the various Technical Standards Committees.

  - Possibly perform a trial run on a low-risk part.
  - Continue to use current prescriptive standards but allow the performance-based standard as an alternative solution.

Thank you!

AAR Quality Assurance
55500 DOT Road
Pueblo, Colorado 81001
www.aar.com

AAR Quality Assurance Auditor and Industry Conference

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Fort Worth, Texas

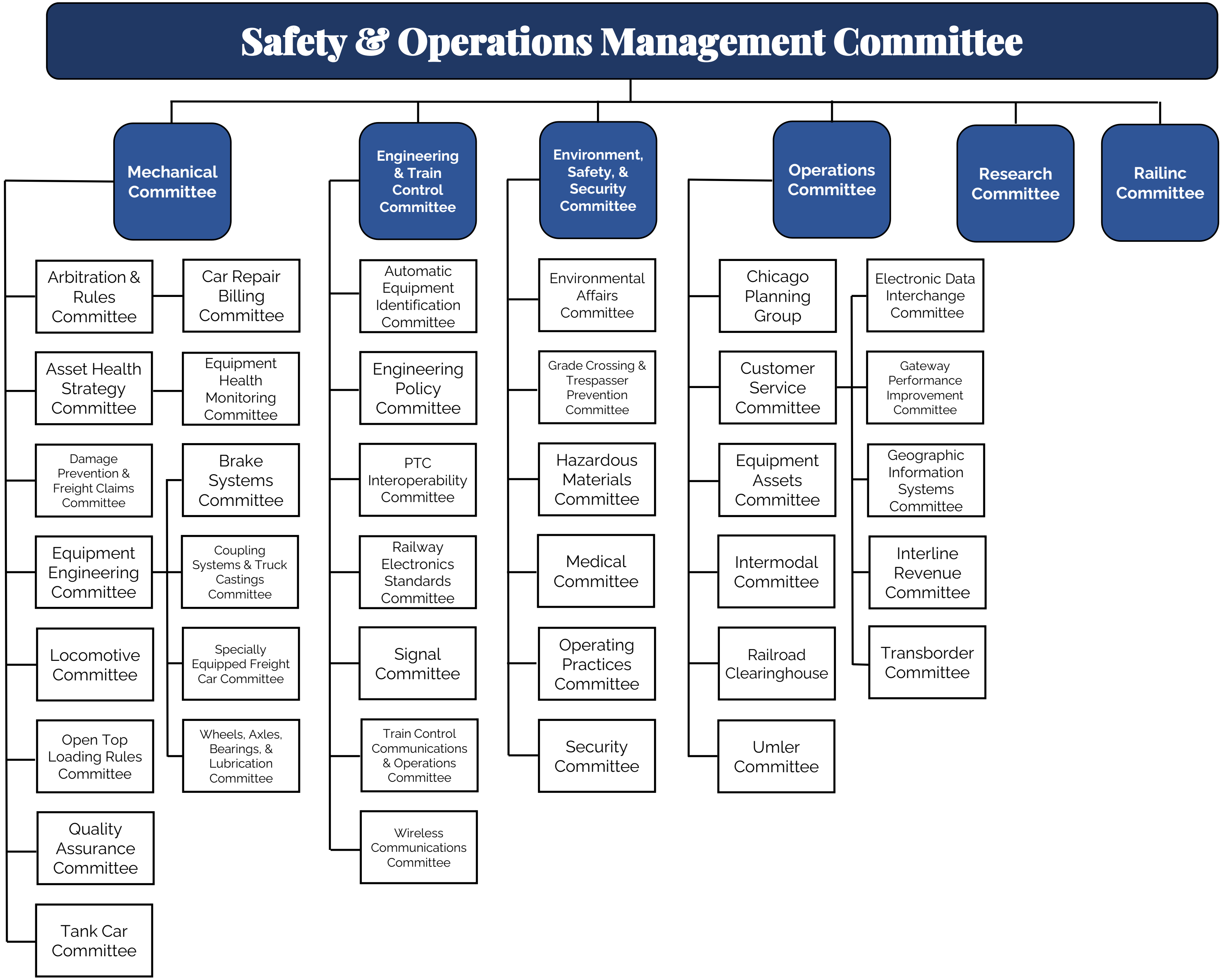
Industry Update

Ron Hynes

AVP – Technical Services

Association of American Railroads

Changes in Safety & Opps


Safety & Operations Management Committee
Mechanical Committee
Arbitration & Rules Committee
Car Repair Billing Committee
Asset Health Strategy Committee
Equipment Health Monitoring Committee
Damage Prevention & Freight Claims Committee
Brake Systems Committee
Equipment Engineering Committee
Coupling Systems & Truck Castings Committee
Locomotive Committee
Specially Equipped Freight Car Committee
Open Top Loading Rules Committee
Wheels, Axles, Bearings, & Lubrication Committee
Quality Assurance Committee
Tank Car Committee
Engineering & Train Control Committee
Automatic Equipment Identification Committee
Engineering Policy Committee
PTC Interoperability Committee
Railway Electronics Standards Committee
Signal Committee
Train Control Communications & Operations Committee
Wireless Communications Committee
Environment, Safety, & Security Committee
Environmental Affairs Committee
Grade Crossing & Trespasser Prevention Committee
Hazardous Materials Committee
Medical Committee
Operating Practices Committee
Security Committee
Operations Committee
Chicago Planning Group
Electronic Data Interchange Committee
Customer Service Committee
Gateway Performance Improvement Committee
Equipment Assets Committee
Geographic Information Systems Committee
Intermodal Committee
Interline Revenue Committee
Railroad Clearinghouse
Transborder Committee
Umler Committee
Research Committee
Railinc Committee

Quality Assurance

For Improved Rail Transportation Services

Railroad Safety and Service

QAC plays an important role

Quality Assurance –

M-1003 QA certification is required for companies that supply components or perform services to any railcar in interchange service

QA audits enhance safety, reliability, and value to our customers – car owners and railroads who provide transportation services – and rail shippers.

MID: Increasing Safety and Reliability

"……..When on Shop or Repair Track"

- Railroad goal: Keep cars out of the shop if possible.
- Don't shop cars for routine maintenance.
- However, when cars are in the shop, maintain and inspect thoroughly.
- Competing demands exist when cars are in the shop.
- The important work of various AAR committees increases car reliability – but only if carried out in the shop!

BOE: Increasing Safety and Reliability

“A hazmat incident can transform your day…………”

- Being sure that rail equipment is manufactured and maintained correctly and with integrity.
- Striving to eliminate Non-Accident Releases (NARs).
- Railroads move a great amount of hazardous materials and are in the spotlight when issues arise.
- Hazmat incidents, including NARs, are costly and disruptive.

Improved Quality Assurance

For Improved Rail Transportation Services

Railroad Competitiveness

Railroad operation requires high levels of QA

- Increased equipment utilization by keeping cars moving.
- Focus on keeping trains moving by eliminating individual mechanical failures.
- Each technical committee is doing its part to make rail equipment more reliable.

Railroad Competitiveness

Some Real-World Comparisons

- Trucks – one or two trailers. If a problem develops, park one or two trailers and wait for a repair person. Other trucks are unaffected.
- Trains – 150 to 200 cars. If a problem develops, the entire train is parked. The location of the needed repair is often inaccessible. Other trains on that section of the railroad are also delayed.

Railroad Safety and Service

Railroads Require a High Level of QA

- A 200-car train can be stopped on the main track for a minor problem.
- A minor problem will cause a major delay.
- A worn air hose, stuck brake, worn anti-creep, all can stop the highest priority train, or the train ahead of the highest priority train.
- All customer’s cars are delayed, not just the problem car.
- Result: system congestion, unreliability, recrews, blocked crossings, customer dissatisfaction, and other woes.

Railroad Safety and Service

Hazardous Material is Very Precious Freight

- QA is essential to prevent the release of hazmat
- Prevent NARs – with high quality valves, PRD's, manways, gaskets, and proper training.
- Unlike any other non-passenger railcar, hazardous material cars are designed for crashworthiness.
- Other railcars can directly affect the safety of hazardous material cars.

Auditing of Facilities

Insisting on Technical and QA Proficiencies

A Q T F

The Mechanical Committee requested the formation of a task force to examine facility audits.

- Relatively large task force was assembled.
- Focused on the differences between TCC facility audits and other audits.
- The task force discovered differences in audits, technical committee oversight of audit activities, and findings.

A Q T F

AQTF made recommendations to the MC:

- The AAR consider Quality Assurance Program Audits and technical approvals as distinct responsibilities.
- The audits should be addressed by the appropriate committee using documented processes and procedures.

Discussion of 49 CFR Part §179

DOT's "Delegated Authority" – In May of 2021, AAR asked the Mechanical Committee to support a petition by the AAR to the Department of Transportation (DOT) requesting that DOT remove the requirement that tank car facilities have a quality assurance program that has been approved by the Tank Car Committee.

Discussion of 49 CFR Part §179

- There would be no impact on the scope of AAR's activities or the safety protections those activities provide.
- AAR Interchange rules will continue to require railcars to be manufactured, maintained, and repaired in M-1002 and M-1003 certified facilities.
- AAR will continue to conduct all necessary facility audits and certifications.
- All other AAR committees function in safety matters without government involvement.

Discussion of CFR Part §179

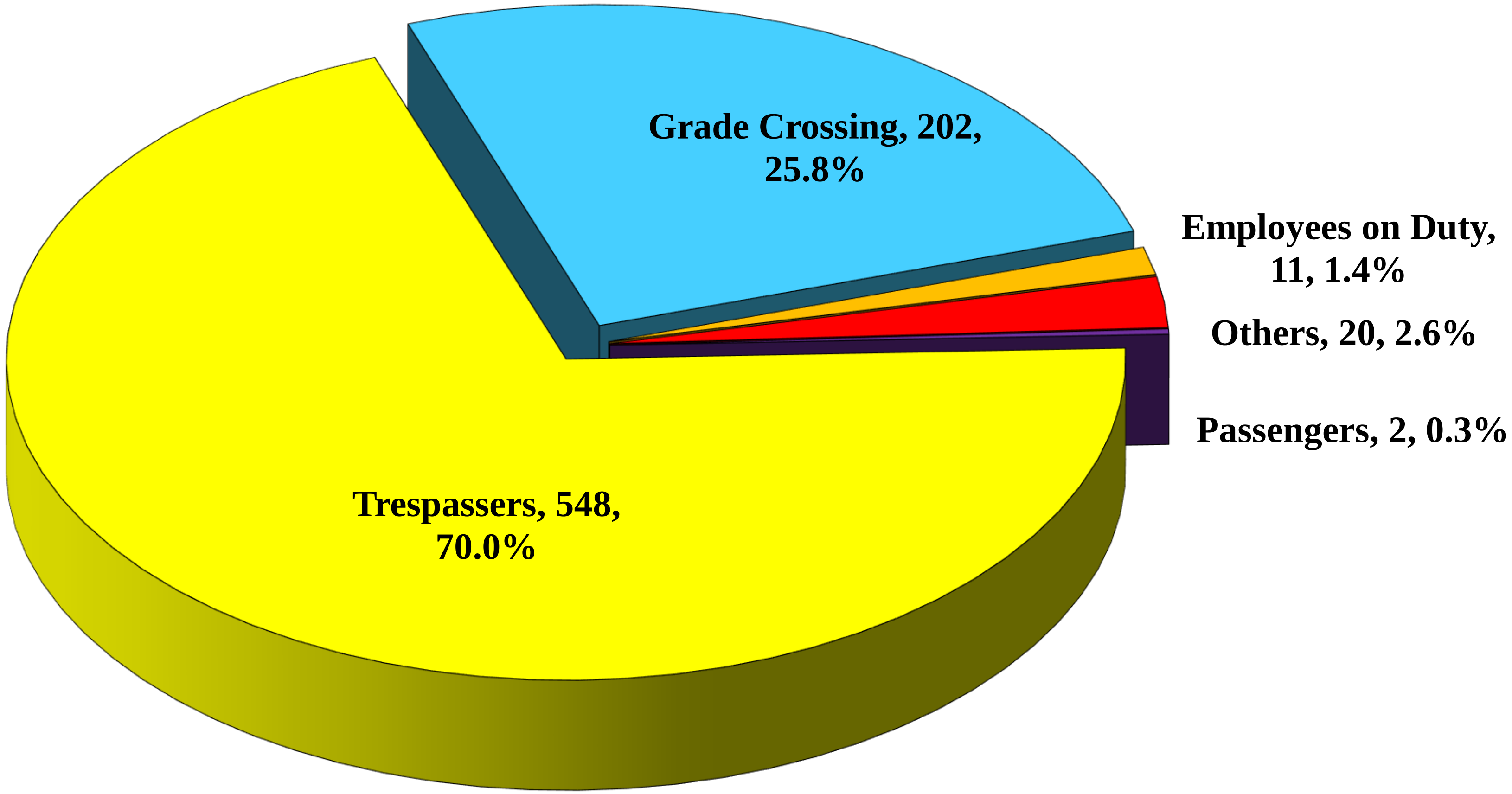
The Mechanical Committee voted on the matter in October. Three railroads asked that before the petition is submitted, a Technical Advisory Group (TAG) review the audit process for tank car facilities and offer suggestions for improvements to the Mechanical Committee.

The Tank Car Facility Audit Process Review Technical Advisory Group (TCF APR TAG) was formed in December and is meeting weekly. The TCF APR TAG will report to the Mechanical Committee during the MC's May meeting.

Safety Statistics

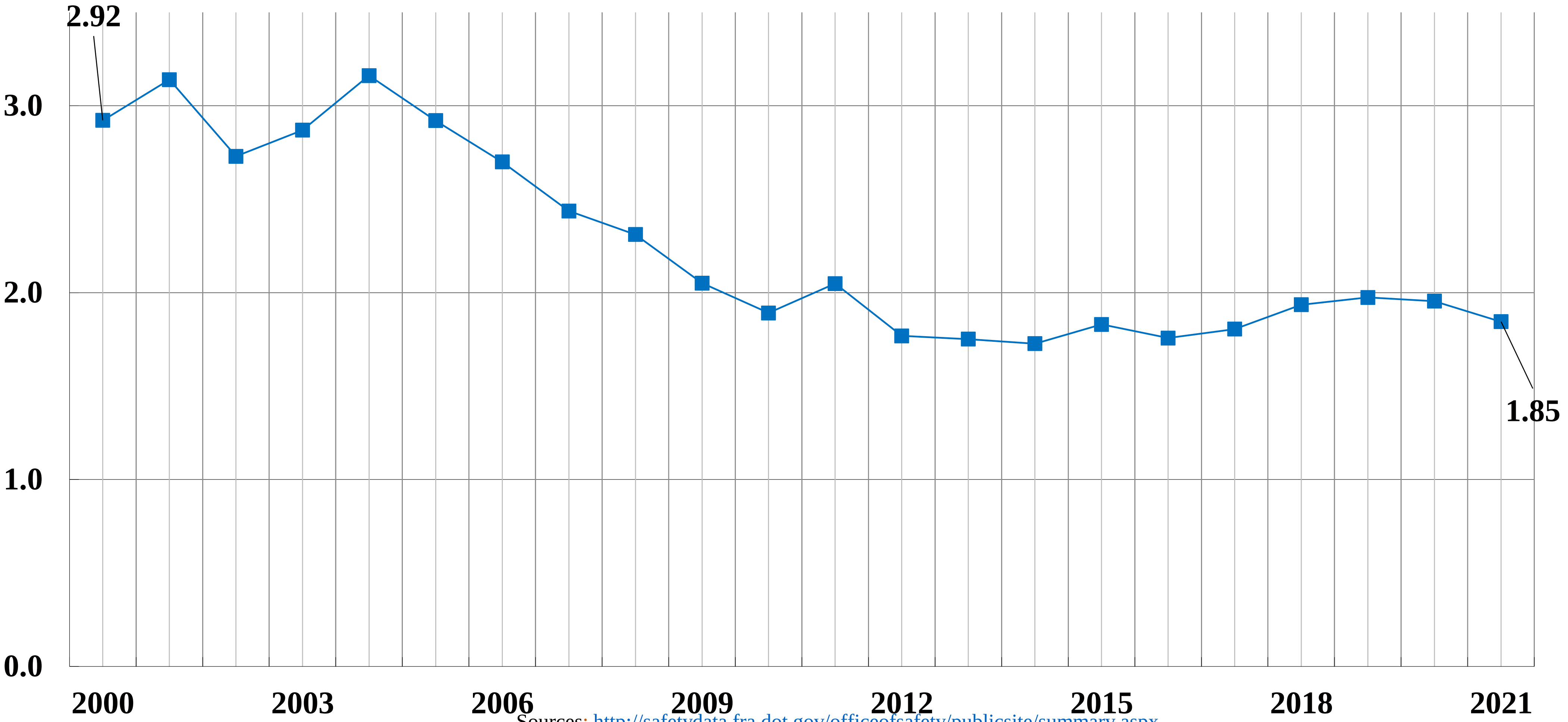
An enabler of Regulatory Modernization

2020 Rail-Related Fatalities at Glance



Source: FRA website (2020 data as of March 2021):http://safetydata.fra.dot.gov/OfficeofSafety/publicsite/summary.aspx
Note: Data for 2020 are preliminary.

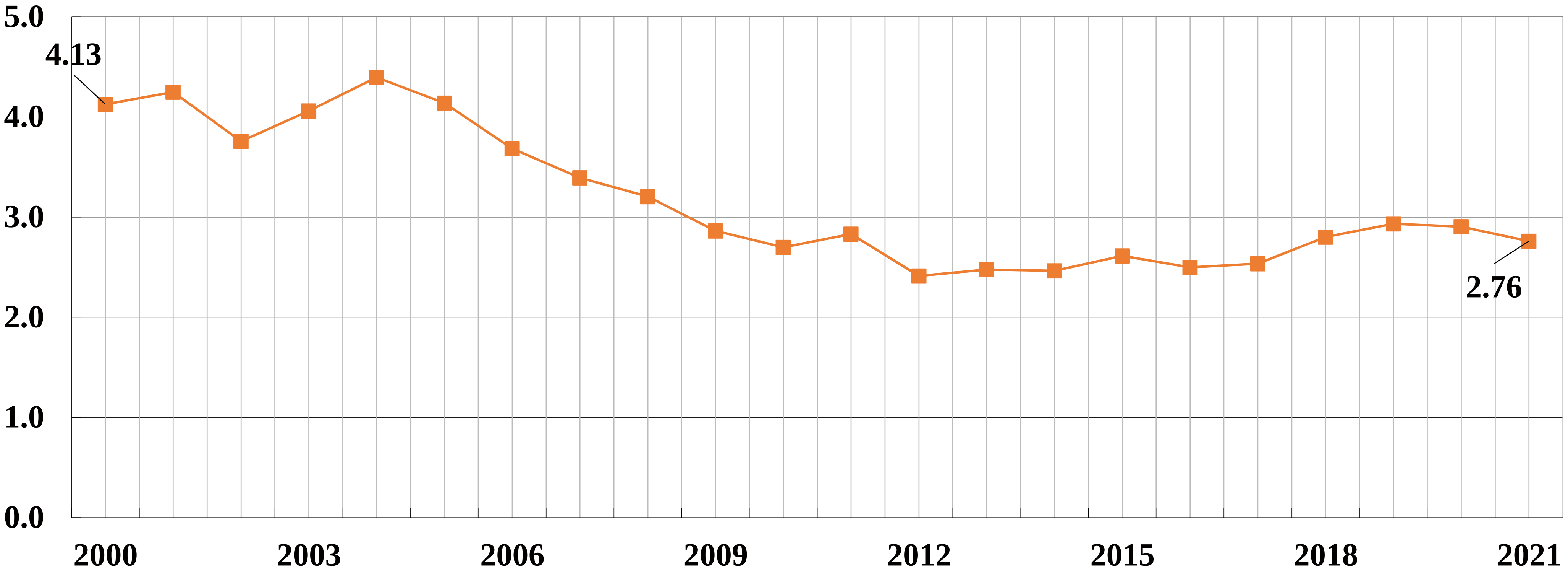
Derailments / Million Train-Miles Dropped 35% Since 2000 and 6% Since 2020



Sources: http://safetydata.fra.dot.gov/officeofsafety/publicsite/summary.aspx

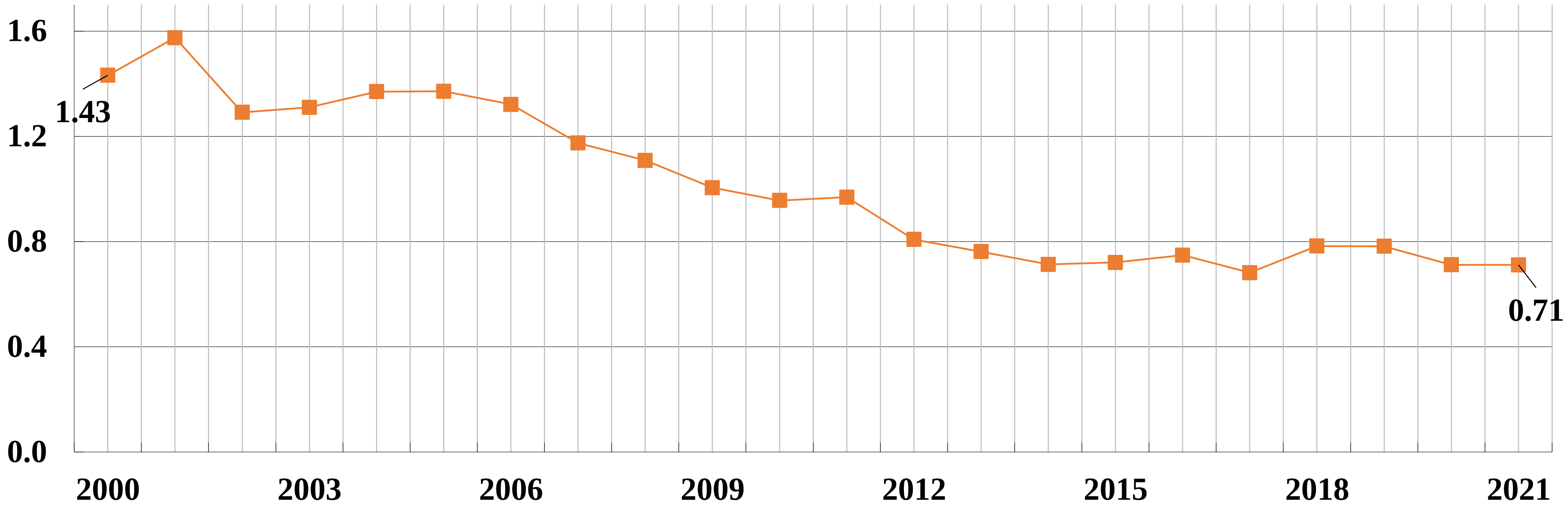
Note: Excludes grade crossing accidents. Data for 2021 is preliminary as of March 2022.

Train Accidents / Million Train-Miles Dropped 33% Since 2000 and 5% Since 2020



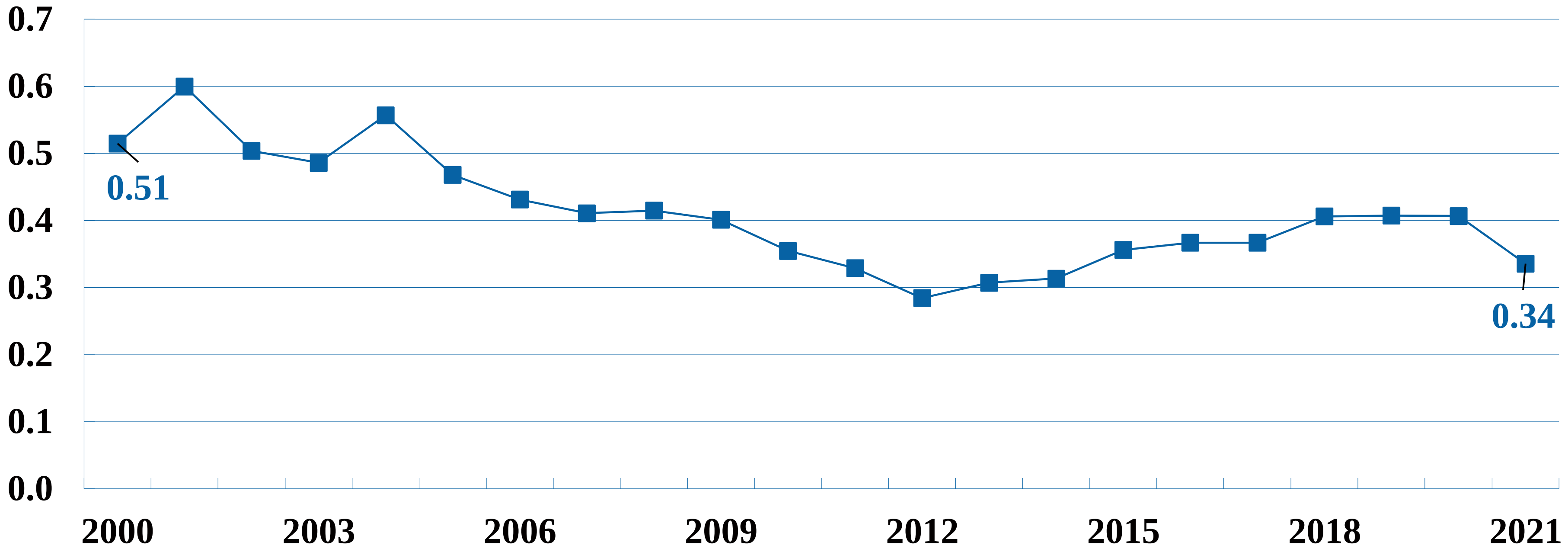
Sources: http://safetydata.fra.dot.gov/officeofsafety/publicsite/summary.aspx. Note: Excludes grade crossing accidents. Data for 2021 is preliminary, as of March 2022.

Track-Caused Accidents / Million Train-Miles Dropped 50% Since 2000 and 0.1% Since 2020



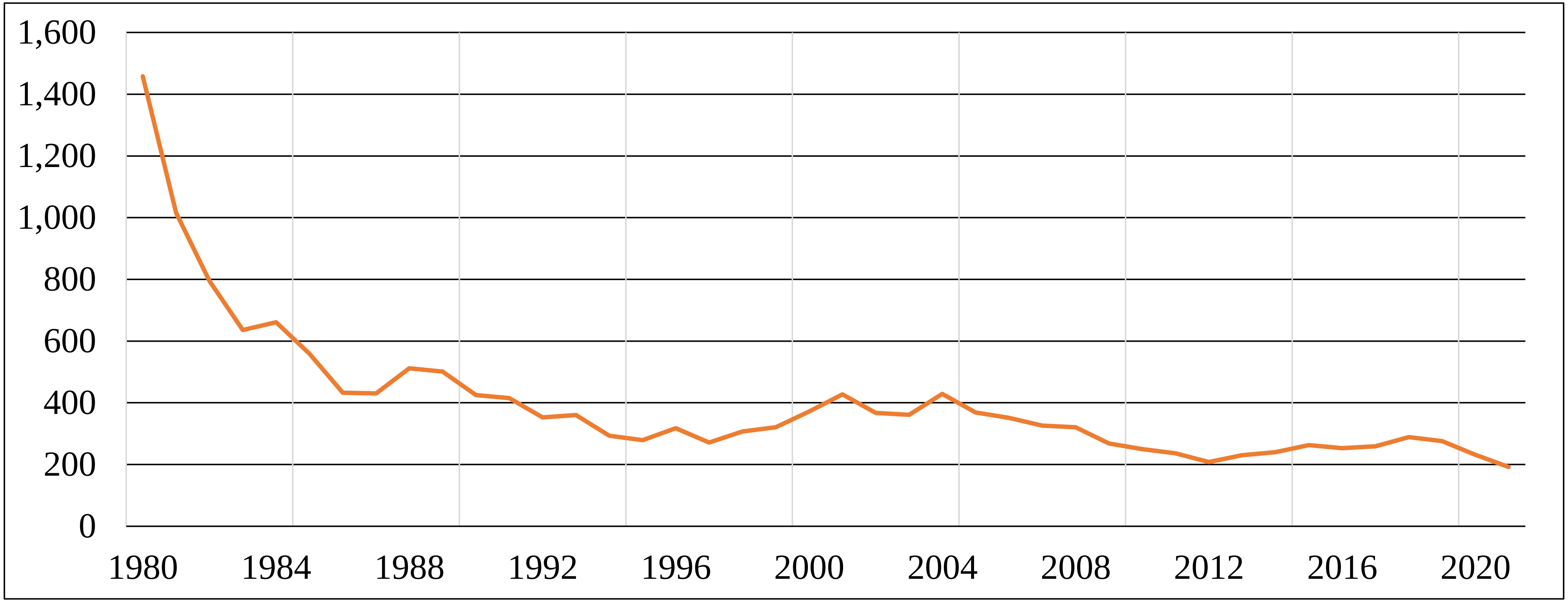
Sources: http://safetydata.fra.dot.gov/officeofsafety/publicsite/summary.aspx
Note: Excludes grade crossing accidents. Data for 2020 and 2021 are preliminary, as of March 2022.

Equipment-Caused Accidents / Million Train-Miles are Low; The Rate Has Dropped 35% Since 2000 and 18% Since 2020



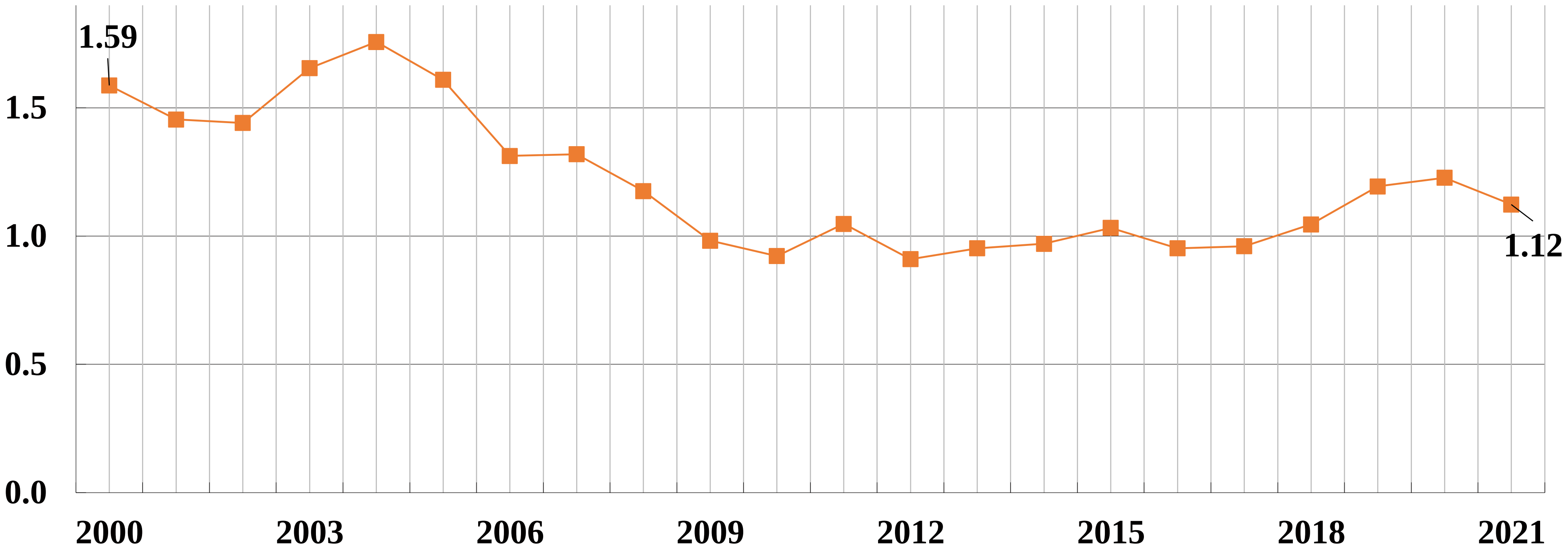
Sources: http://safetydata.fra.dot.gov/officeofsafety/publicsite/summary.aspx Note: Excludes grade crossing accidents. Data for 2021 is preliminary, as of March 2022.

Equipment-Caused Accidents Dropped Dramatically Since 1980



Sources: http://safetydata.fra.dot.gov/officeofsafety/publicsite/summary.aspx
Note: Excludes grade crossing accidents. Data for 2021 is preliminary, as of March 2022.

Human Factors Accidents / Million Train-Miles Dropped 29% Since 2000 and 8% Since 2020



Sources: http://safetydata.fra.dot.gov/officeofsafety/publicsite/summary.
Note: Excludes grade crossing accidents. Data for 2022 is preliminary as of March 2022.

Regulatory Modernization

Making Progress

Brake Valves in Cold Weather

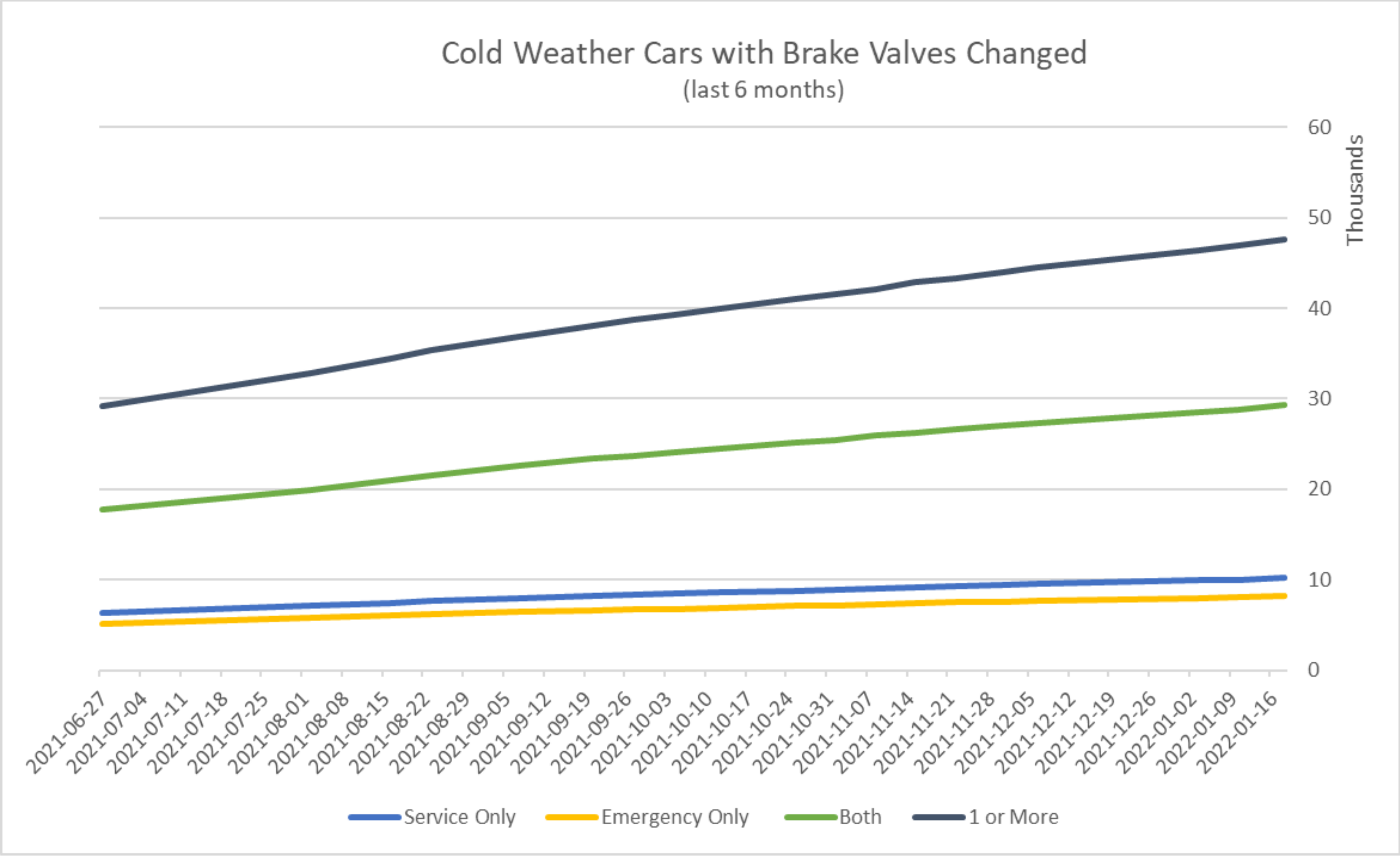
Problem: Old brake valves can pass a SCABT, but not work properly when cold

Unit trains are a concern:

1. Similar equipment of same type and age may have a high percentage of brakes that do not operate when cold.
2. Often leased equipment, may have been in storage.
3. Can be expected to carry heavy commodities on steep grades.

Brake Valves in Cold Weather

Problem: Old brake valves can pass a SCABT, but not work properly when cold



New Equipment Advisory System in Effect

- Equipment-based versus Notice/Letter based
- Enable the prioritization of equipment and components
- Include location of component on car
- Improve workflow of advisory development
- Effective July, 2021

Labor's Effort to Overturn Brakes 1

Labor has initiate action though the courts to overturn the "Brakes 1", which contains much more than just allowing cars to be "off-air" for up to 24 hours before requiring another air test.

AAR was glad that FRA decided to defend the rule, and AAR supported FRA's efforts.

Oral arguments were heard in DC Circuit Court on February 25. No decision has been reached as of this time.

Other Regulatory Modernization Efforts

The Electronic Air Brake Slip NPRM was published in January of 2021. Nothing much has happened since.

Waivers have slowed down; some important wavers must be renewed.

Not just air brake waivers at risk, also waivers to allow advances in other technologies.

Regulatory Modernization

Electronic Air Brake Slip (eABS)

- The eABS NPRM was published on January 15, 2020.
- Important enabler of Regulatory Modernization by allowing increased operational freedom for making pick-ups and set-offs.
- Removes restrictions for extended-haul trains.
- Mileage increased between FRA-required brake tests to 2,500 miles in many cases.
- eABS will track the mileage remaining before the next air brake test is due.
- User interface for short lines.

Questions?

Thank you!

AAR Quality Assurance
55500 DOT Road
Pueblo, Colorado 81001
www.aar.com

AAR Quality Auditors and Industry Conference

April 12-14, 2022

Fort Worth, Texas

2022 M-1003 Revisions

Thomas Cavanagh
Lead Quality Assurance Analyst
Amtrak

John Gronberg
Manager, Quality
Watco

2022 M-1003 Revisions 1

Reissued: January 2022

Effective: July 1, 2022

2022 M-1003 Type of Changes

- 3 Types of Changes Identified
    - Editorial
    - Clarification
    - Intent

2022 M-1003 – Editorial Revisions

Effected Paragraphs	Change	Description
32	Editorial	Most of the changes are due to the use of definitions in place of phases

Example

Paragraph	Prior Revision	Change
2.16.4	Apply appropriate methods for preservation and segregation of materials, products, and services (activities) when under facility control.	Apply appropriate methods for preservation and segregation of *activities* when under *facility* control.

2022 M-1003 – Clarifications Revisions

Effected Paragraphs	Change	Description
18	Clarifications	Made statements less confusing and more comprehensible

Example

Paragraph	Prior Revision	Change
2.6.1.1	Continuously improve the effectiveness of the Quality Assurance Program through the use of corrective action, preventive action, internal audit results and actions resulting from management reviews.	Continuously improve the effectiveness of the *Quality Assurance Program* through the use of (but not limited to) *corrective action, preventive action, internal audit* results and actions resulting from management reviews.

2022 M-1003 – Intent Revisions

Effected Paragraphs	Change	Description
10	Intent	Change to a key element of the standard

Example

Paragraph	Prior Revision	Change
Definitions	**Transgression:** A type of adverse audit finding in which the facility's quality assurance program does not meet a specified requirement. This audit finding identifies a discrete problem or discrepancy within the facility's quality assurance program.	Removed

2022 M-1003 Revisions 1

Definitions

Definitions

- **Adverse Audit Finding -** A *noncompliance* identified during an *audit*.
- **Corrective Action -** Steps taken to eliminate the root cause and prevent recurrence of a *nonconformance.*
- **Item of Concern -** A type of *adverse audit finding* that identifies a potential *noncompliance* within the *facility's quality assurance program*.
- **Noncompliance -** An *adverse audit finding* in which the *facility's quality assurance program* does not meet specified requirements.
- **Preventive Action -** Steps taken to avoid the cause of a potential *nonconformance* or *noncompliance*.
- **Annually -** When used in chapter 2 of this specification means within 365 days not to exceed 400 days.
- **Transgression** - removed.

2022 M-1003 Revisions 1

What’s New

New

- Made all words that are linked to a definition *italicized throughout Section J*
- (Material, Product, and Services) replaced with *Activity*
- *TSWC replaced with Mechanical Committee*
- *Appendix A from "Reference Guide" to "Activity Code Guide"*
- *Appendix C was moved from Section J and added to our FAQ page at https://aar.com/standards/FAQ.html*
- *Definition: Annually - When used in chapter 2 of this specification means within 365 days not to exceed 400 days.*

2022 M-1003 Revisions 1

Section J 2.3.2.6

Section J 2.3.2.6

2.3 Quality Assurance Program and Manual Requirements

Paragraph	Prior Revision	Change
2.3.2.6	Include or reference a production, inspection and test plan (see element 2.5).	Include or reference a facility’s production, inspection and test plan (see element 2.5). The production, inspection and test plan shall describe the facility’s overall process and is not required to include each activity or product line.

2022 M-1003 Revisions 1

Section J 2.4.4.1

Section J 2.4.4.1

- Review the *Quality Assurance Program annually* to ensure its continuing suitability and effectiveness in satisfying the requirements of this specification and the *facility's* quality policy and objectives. Review shall include but is not limited to the following:

2022 M-1003 Revisions 1

Section J 2.5.2.2

Section J 2.5.2.2

2.5 Production, Inspection, and Test Planning

Paragraph	Prior Revision	Change
2.5.2.2	Identify the characteristics to be inspected, examined, and tested at each point and specify acceptance criteria to be used.	Identify or make reference to the characteristics to be inspected, examined, and tested at each point and specify acceptance criteria to be used. The production, inspection and test plan is not required to list every potential document used.

2022 M-1003 Revisions 1

Section J 2.7.5.1

Section J 2.7.5.1

2.7 Document Control

Paragraph	Prior Revision	Change
2.7.5.1	Ensure that changes to documents receive the same authorization as the original.	Ensure that changes to documents are approved by authorized personnel.

2022 M-1003 Revisions 1

Section J 2.8 Measure and Test

Section 2.8 Measuring and Testing Equipment

Paragraph	Prior Revision	Change
2.8.2	At prescribed intervals or prior to use, measuring and testing equipment shall be verified, calibrated, or adjusted utilizing certified equipment having a known valid relationship to nationally recognized standards	At prescribed intervals or prior to use, measuring and testing equipment shall be verified or *calibrated* utilizing certified equipment having a known valid relationship to nationally recognized standards.
2.8.4.4	Identification number.	Unique identification number.
2.8.4.6	Frequency of checks	Frequency of checks. (Note: Calibration intervals can be dependent upon the severity of the environment in which the devices are stored and/or the criticality of the measurements being taken. A track record should be developed over the course of time.)
2.8.5.1	N/A	The user of the measuring and testing equipment must be aware of its calibration status.
2.8.5.2	N/A	Access to the status should be at or near the work area.
2.8.9	Safeguard all measuring and testing equipment from adjustments that would invalidate the calibration setting.	Safeguard all measuring and testing equipment from adjustments that would invalidate the calibration setting. (Note: This can be in the form of a seal or a physical means to identify tampering, or password protection, or physical barriers to access points of adjustment.)

2022 M-1003 Revisions 1

Section J 2.13 Inspection Status

Section 2.13 Inspection Status

Paragraph	Prior Revision	Change
2.13.2	Establish and maintain a system for tags or stamped impressions on the activity or its container—or other physical means—that indicates final acceptance of activity. Final-acceptance indicators, in-process indicators, and incoming-inspection indicators must not be identical	Establish and maintain a system (electronic, tags, stamped impressions or other means) that:
2.13.2.1		Provides controls for acceptance status, including the authority for changing inspection status of the *activity*.
2.13.2.2		Shows the identity of the *facility* and its inspector of any inspection stamps used.
2.13.2.3		Indicates final acceptance for the *activity* and/or on its packaging. Final acceptance indicators, inprocess indicators, and incoming inspection indicators must not be identical.

2022 M-1003 Revisions 1

Section J 2.19 Quality Assurance Program Review and Manual Revision

Section 2.19 Quality Assurance Program Review and Manual Revision

Paragraph	Prior Revision	Change
2.19.1	The facility shall review the Quality Assurance Program and manual at least annually.	The facility shall review the Quality Assurance Program and manual *annually*.

2022 M-1003 Revisions 1

Section J 2.20 Statistical Methods

Section 2.20 Statistical Methods

Paragraph	Prior Revision	Change
2.20	Process Capability/Statistical Methods	**Statistical Methods** **2.20** Statistical Methods **2.20.1** The facility shall: **2.20.1.1** Maintain documented procedures to implement, analyze, and control the use of statistical methods for process control and continuous improvement. **2.20.1.2** Determine the applicable use of statistical methods and identify where used. **2.20.1.3** Use statistical methods to evaluate and control the variability of processes and key quality characteristics. **2.20.2** The facility should use statistical methods such as statistical process control, process capability studies, and analysis of measurement variability.

2022 M-1003 Revisions 1

Section J 3.10 Audit Termination or Rescheduling

Section 3.10 Audit Termination or Rescheduling
3.10.1 Facility Requests

- In instances when a facility requests an audit be rescheduled or terminated, the auditor will immediately contact the QAM and the audit agency manager to review the request.
- **3.10.1.1** If the facility requests the audit be rescheduled due to unforeseen circumstances beyond its control, the QAM and the audit agency manager will review and discuss the circumstances for the facility's request and may permit the auditor to reschedule (one-time allowance) the audit on an expedited basis. For rescheduled audits the auditor will coordinate with the facility for scheduling. The facility is responsible for all costs associated with a rescheduled audit.
- **3.10.1.2** If the facility requests the audit be terminated, the auditor will immediately notify the QAM and the audit agency manager and inform the facility that its current M-1003 certification will be withdrawn immediately. If the auditor is unable to contact the QAM and the audit agency manager, the auditor may leave the facility after informing them that request for termination has been forwarded to QAM and the audit agency manager. For audits terminated by the facility, if the facility desires M-1003 certification, they must reapply for new M-1003 QA certification in accordance with paragraph 3.3.

Section 3.10 Audit Termination or Rescheduling
3.10.2 Auditor Requests (1 of 2)

- In instances when an auditor believes an audit should be terminated or rescheduled (e.g. unsafe conditions or hostile work environment), the auditor may suspend the audit and immediately contact the QAM and the audit agency manager to review the request. If the auditor is unable to contact the QAM and the audit agency manager, the auditor may leave the facility after informing them that the audit has been suspended pending consultation with the QAM and the audit agency manager.
- **3.10.2.1** If the QAM or Audit Agency Manager approves the auditor’s request to terminate the audit:
- **3.10.2.1.1** The QAM or Audit Agency Manager will notify the facility and responsible technical committees that the audit was terminated.
- **3.10.2.1.2** The auditor will complete the Audit Termination Report recommending denial or withdrawal of certification and provide a copy to the QAM and audit agency management.

Section 3.10 Audit Termination or Rescheduling
3.10.2 Auditor Requests (2 of 2)

- **3.10.2.1.3** The QAM will present the completed Audit Termination Report to the Quality Assurance Committee for processing.
- **3.10.2.1.4** If the QAC processes the Audit Termination Report to deny or withdraw certification it will be addressed per 3.11 of this standard.
- **3.10.2.2** If the QAM or Audit Agency Manager approves the auditor’s request to reschedule the audit due to unforeseen circumstances beyond its control:
- **3.10.2.2.1** The QAM or Audit Agency Manager will notify the facility and responsible technical committees that the audit has been recommended for rescheduling.
- **3.10.2.2.2** The auditor will complete the Audit Termination Report recommending audit rescheduling and provide a copy to the QAM and audit agency management.
- **3.10.2.2.3** The QAM will present the completed Audit Termination Report to the Quality Assurance Committee for processing.
- **3.10.2.2.4** If the QAC processes the Audit Termination Report to reschedule the audit, the auditor will coordinate with the facility to reschedule the audit.

2022 M-1003 Revisions 1

Chapter 5 and Appendix Changes

Chapter 5 and Appendix Changes

Paragraph	Prior Revision	Change
Chapter 5	Reserved	Commonly Used Hyperlinks for Section J Quality Assurance Program
Appendix A	Reference Guide	Activity Code Guide
Appendix C	Views and Interpretations	Moved to FAQ page (website): https://aar.com/standards/FAQ.html

CHAPTER 5. COMMONLY USED HYPERLINKS FOR SECTION J QUALITY ASSURANCE PROGRAM:

- AAR QA Resource Center - iirx
- Chpt 7 Nonconformance - iirx
- MSRP Publications
- MSRP Online Library
- Circular Publications
- Circulars Library
- QAPE link
- Auditor Handbook
- TTCI QA Page

AAR Manual of Standards and Recommended Practices
Specification for Quality Assurance

M-1003 APPENDIX A

APPENDIX A
ACTIVITY CODE GUIDE

Shown below is a listing of *activities* that require M-1003 *certification*, the AAR *Field Manual* rule and/or circular letter that added the *activities* to the M-1003 program, and the number of the standard or specification that requires technical approval in addition to M-1003 *certification*.

- **Next Generation for 2024 M-1003 Improvements:**

- ❑ Review of ISO-22163
- ❑ Value Added Auditing
- ❑ Risk-Based vs. Prescriptive Auditing

Thank you!

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Pueblo, Colorado 81001
www.aar.com

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April 12-14, 2022

Fort Worth, Texas

Audit Finding Guidelines
Noncompliance vs. Item of Concern

Tracy Ulm
Chief Mechanical Officer
Rio Grande Pacific Corp.

2022 Revision of Section J

- **Docket Item: QA-11 Revisions to M-1003 and QAPE**
  - A Joint AAR/RSI QA Task force was formed in April 2021
  - Met over several weeks in March/April 2021 to review possible improvements to the standard
  - One point of emphasis was to try to remove ambiguity in the standard
  - Help make it clear and concise.

Old Definitions

- Adverse Audit Finding
  - An item of concern, transgression, or a noncompliance identified during an audit.
- Noncompliance
  - A type of audit finding in which the facility’s quality assurance program **does not meet specified requirements**. This audit finding identifies a systemic **problem** or widespread **discrepancy** within the facility’s quality assurance program.
- Transgression
  - A type of adverse audit finding in which the facility’s quality assurance program **does not meet a specified requirement**. This audit finding identifies a discrete **problem** or **discrepancy** within the facility’s quality assurance program.”
- Item of Concern
  - A type of adverse audit finding that identifies **a potential noncompliance or potential transgression** within the facility’s quality assurance program.

Task Force Discussion

- The differences between a noncompliance, transgression and IOC and how they could be subjective as currently defined.

- Why further define noncompliant audit findings into:
  - a systemic problem or widespread discrepancy
  - a discrete problem or discrepancy

  and
  - a potential noncompliance or potential transgression

- Should a noncompliance and a transgression be looked at differently

- Is one finding less important than another?
- One gauge out of 300 had a calibration sticker missing and maybe that one gauge passed a critical component in a wheelset
- Maybe that component failed and caused this

- Is one finding less important than another?
- Maybe one old outdated procedure was used to inspect the coupler and draft gear installed on a tank car
- Maybe that broken draw bar caused this

Continuous Improvement

- In the end the task force and the full QAC agreed:
- A finding that identifies that the facility is not complying with a specified requirement is a noncompliance
- A Finding is a Finding is a Finding
- All were opportunities for improvement
- If the finding contradicts the standard, then it is a finding regardless if it is “one” or “one-hundred”

Continuous Improvement

- If it’s “one” or “one-hundred” then correcting the problem with the RCCA process is promoting continuous improvement

  – No more “one-of” findings
  – No more “is it a system-wide” findings
  – No more “major” findings
  – No more “minor” findings

Item of Concern

- Identifies something that is still **<u>in compliance</u>** but could potentially become noncompliant
  - A facilities procedure on a requirement covers all items but is not clear in an area
  - A process or system in place that could easily be misunderstood
  - Changes to the M-1003 not yet auditable
- These are the Auditors helpful notes and observations

New Definitions

- **Adverse Audit Finding**
  - A noncompliance identified during an audit.
- **Noncompliance**
  - An adverse audit finding in which the facility's quality assurance program does not meet specified requirements.
- **Item of Concern**
  - A type of adverse audit finding that identifies a potential noncompliance within the facility's quality assurance program.
- ~~**Transgression**~~
  - ~~A type of adverse audit finding in which the facility's quality assurance program does not meet a specified requirement. This audit finding identifies a discrete problem or discrepancy within the facility's quality assurance program~~

Please hold off on your questions for the Quality Assurance Committee until this afternoons Q&A session

Please hold off on your questions for the Quality Assurance Committee until this afternoons Q&A session

Thank you!

AAR Quality Assurance
55500 DOT Road
Pueblo, Colorado 81001
www.aar.com

Association of American Railroads Quality Auditors & Industry Conference

April 13, 2022

Fort Worth, TX

2.5 Inspection & Test Plan

Ray Morgan
Director Quality Engineering & Warranty
Greenbrier

Good Morning

Production Inspection and Test Plan

- Element 2.5
  - What it is
  - What is required
  - What's not required

Production Inspection and Test Plan

– Facility Plan(s) for Production, Inspection and Testing
    - Can be a single or multiple
    - Any format
    - Must include Inspection and Test
        - What, who, where, when how & how often

Modelo Car Type	N° Control	Plan de Control / Control Plan Aseguramiento de la Calidad / Quality Assuranc
Hopper	PC-HOP-02	El manejo de materiales utilizados en todas las etapas del proceso debera realizarse de acuerdo a P… at all the process stages must be performed according PMA-03 and IMA-03-01 Todas las caracteristicas descritas estan sujetas a cualquier metodo de auditoria de acuerdo a PAC… procedimiento del proceso / All the characteristics here described can be audited with any method ac… of the process procedures

Equipo Multidisciplinario Multidisciplinary team		Rev.	Fecha Date	Motivo de Revisión Description of Changes	Caracteristicas Especiales Ref. QS-002 "Indicadores de Desempeño de… Special characteritcs Ref. QS-002 "Quality Performance Measureme…
Calidad: Quality	Joel Vazquez	0	06/Ene/20	First Edition	**Defectos Criticos (C)** – Una omisión critica que puede resultar en un descarrilamiento, falla mayor o daño, o un def… probable que no permita el desempeño adecuado de un componente o de un carro de ferrocarril. A critical exception may result in a derailment, catastrophic failure or injury, or a defect that is likely to prevent intend… the component or railcar.
Produccion: Production	Jose Avila	1	09/Dic/20	General Revision	**Defectos Mayores (M)**– Una omisión Mayor que pueda afectar adversamente el desempeño y la vida útil del compo… de ferrocarril. Un defecto Mayor significa el total mal funcionamiento del Sistema de Calidad, Proceso o Procedimien… A major exception may adversely affect the performance and expected life of the component or railcar. A major exce… breakdown of a quality system, process or procedure.
Manufactura: Manufacturing	Johnatan Reyes	2			**Defectos menores (m)**– Una omisión Menor es probable que no afecte el desempeño y periodo de vida esperado d… carro de ferrocarril. Un defecto menor observado en el Sistema de Calidad, Proceso o Procedimiento.
Ingenieria: Engennering	Denise Becerra	3			A minor exception is not likely to impact the performance and expected life of the component or railcar. A single obs… quality system, process or procedure.
Mejora continua: Countinous improvement	Edwin Munguia	4			

…N	MECANISMOS, HERRAMIENTAS, MAQUINA MECHANISMS, TOOLS, MACHINARY.	Características de Inspección Inspection Characteristics P.I. I.P.	 Proceso Process	 Producto Product	 Características Especiales Quality Performance Measurements	Especificación y/o Criterios de Aceptación Specification and/or Acceptance Criteria	Dibujos de Referencia Reference Drawings	Métodos Methods Técnica de Evaluación y Medición Measurement Technique and Evaluation	Muestra Sample Tamaño de muestra Size sample	 Frecuencia de Inspección Insp Frequency	 Método d… Contro…
R… …D)		⊙	Release and verification of device		Accord to PIN-01	According to procedure PIN-01	N/A	measuring tape, square	100%	Accordin to PIN-01	Accordin…
		⊙		Distance between CENTRAL LINE and END SLOPE SHEET SUPPORT (RH / LH)	m	Verify distance according to reference drawing	B	Jig	100%	Each assembly	
		⊙		Final height of the END SLOPE SHEET SUPPORT (LH / RH)	m	According to reference drawing	B	Measuring tape Square	100%	Each assembly	
		⊙		Position of SLOPE SUPPORT STIFFENER	m	Verify position according to reference drawing	B	Measuring Tape Square	100%	Each assembly	
		⊙		Position of END SLOPE CONNECT	m	Verify position of END SLOPE CONNECT According to reference drawing	B	Jig Measuring Tape Square	100%	Each assembly	
…FENER …ID) welding		⊙		Welding Application	M	According to reference drawing Welding Defects according to AWS D15.1 and WPS	B	Visual Welding Gage	100%	Each welding application	
		⊙	Release and verification of device		Accord to PIN-01	According to procedure PIN-01	N/A	measuring tape, square	100%	Accordin to PIN-01	Accordin…
		⊙		Centered position of END SLOPE SHEET ASSEMBLY AND SLOPE SHEET STIFFENER ASSEMBLY (A END / B END)	m	Verify centered position according to reference drawing	A	Measuring Tape Square Jig	100%	Each assembly	

Puntos de Inspección / Inspection Points (I.P.)			Registros de Inspección / Inspection Records (I.R.)			
Punto de Prueba Test Point	⊙ Punto de Inspección Inspection Point	⊗ Punto de retención Cliente Customer Hold Point	◇ Reporte de conformidad Conformity record of testing	▣ Documentación de proveedores Documentation received by supplier	☐ Registros no incluidos en libro historial del carro These records are not included in the car history book	■ Registro incluido e… These records are included in the ca…

Production Inspection and Test Plan

- Plan(s) must include all covered items
  - What are covered items?
    - Incoming inspection through shipping/elements (2.10 – 2.16)

Plant	West		Car Type	Tank	117J100W	12345	Date	2/17/2020	Orig
Position W=West E=East	Process	Work Inst. / SOP	Measure & Test Assess-ments	Drawings	Records	Quality Criteria/ Special Instructions	Lots / Batches Inspection Level	Subcontract Services	SPC
Inbound	QA Hold Point Incoming Inspection	AQ 1.10	AQ 1.10	As Required Per QAII	FAQ 1.10-1	Reference Per QAII	AQ 1.10	Approved Vendors List Calibrations	None
Material	Perservation / Packaging	SOP 9020	None	None	None	None	None	None	None
1020 W	Plasma Table	SOP 1020	SOP 1020	Shell Shell	F1020-1 F1020-2 F1010-1 F1020-3	Drawing	100% 1st Piece	Calibration Vendors	None
1015 W	Plate Bevel	SOP 1015	SOP 1015	Shell Shell	F 1015-1 F1010-1	SOP 1015	100%	Calibration Vendors	None
1010 W	Plate Blast	SOP 1010	SOP 1010	Shell Shell	F1010-1	ES 1094 ES 1090 SOP 1010	100%	Calibration Vendors	None
1030 W	Plate Roll	SOP 1030	SOP 1030	Shell Shell	F1030-1 F1010-1	Drawing SOP 1030 EW 1.02	100%	Calibration Vendors	None
1160 W 2090 E	QA Hold Point Tank Visuals	SOP 1060	SOP 1060	Shell Tank Arrgt	VT Report	Drawing SOP 1160	100%	Vendors	Defects / Acceptance

Inbound	QA Hold Point Incoming Inspection	AQ 1.10	AQ 1.10	As Required Per QAII	FAQ 1.10-1	Reference Per QAII	AQ 1.10	Approved Vendors List Calibrations	None

Production Inspection and Test Plan

Identifies the characteristics

- Inspected
- Tested
- Each point
  - What, who, where, when how & how often

Reference Acceptance Criteria

- Characteristic – "Weld"
  - Acceptance Criteria – AWS D.15.1 or Appendix W
- Characteristics – "Length of railcar over coupler pulling face"
  - Acceptance Criteria = X +/- ½"

Production Inspection and Test Plan

Identifies

- Mandatory Hold Points

Defines

- Sampling plans and statistical process control (where they are used)
  - Incoming inspection based on an AQL
  - Radiography for General Service Tank Car
- Verification of compliance
- Lots and batches

Indicates

- Subcontracted services employed

Production Inspection and Test Plan

- Identify where in the process any SPC is being used
  - Defect tracking
  - Scrap rates
- Identify where measurement and test records are maintained

Production Inspection and Test Plan

- Define compliance to process procedures
  - Sign off sheets/travelers
  - Inspection reports

Production Inspection and Test Plan

- Element 2.5
  - What it is
  - What is required
  - What's not required

- Element 2.5 does not require the facility to list every potential document used in the inspection and test plan.

Obtain current AAR QAPE Checklist from TTCI Website https://aar.com/standards/FAQ.html

M-1003 Certification

Where can I find the most current Quality Assurance Program Evaluation (QAPE) Checklist?

The most current Quality Assurance Program Evaluation Checklist – or QAPE for short – can be downloaded by **clicking here**. Check this link periodically for any updates to the QAPE.

Thank you!

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AAR Quality Assurance Auditor and Industry Conference

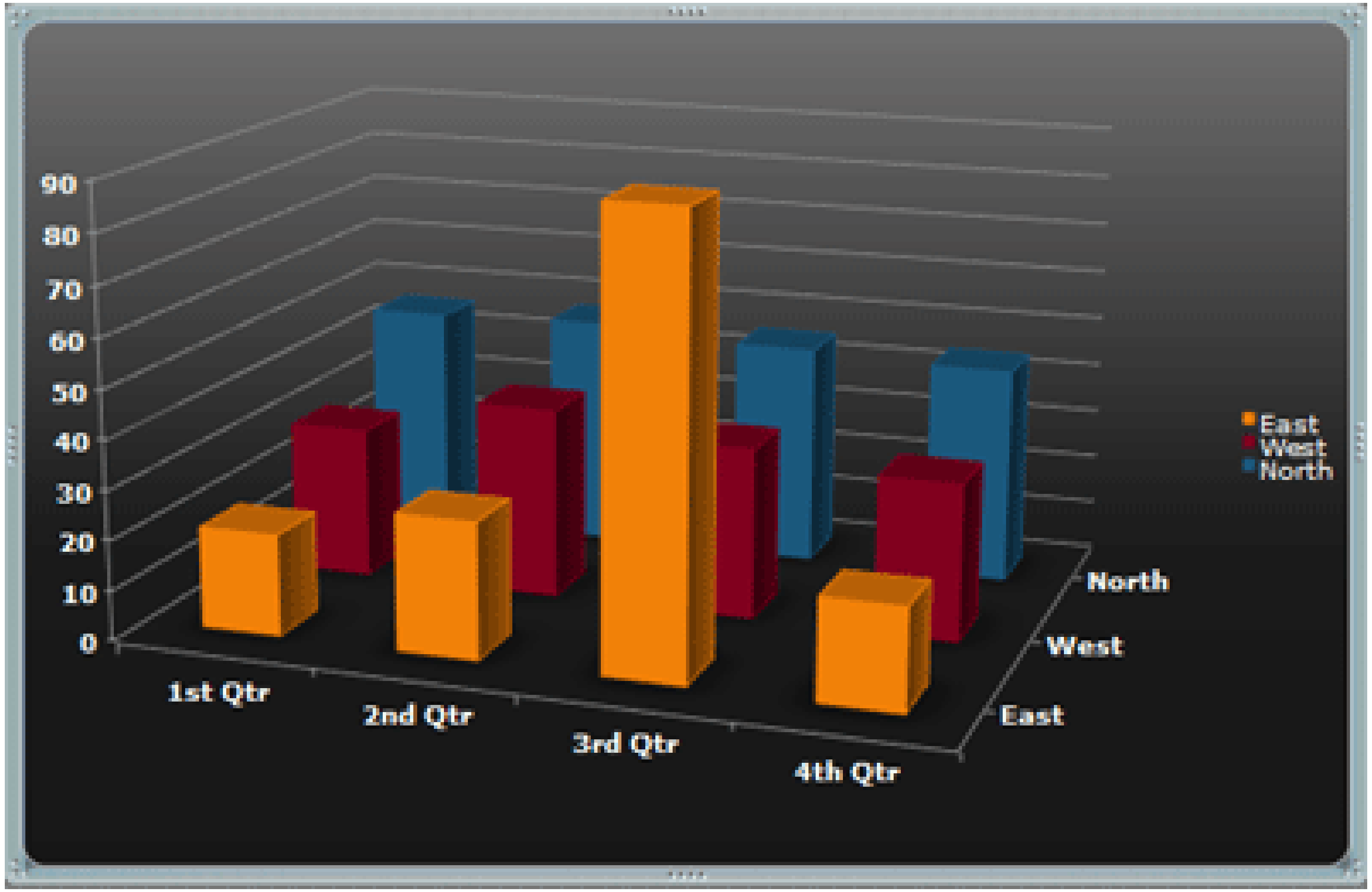
April 12-14, 2022

Fort Worth, Texas

2.20 Statistical Methods

Joy Cooke
AAR Accredited Auditor
International Quality Consultants

2.20 Statistical Methods



2.20 Statistical Methods

- **2.20.1** The *facility* shall:
- **2.20.1.1** Maintain documented procedures to implement, analyze, and control the use of statistical methods for process control and continuous improvement.
- **2.20.1.2** Determine the applicable use of statistical methods and identify where used.
- **2.20.1.3** Use statistical methods to evaluate and control the variability of processes and key quality *characteristics*.
- **2.20.2** The *facility* should use statistical methods such as statistical process control, process capability studies, and analysis of measurement variability.

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- **2.20.2** The *facility* should use statistical methods such as statistical process control, process capability studies, and analysis of measurement variability.

2022 MSRP Section J 2.20

Reissued: January 2022

Effective: July 1, 2022

2.20 Statistical Methods

- What the auditor will be looking for?

2.20.1	Does the facility do the following:					
2.20.1.1	Maintain documented procedures to implement, analyze, and control the use of statistical methods for process control and continuous improvement?					
2.20.1.2	Determine the applicable use of statistical methods and identify where used?					
2.20.1.3	Use statistical methods to evaluate and control the variability of processes and key quality characteristics?					
2.20.2	Does the facility use statistical methods such as statistical process control, process capability studies, and analysis of measurement variability?					

2.20 Statistical Methods Policy

AMTRAK

Mechanical Department Policy

Statistical Methods for Wheel Operations

MDP-MEC-29-WT20

Revision: 1.0
Issue Date: 1/1/2022

2.20 Statistical Methods Policy

MDP-MEC-29-WT20

AMTRAK®

DEFINITIONS

Statistical methods – are mathematical formulas, models, and techniques that are used in statistical analysis of raw data. The application of statistical methods extracts information from data and provides different ways to assess the performance indicators.

Scrap – Only wheels inspected per SMP 05402 and considered secondhand that are found to be unserviceable after attempting to true are to be documented as scrap on the Wheels Trued by Defect form (TMP-MEC-29-001) for purposes of statistical methods.

1. PURPOSE
   1.1. Amtrak has developed this documented procedure to implement, analyze, and control the use of statistical methods for process control and continuous improvement. This procedure is used to determine the applicable use of statistical methods and identify where used.

2. SCOPE
   2.1. Amtrak may use statistical methods to evaluate and control the variability of processes and key quality characteristics. Amtrak may use statistical methods for statistical process control, process capability studies, and analysis of measurement variability.
   2.2.

2.20 Statistical Methods Policy

4. POLICY/PLAN
   - 4.1. No later than the 5th of the following month, the corresponding field(s) on the Wheels Trued by Defect form is to be filled out using the WT/UT Daily Production Logs (FRM-MEC-29-WT5) or equivalent record system as a data source.
   - 4.2. The Wheels Trued by Defect document is maintained on the SharePoint “Mechanical Department Wheel Set AAR Compliance”.
   - 4.3. Each QAD and alternate shall request access to the Wheels Trued by Defect Repository by sending an email to the Mechanical Department Wheelset AAR Process Focus Team Quality Assurance Analysist, a link like the one below shall be provided in an email response. Clicking on the link within the email will grant permission to use the repository.
   - 4.4. Wheels Trued by Defect Repository – To access the repository please copy the link below and paste into Chrome browser. This website does not support other browsers.
     - 4.4.1. https://amtrak.sharepoint.com/sites/MechanicalDepartmentWheelSetAARComplianceProcessFocusTeam/SitePages/Home2.aspx
   - 4.5. RSE will perform a periodic, at a minimum of annually, analysis/review of the data. The result of which could result in statistical process control, process capability studies, and analysis of measurement variability.
   - 4.6. Any findings as result of the analysis/review will be discussed during the Mechanical Department Wheelset AAR Process Focus Team meeting(s). At this time any alterations to process control and continuous improvements will be introduced.

2.20 Statistical Methods

- What the auditor will be looking for?

2.20.1	Does the facility do the following:					
2.20.1.1	Maintain documented procedures to implement, analyze, and control the use of statistical methods for process control and continuous improvement?					
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2.20 Statistical Methods Policy

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2. SCOPE
   2.1. Amtrak may use statistical methods to evaluate and control the variability of processes and key quality characteristics. Amtrak may use statistical methods for statistical process control, process capability studies, and analysis of measurement variability.
   2.2.

3. RESPONSIBILITY
   3.1. Quality Assurance Designee (QAD): maintain the Wheels Trued by Defect form (TMP-MEC-29-001) in accordance with this document utilizing the Daily Production log

2.20 Statistical Methods Policy

4. POLICY/PLAN
   4.1. No later than the 5th of the following month, the corresponding field(s) on the Wheels Trued by Defect form is to be filled out using the WT/UT Daily Production Logs (FRM-MEC-29-WT5) or equivalent record system as a data source.
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2.20 Statistical Methods Policy

Excel FY22-FRM-ALB-REN-29-001 - Saved

Locomotive Wheel True

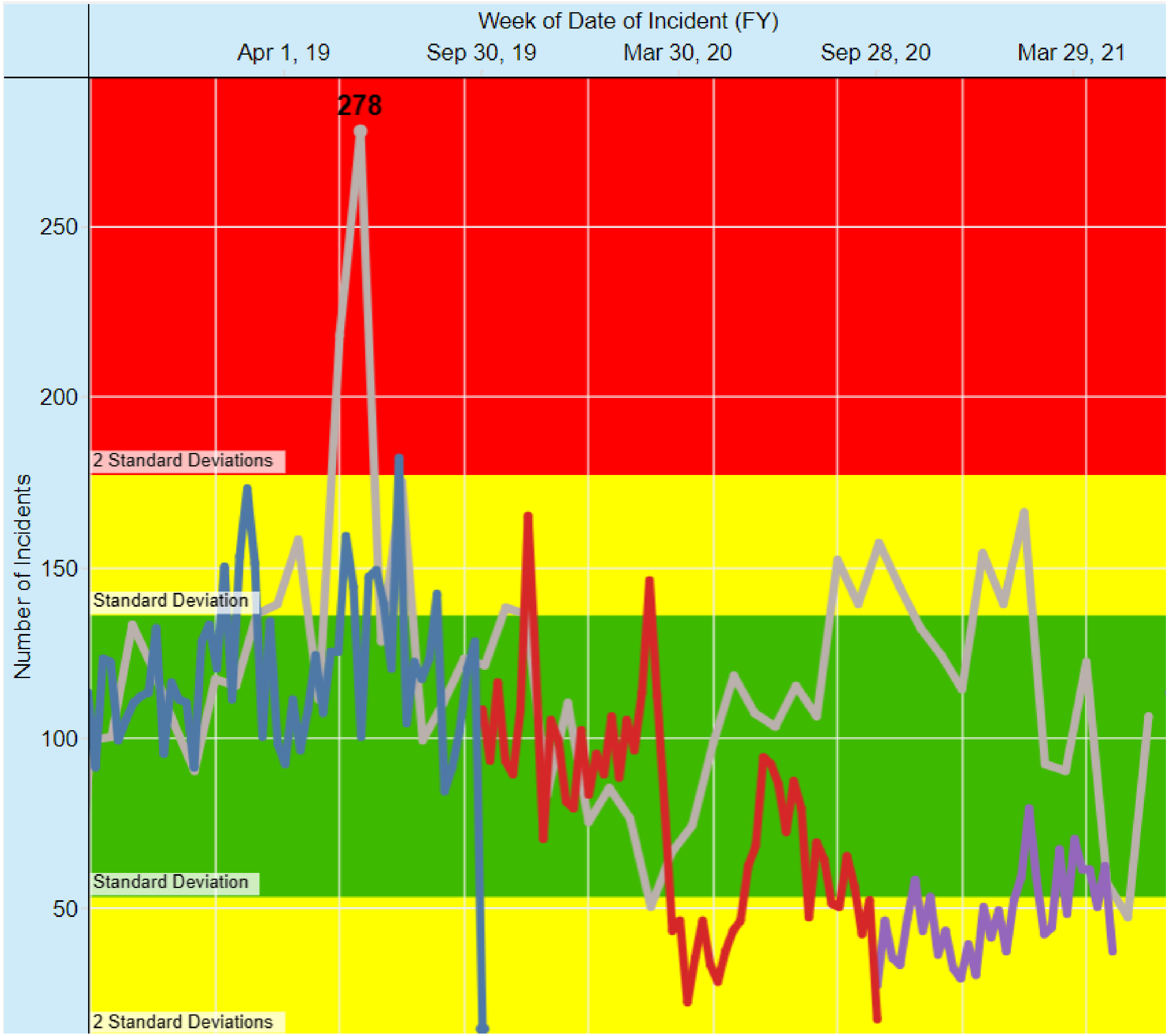
Location: Rensselaer NY

FY: 2022 Feb-Sept

AMTRAK

Equipment Type	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	FY Total
G.E.P-42													
Flat Spot					4								4
Shelled Tread					5	11							16
Worn Tread					1								1
Thin Flange													0
Reprofile / Inspection					2	3							5
High Flange					1								1
Chipped Rim													0
Thermal Crack													0
Built Up Tread													0
Ultrasonic Testing													0
Defects per month	0	0	0	0	13	14	0	0	0	0	0	0	27
Scrapped Wheel set													0
ACS-64													
Flat Spot													0

2.20 Statistical Methods Policy



2.20 Statistical Methods

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4.5. RSE will perform a periodic, at a minimum of annually, analysis/review of the data. The result of which could result in statistical process control, process capability studies, and analysis of measurement variability.

4.6. Any findings as result of the analysis/review will be discussed during the Mechanical Department Wheelset AAR Process Focus Team meeting(s). At this time any alterations to process control and continuous improvements will be introduced.

5. REFERENCES

5.1. AAR Manual J

5.2. WT/UT Daily Production Logs (FRM-MEC-29-WT5)

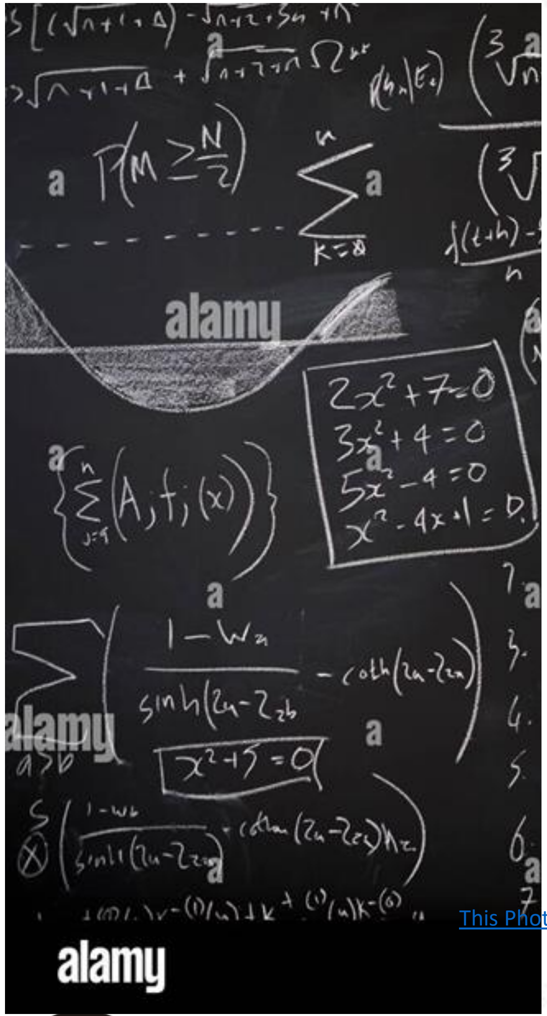
5.3. Wheels Trued by Defect (TMP-MEC-29-001)

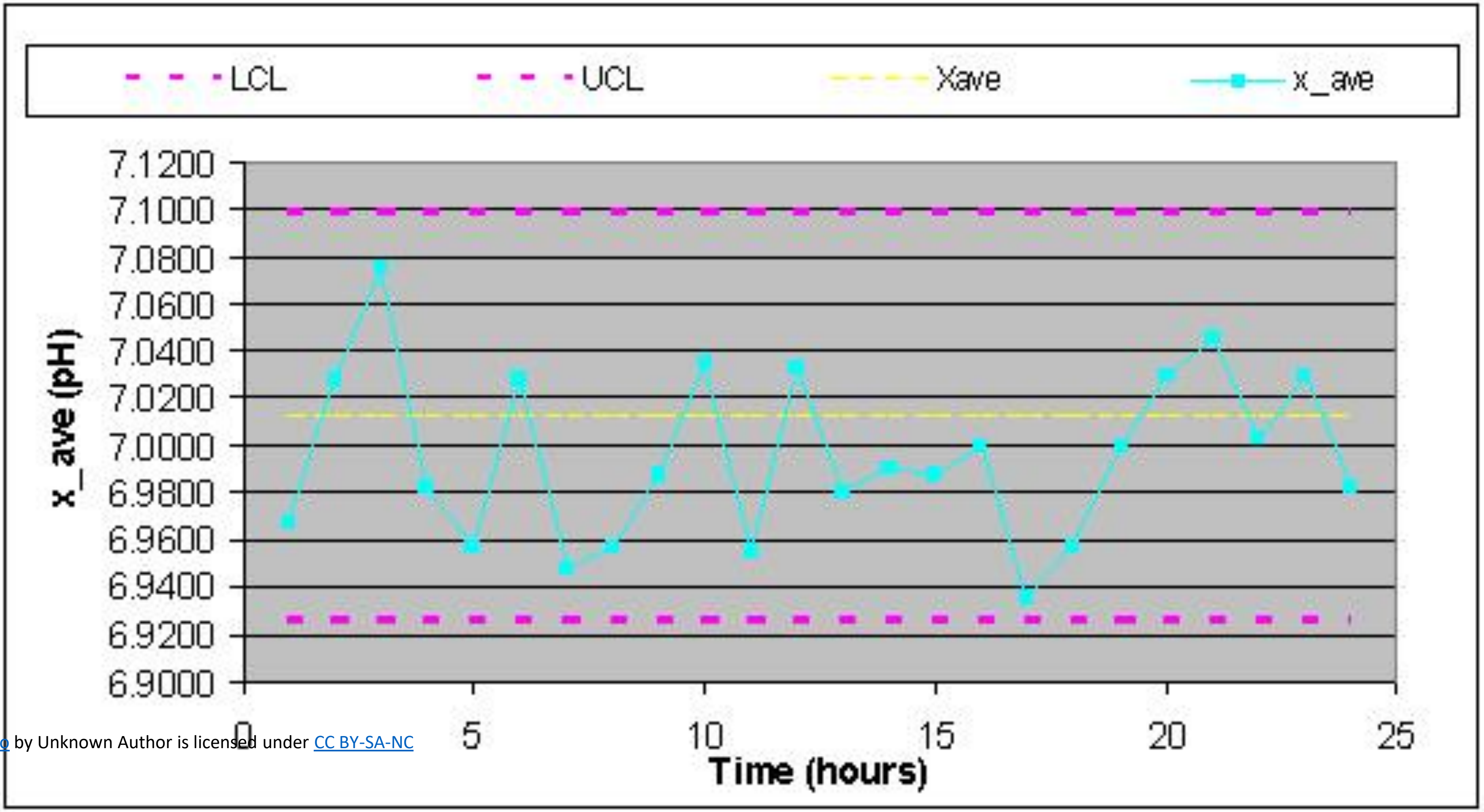
2.20 Statistical Methods Policy

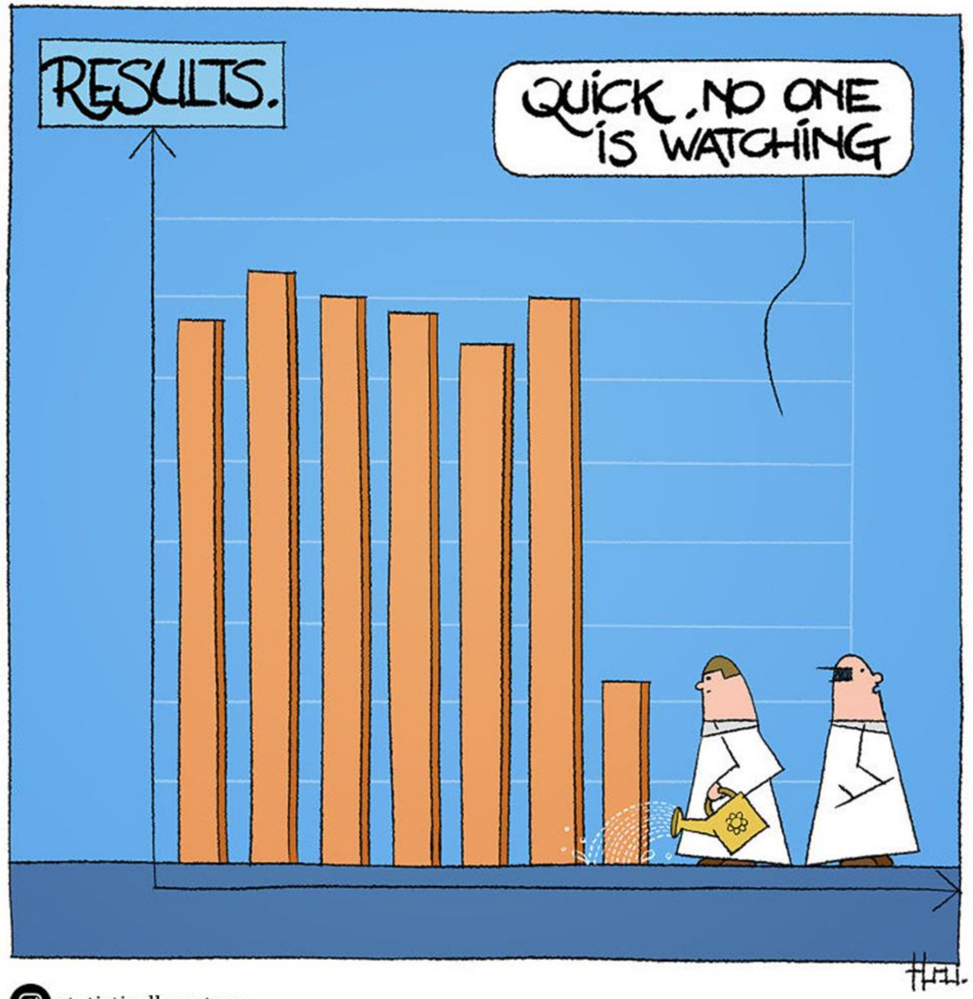
MECHANICAL DEPARTMENT WHEELSET AAR COMPLIANCE PFT Minutes FOR February 2022
Please be advised that the purpose of this PFT and monthly meeting is a vehicle to communicate to all applicable personnel, Amtrak's commitment to the safety of our riders. It is also an AAR requirement per Specification M-1003, 2.4.4 (Management Responsibility).
It is HIGHLY recommended the names listed below attend these monthly meetings/calls. If you cannot attend, it is important that you assign an alternate

Statistical Methods ***Inspection results (scrap rates, rework status, inspection data and on-time delivery- Reviewed Annually***		
Troy Congdon	Statistical Methods	I am currently working on the data and will have an update next month
Troy Congdon	Data Collection	No later than the 5th of the month, the previous months data must be entered.
Troy Congdon	Scrap definition	Only wheel inspected to be considered for 2nd hand and found to be unserviceable.
Troy Congdon	Presentation of Statistical Method.	An excel spread sheet was displayed and explained Updated 2/17/21

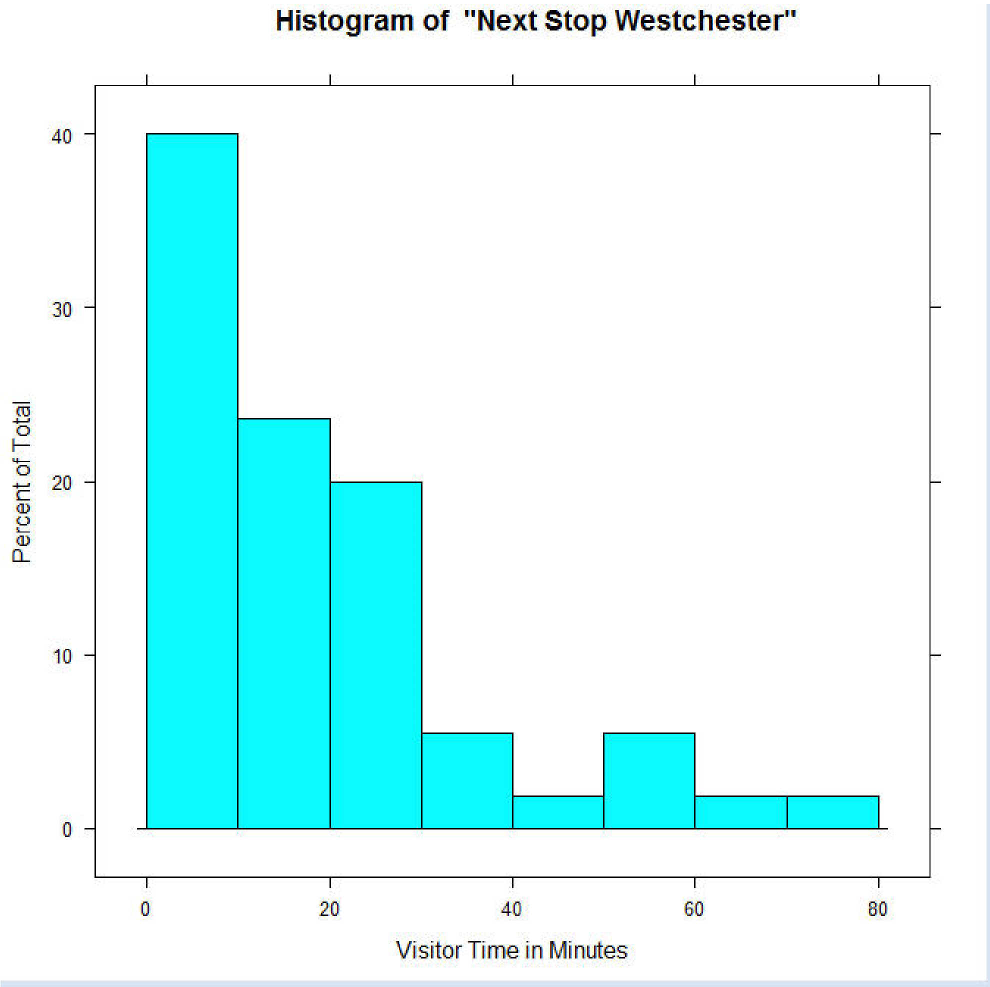
Statistics!




LCL
UCL
Xave
x_ave
7.1200
7.1000
7.0800
7.0600
7.0400
7.0200
7.0000
6.9800
6.9600
6.9400
6.9200
6.9000
x_ave (pH)
0
5
10
15
20
25
Time (hours)



statisticallycartoon



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Questions?

Thank you!

AAR Quality Assurance
55500 DOT Road
Pueblo, Colorado 81001
www.aar.com

AAR Quality Assurance Auditor and Industry Conference

April 12-14, 2022

Fort Worth, Texas

Overview of 2.4 Management Review

Joshua S. Paserba
President
International Quality Consultants, Inc.

2.4 Management Review

- Review of Standard Requirements
  - 2.4.4.1 Explanation
  - 2.4.4.1.1 – 2.4.4.1.6
  - 2.4.4.2 Explanation
- Examples for Evidence of Compliance
- Additional Reviewed Items
- Questions?

Review of Standard Requirements

2.4 Management Review

2.4.4.1 - Review the Quality Assurance Program annually to ensure its continuing suitability and effectiveness in satisfying the requirements of this specification and the facility’s quality policy and objectives. Review shall include but is not limited to the following:

2.4 Management Review

2.4.4.1.1 Internal and external quality audits.

2.4.4.1.2 Internal and external nonconformances and Chapter 7 requirements.

2.4.4.1.3 Corrective and preventive actions.

2.4.4.1.4 Previous management review and action items.

2.4.4.1.5 Changes to Quality Assurance Program.

2.4.4.1.6 Performance indicators; for example, inspection results, scrap rates, etc.

2.4 Management Review

2.4.4.2 Maintain records of such reviews.

- Management Review is a Quality Records and should be controlled by the procedure for 2.17 Quality Records

Examples for Evidence of Compliance

2.4 Management Review

2.4.4.1.1 Internal and external quality audits.

– Review results from all audits (Internal, Customer, and AAR audits including quality and technical inspections)

2.4.4.1.2 Internal and external nonconformances and Chapter 7 requirements.

– Include all non-conformances
– Be sure to specifically note chapter 7 items both received and initiated by the company

2.4.4.1.3 Corrective and preventive actions.

– All Corrective and Preventive actions initiated from the last Management Review
– Also include CAPAs that are still open from the previous Management Review

2.4.4.1.4 Previous management review and action items.

– Action Items or Outputs from the previous Management Review
– Action Items do not need to be completed but a status updated is needed to be documented.

2.4.4.1.5 Changes to Quality Assurance Program.

– Can include new equipment, change in employee count, new processes to the QMS

2.4 Management Review

2.4.4.1.6 Performance indicators; for example, inspection results, scrap rates, etc.

- On-time Delivery
- 1st pass yield
- Internal and External Scrap rates
- Past due corrective actions
- Customer Satisfaction
- Supplier Defects
- What other Performance Indicators can be used?

Additional Reviewed Items

2.4 Management Review

2.4.3 Resources

The facility shall ensure that adequate resources are identified and provided, including the assignment of trained

personnel for the following:

2.4.3.1 Management.

2.4.3.2 Performance of work.

2.4.3.3 Verification processes, including internal quality audits.

2.4.3.4 Training.

2.4 Management Review

2.20 Statistical Methods

2.20.1 The facility shall:

2.20.1.1 Maintain documented procedures to implement, analyze, and control the use of statistical methods for process control and continuous improvement.

- Management Review is a good place to review all Performance Indicator in place

2.4 Management Review

Employee Resources
- New Hires
- Cross-training
- Retirements

Maintenance
- Equipment Performance

Project/Design Status

Questions?

Thank you!

AAR Quality Assurance
55500 DOT Road
Pueblo, Colorado 81001
www.aar.com

AAR Quality Assurance

2022 QA Conference

April 13, 2022

Ft. Worth, TX

QA BENEFITS to TECHNICAL INSPECTIONS

Billy M Benton

Senior Inspector MID

QA BENEFITS to TECHNICAL INSPECTIONS

- This presentation is to show how using elements of the QA program can enhance technical inspections
- Items included in a technical Inspection
- Areas that need improvement
- Elements that could enhance the inspections

QA BENEFITS to TECHNICAL INSPECTIONS

- The MID Inspectors use checklists to ensure that inspection of all items are covered during their inspections. Categories include:

Including:

- Outbound Inspections
- Inbound Inspections
- Scrap Inspections
- Repair Practices including Air Brake, Coupler/Draft Gear, Running Repair, Car Body, Truck Side Frame/Bolsters, Gages and Publications, AAR Billing and Forms
- Material ID/Packaging and Storage

The number of exceptions in 2021 2143

- Material Storage 454 = 24.1%
- Outbound Inspection 338 = 17.9%
- Wheel Sets 223 = 11.9%
- Billing Items 199 = 10.6%
- Airbrake Items (test/device) 172 = 9.1%

- Gages (missing and use) 136 = 7.2%
- Publications Items 70 = 3.7%

Elements that can be used

- Material Storage / 2.16 Preservation, Packaging and shipping
- Outbound Inspections / 2.12 Final Inspections
- Wheel Sets / 2.16 Preservation, Packaging and Shipping and/or 2.22 Training
- Billing Items / 2.17 Quality Records
- Airbrakes / 2.22 Training
- Gages and their Use / 2.8 Measuring and test and 2.22 Training
- Publications / 2.7 Document Control

Elements that can improve

- ELEMENT 2.6 Corrective and Preventive Action
- Root cause
- Corrective actions

M-1003 Shop Vs. Non M-1003

Random sampling of exceptions taken at shops that M-1003 certified compared to shops that were not M-1003 certified.

Shops that were not M-1003 certified had 34% more exceptions.

Thank you!

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Quality Assurance Program Evaluation (QAPE) Checklist

Chad Mowery
Vice President of Operations
Katahdin Rail Services

QAPE Checklist - 2022

Association of American Railroads | **Quality Assurance Program Evaluation (QAPE) Checklist** | **Rev. 01-10-2022**

ASSOCIATION OF AMERICAN RAILROADS

Facility: ________________ **Prepared:** ________________ **Date:** ________________

Paragraph	Element	Manual		Audit		Objective Evidence
		Yes	No	Yes	No	
2.1	Objective of Quality Assurance Program					
2.2	Applicability and Scope					
2.3	Quality Assurance Program and Manual Requirements					
2.4	Management Responsibility					
2.5	Production, Inspection, and Test Planning					
2.6	Corrective and Preventive Actions					
2.7	Document Control					
2.8	Measuring and Testing Equipment					
2.9	Purchasing/Subcontracting					
2.10	Incoming Inspection					
2.11	In-Process Inspection					
2.12	Final Inspection					
2.13	Inspection Status					
2.14	Identification and Traceability					
2.15	Process Control					
2.16	Preservation, Packaging and Shipping					
2.17	Quality Records					
2.18	Nonconformance Control					
2.19	Quality Assurance Program Review and Manual Revision					
2.20	Statistical Methods					
2.21	Internal Quality Audits					
2.22	Training					
2.23	Contract Review					
2.24	Design Control					

QAPE Checklist – Instructions

Quality Assurance Program Evaluation (QAPE)

1/10/2022

The QAPE is an evaluation form that must be used to evaluate a facilities 24-element M-1003 Quality Assurance Program. The 240-question QAPE must be completed prior to an AAR M-1003 Quality Assurance Audit. The following bullets are instructions on how to complete the QAPE.

- ***The first column*** titled Paragraph references the location of the element in Chapter 2 of M-1003.

- ***The second column*** titled Element is the element description in question format in Chapter 2 of M-1003.

- ***The third & fourth columns*** titled Manual (yes/no) are completed when the facility or auditor audits the Quality Assurance Manual. The yes or no checkboxes are marked as the facility or auditor ensures that the Quality Assurance Manual satisfies the M-1003 requirements for each question.

- ***The fifth & sixth columns*** titled Audit (yes/no) are completed when the facility or auditor physically audits and verifies that the facility has implemented their Quality Assurance Program per their Quality Assurance Manual. The yes or no checkboxes are marked as the facility or auditor ensures that the Quality Assurance Program satisfies the M-1003 requirements for each

- ***The seventh column:***

- The facility shall maintain a completed Quality Assurance Program Evaluation Checklist, documenting the corresponding line item from the facility's Quality Assurance Manual and supporting Quality Assurance Program procedure(s) that address each requirement in the current Specification M-1003.

- If facility uses QAPE for internal audits - titled Evidence is completed with the evidence or direction where the objective evidence can be located to satisfy the question from the second column titled Element. The Auditor shall record enough evidence to make a decision to be confident that the auditee is either in-compliance or out-of-compliance. Some examples include: SOP #s, gauge #s, training records, locations, specific references, etc.

QAPE Checklist – Three Different Applications

- **2.19 – Quality Assurance Program Review and Manual Revision**
- **2.21 – Internal Quality Audits**
- **Chapter 3 – External Quality Audits**

QAPE Checklist – QA Program and Manual

- **2.19.1.1 – The facility shall maintain a completed Quality Assurance Program Evaluation Checklist, documenting the corresponding line item from the facility's Quality Assurance Manual and supporting Quality Assurance procedures that address each requirement in the current Specification M-1003.**

- **Key Requirements – "*documenting the corresponding line item…that address each requirement*".**

QAPE – Quality Program and Manual Review – *Acceptable ?*

Paragraph	Element	Manual		Audit		Objective Evidence
		Yes	No	Yes	No	
2.10	**INCOMING INSPECTION**					
2.10.1	Does the facility inspect, test, and identify incoming items as required by the inspection and test plans?	X				Quality Assurance Manual, Rev 2
2.10.2	Does the facility check the evidence provided by subcontractors and suppliers as a means of verifying quality per the requirements of paragraph 2.10.1?	X				Yes
2.10.3	Does the facility hold incoming items until the required inspection and tests are completed or the necessary inspection and test reports are received and verified (except when items are released under positive recall)?	X				Yes. Hold for tests.

QAPE – Quality Program and Manual Review –
Not Acceptable – Does not include corresponding line items from the QA Manual or Procedures

Paragraph	Element	Manual		Audit		Objective Evidence
		Yes	No	Yes	No	
2.10	**INCOMING INSPECTION**					
2.10.1	Does the facility inspect, test, and identify incoming items as required by the inspection and test plans?	X				Quality Assurance Manual, Rev 2
2.10.2	Does the facility check the evidence provided by subcontractors and suppliers as a means of verifying quality per the requirements of paragraph 2.10.1?	X				Yes
2.10.3	Does the facility hold incoming items until the required inspection and tests are completed or the necessary inspection and test reports are received and verified (except when items are released under positive recall)?	X				Yes. Hold for tests.

QAPE Checklist – 2.19.1.1 QA Program Review and Manual Revision

Paragraph	Element	Manual		Audit		Objective Evidence
		Yes	No	Yes	No	
2.10	**INCOMING INSPECTION**					
2.10.1	Does the facility inspect, test, and identify incoming items as required by the inspection and test plans?	X				Quality Manual (QM) Section 10.0, paragraph 3.1.1
2.10.2	Does the facility check the evidence provided by subcontractors and suppliers as a means of verifying quality per the requirements of paragraph 2.10.1?	X				Quality Manual (QM) Section 10.0, paragraph 3.1.2 and 3.1.3
2.10.3	Does the facility hold incoming items until the required inspection and tests are completed or the necessary inspection and test reports are received and verified (except when items are released under positive recall)?	X				Quality Manual (QM) Section 10.0, paragraph 3.1.5 and 3.1.6

QAPE Checklist – 2.19.1.1 QA Program Review and Manual Revision

Paragraph	Element	Manual		Audit		Objective Evidence
		Yes	No	Yes	No	
2.16	**PRESERVATION, PACKAGING, AND SHIPPING**					
2.16.1	Does the facility establish and maintain documented procedures for handling, storage, preservation, and delivery of activities?	X				Quality Manual (QM) Section 16.0, paragraph 3.1.1
2.16.2	Does the facility provide methods of handling and storing activities that prevent damage?	X				Quality Manual (QM) Section 16.0, paragraph 3.1.2 and 3.1.3
2.16.3	Does the facility control packing, packaging, storing, shipping and marking processes?	X				Quality Manual (QM) Section 16.0, paragraph 3.1.4 and 3.1.6
	Do procedures apply to ensure conformance to specified requirements, including, as applicable, materials used, rotation of dated materials, consideration of environmental factors affecting product, and technical requirements?	X				Quality Manual (QM) Section 16.0, paragraph 3.2.1, 3.2.2 and 3.2.5
2.16.4	Does the facility apply appropriate methods for preservation and segregation of activities when under facility control?	X				Quality Manual (QM) Section 16.0, paragraph 3.3.1
2.16.5	Does the facility arrange for the protection of activities after final inspection and test?	X				Quality Manual (QM) Section 16.0, paragraph 3.5.1 and 3.5.2

QAPE Checklist – Internal Quality Audits

- **2.21.3 – The internal audits shall be performed in accordance with documented procedures (using appropriate checklists) by trained personnel who have the organizational freedom to document results.**
- **The facility's procedure must address all the requirements in M-1003 section 2.21 and define what type of checklist shall be used.**
- **The QAPE checklist is an "appropriate checklist" if the facility wants to use it. The facility may specify other applicable checklists to be used for internal audits.**
- **The Internal Auditor shall record enough evidence to make a decision to be confident that the auditee is either in-compliance or out-of-compliance.**

Technical Checklists and M-1003 Requirements

- The facility's Internal Audit procedure shall define the "appropriate checklists" to be used.
- Technical Checklists may not address all M-1003 requirements.
- Using the QAPE checklist in conjunction with Technical or Facility approved "Appropriate Checklists" is recommended.
- Technical Checklists or Process Specific Checklists can be used to determine compliance with applicable technical requirements.

M-107/M-208 Checklist – Internal Quality Audits

5.2	**Qualification of Personnel**			
5.2.1	Are all personnel engaged in ultrasonic operations qualified to NDT Level I as defined by ASNT Recommended Practice SNT-TC-1A, latest revision?			NDT18.002, p. 5.2.1
	This SNT requirement is under review by WABL any recognized UT procedure in combination with technical approval is currently acceptable. Please note standard in use for future reference.			
5.2.2	Are all personnel conducting inspection setups and machinery setups qualified to NDT Level II as defined by ASNT Recommended Practice SNT-TC-1A, latest revision?			NDT18.002, p. 5.2.2
5.2.3	Does the manufacturer employ or retain the services of an individual qualified to NDT Level III as defined by ASNT Recommended Practice SNT-TC-1A, latest revision?			NDT18.002, p. 5.2.3
5.2.4	Does the manufacturer maintain certification records for all personnel involved in ultrasonic operations that detail each employee's level of qualification?			NDT18.002, p. 5.7.1 and 5.7.2.b
5.2.4.1	Are these records kept for at least five years?			NDT18.002, p. 5.7.3
5.3	**Calibration**			
5.3.1	Is manufacturer's reference standard made from a wheel, or portion of a wheel rim, that contains simulated defects?			NDT10.101, p. 5.1
5.3.1.1	Are the reference standards made from rim-treated wheel steel made by the same process as the wheels being inspected?			Yes - Refer to "UT calibration wheel 36 inch.doc"
5.3.1.2	Does the reference standard for axial testing have a 1/8-inch diameter Flat Bottom Hole perpendicular to the rim face at the mid-thickness of the rim with a depth of 1 1/2-inches (+ or - 1/16-inch) per Figure B.1 of M-107/M-208?			Yes - Test wheel prepared in accordance with M107/M208 figure B.1
5.3.1.2.1	Is the sensitivity of the ultrasonic testing device adjusted to produce an approximate full-scale reflection from the axial testing reference standard?			NDT09.101, p. 5.2.4
5.3.1.3	Does the reference standard for radial testing have a 1/8-inch diameter Flat Bottom Hole generated from the inside diameter of the rim and perpendicular to the tread surface with a depth that is a minimum of 1 1/4-inches from the tread surface per Figure B.2 of M-107/M-208?			Yes - Test wheel prepared in accordance with M107/M208 figure B.1

QAPE – Internal Quality Audits – *Acceptable ?*

Paragraph	Element	Manual		Audit		Objective Evidence
		Yes	No	Yes	No	
2.10	**INCOMING INSPECTION**					
2.10.1	Does the facility inspect, test, and identify incoming items as required by the inspection and test plans?			X		*QM 10.0, para 3.1.1 specifies requirements for incoming inspection process at receiving area. QP 030, Rev 2, dated 10/15/21 defines specific requirements for purchased items. All items are identified with a part number and placed in designated location - OK. Observed Team members - OK.*
2.10.2	Does the facility check the evidence provided by subcontractors and suppliers as a means of verifying quality per the requirements of paragraph 2.10.1?			X		*QM 10.0, para. 3.1.2 specifies which purchased items require certificates of conformance. Team member explained where to find list - OK.*
2.10.3	Does the facility hold incoming items until the required inspection and tests are completed or the necessary inspection and test reports are received and verified (except when items are released under positive recall)?			X		*QM 10.0, para. 3.1.5 requires all incoming material to be held until required tests and reports are verified. Team members explained the same - OK. No positive recall items at time of audit.*

QAPE – Internal Quality Audits –

Not Acceptable – Does not include enough evidence to determine compliance or non-compliance

Paragraph	Element	Manual		Audit		Objective Evidence
		Yes	No	Yes	No	
2.10	**INCOMING INSPECTION**					
2.10.1	Does the facility inspect, test, and identify incoming items as required by the inspection and test plans?			X		*QM 10.0, para 3.1.1 specifies requirements for incoming inspection process at receiving area. QP 030, Rev 2, dated 10/15/21 defines specific requirements for purchased items. All items are identified with a part number and placed in designated location - OK. Observed Team members - OK.*
2.10.2	Does the facility check the evidence provided by subcontractors and suppliers as a means of verifying quality per the requirements of paragraph 2.10.1?			X		*QM 10.0, para. 3.1.2 specifies which purchased items require certificates of conformance. Team member explained where to find list - OK.*
2.10.3	Does the facility hold incoming items until the required inspection and tests are completed or the necessary inspection and test reports are received and verified (except when items are released under positive recall)?			X		*QM 10.0, para. 3.1.5 requires all incoming material to be held until required tests and reports are verified. Team members explained the same - OK. No positive recall items at time of audit.*

QAPE Checklist – Internal Quality Audits

Paragraph	Element	Manual Yes	Manual No	Audit Yes	Audit No	Objective Evidence
2.10	**INCOMING INSPECTION**					
2.10.1	Does the facility inspect, test, and identify incoming items as required by the inspection and test plans?			X		*QM 10.0, para 3.1.1 specifies requirements for incoming inspection process at receiving area. QP 030, Rev 2, dated 10/15/21 defines specific requirements for purchased items. Checked 8 inbound items with receiving team. Visual inspection of all items and verification of purchasing description on all - OK. Any items requiring on site testing is "checked off" on PO and material marked "Hold for Test" - verified PO 16675 - OK. All items are identified with a part number and placed in designated location - OK. Team members demonstrated access to work instructions and explained properly - OK.*
2.10.2	Does the facility check the evidence provided by subcontractors and suppliers as a means of verifying quality per the requirements of paragraph 2.10.1?			X		*QM 10.0, para. 3.1.2 specifies which purchased items require certificates of conformance. Team member explained where to find list - OK. 3.1.3 provides detailed instructions how to verify material and certificates meet requirements - OK. Checked PO 17334, 17401 and 17542 - OK.*
2.10.3	Does the facility hold incoming items until the required inspection and tests are completed or the necessary inspection and test reports are received and verified (except when items are released under positive recall)?			X		*QM 10.0, para. 3.1.5 requires all incoming material to be held until required tests and reports are verified. Team members explained the same - OK. Material must be accepted and logged in on-line before it can be moved to warehouse or facility - OK. Checked PO 16987 and 16992 - OK. Methods to identifiy and control items when released under positive recall are defined in para. 3.1.6 - OK. None at time of audit.*

QAPE Checklist – Internal Quality Audits

Paragraph	Element	Manual Yes	Manual No	Audit Yes	Audit No	Objective Evidence
2.16	**PRESERVATION, PACKAGING, AND SHIPPING**					
2.16.1	Does the facility establish and maintain documented procedures for handling, storage, preservation, and delivery of activities?			X		*QM 16.0, para. 3.1.1 defines requirements for handling, storage, preservation, and delivery. Refers to QP 025, rev. 2, dated 1/15/21 which shows specific requirements for each part number.*
2.16.2	Does the facility provide methods of handling and storing activities that prevent damage?			X		*QM 16.0, para. 3.1.2 specifies methods and required devices for handling. Para. 3.1.3 specifies storage requirements. Observed handling using fork lift equipped with lifting lugs - OK. Checked 10 skids of product in annex - stored with protective coating - OK.*
2.16.3	Does the facility control packing, packaging, storing, shipping and marking processes?			X		*QM 16.0, para. 3.1.4 refers to specific work instructions for packing and storing by part number. Storing and shipping are defined in 3.1.6. Interviewed four (4) team members at packing area. All explained their jobs as defined - OK. Work instructions on-line at work station - OK.*
	Do procedures apply to ensure conformance to specified requirements, including, as applicable, materials used, rotation of dated materials, consideration of environmental factors affecting product, and technical requirements?			X		*QM 16.0, para. 3.2.1 specifies materials to be used by part number. Checked at work station - OK. Para. 3.2.2 specifies date code to be applied for rotation of materials. Note: not all parts require rotation by date. Team member explained - OK. Specific parts, as defined in Technical requirements, require application of rust preventative - defined in para. 3.2.5.*
2.16.4	Does the facility apply appropriate methods for preservation and segregation of activities when under facility control?			X		*QM 16.0, para. 3.3.1 defines preservation and segregation of products at the facility. Work Instruction QP 025 section 5.0 lists requirements by part number. Checked product at final inspection area for correct packaging - OK. Team member demonstrated access to work instruction and explained their tasks - OK. Checked products in warehouse - identified and stored per QP 025 para. 5.1.3 - OK.*
2.16.5	Does the facility arrange for the protection of activities after final inspection and test?			X		*QM 16.0, para. 3.5.1 refers to contract review process to determine customer requirements if applicable - OK. Para. 3.5.2 refers to acceptable methods of protection. Typically not a customer requirement. None in process at time of internal audit.*

QAPE Checklist – External Audits

- AAR Auditor will contact the facility and request the latest revisions of the facility's QA Manual and completed QAPE checklist. Auditor will review for acceptability.
- Revisions to the QA Program and QA Manual must be submitted to the AAR Auditor approximately 60 days prior to the scheduled AAR M-1003 Audit.
- AAR Auditor is required to the use the QAPE checklist to conduct and record evidence identified during the audit.
- The Auditor must complete the checklist with enough evidence to make a decision to be confident that the auditee is either in-compliance or out-of-compliance with specified requirements.

QAPE – External Quality Audits – *Acceptable ?*

Paragraph	Element	Manual		Audit		Objective Evidence
		Yes	No	Yes	No	
2.10	**INCOMING INSPECTION**					
2.10.1	Does the facility inspect, test, and identify incoming items as required by the inspection and test plans?	X		X		*QM 10.0, para 3.1.1 - incoming inspection process at receiving area. QP 030, Rev 2, dated 10/15/21 - requirements for purchased items - both OK. Interviewed 3 receiving team members - OK. All items are identified with a part number and placed in designated location - OK. Work instructions are OK.*
2.10.2	Does the facility check the evidence provided by subcontractors and suppliers as a means of verifying quality per the requirements of paragraph 2.10.1?	X		X		*QM 10.0, para. 3.1.2 specifies which purchased items require certificates of conformance. Team member demonstrated where to find list - OK. Verified accepted status using on-line system - OK.*
2.10.3	Does the facility hold incoming items until the required inspection and tests are completed or the necessary inspection and test reports are received and verified (except when items are released under positive recall)?	X		X		*QM 10.0, para. 3.1.5 - all incoming material to be held until required tests and reports are verified - OK. Material is logged in on-line before it can be moved to warehouse or facility - OK. Methods to identifiy and control items when released under positive recall are defined in para. 3.1.6 - OK.*

QAPE – External Quality Audits – *Not Acceptable – Does not include enough evidence to determine compliance or non-compliance*

Paragraph	Element	Manual		Audit		Objective Evidence
		Yes	No	Yes	No	
2.10	INCOMING INSPECTION					
2.10.1	Does the facility inspect, test, and identify incoming items as required by the inspection and test plans?	X		X		*QM 10.0, para 3.1.1 - incoming inspection process at receiving area. QP 030, Rev 2, dated 10/15/21 - requirements for purchased items - both OK. Interviewed 3 receiving team members - OK. All items are identified with a part number and placed in designated location - OK. Work instructions are OK.*
2.10.2	Does the facility check the evidence provided by subcontractors and suppliers as a means of verifying quality per the requirements of paragraph 2.10.1?	X		X		*QM 10.0, para. 3.1.2 specifies which purchased items require certificates of conformance. Team member demonstrated where to find list - OK. Verified accepted status using on-line system - OK.*
2.10.3	Does the facility hold incoming items until the required inspection and tests are completed or the necessary inspection and test reports are received and verified (except when items are released under positive recall)?	X		X		*QM 10.0, para. 3.1.5 - all incoming material to be held until required tests and reports are verified - OK. Material is logged in on-line before it can be moved to warehouse or facility - OK. Methods to identifiy and control items when released under positive recall are defined in para. 3.1.6 - OK.*

QAPE Checklist – External Audits

Paragraph	Element	Manual		Audit		Objective Evidence
		Yes	No	Yes	No	
2.10	**INCOMING INSPECTION**					
2.10.1	Does the facility inspect, test, and identify incoming items as required by the inspection and test plans?	X		X		*QM 10.0, para 3.1.1 - incoming inspection process at receiving area. QP 030, Rev 2, dated 10/15/21 - requirements for purchased items - both OK. Interviewed 3 receiving team members who explained - visual inspection of all items and verification of purchasing description on all - OK. Team showed how PO is "checked off" when material required to be "Held for Test" - verified PO 19675 - OK. Team explained that all items are identified with a part number and placed in designated location, checked 10 items - OK. Team members demonstrated access to work instructions and explained properly - OK.*
2.10.2	Does the facility check the evidence provided by subcontractors and suppliers as a means of verifying quality per the requirements of paragraph 2.10.1?	X		X		*QM 10.0, para. 3.1.2 specifies which purchased items require certificates of conformance. Team member demonstrated where to find list and which items are required to have certs - OK. Team member demonstrated how to compare material certs for PO 19872 and 19841 with system requirements as defined in para. 3.1.3 - OK. Verified accepted status using on-line system - OK.*
2.10.3	Does the facility hold incoming items until the required inspection and tests are completed or the necessary inspection and test reports are received and verified (except when items are released under positive recall)?	X		X		*QM 10.0, para. 3.1.5 - all incoming material to be held until required tests and reports are verified. Team members explained the same - OK. Team member demonstrated how material is logged in on-line before it can be moved to warehouse or facility - OK. Checked PO 18987 and 18992 - OK. Methods to identifiy and control items when released under positive recall are defined in para. 3.1.6 - OK. None at time of audit.*

QAPE Checklist – External Audits Page 1

Paragraph	Element	Manual		Audit		Objective Evidence
		Yes	No	Yes	No	
2.16	**PRESERVATION, PACKAGING, AND SHIPPING**					
2.16.1	Does the facility establish and maintain documented procedures for handling, storage, preservation, and delivery of activities?	X		X		*QM 16.0, para. 3.1.1 -requirements for handling, storage, preservation, and delivery. Refers to QP 025, rev. 2, dated 1/15/21 - specific requirements for each part number - both OK. Team member demonstrated acess to QP 025 on-line - OK. Observed handling and packaging of 10 parts at final inspection area. All acceptable.*
2.16.2	Does the facility provide methods of handling and storing activities that prevent damage?	X		X		*QM 16.0, para. 3.1.2 specifies methods and required devices for handling. Para. 3.1.3 specifies storage requirements. Observed handling using fork lift equipped with lifting lugs - OK. Checked 15 items in warehouse - all in designated location, packed and marked properly. Supervisor demonstrated how to pull parts from warehouse for delivery to a specific customer - OK. Checked Load ID 15443, 15444, 15621 - OK.*

QAPE Checklist – External Audits Page 2

2.16.3	Does the facility control packing, packaging, storing, shipping and marking processes?	X		X		QM 16.0, para. 3.1.4 refers to work instructions for packing and storing by part number. Storing and shipping are defined in 3.1.6 - OK. Observed four (4) team members at packing area. All explained their jobs as defined - OK. Demonstrated access to work instructions on-line at work station - OK.
	Do procedures apply to ensure conformance to specified requirements, including, as applicable, materials used, rotation of dated materials, consideration of environmental factors affecting product, and technical requirements?	X		X		QM 16.0, para. 3.2.1 specifies materials to be used by part number. Checked at work station - OK. Para. 3.2.2 specifies date code to be applied for rotation of materials. Team member explained how to determine which parts require rotation by date - same as procedure - OK. Technical requirements define which parts require rust preventative - para. 3.2.5 - OK. Team member demonstarted how to apply - OK.
2.16.4	Does the facility apply appropriate methods for preservation and segregation of activities when under facility control?	X		X		QM 16.0, para. 3.3.1 - preservation and segregation of products at the facility. QP 025 section 5.0 lists requirements by part number. Checked products at final inspection area for correct packaging - OK. Team member demonstrated access to work instruction and explained their tasks - OK. Checked products in warehouse - identified and stored per QP 025 para. 5.1.3 - OK.
2.16.5	Does the facility arrange for the protection of activities after final inspection and test?	X		X		QM 16.0, para. 3.5.1 refers to contract review process to determine customer requirements if applicable - PO 566221 dated 1/12/22 requires special pallets - OK. Sales personnel demonstrated how requirements are entered on-line - OK Reviewed on-line router for customer requirements - OK. Para. 3.5.2 refers to acceptable methods of protection listed by specific customer - OK. None at time of audit.

QAPE Checklist – Notes and Lack of Space

- Many of the elements on the QAPE checklist have a limited amount of space to record the evidence you are evaluating.
- It is acceptable to make notes on the back of the QAPE and/or supplemental pages when necessary.
- Recommendation: Sign and Date the pages.

QAPE Checklist – Notes and Lack of Space

Paragraph	Element	Manual		Audit		Objective Evidence
		Yes	No	Yes	No	
2.10	**INCOMING INSPECTION**					
2.10.1	Does the facility inspect, test, and identify incoming items as required by the inspection and test plans?			X		*QM 10.0, para 3.1.1 specifies requirements for incoming inspection process at receiving area. QP 030, Rev 2, dated 10/15/21 defines specific requirements for purchased items. Checked 8 inbound items with receiving team. Visual inspection of all items and verification of purchasing description on all - OK.* ***See notes on reverse side of page.***
2.10.2	Does the facility check the evidence provided by subcontractors and suppliers as a means of verifying quality per the requirements of paragraph 2.10.1?			X		*QM 10.0, para. 3.1.2 specifies which purchased items require certificates of conformance. Team member explained where to find list - OK. 3.1.3 provides detailed instructions how to verify material and certificates meet requirements - OK. Checked PO 17334, 17401 and 17542 - OK.*
2.10.3	Does the facility hold incoming items until the required inspection and tests are completed or the necessary inspection and test reports are received and verified (except when items are released under positive recall)?			X		*QM 10.0, para. 3.1.5 requires all incoming material to be held until required tests and reports are verified. Team members explained the same - OK. Material must be accepted and logged in on-line before it can be moved to warehouse or facility - OK. Checked PO 16987 and 16992 - OK. Methods to identifiy and control items when released under positive recall are defined in para. 3.1.6 - OK. None at time of audit.*

QAPE Checklist – Evidence

- **2.19.1.1 Be specific when documenting the corresponding line item from the QA Manual and supporting Procedures.**

- **2.21.4 Internal Audit notes must include evidence of conformance and/or nonconformance of activities to specified requirements.**

QAPE Checklist – Auditor’s Evidence

- Did you make notes of form numbers, procedures, revision dates, names, gauges, and observations?
- Is the evidence sufficient to confirm conformance to specified requirements?
- In the event questions arise after the audit is complete, do you have sufficient documentation to demonstrate conformance at the time of the audit? Will you be able to recall what you observed?

Thank you!

AAR Quality Assurance
55500 DOT Road
Pueblo, Colorado 81001
www.aar.com

AAR Quality Assurance Auditor and Industry Conference

April 12-14, 2022

Fort Worth, Texas

Quality Assurance Committee Expectations: Auditors and Facilities

Gordana Halvadzija
Manager of Quality Assurance
Canadian Pacific Railway

Audit Cycle

- **Audit planning and preparation:**

  Audit preparation consists of planning everything that is done in advance by interested parties, such as the auditor, the lead auditor, the facility, and the quality assurance management (QAM), to ensure that the audit complies with the facility's objective. This stage of an audit begins with the decision to conduct the audit and ends when the audit itself begins.
- **Audit execution**
- **Audit reporting**
- **Audit follow-up and closure**

Audit Types: CT - Certification; RE - Recertification; C1/C2 - Compliance 1/2

Quality Assurance Program Requirements

2.1 Objective of Quality Assurance Program

2.1.1 The *Quality Assurance Program* must be established and maintained by the *facility* for the purpose of ensuring that the *activities* conform with all applicable standards, specifications, rules, codes, statutes, regulations, contractual requirements, and adopted recommended practices. At a minimum, the *facility's Quality Assurance Program* must include the 24 required elements specified in this chapter.

2.1.2 The principal objectives of a *Quality Assurance Program* shall:

2.1.2.1 Fulfill the specified requirements outlined in elements 2.1 through 2.24.

2.1.2.2 Provide for prevention, early detection, and disposition of *nonconformances*.

2.1.2.3 Strive for continuous improvement of *activities* and the processes producing them.

2.1.2.4 Document the processes and *characteristics* affecting quality in *activities* covered by this specification in order to verify that *activities* meet contractual, statutory, and regulatory requirements.

M-1003 Certified Facility

Shall establish, implement and maintain a Quality Assurance Program (QAP), documented in a Quality Assurance Manual that:

- Include all 24 Elements from MSRP, Section J Specification M-1003
- Include or make reference to the QAP's procedures
- Outline structure of the documentation used in QAP to plan and perform work so non-conformances are prevented and those that occur are detected / resolved
- Provide the means for effectively implementing and improving Quality Program
- Include a description of the organization
- Include or reference a facility's production, inspection and test plan
  - Plan shall describe the overall process and is not required to include each activity
- Document each QAP function, including purpose, scope and an outline of what shall be done

AAR Accredited Auditor

- The lead auditor will contact the facility (approx. 60 days prior) to schedule the audit, at which time the facility must confirm both the audit date(s) and its readiness for the Quality Assurance Program audit.
  - These acknowledgments will be documented in the audit fee letter sent to the facility.
  - The audit schedule will be developed in conjunction with the facility.

AAR Accredited Auditor

- At this time AAR will request the following:
  - The latest revisions of the facility QA manual and completed Quality Assurance Program Evaluation checklist (QAPE).
    - To be submitted approximately 60 days prior to the scheduled M-1003 audit.
  - Send facility the latest Facility Profile Data Sheet - Verification of the current activities as per Appendix A.

AAR Accredited Auditor

- Confirm that the requested activities from the Facility Profile Data Sheet match the activities listed in the AAR Registry of M-1003 Certified facilities (http://aar.iirx.net/Registry/Registry).
  - If the facility wishes to change the scope of M-1003 certification (i.e. add or remove activities) they must contact the Quality Assurance Management (QAM) at QA@aar.com 60 days before their next audit date.
    - If the newly requested activity requires a new technical approval, the auditor is to perform a full 24-element recertification audit.
    - If the newly requested activity does not require a new technical approval, the auditor is to conduct the regularly scheduled audit.
- The above requirements are to be used to assist the auditor in estimating time required to perform the audit.

AAR Accredited Auditor

- QAM must be copied on the Program Schedule Letter when sent to the facility.
- Audits are to be scheduled approximately 60 calendar days prior to the facility's M-1003 certificate expiration date.
  - The facility may request a change or an extension to their annual audit as long as the date requested is prior to their expiration date, the request must be submitted to their AAR Accredited Auditor and copied to QAM (QA@aar.com) prior to the change being granted by the auditor.

AAR Accredited Auditor

- The auditor should establish the scope of the audit.
  - Elements 2.6, 2.15, 2.18, & 2.21 must be audited at every audit in 2022
  - Compliance audits consist of 6 to 8 elements (4 plus 2 to 4)
- As a basis for planning the audit, the auditor may review the auditee Quality Assurance Program documents, which include, but are not limited to:
  - The Quality Assurance Manual,
  - Past audit reports,
  - Response to audit findings,
  - Nonconformance reports/responses, and
  - Governing technical specifications.

Facility

- Start detailing gaps in paperwork (Initial Certification) – Internal audit will have determined these
- Update procedures as required
- Start ramping up internal checks and inspections
- Ensure support from all levels of management
- Advise workforce through meetings of audit goals
- Get everyone’s buy-in to audit goals

Facility

- Conduct internal system audit
- Review results with facility's key players
- Implement corrective actions to identified non-compliances
- Communicate results with employees, as appropriate

Facility

- The Facility must submit (60 days prior to an audit):
  - Completed Facility Profile,
  - The latest revisions of the facility QA manual, and
  - Completed Quality Assurance Program Evaluation checklist (QAPE).

- Confirm audit schedule with auditor

Facility

- Identify key players to participate in the AAR audit
  - Ensure resources in place to follow auditor through audit
  - Ensure participants are available when and where needed
- Arrange work schedules to meet audit needs
- Identify records and programs that will be needed and ensure access to facilitate audit flow
  - As required, get keys to cabinets, rooms, etc. to keep audit flow moving and any other resources, e.g. computers
- Continue communications with employees

Facility

- The auditor is looking for objective evidence that the systems and documentation conform to the applicable AAR requirements.
- Here are some tips to prepare your teams for a successful audit:
  - Just answer the question. Answer honestly. If you don't understand the question, say so.
  - If you are in the middle of a task, and it is important that you finish the task, ask the auditor if he/she can come back in XX minutes.
  - Know where the documentation that applies to your job.
  - Ensure the documentation you are using is the latest revision and that all quality records are completed accordingly (and fully).
  - Know and understand the quality policy, and where you can find it.
  - Know the objectives that apply to you and how you affect them.
  - In short, auditor is looking to see that:
    - Say (document) what you do
    - Do what you say (have documented)
    - Can prove it (completed records in place)

Thank you!

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2022 AAR Quality Assurance Auditor & Industry Conference

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Fort Worth, Texas

AWS D15.1 Workshop
Chapter 11 – Annex H

John Killion
Manager, Welding Processes
Marmon Rail (UTLX)

Clauses 1 - 10

John Gronberg

AWS D15.1/D15.1M:2019

- Railroad Welding Specification for Cars and Locomotives
- An American National Standard
- Approved by the American National Standards Institute (ANSI) March 8, 2019
- 6th Edition which supersedes AWS D15.1/D15.1M:2012
- Prepared by the American Welding Society (AWS) Committee on Railroad Welding
- Under the Direction of the AWS Technical Activities Committee (TAC)

AWS D15.1/D15.1M:2019

- **Personnel**
- AWS D15 Committee on Railroad Welding
- AWS D15A Subcommittee on Cars and Locomotives
- Advisors

Personnel

AWS D15 Committee on Railroad Welding

D. M. Allbritten, Chair	*Salco Products*
M. R. Untermeyer, 1st Vice Chair	*Alltranstek*
D. M. Smook, 2nd Vice Chair	*Midwest Railcar Repair, Incorporated*
J. M. Rosario, Secretary	*American Welding Society*
K. L. Anderson	*CSX Transportation*
J. A. Barrett	*WABTEC*
T. R. Berg	*Starfire Engineering, Incorporated*
R. C. Bly	*TTX-US Repair Shop Operations*
M. A. Bohmont	*Kawasaki Motors Manufacturing Corporation*
C. Boulden	*Trinity Industries, Incorporated*
L. B. Broadway	*American Railcar Industries*
P. A. Burys	*Raul V. Bravo & Associates*
R. A. Conrad	*ITW Welding North America*
R. W. Delgatty	*UTLX*
R. M. Dull	*Edison Welding Institute*
M. A. Forsstrom	*CIT*
D. S. Galda	*ITW Welding North America*
B. K. Gattie	*Norfolk Southern Corporation*
J. S. Gronberg	*WATCO*
C. W. Hackler	*Union Pacific Railroad*
T. E. Hawkins	*TrinityRail Maintenance Services*
S. J. Hopper	*Greenbrier Management Services*
J. M. Killion	*Union Tank Car Company*
J. P. Kladifko	*Union Pacific Railroad*
S. J. McCullough	*Alltranstek*
C. L. Meeker	*UTLX*
L. W. Miller	*Select-Arc*
T. M. Nelson	*LTK Engineering Services*
M. E. Oddie	*Progress Rail*
J. L. Pasqua	*Salco Products*
J. B. Pearson	*ALRV Consultant, LLC*
J. P. Plummer	*Norfolk Southern Corporation*
A. R. Pohm	*Norfolk Southern Corporation*
B. S. Quig	*CSX Mechanical Engineering*
T. A. Robertson	*UTLX*
G. M. Sallaz	*Salco Products*
T. Schmidt	*ECE Global*
D. E. Seely	*Steel Dynamics, Incorporated*
B. E. Senior	*National Steel Car Limited*
J. H. Shomo	*Progress Rail*

AWS D15.1/D15.1M:2019, Forward (Info only)

- This specification establishes minimum welding standards for the manufacture and maintenance of railcars, locomotives, and their components, intended for North American railroad service

AWS D15.1/D15.1M:2019, Clause 1

- **1. General Requirements**
- For welding tank car tanks, refer to Association of American Railroads (AAR) Manual of Standards and Recommended Practices, Section C-III, Specification for Tank Cars, M-1002

AWS D15.1/D15.1M:2019, Clause 1

- **Units of Measurement**
- This standard makes use of both U.S. Customary Units and the International System of Units (SI)
- (SI) units are shown within brackets ([ ]) or in appropriate columns in tables and figures
- The measurements may not be exact equivalents; therefore, each system must be used independently

AWS D15.1/D15.1M:2019, Clause 1

- **Safety**
- Safety and health issues and concerns are beyond the scope of this standard; some safety and health information is provided but not fully addressed herein
- Safety and health information is available from the following sources
- American Welding Society
- Material or Equipment Manufacturers
- Applicable Regulatory Agencies (FRA)

AWS D15.1/D15.1M:2019, Clause 2

- **2. Normative References – (Not all Inclusive)**
- AWS Standards
  - AWS AX.X/AX.XM Electrode Specifications
  - AWS B2.1/B2.1M Procedure and Performance Qualification
- ANSI Standards
  - ANSI Z49.1 Safety in Cutting and Allied Processes, (free download AWS.org)
- AAR Standards
  - M-1002
  - S-137, S-269, S-306, S-307, S-308, S402

AWS D15.1/D15.1M:2019, Clause 3

- **<u>3. Terms and Definitions</u>**
- AWS A3.0M/A3.0 Standard Welding Terms and Definitions, provides the basis used herein
- There are a number included to accommodate usage specific to this document
  - Class 1 Weld
  - Class 2 Weld
  - Designated Inspector
  - Essential Variables

AWS D15.1/D15.1M:2019, Clause 4

- **4. General Information**
- **AWS B2.1/B2.1M Specification for Welding Procedure and Performance Qualification**.
- Provides an extensive list of materials grouped into categories to minimize the number of qualification tests required. (free download, AWS.org)
- It does not imply that materials in one group are interchangeable or equivalent for any given application
- Annex A provides additional materials specific to this specification

AWS D15.1/D15.1M:2019, AWS B2.1/B2.1M

Table C.1
List of Base Metal Specifications—Ferrous Alloys

Standard	Base Metal Specification	Material Number	Group Number	ISO 15608 Group	Type, Grade, or Alloy Designation	UNS Number	Product Form
Steel and Steel Alloys							
AAR	M201	1	1	11.1	A	—	Castings
AAR	M201	1	2	11.1	B	—	Castings
AAR	M201	1	3	11.1	B+	—	Castings
AAR	M201	1	4	11.1	C	—	Castings
AAR	TC128	10C	1	11.1	B	—	Plate

Table C.2
M-Number Listing of Base Metals—Ferrous Alloys (see C.1, I2.2.1, and I3)

Material Number	Group Number	ISO 15608 Group	Standard	Base Metal Specification	Type, Grade, or Alloy Designation	UNS Number	Thickness or Diameter Limitations, in [mm]	Minimum Tensile/Yield Strength, ksi [MPa]	Product Form	Nominal Composition
Steel and Steel Alloys										
1	1	11.1	AAR	M201	A	—		60/30 [415/205]	Castings	C-Mn-Si
1	1	1.1	ASTM	A1018	SS 40	—		55/40 [380/275]	Sheet & Strip	C
1	1	1.1	ABS	ABS	A	K02300		58/34 [400/235]	Plate, Bar, & Shapes	C
1	1	1.2	ABS	ABS	AH32	K11846		64/46 [440/315]	Plate, Bar, & Shapes	C-Mn-Si
1	1	1.1	ABS	ABS	B	K02102		58/34 [400/235]	Plate, Bar, & Shapes	C
1	1	1.1	ABS	ABS	D	K02101		58/34 [400/235]	Plate, Bar, & Shapes	C-Si
1	1	1.2	ABS	ABS	DH32	K11846		64/46 [440/315]	Plate, Bar, & Shapes	C-Mn-Si
1	1	1.1	ABS	ABS	E	K01801		58/34 [400/235]	Plate, Bar, & Shapes	C-Si
1	1	1.2	ABS	ABS	EH32	K11846		64/46 [440/315]	Plate, Bar, & Shapes	C-Mn-Si

AWS D15.1/D15.1M:2019, Clause 4

- **4.3 General Information**
- Clauses 1 through 17 give the general requirements for welded construction for metal components 1/8 in [3 mm] or greater in thickness
- Clauses 18 through 23 give specific requirements for welding of base metals less than 1/8 in [3 mm]
- Material 0.1196 in [3 mm] nominal may be considered 1/8 in [3 mm]

AWS D15.1/D15.1M:2019, Clause 5

- **<u>5. Requirements for all Welding</u>**
- 5.1 General – Welding Procedure Specification Data
- WPS may be presented in any format, written or tabular provided the data in the matrix is included for each applicable process

  - FCAW-G, FCAW-S
  - FW Flash Welding, (form of resistance welding)
  - GMAW Gas Metal Arc Welding
  - GTAW Gas Tungsten Arc Welding
  - SAW Submerged Arc Welding
  - SMAW Shielded Metal Arc Welding

AWS D15.1/D15.1M:2019, Clause 5

- Welding Procedure Specification Data Matrix Covers what you need to have on the WPS
  - 5.1.1 Joint Design
  - 5.1.2 Base Metals
  - 5.1.3 Filler Metals
  - 5.1.4 Position/Progression
  - 5.1.5 Preheat & Interpass
  - 5.1.6 Heat Treatment
  - 5.1.7 Shielding Gas
  - 5.1.8 Electrical
  - 5.1.9 Variables

AWS D15.1/D15.1M:2019, Clause 5

	FCAW-G	FCAW-S	FW	GMAW	GTAW	SAW	SMAW
(2) Amplitude and number of PWHT cycles following welding cycle.			X				
5.1.7 Shielding Gas							
(1) Torch shielding gas and flow rate range.	X			X	X		
(2) Root shielding gas and flow rate range.					X		
(3) Shielding gas composition pressure, and purging time.			X				
5.1.8 Electrical							
(1) Current (or wire feed speed), current type, and polarity.	X	X		X	X	X	X
(2) Voltage range (except for manual welding).	X	X		X	X	X	
(3) Specification, classification, and diameter of tungsten electrode.					X		
(4) Transfer mode.	X	X		X			
(5) Pulsed current mode shall be indicated.	X	X		X	X		X
(6) Flash time.			X				
(7) Upset current time.			X				

AWS D15.1/D15.1M:2019, Clause 5

- **<u>5. Requirements for all Welding</u>**
- 5.2.2 Capacitor Discharge Welding
  - Written welding procedure is required
  - The Welder shall be trained on proper use of the welding equipment
  - The training must be documented
  - Welding procedure qualification is not required
  - Welder performance qualification is not required
  - Welds subject to acceptance criteria of a temporary weld 17.1

AWS D15.1/D15.1M:2019, Clause 5

- **<u>5. Requirements for all Welding</u>**
- 5.3 Welding Procedure Qualification
- 5.3.1 Prequalified Procedures
  - Approved for use without performing procedure qualification tests
  - Steels listed in Clauses 7 & 8 tables 8.1 and 8.2
  - FCAW, SMAW, SAW GMAW (except short circuit)
  - Conforming to Clauses 5 through 8
  - AWS SWPS's may also be used

AWS D15.1/D15.1M:2019, Clause 5

- **5. Requirements for all Welding**
- 5.3.2 Other materials or welding procedure specifications using one the processes covered may be used provided they are qualified by testing in accordance with Clause 10
- 5.3.3 Qualification of a procedure by one company shall not qualify that procedure for another company (see 9.4.1)
- 5.3.4 The welding of test coupons to produce a procedure qualification record shall not be subcontracted

AWS D15.1/D15.1M:2019, Clause 5

- **5. Requirements for all Welding**
- 5.3.7 Welding Procedure Specifications qualified with other listed specifications shall be considered acceptable
- 5.3.8 Welders or Welding Operators qualified for materials, processes or procedures being with listed specifications shall be considered qualified to weld
- Within the limitations of essential variables and method of testing specimens

AWS D15.1/D15.1M:2019, Clause 5

5.4 Qualification of Welders and Welding Operators

5.4.1 All welders (including tack welders) and welding operators performing work in accordance with this specification shall be qualified in accordance with 9.3, except for those cases defined in 5.4.2, 5.4.3, or 5.4.4.

5.4.2 Welders or welding operators who are qualified for the materials, processes, and procedures being used in accordance with one of the following specifications shall be considered qualified to weld within limitations of the essential variables and method of testing specimens of this specification:

(1) ASME, *Boiler and Pressure Vessel Code*, Section IX

(2) AAR M-1002, *Specification for Tank Cars*, Appendix W

(3) AWS D1.1/D1.1M, *Structural Welding Code—Steel*

(4) AWS D1.2/D1.2M, *Structural Welding Code—Aluminum*

(5) AWS D1.3/D1.3M, *Structural Welding Code—Sheet Steel*

(6) AWS D1.5M/D1.5, *Bridge Welding Code*

(7) AWS D1.6/D1.6M, *Structural Welding Code—Stainless Steel*

(8) ASTM A488, *Practice for Steel Castings, Welding, Qualifications of Procedures and Personnel*

(9) AWS B2.1/B2.1M, *Specification for Welding Procedure and Performance Qualification* (qualification by visual inspection alone is prohibited)

(10) CSA W47.1, *Certification of Companies for Fusion Welding of Steel Structures*

(11) CSA W47.2, *Certification of Companies for Fusion Welding of Aluminum*

AWS D15.1/D15.1M:2019, Clause 5

- **5. Requirements for all Welding**
- 5.4.5 A thread deforming weld to retain a nut on a bolt shall be made by a qualified welder or tack welder
- 5.5 Design of Welded Joints
  - Drawings and Welding Procedure Specifications
  - Effective Weld Areas, Lengths and Sizes
  - Filler Plates
  - Details of Fillet Welds
  - Intermittent Fillet Welds
  - Lap Joints
  - Mechanical Fasteners

AWS D15.1/D15.1M:2019, Clause 5

- **5. Requirements for all Welding**
- 5.6 Consumables
- 5.6.1 Welding consumables that have been removed from their original package shall be protected and stored so that the welding properties are not affected. Electrodes shall be dry and in condition suitable for use.
- Low Hydrogen Electrodes – Are those whose classification ends in a 5, 6 or 8. (E7018)

AWS D15.1/D15.1M:2019, Clause 5

- **5. Requirements for all Welding**
- 5.6.6.1 All low hydrogen electrodes shall be purchased in hermetically sealed containers or shall be baked as prescribed.
- After hermetically sealed containers are opened, Electrodes shall be consumed or placed in a storage oven held at a temperature of at least 250 degrees F. [121 C]

AWS D15.1/D15.1M:2019, Clause 5

- **5.5.6.2 Baking Electrodes**
- Low hydrogen electrodes not purchased in hermetically sealed containers, from damaged containers or exposed beyond their limits shall be baked as follows
- AWS A5.1/5.1M – 2 hrs. between 500- and 800-degrees F
- AWS A5.5/5.5M – 2 hrs. between 700- and 800-degrees F
- Low hydrogen electrodes shall be re-baked no more that once.
- Electrodes that have been wet shall not be used

AWS D15.1/D15.1M:2019, Clause 5

- **5.6.6.3 Approved Atmospheric Exposure Time Periods**
- After hermetically sealed containers are opened, or after the electrodes are removed from storage or baking ovens, shall not exceed the times shown in Table 5.6 column A.
- If they are exposed to the atmosphere less than the times shown in table 5.6, they may be returned to the oven
- After 2 hrs. they may be reused
- Table 5.6 column B is time limits established by testing.

AWS D15.1/D15.1M:2019, Clause 5

Table 5.6
Allowable Atmospheric Exposure of Low Hydrogen Electrodes

Electrode	Column A (hours)	Column B (hours)
A5.1/A5.1M		
E70XX	4 max.	
E70XXR	9 max.	Over 4 to 10 max.
E70XXHZR	9 max.	
E7018M	9 max.	
A5.5/A5.5M		
E70XX-X	4 max.	Over 4 to 10 max.
E80XX-X	2 max.	Over 2 to 10 max.
E90XX-X	1 max.	Over 1 to 5 max.
E100XX-X	1/2 max.	Over 1/2 to 4 max.
E110XX-X	1/2 max.	Over 1/2 to 4 max.
E120XX-X	1/2 max.	Over 1/2 to 4 max.
E70XX-X R	9 max.	

AWS D15.1/D15.1M:2019, Clause 5

E70XX-X R	9 max.
E80XX-X R	9 max.
E90XX-X R	9 max.
E100XX-X R	9 max.
E110XX-X R	9 max.
E120XX-X R	9 max.

Notes:
1. Column A: Electrodes exposed to atmosphere for longer periods than shown shall be baked before use.
2. Column B: Electrodes exposed to atmosphere for longer periods than those established by testing shall be baked before use.
3. Entire table: Electrodes shall be issued and held in quivers, or other small open containers. Heated containers are not mandatory.
4. The optional supplemental designator, R, designates a low hydrogen electrode that has been tested for covering moisture content after exposure to a moist environment for 9 hours and has met the maximum level allowed in AWS A5.1/A5.1M, *Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding*, and AWS A5.5/A5.5M, *Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding*.

AWS D15.1/D15.1M:2019, Clause 6

- **<u>6. Technique and Workmanship</u>**
- 6.1.1 Scope. This clause applies to the production and inspection of welded assemblies and structures
- 6.1.2 Equipment. All welding and cutting equipment shall be so designed and manufactured and shall be in such condition as to enable qualified welders, welding operators and tack welders to follow procedures and obtain the results prescribed

AWS D15.1/D15.1M:2019, Clause 6

- **<u>6. Technique and Workmanship</u>**
- 6.1.3 Welding Conditions. Welding shall not be allowed when the surfaces to be welded a wet, or exposed to rain, snow or high wind or when the ambient temperature in the area to be welded is below 0 degrees, F.
- Does not alter or preclude the minimum preheat or interpass temperatures required by the WPS

AWS D15.1/D15.1M:2019, Clause 6

- **6. Technique and Workmanship**
- 6.2 Preparation of Base Metal
- 6.2.1 Steel and Aluminum Base Metals
  - Thermal Cutting Criteria
  - Repair of Discontinuities
- 6.2.2 Steel Base Metal only
  - Edge and Surface Requirements
  - Acceptable Joint Preparation Methods

AWS D15.1/D15.1M:2019, Clause 6

- **6. Technique and Workmanship**
- 6.2.3 Aluminum Base Metal Only
  - Base Metal Preparation
  - Joint Preparation and Backgouging Methods
  - Surface Requirements
  - 6.2.3.4 Brushes for Cleaning Aluminum
    - Exclusively for aluminum
    - Kept clean
    - Interval between cleaning and welding shall be kept as short as possible

AWS D15.1/D15.1M:2019, Clause 6

- **6. Technique and Workmanship**
- 6.3 Steel and Aluminum Assembly Criteria
- 6.3.1 Root Opening, fillet welds
  - Shall not exceed 3/16 in [5 mm]
  - If greater than 1/16 in [1.5 mm] increase weld size by the amount of separation
- Faying Surfaces, Separation shall not exceed 1/16 in [1.5 mm] (lap joints, plug and slot welds, groove weld with backing)
- Fillers, Use of fillers is prohibited unless specified or approved

AWS D15.1/D15.1M:2019, Clause 6

- **<u>6. Technique and Workmanship</u>**
- 6.3.2 Maximum Root Opening, partial joint penetration groove welds parallel to length of member, 3/16 in [5 mm]
- 6.3.3 Butt Joint Alignment, Shall not exceed 30% the thickness of the thinner part, but in no case more than 1/8 in [3 mm]

AWS D15.1/D15.1M:2019, Clause 6

- **<u>6. Technique and Workmanship</u>**
- 6.3.4 Out-of-Tolerance Joints, table 6.2 provides tolerances. If exceeds; need Engineer's approval or correction
- Excessive Root Opening, may be corrected by welding with limitations (twice the thickness of the thinner member or ¾ in [19 mm])
- Gouging, grooves produced by gouging shall be in accordance with the groove profile dimensions of the WPS

AWS D15.1/D15.1M:2019, Clause 6

Table 6.2
Joint Dimension Tolerances

	Root Not Gouged, in [mm]	Root Gouged, in [mm]
Root face of joint	±1/16 [1.5]	Not limited
Root opening of joints without fused metallic backing	±1/16 [1.5]	±1/16 [1.5]
Root opening of joints with fused metallic backing	+1/4 [6] –1/16 [1.5]	Not applicable
Groove angle of joint	+10° –5°	+10° –5°

AWS D15.1/D15.1M:2019, Clause 6

- **<u>6. Technique and Workmanship</u>**
- 6.3.4 Continued
- Fixturing
- Backing, same as faying surfaces 1/16 in [1.5 mm]
- Complete Joint Penetration Groove Welds
- Transverse Groove Weld Requirements (Load-Bearing)

AWS D15.1/D15.1M:2019, Clause 6

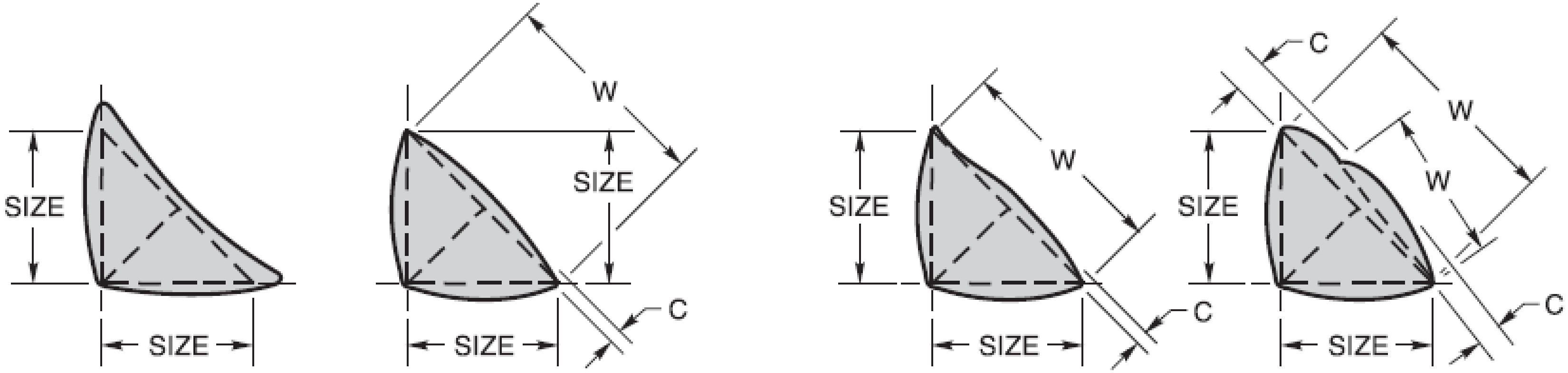
- **6. Technique and Workmanship**
- Tack Welds
  - Qualified welder or tack welder
  - In accordance with a written WPS (prequalified or qualified)
  - Subject to same quality requirements as final welds
  - If incorporated into final weld, filler metal must be the same composition as that used for the final weld
  - Shall be cleaned thoroughly before incorporation
  - If they are not incorporated into the final weld and not shown on the drawing they must be removed

AWS D15.1/D15.1M:2019, Clause 6

- **<u>6. Technique and Workmanship</u>**
- 6.4 Weld Profiles
- Fillet Welds
- Groove Welds
- Joint Surface Reinforcement
- Joint End Profile
- Overlap
  - Overlap in fillet welds **shall not be permitted.**
  - Overlap in groove welds **shall not be permitted.**

AWS D15.1/D15.1M:2019, Clause 6

- **Fillet Welds**. Faces may be slightly convex, flat or slightly concave Figure 6.2(A) and (B)



(A) DESIRABLE FILLET WELD PROFILES

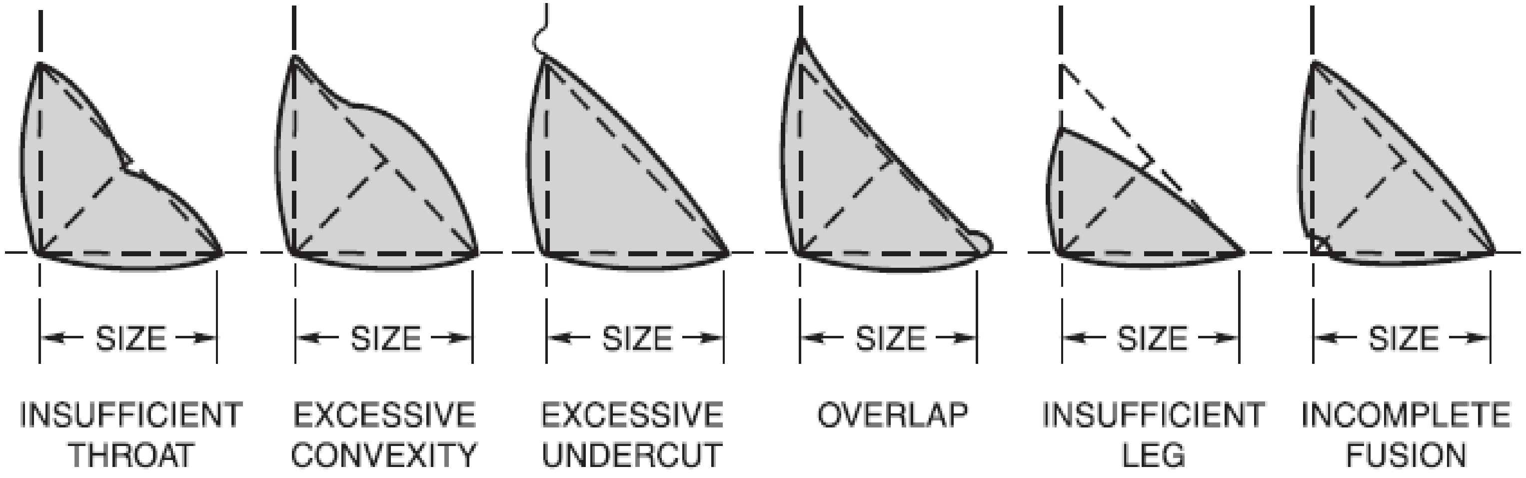
(B) ACCEPTABLE FILLET WELD PROFILES

Note: Convexity, C, of a weld or individual surface bead with dimension W shall not exceed the value of the following table:

WIDTH OF WELD FACE OR INDIVIDUAL SURFACE BEAD, W	MAX. CONVEXITY, C
W ≤ 5/16 in [8 mm]	1/16 in [1.5 mm]
W > 5/16 in [8 mm] to W < 1 in [25 mm]	1/8 in [3 mm]
W ≥ 1 in	3/16 in [5 mm]

AWS D15.1/D15.1M:2019, Clause 6

- **Fillet Welds**



(C) UNACCEPTABLE FILLET WELD PROFILES

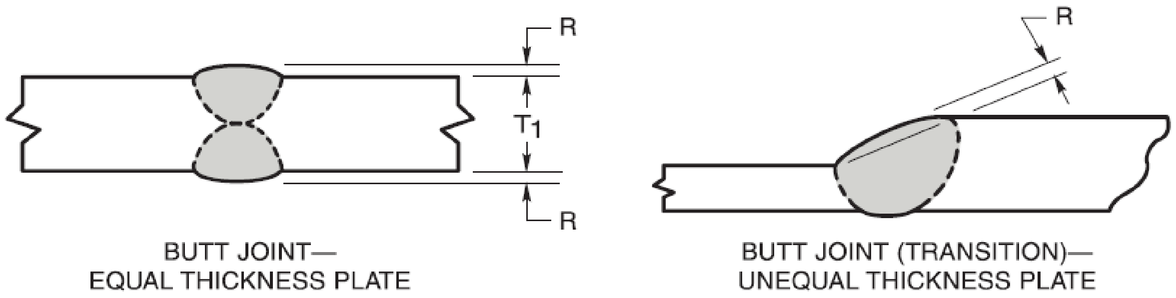
AWS D15.1/D15.1M:2019, Clause 6

- **Groove Welds.** Shall be made with slight reinforcement unless, unless otherwise specified.
- The convexity (reinforcement) shall not exceed the values shown in figure 6.2(D)

    And it goes on to say

- The reinforcement shall have a gradual transition to the plane of the base metal surface. Figures 6.2(D), (E)

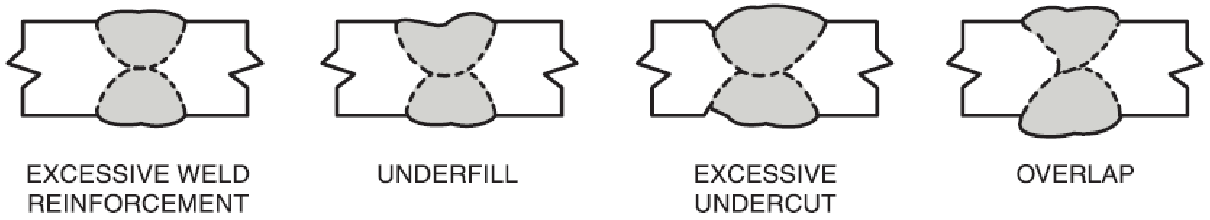
AWS D15.1/D15.1M:2019, Clause 6



Note: Maximum reinforcement for butt joints of unequal thickness plate shall be based on the thinner member being joined.

BASE METAL THICKNESS	MAX. CONVEXITY (REINFORCEMENT), R
1/2 in [13 mm] thick or less	3/32 in [2.5 mm]
Over 1/2 [13 mm] to 1 in [25 mm] thick	1/8 in [3 mm]
Over 1 in [25 mm] thick	5/32 in [4 mm]

(D) ACCEPTABLE GROOVE WELD PROFILE IN BUTT JOINT



(E) UNACCEPTABLE GROOVE WELD PROFILES IN BUTT JOINTS

AWS D15.1/D15.1M:2019, Clause 6

- **6. Technique and Workmanship**
- 6.5 Repairs - After Welding
  - Joint Preparation Methods
  - Extent of Repairs
  - Inspection Methods and Repair of Cracks
  - Distortion Control (steel and aluminum)
  - Engineer Approval and Notification
  - Accessibility for Repair
  - Repair of Mislocated Holes

AWS D15.1/D15.1M:2019, Clause 6

- **6. Technique and Workmanship**
- 6.6 Arc Strikes
- 6.7 Cleaning (single and multi pass) and protective coatings
- 6.8 Weld Terminations – Run off tabs
- 6.9 Groove Weld Backing – Continuous or complete penetration
- 6.10 Heat Input Control for Quenched and Tempered Steel
- 6.11 Stress Relief/Postweld Heat Treatment (PWHT)
- 6.12 Peening – Slag hammers, tools for removal of slag is not peening
- 6.13 Stud Arc Welding
- 6.14 Workpiece Leads – See also FM Rule 82
- 6.15 Welding of Air Brake Pipe – MSRP E, S-402

AWS D15.1/D15.1M:2019, Clause 7

- **7. Prequalified Welding Procedure Specifications**
- Prequalification requires compliance with clauses 5 thru 8 when specified, notch toughness must be qualified by testing
- 7.1 Groove Weld Size (Effective Weld Size)
- 7.2 Joint Designs
- 7.3 Fillet Welds
- 7.4 Details of Plug and Slot Welds
- 7.5 Complete Joint Penetration Groove Welds
- 7.6 Partial joint Penetration Groove Welds

AWS D15.1/D15.1M:2019, Clause 7

Table 7.1
Minimum and Maximum Plug Diameter and Slot Width

Base Metal Thickness (t)		Minimum		Maximum is greater of			
		in	mm	in	mm	in	mm
in	mm	t + 5/16	t + 7.94	Min + 1/8	Min. + 3.17	t × 2-1/4	t × 57.15
1/4	6	9/16	14	11/16	17	9/16	14
5/16	8	5/8	16	3/4	19	45/64	18
3/8	10	11/16	17	13/16	21	27/32	21
7/16	11	3/4	19	7/8	22	63/64	25
1/2	13	13/16	21	15/16	24	1-1/8	29
9/16	14	7/8	22	1	25	1-17/64	32
5/8	16	15/16	24	1-1/16	27	1-13/32	36
11/16	17	1	25	1-1/8	29	1-35/64	39
3/4	19	1-1/16	27	1-3/16	30	1-11/16	43
13/16	21	1-1/8	29	1-1/4	32	1-53/64	46
7/8	22	1-3/16	30	1-5/16	33	1-31/32	50
15/16	24	1-1/4	32	1-3/8	35	2-7/64	54
1	25	1-5/16	33	1-7/16	37	2-1/4	57

AWS D15.1/D15.1M:2019, Clause 7

Table 7.3
Minimum Fillet Weld Size

Base Metal Thickness of Thicker Part Joined (T), in [mm]	Minimum Size of Fillet, in[a, b] [mm][a, b]
T ≤ 1/4 [6]	1/8 [3]
1/4 [6] < T ≤ 1/2 [13]	3/16 [5]
1/2 [13] < T ≤ 3/4 [19]	1/4 [6]
3/4 [19] < T	5/16 [8]

[a] Except that the weld size need not exceed the thickness of the thinner member joined. For this exception, particular care should be taken to provide sufficient preheat to ensure weld soundness.
[b] For non-low hydrogen processes, single pass welds shall be used unless a Procedure Qualification is performed in accordance with 10.6.3.

AWS D15.1/D15.1M:2019, Clause 7

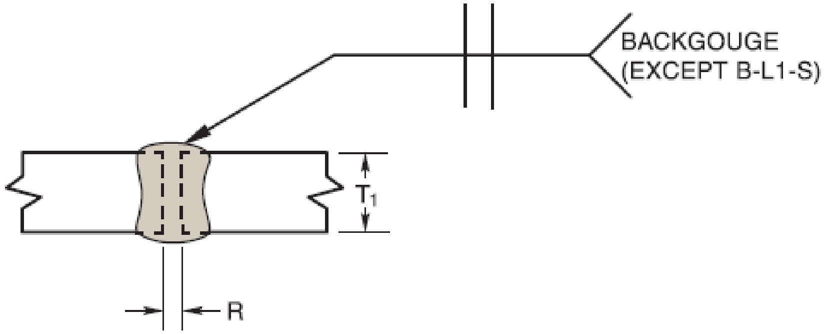
- **7. Prequalified Joint Details**
- There are 22 prequalified complete joint penetration (CJP) groove weld details. Figures 7.1A – 7.1L
- And 12 prequalified partial joint penetration (PJP) groove weld details. Figures 7.2A – 7.2J
- The legend and notes outlined for all joint details are at the beginning of the figures

AWS D15.1/D15.1M:2019, Clause 7

Notes for Figures 7.1A–7.1L and 7.2A–7.2J
[a] Not prequalified for gas metal arc welding using short circuiting transfer.
[b] Gouge root to sound metal before welding second side.
[c] Minimum weld size (S) as shown in Table 5.1; D as specified on drawings.
[d] If fillet welds are used to reinforce groove welds in corner and T-joints, they shall be at least 1/4T1, but need not exceed 3/8 in [10 mm].
[e] Double-groove welds may have grooves of unequal depth, but the depth of the shallower groove shall be no less than one-fourth of the thickness of the thinner part joined.
[f] Double-groove welds may have grooves of unequal depth, provided they conform to the limitations of Note c. Also, the weld size (S), less any reduction applies individually to each groove.
[g] The orientation of the two members in the joints may vary from 135° to 180° provided that the basic joint configuration (groove angle, root face, root opening) remain the same and that the design weld size is maintained.
[h] For corner and T-joints, the member orientation may be changed provided the groove angle is maintained as specified.
[i] The member orientation may be changed provided that the groove dimensions are maintained as specified.
[j] The orientation of two members in the joints may vary from 45° to 135° for corner joints and from 45° to 90° for T-joints, provided that the basic joint configuration (groove angle, root face, root opening) remain the same and that the design weld size is maintained.
[k] For corner joints, the outside groove preparation may be in either or both members, provided the basic groove configuration is not changed and adequate edge distance is maintained to support the welding operations without excessive edge melting.
[l] Weld Size (S) shall be based on joints welded flush.
[m] For flare-V-groove welds and flare-bevel-groove welds to rectangular tubular sections, r shall be as two times the wall thickness.
[n] For flare-V-groove welds to surfaces with different radii, r, the smaller r shall be used.

AWS D15.1/D15.1M:2019, Clause 7

Square-groove weld (1)
Butt joint (B)



All dimensions: in [mm]

Welding Process	Joint Designation	Base Metal Thickness (U = Unlimited) T_1	T_2	Groove Preparation: Root Opening	Tolerances: As Detailed (see 7.5.2)	As Fit-Up (see 6.3)	Permitted Welding Positions	Gas Shielding for FCAW	Notes
SMAW	B-L1b	1/4 [6] max.	—	$R = \frac{T_1}{2}$	+1/16, –0 [+2, –0]	+1/16, –1/8 [+2, –3]	All	—	b, g
GMAW FCAW	B-L1b-GF	3/8 [10] max.	—	R = 0 to 1/8 [3]	+1/16, –0 [+2, –0]	+1/16, –1/8 [+2, –3]	All	Not Required	a, b, g
SAW	B-L1-S	3/8 [10] max.	—	R = 0	±0	+1/16, –0 [+2, –0]	F	—	g
SAW	B-L1a-S	3/8 [10] max.	—	R = 0	±0	+1/16, –0 [+2, –0]	F	—	b, g

Figure 7.1A—Prequalified Complete Joint Penetration (CJP) Groove Welded Joint Details

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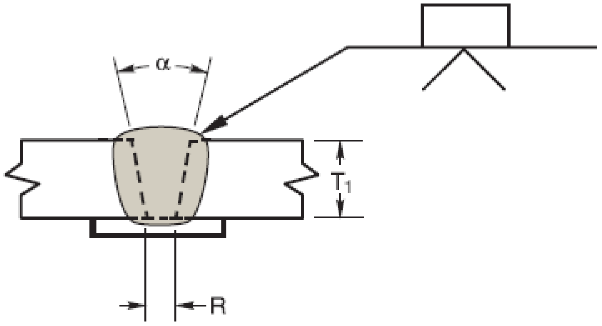
Single-V-groove weld (2)
Butt joint (B)



Tolerances	
As Detailed (see 7.5.2)	As Fit-Up (see 6.3)
R = +1/16, –0 [+2, –0]	+1/4, –1/16 [+6, –2]
α = +10°, –0°	+10°, –5°

All dimensions: in [mm]

Welding Process	Joint Designation	Base Metal Thickness (U = Unlimited)		Groove Preparation		Permitted Welding Positions	Gas Shielding for FCAW	Notes
		T_1	T_2	Root Opening	Groove Angle			
SMAW	B-U2a	U	—	R = 1/4 [6]	α = 45°	All	—	g
				R = 3/8 [10]	α = 30°	F, OH, V	—	g
				R = 1/2 [13]	α = 20°	F, OH, V	—	g
GMAW FCAW	B-U2a-GF	U	—	R = 3/16 [5]	α = 30°	F, OH, V	Required	a, g
				R = 3/8 [10]	α = 30°	F, OH, V	Not Required	a, g
				R = 1/4 [6]	α = 45°	F, OH, V	Not Required	a, g
SAW	B-L2a-S	2 [50] max.	—	R = 1/4 [6]	α = 30°	F	—	g
SAW	B-U2-S	U	—	R = 5/8 [16]	α = 20°	F	—	g

Figure 7.1B—Prequalified Complete Joint Penetration (CJP) Groove Welded Joint Details

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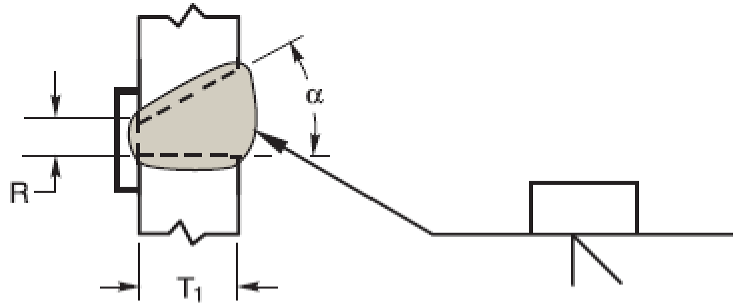
See Notes on Page 39

Single-bevel-groove weld (4)
Butt joint (B)



All dimensions: in [mm]

Tolerances	
As Detailed (see 7.5.2)	As Fit-Up (see 6.3)
R = +1/16, –0 [+2, –0]	+1/4, –1/16 [+6, –2]
α = +10°, –0°	+10°, –5°

Welding Process	Joint Designation	Base Metal Thickness (U = Unlimited)		Groove Preparation		Permitted Welding Positions	Gas Shielding for FCAW	Notes
		T_1	T_2	Root Opening	Groove Angle			
SMAW	B-U4a	U	—	R = 1/4 [6]	α = 45°	All	—	g
				R = 3/8 [10]	α = 30°	All	—	g
GMAW FCAW	B-U4a-GF	U	—	R = 3/16 [5]	α = 30°	All	Required	a, g
				R = 1/4 [6]	α = 45°	All	Not Required	a, g
				R = 3/8 [10]	α = 30°	F	Not Required	a, g

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- **<u>8. Technique for Prequalified WPS's</u>**
- 8.1 Base Metal, Filler Metal and Other Material Requirements
  - **Listed base metals and filler metals in Table 8.1** are the only ones that may be used in prequalified WPS's
  - Unlisted base metals and filler metals must be qualified per clause 10
  - Chromium Molybdenum and G-series filler metals are not allowed prequalified
  - Other material requirements, run-off tabs, fillers, fused metal backing - same "M" number as the base metal
  - Welding Parameters of the WPS shall be within the limits recommended by the electrode manufacturer

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- **<u>8. Technique for Prequalified WPS's</u>**
- 8.2 Preheat, Interpass and PWHT Requirements
  - **Table 8.2 outlines preheat requirements**
  - Preheated area, distance equal to the thickness of the part being welded but not less that 3 in [75 mm] in all directions
  - Preheat and Interpass Temperatures
  - Stress Relief/Postweld Heat Treatment, **prequalified WPS's shall not be used if PWHT is specified**

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- **8. Technique for Prequalified WPS's**
- 8.3 Shielded Metal Arc Welding (SMAW)
- 8.4 Submerged Arc Welding (SAW)
- 8.5 Gas Metal Arc and Flux Core Arc Welding (GMAW / FCAW)
- 8.6 Plug and Slot Welds
- 8.7 Welding Wear Plates and Wear Liners (References the MSRP)
- Information in these paragraphs address things like
  - Position, progression
  - Electrode diameters
  - Weld layer thickness
  - Max wind velocity

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Table 8.1
Prequalified Base Metal—Filler Metal Combinations for Matching Strength

Steel Specification Requirements						Filler Metal Requirements[j]		
		Minimum Yield Point/Strength		Tensile Range				
Steel Specification[a, b, c]		ksi	MPa	ksi	MPa	Process	AWS Electrode Specification	Electrode Classification[f, h, k]
Class I								
ASTM A27	Grade U	30	207	60 min.	414 min.	SMAW	A5.1/A5.1M	E60XX, E70XX
ASTM A36[d]		36	248	58/80	400/552		A5.5/A5.5M	E70XX-XX
ASTM A53	Type S or E Grade B	35	241	60 min.	414 min.	SAW	A5.17/A5.17M	F6AX-EXXX
	Type S or E Grade A	30	207	48 min.	331 min.			F7AX-EXXX
	Type F	25	172	45 min.	310 min.		A5.23/A5.23M	F7AX-EXX-XX
ASTM A106	Grade B	35	241	60 min.	414 min.	GMAW	A5.18/A5.18M	ER70S-X
ASTM A131	Grades A, B, CS, D, DS, E	32	221	58/71	400/490			E70C-6X
ASTM A139	Grade B	35	241	60 min.	414 min.			E70C-3X
ASTM A216	Grade WCA	30	207	60 min.	414 min.	FCAW	A5.36/A5.36M	E6TX-XXX-X
ASTM A283	Grades A, B, C, D	25/32	172/221	45/60	310/414			E7XTX-XXX-X
ASTM A381	Grade Y35	35	241	60 min.	414 min.		A5.20/A5.20M	E6XT-X
ASTM A500	Grade A	33/39	228/269	45 min.	310 min.			E7XT-X
	Grade B	42/46	290/317	58 min.	400 min.			(Except -2, -3, -10, -GS)
ASTM A501		36	248	58 min.	400 min.		A5.29/A5.29M	E7XTX-XX
ASTM A515	Grade 55	30	207	55/75	379/517		A5.36/A5.36M	E7XTX-XXX-X
	Grade 60	32	221	60/80	414/552			
ASTM A516	Grade 55	30	207	55/65	379/448			
	Grade 60	32	221	60/72	414/496			
ASTM A524	Grade 1	35	241	60/85	414/586			
	Grade 11	30	207	55/60	379/414			
ASTM A529[i]		42	290	60/85	414/586			
ASTM A569		(Note g)		(Note g)				
ASTM A570	Grade 30	30	207	49 min.	340 min.			
	Grade 33	33	228	52 min.	359 min.			
	Grade 36	36	248	53 min.	365 min.			
	Grade 40	40	276	55 min.	379 min.			
	Grade 45	45	310	60 min.	414 min.			
	Grade 50	50	345	65 min.	448 min.			
ASTM A573	Grade 65	35	241	65/77	448/531			
ASTM A656	Grade 50	50	345	60 min.	414 min.			
ASTM A709[d]	Grade 36 (4)	36	248	58/60	400/414			

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Table 8.1 (Continued)
Prequalified Base Metal—Filler Metal Combinations for Matching Strength

Steel Specification Requirements						Filler Metal Requirements[j]		
		Minimum Yield Point/Strength		Tensile Range				
Steel Specification[a, b, c]		ksi	MPa	ksi	MPa	Process	AWS Electrode Specification	Electrode Classification[f, h, k]
Class I (Continued)								
	HSLAS Grade 45 Class 2	45	310	55	380			
	HSLAS Grade 50 Class 2	50	345	60	414			
	HSLAS-F Grade 50	50	345	60	414			
API 5L	Grade B	35	241	60 min.	414 min.			
	Grade X42	42	290	60 min.	414 min.			
AAR M201	Grade A	30	207	60 min.	414 min.			
	Hot rolled, annealed, or normalized weldable steel grades purchased to max. limits of C 0.28, Mn 1.00, P 0.04, S 0.05	(Note g)		(Note g)				
ABS	Grades A, B, CS, D, DS, and E	—		58/71	400/490			
Class II								
ASTM A27	Grade 65-35	35	241	65 min.	448 min.	SMAW	A5.1/A5.1M	E7015
	Grade 70-36	36	248	70 min.	483 min.			E7016
	Grade 70-40	40	276	70 min.	483 min.			E7018
ASTM A131	Grades AH32, DH32, EH32	45.5	314	68/85	469/586			E7028
	Grades AH36, DH36, EH36	51	352	71/90	490/621		A5.5/A5.5M	E7015-XX
	EH36							E7016-XX
ASTM A216	Grade WCB	36	248	70 min.	483 min.			E7018-XX
	Grade WCC	40	276	70 min.	483 min.	SAW	A5.17/A5.17M	F7AX-EXXX
ASTM A242[e]	Type 1	42/50	290/345	63/70	434/483		A5.23/A5.23M	F7AX-EXX-XX
ASTM A441		42/50	290/345	63/70	434/483	GMAW	A5.18/A5.18M	ER70S-X
ASTM A500	Grade C	46	317	62 min.	427 min.			E70C-3X
ASTM A515	Grade 65	35	241	64/85	441/586			E70C-6X
	Grade 70	38	262	70/90	482/621		A5.36/A5.36M	E7XTX-XXX-X
ASTM A516	Grade 65	35	241	65/77	448/531			E8XTX-XXX-X
	Grade 70	38	262	70/85	483/586	FCAW	A5.20/A5.20M	E7XT-X
ASTM A537	Class 1	50	345	70/90	483/621			(Except -2, -3, -10, -GS)
ASTM A572	Grade 42	42	290	60 min.	414 min.		A5.29/A5.29M	E7XTX-XX
	Grade 50	50	345	65 min.	448 min.		A5.36/A5.36M	E7XTX-XXX-X
ASTM A588[e]	(4 in [100 mm] and under)	50	345	70 min.	483 min.			E8XTX-XXX-X
ASTM A595	Grade A	55	379	65 min.	448 min.			

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Table 8.1 (Continued)
Prequalified Base Metal—Filler Metal Combinations for Matching Strength

Steel Specification Requirements						Filler Metal Requirements[j]		
Steel Specification[a, b, c]		Minimum Yield Point/Strength ksi	Minimum Yield Point/Strength MPa	Tensile Range ksi	Tensile Range MPa	Process	AWS Electrode Specification	Electrode Classification[f, h, k]
Class IV								
ASTM A514[i]	(Over 2-1/2 in [64 mm])	90	621	100/130	689/896	SMAW	A5.5/A5.5M	E10015-XX E10016-XX E10018-XX
ASTM A709[i]	Grades 100, 100W (2-1/2 in to 4 in [64 mm to 100 mm])	90	621	100/130	689/896	SAW	A5.23/A5.23M	F10AX-EXX-XX F10AX-E(C)XX-XX
						GMAW	A5.5/A5.5M	ER100S-XX
						FCAW	A5.29/A5.29M	E10XTX-XX
Class V								
ASTM A514[i]	(2-1/2 in [64 mm] and under)	100	689	110/130	758/896	SMAW	A5.5/A5.5M	E11015-XX E11016-XX E11018-XX
ASTM A517[i]		100	689	115/135	792/931	SAW	A5.23/A5.23M	F11AX-EXX-XX F11AX-E(C)XX-XX
ASTM A709[i]	Grades 100, 100W (2-1/2 in [64 mm] and under)	100	689	100/130	689/896	GMAW	A5.28/A5.28M A5.36/A5.36M	ER110S-XX E11XTX-XXX-X
						FCAW	A5.29/A5.29M A5.36/A5.36M	E11XTX-XX E11XTX-XXX-X

[a] In joints involving base metals of different classes, low hydrogen filler metal requirements applicable to the lower strength class may be used. The low hydrogen processes shall be subject to the technique requirements applicable to the higher strength class.
[b] Match API Standard 2B (fabricated tubes) according to the steel use.
[c] The addition of 0.2% min. copper is permitted.
[d] Only low hydrogen electrodes shall be used when welding steel more than 1 in [25 mm] thick.
[e] Special welding materials and procedures (e.g., E80XX-XX low hydrogen electrodes) may be required to match the notch toughness of base metal (for applications involving impacting or low temperature), or for atmospheric corrosion and weathering characteristics.
[f] The use of chromium-molybdenum alloys (B-series filler metals) is not permitted.
[g] Mechanical properties generally are not specified.
[h] Deposited weld metal shall have a minimum impact strength of 20 ft·lb [27 Joules] at 0°F [-18°C] when Charpy V-notch specimens are required.
[i] When welding ASTM A514, A517, and A709 Grade 100 and 100W, the heat input shall not exceed the manufacturer's recommendation. This includes control of preheat and interpass temperatures, as well as, arc energy (joules/inch).
[j] AWS A5M (SI Units) electrodes of the same classification may be used in lieu of the AWS A5 (U.S. Customary Units) electrode classification.
[k] When required impact values exceed the minimum impact requirements of the filler metal classification, the WPS cannot be prequalified.
[l] Class I, ASTM A529 is discontinued and has been added for historical information only.

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Table 8.2
Prequalified Minimum Preheat and Interpass Temperature (Steel)[a, b]

Preheat Category	Steel Specification[c]		Steel Specification[c]		Welding Process	Thickness of Thickest Part at Point of Welding (in)	Thickness of Thickest Part at Point of Welding (mm)	Minimum Temperature (°F)	Minimum Temperature (°C)
	ASTM A27	Grade U60-30	ASTM A515	Grades 55 and 60		≤3/4	≤20	32	0
		Grade 60-30							
	ASTM A36[d]		ASTM A516	Grades 55 and 60					
	ASTM A53		ASTM A524	Grades 1 and 11		Over 3/4 through 1-1/2	Over 19 through 38	150	65
		Types S or E Grades	ASTM A529						
		A and B, Type F	ASTM A569						
	ASTM A106	Grade B							
			ASTM A570	All Grades					
	ASTM A313	Grades A, B, CS, D, DS, E	ASTM A573	Grade 65					
	ASTM A139	Grade B	ASTM A656	Grade 60					
	ASTM A216	Grade WCA	ASTM A1008	CS Types A, B, C, DS Types A, B, SS Grades 25, 30, 33 Types 1, 2, 40 Types 1, 2					
				HSLAS Grade 45 Class 1 & 2, Grade 50 Class 2 HSLAS-F Grade 50					
A	ASTM A283	Grades A, B, C, D	ASTM A1011	CS Types A, B, C, DS Types A, B, SS Grades 30, 33, 36 Types 1 & 2, 40, 45	Shielded metal arc welding with other than low hydrogen electrodes. For other processes, see Category B instructions.	Over 1-1/2 through 2-1/2	Over 38 through 63	225	104
				HSLAS Grade 45 Class 1 & 2, Grade 50 Class 2, HSLAS-F Grade 50					
			ASTM A1018	CS (All Grades except 1524), DS, SS Grades 30, 33, 36 Types 1 & 2, 40					
				HSLAS Grade 45 Class 1 & 2, Grade 50 Class 2, HSLAS-F Grade 50					
	ASTM A381	Grade Y35	ASTM A7094	Grade 36					
	ASTM A500	Grade A	API 5L	Grade B					
		Grade B	API 5LX	Grade X42		Over 2-1/2	Over 63	300	149
	ASTM A501		AAR M201	Grade A					
			Hot rolled, annealed, or normalized weldable grades of carbon steel purchased to max. limits of C 0.28, Mn 1.00, P 0.04, S 0.05						

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Table 8.2 (Continued)
Prequalified Minimum Preheat and Interpass Temperature (Steel)[a, b]

Preheat Category	Steel Specification[c]		Steel Specification[c]		Welding Process	Thickness of Thickest Part at Point of Welding (in)	Thickness of Thickest Part at Point of Welding (mm)	Minimum Temperature (°F)	Minimum Temperature (°C)
	ASTM A27	Grades 65-35, 70-36, 70-40	ASTM A570	All Grades					
			ASTM A572	Grades 42, 50					
	ASTM A36[d]		ASTM A573	Grades 65					
	ASTM A53	All grades	ASTM A588						
	ASTM A106	Grade B	ASTM A595	Grades A, B, C					
	ASTM A131	Grades A, B, CS, D, DS, E	ASTM A606			≤3/4	≤19	32	0
		AH 32 and 36	ASTM A607	Grades 45, 50, 55					
		DH 32 and 36	ASTM A618						
		EH 32 and 36							
			ASTM A633	Grades A, B					
	ASTM A139	Grade B		Grades C, D					
	ASTM A216	Grade WCB, WCC							
	ASTM A242	Grade 2							
	ASTM A283	Grades A, B, C, and D							
B	ASTM A381	Grade Y35			Shielded, metal arc welding with low hydrogen electrodes, submerged arc welding, gas metal arc welding, flux cored arc welding	Over 3/4 through 1-1/2	Over 19 through 38	50	10
	ASTM A441		ASTM A656	Grades 50 and 60					
	ASTM A500	Grades A, B							
	ASTM A501		ASTM A709[d]	Grades 36, 50, 50W					
			ASTM A1008	SS Grade 50, HSLAS Grades 50 Class 1, 55 Class 1 & 2, 60 Class 2, HSLAS-F Grade 60					
			ASTM A1011	SS Grades 50, 55, HSLAS Grades 50 Class 1, 55 Class 1 & 2, 60 Class 2, HSLAS-F Grade 60					
			ASTM A1018	HSLAS Grades 50 Class 1, 55 Class 1 & 2, 60 Class 2, HSLAS-F Grade 60		Over 1-1/2 through 2-1/2	Over 38 through 64	150	65
				SS Grade 50, HSLAS Grades 50 Class 1, 55 Class 1 & 2, 60 Class 2					
			API 5L	Grade B					
	ASTM A515	Grades 65 and 70							

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Table 8.2 (Continued)
Prequalified Minimum Preheat and Interpass Temperature (Steel)[a, b]

Preheat Category	Steel Specification[c]		Steel Specification[c]		Welding Process	Thickness of Thickest Part at Point of Welding: in	Thickness of Thickest Part at Point of Welding: mm	Minimum Temperature: °F	Minimum Temperature: °C
B (Cont'd)	ASTM A516 ASTM A524 ASTM A529 ASTM A537	Grades 65 and 70 Grades 1 and 11 Classes 1 and 2	API 5LX AAR M201 Hot rolled, annealed, or normalized weldable grades of carbon steel purchased to max. limits of: C 0.35, Mn 1.00, P 0.04, S 0.05	Grade X42 Grade B	Shielded, metal arc welding with low hydrogen electrodes, submerged arc welding, gas metal arc welding, flux cored arc welding	Over 2-1/2	Over 64	225	107
C	ASTM A572	Grade 60 and 65	ASTM A1008	SS Grade 60, HSLAS Grades 60 Class 1, 65 Class 1 & 2, 70 Class 2, HSLAS-F Grade 70	Shielded, metal arc welding with low hydrogen electrodes, submerged arc welding, gas metal arc welding, flux cored arc welding	≤3/4	≤19	50	10
	ASTM A633 API 5 LX	Grade E Grade X52	ASTM A1011	SS Grade 60, HSLAS Grades 60, 65 Class 1 & 2, 70 Class 2, HSLAS-F Grade 70		Over 3/4 through 1-1/2	Over 19 through 38	150	66
	AAR TC128 AAR M201	Grade B Grade B+	ASTM A1018	HSLAS Grades 60 Class 1, 65 Class 1 & 2, 70 Class 2, HSLAS-F Grade 70		Over 1-1/2 through 2-1/2	Over 38 through 64	225	107
				SS Grade 60, HSLAS Grades 60 Class 1, 65 Class 1 & 2, 70 Class 2		Over 2-1/2	Over 64	300	149
D	ASTM A514[e]				Shielded metal arc welding with low hydrogen electrodes, submerged arc welding with carbon or alloy steel wire neutral flux, gas metal arc welding, or flux cored arc welding	≤3/4	≤19	50	10
	ASTM A517[e]					Over 3/4 through 1-1/2	Over 19 through 38	125	52
	ASTM A709[e]	Grades 100 and 100W				Over 1-1/2 through 2-1/2	Over 38 through 64	175	79
						Over 2-1/2	Over 64	225	107

[a] When the base metal is below the temperature listed for the welding process being used and the thickness of the base metal being welded, it shall be preheated (except as otherwise provided or as qualified in accordance with Clauses 9 through 13) in such manner that the surfaces of the base metal in which weld metal is being deposited are at or above the specified minimum temperature for a distance equal to the thickness of the members being welded, but not less than 3 in [75 mm] in all directions from the point of welding. Preheat and interpass temperatures must be sufficient to prevent crack formation. Temperature above the minimum shown may be required for highly restrained welds.
[b] In joints involving combination of base metals, preheat shall be as specified for the higher strength steel being welded.
[c] The addition of 0.2% min. copper is permitted.
[d] Only low hydrogen electrodes shall be used when welding A36 or A709 Grade 36 steel more than 1 in [25 mm].
[e] When welding ASTM A514, A517, and A709 Grade 100 and 100W, the heat input shall not exceed the manufacturer's recommendation. This includes control of preheat and interpass temperatures, as well as, arc energy (joules/inch).

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- **9. General Requirements for Qualification**
- 9.1 Prequalified Procedures
- 9.2 Qualified Procedures
- 9.3 Welders, Welding Operators, and Tack Welders
- 9.4 Qualification Responsibility
  - Company Requirements
    - Procedure Qualification
    - Performance Qualification
    - Change of Ownership

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- Each company shall be responsible for welding procedure qualifications used by the company and their subcontractors.
- When a facility changes ownership, the new owner shall
  - Review the procedure qualification records to determine they conform to the requirements of this specification
  - Properly documented and conforming WPS's may be used without re-qualification, provided
    - The new owner accepts responsibility
    - WPS's reflect the name of the new owner

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- Each company shall be responsible for performance qualifications of **welders, tack welders and welding operators** used by the company and their subcontractors.
- When a facility changes ownership, the new owner shall
  - Review the performance qualification test records to determine they conform to the requirements of this specification
  - Welders, tack welders and welding operators whose qualification records conform may continue to weld without re-qualification, provided
    - The new owner accepts responsibility
    - Their qualification records reflect the name of the new owner

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- The term “company” as used in clause 5.3.3 and 9.4.2 includes all companies under common ownership that utilize the same program of welding standards and documentation
- Qualifications that were performed to and met the requirements of **earlier editions of AWS D15.1** while those editions were in effect are valid and may be used as long as they meet the requirements of this specification.
  - **It is not acceptable to use an earlier edition in lieu of the current edition unless the specific earlier edition is a contractual requirement.**

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- **10. Procedure Qualification**
- 10.1 Limitation of Essential variables, Table 10.1
- 10.2 Types of Tests and Purposes, Table 10.2
- 10.3 Base Metal and its Preparation
- 10.4 Position of Test Welds
- 10.5 Joint Welding Procedure Specification
- 10.6 Test Specimens; Number, Type and Preparation
- 10.7 Special Test Conditions
- 10.8 Method of Testing Specimens
- 10.9 Test Results Required
- 10.10 Records

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Table 10.1
PQR Essential Variable Changes Requiring WPS Requalification for SMAW, SAW, GMAW, FCAW, FW, and GTAW (See 10.1)

Essential Variable Changes to PQR Requiring Requalification:	Process: SMAW	SAW	GMAW	FCAW	GTAW	FW
Joint Design						
(1) A change in joint design type from one of the below to another type except that backgouging may be added: (a) Square groove (b) Single- or double-bevel or J groove (c) Single- or double U or V groove	X	X	X	X	X	
(2) A change in groove joint design that results in: (a) A decrease in the groove angle (b) A decrease in root opening (c) An increase in root face for CJP welds (d) The omission, but not addition, of backing material (e) The addition or omission of consumable inserts	X	X	X	X	X	
(3) For plug and slot welds: (a) A change in the specified slot width or hole diameter (b) A change in the depth of the slot or hole of more than 1/16 in [1.5 mm] (c) A decrease in thickness of the specified backing base metal of more than 1/16 in [1.5 mm]	X	X	X	X	X	
Base Metal, Backing Bar, Filler, Spacer Strips, and Run-off Tabs						
(4) For M1 material, a change to a higher group number (see AWS B2.1/B2.1M and/or Annex A for M number classifications)	X	X	X	X	X	
(5) A change from one "M" number to another "M" number or to an unlisted base metal, unless the unlisted base metal can be shown to have mechanical properties in the same range and a similar chemical composition within the same range as verified by the Fabricator's Engineer	X	X	X	X	X	X
(6) For joints between base metals of different M numbers, requalification is required except for M1, M3, M4, and M5 (of 3% maximum nominal chromium content); a procedure with one M number shall also qualify for that metal welded to each of the lower M number.	X	X	X	X	X	
(7) For M11 material, a change of group number	X	X	X	X	X	

(Continued)

AWS D15.1/D15.1M:2019, Clause 10

- **Procedure Qualification, Table 10.1**
- Joint Design
- Filler Metals
- Process Parameters
- Shielding Gas
- Submerged Arc Welding (SAW)
- Flash Welding (FW)
- Preheat and Interpass, Post Weld Heat Treat (PWHT)
- General
- Supplemental when notch toughness is specified

AWS D15.1/D15.1M:2019, Clause 10, Table 10.2

Table 10.2
Procedure Qualification—Number and Type of Specimens and Range of Thickness Qualified—Complete Joint Penetration Groove Weld[a, b, e, f, g]

1. Tests on Plate

Nominal Plate Thickness (T) Tested, in [mm]	Number of Specimens				Nominal Plate, Pipe, or Tube Thickness[c] Qualified, in [mm]	
	Reduced Section Tension (see Fig. 10.11)	Root Bend (see Fig. 10.14)	Face Bend (see Fig. 10.14)	Side Bend (see Fig. 10.13)	Min.	Max.
1/8 ≤ T ≤ 3/8 [3 ≤ T ≤ 10]	2	2	2	(Note f)	1/8 [3]	2T
3/8 < T < 3/4 [10 < T < 19]	2	—	—	4	3/16 [5]	2T
3/4 [19] and over	2	—	—	4	3/16 [5]	Unlimited

AWS D15.1/D15.1M:2019, Clause 10

2. Tests on Pipe or Tubing[d]

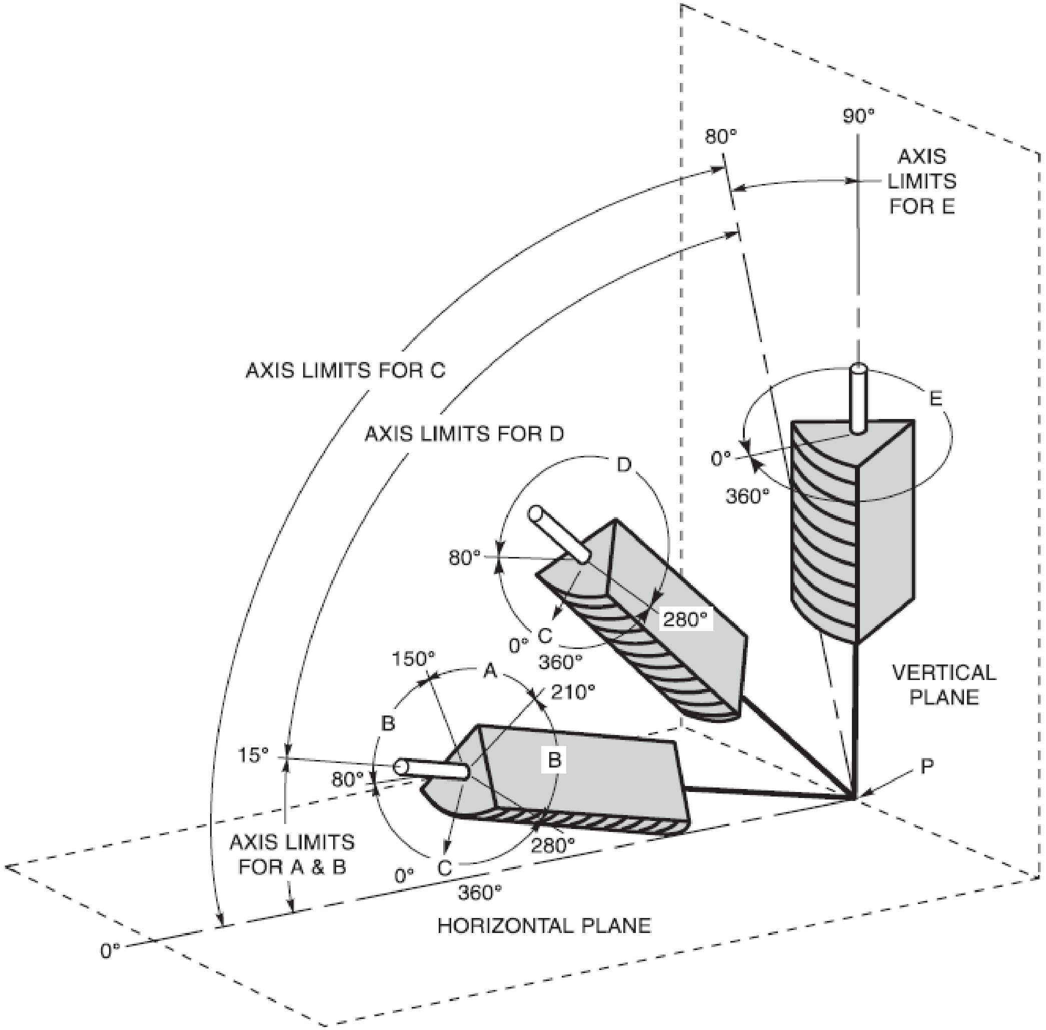
			Number of Specimens					Nominal Plate, Pipe, or Tube Wall Thickness[c] Qualified, in [mm]	
	Nominal Pipe Size or Diam, in [mm]	Nominal Wall Thickness, T, in [mm]	Reduced Section Tension (see Fig. 10.11)	Root Bend (see Fig. 10.14)	Face Bend (see Fig. 10.14)	Side Bend (see Fig. 10.13)	Nominal Diameter of Pipe or Tube Size Qualified, in [mm]	Min.	Max.
Test Pipes	<24 [610]	1/8 ≤ T ≤ 3/8 [3 ≤ T ≤ 10]	2	2	2	(Note f)	Test diam. and over	1/8 [3]	2T
		3/8 < T < 3/4 [10 < T < 19]	2	—	—	4	Test diam. and over	3/16 [5]	2T
		3/4 [19] and over	2	—	—	4	Test diam. and over	3/16 [5]	Unlimited
	≥24 [610]	1/8 ≤ T ≤ 3/8 [3 ≤ T ≤ 10]	2	2	2	(Note f)	Test diam. and over	1/8 [5]	2T
		3/8 < T < 3/4 [10 < T < 19]	2	—	—	4	24 [610] and over	3/16 [5]	2T
		3/4 [19] and over	2	—	—	4	24 [610] and over	3/16 [5]	Unlimited

[a] All welded test plates shall be inspected (see 10.9.6).
[b] A minimum of 6 in [150 mm] effective weld length shall be tested by radiographic or ultrasonic testing prior to mechanical testing (see 10.6.1.3).
[c] For square groove welds, the maximum thickness qualified shall be the test plate thickness.
[d] All welded test pipes or tubing shall be visually inspected (see 10.9.5).
[e] For pipe or tubing, the full circumference of the completed weld shall be tested by RT or UT prior to mechanical testing (see 10.6.1.3).
[f] For 3/8 in [10 mm] plate or wall thickness, a side bend test may be substituted for each of the required face- and root-bend tests.
[g] All groove welds qualify fillet welds on base metal 1/8 in [3 mm] and thicker, except as limited by Table 10.1.

AWS D15.1/D15.1M:2019, Clause 10

- **<u>Number and Type of Specimens Range of Thickness</u>**
- Table 10.3 – Partial Joint penetration Groove Welds
- Table 10.4 – Fillet Welds
- Table 10.5 – Position Limitations / Notch Toughness
- Table 10.6 – As Welded Strength / Aluminum Alloys
- Figures 10.1 Thru 10.18 Gives us
  - Positions of Groove Welds Fillet Welds and Test Plates
  - Location of Specemins
  - Details of Specimens

AWS D15.1/D15.1M:2019, Clause 10



AWS D15.1/D15.1M:2019, Clause 10

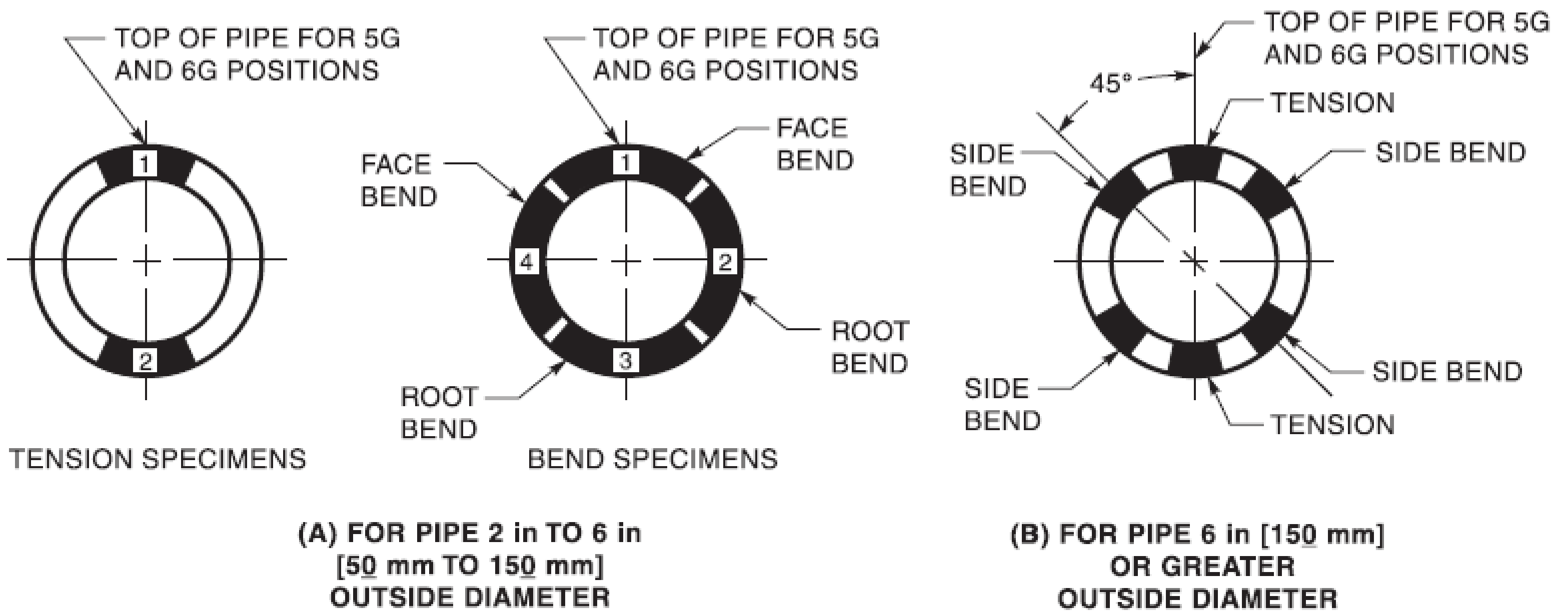
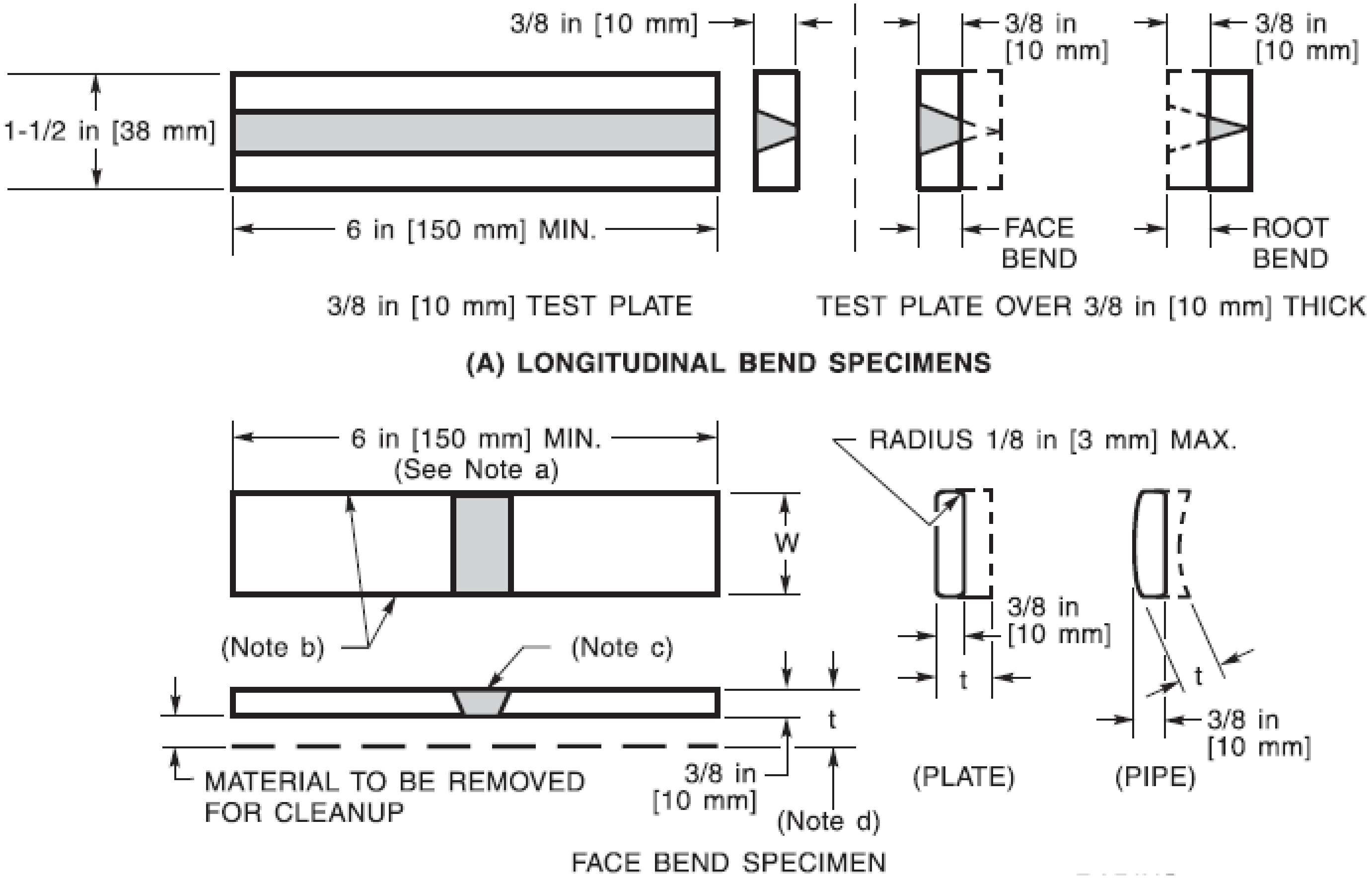
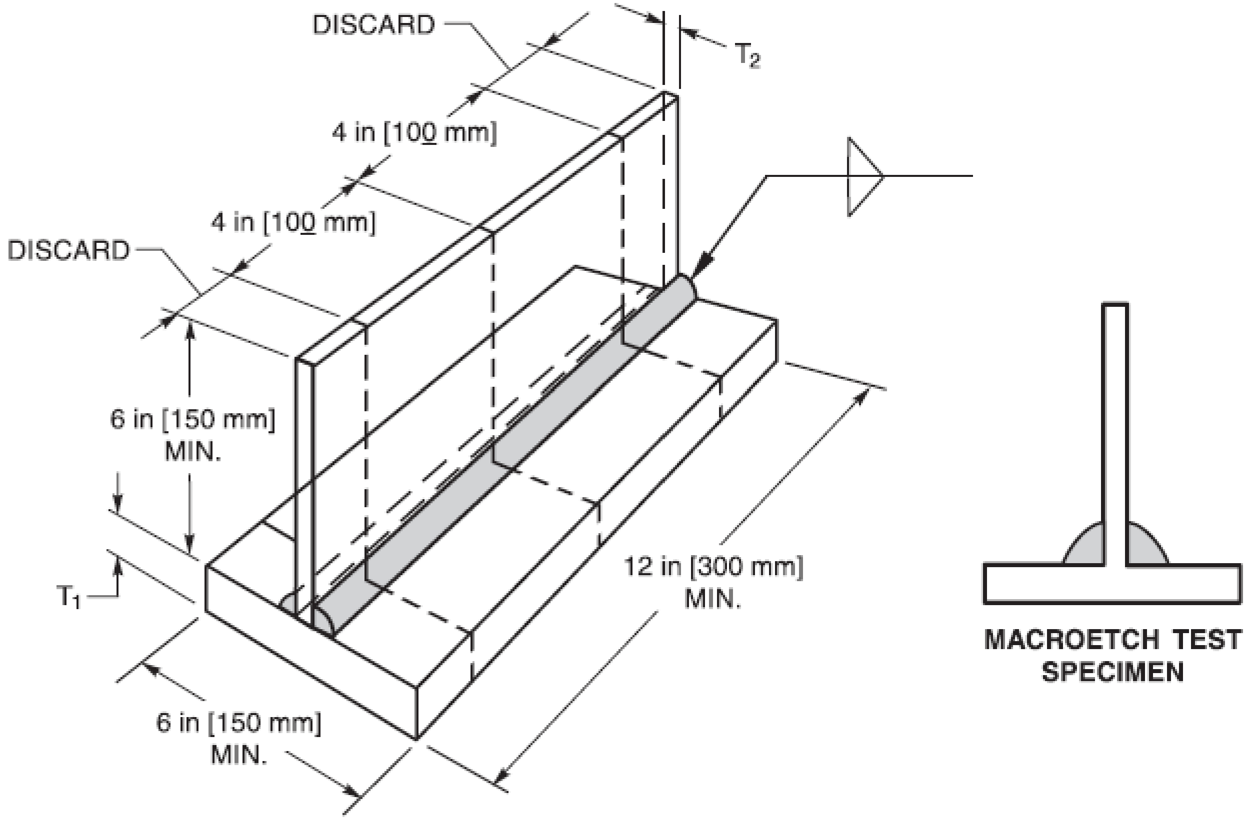


Figure 10.7—Location of Test Specimens on Welded Test Pipe

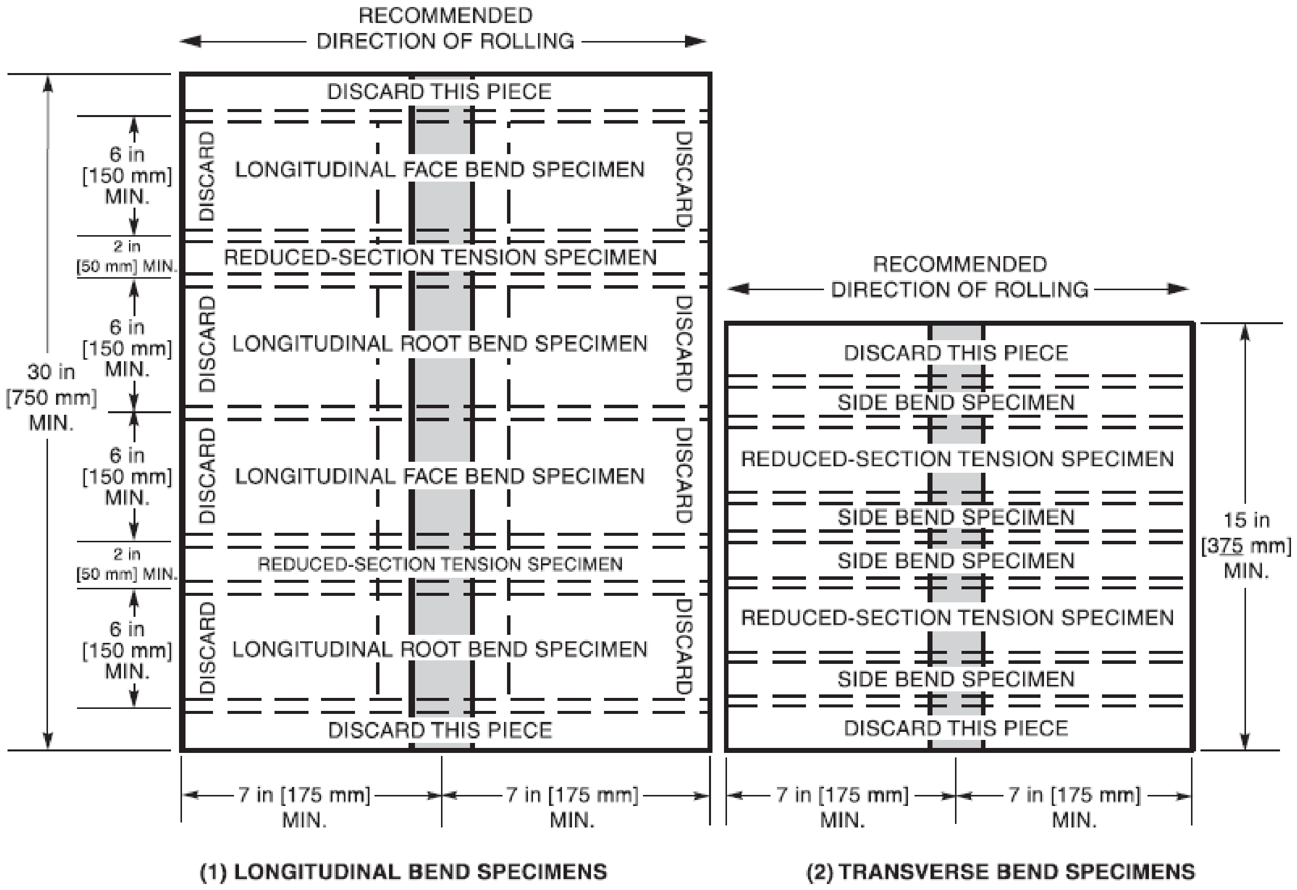
AWS D15.1/D15.1M:2019, Clause 10



AWS D15.1/D15.1M:2019, Clause 10



AWS D15.1/D15.1M:2019, Clause 10



Concludes Clauses 1 - 10

John Gronberg

AWS D15.1 Workshop

John Gronberg
Manager of Quality
Watco

AWS D15.1 Performance Qualification (Chapter 11)

11. Welder Qualification

11.1 General. The qualification tests described in this clause are specially devised tests to determine the welder's ability to produce sound welds. The qualification tests are not intended to be used as guides for welding during actual construction. The latter shall be performed in accordance with the requirements of the welding procedure specification.

11.2 Limitation of Variables. Any change from the limitations in Table 11.1 shall require separate qualification.

11.2.1 A welder shall be qualified for each process used.

11.2.1.1 GMAW-S (short circuiting mode) is considered a separate process.

11.2.1.2 Welders qualified using GMAW, FCAW, or GTAW shall be considered as qualified welding operators in the same process(es), subject to the same essential variable limitations of 12.2 and provided that there is sufficient evidence that the welders have received training and have demonstrated their ability to produce satisfactory production welds.

AWS D15.1 Performance Qualification (Chapter 11)

11.3 Qualification Tests Required

11.3.1 Plate and Structural Shapes

11.3.1.1 The welder qualification tests for manual and semiautomatic welding shall be as follows:

(1) Groove weld qualification tests for plate in accordance with 11.4

(2) Fillet weld qualification tests (only) in accordance with 11.6.1

11.3.1.2 A welder may also be qualified by welding a satisfactory procedure qualification test plate, as specified in 10.6.1, that meets the requirements of 10.9.

11.3.2 Pipe or Square or Rectangular Tubing

11.3.2.1 Welder qualification tests for manual and semiautomatic welding shall be as follows:

(1) Groove weld qualification tests for butt joints on pipe, or square or rectangular tubing in accordance with 11.5

(2) Groove weld qualification tests on plate for butt joints in accordance with 11.4

(3) Fillet weld qualification tests for fillet welds in accordance with 11.6.2

AWS D15.1 Performance Qualification (Chapter 11)

11.3.2.2 A welder may also be qualified by welding a satisfactory procedure qualification test pipe, without backing, as specified in 10.6.1, that meets the requirements of 10.9. The welder is thereby qualified to weld pipe and tubing with the process and in the test position used for procedure qualification. The diameter and wall thickness ranges qualified for shall be as specified in Table 11.3(2).

11.4 Groove Weld Plate Qualification Test for Plate. Suggested groove weld joint designs are given in Figures 11.1 through 11.4. Other joint designs may be used.

11.5 Groove Weld Qualification Test for Pipe or Square or Rectangular Tubing. Suggested joint details are shown in Figures 11.5 and 11.6. Other joint designs may be used.

11.6 Fillet Weld Qualification Test for Fillet Welds Only

11.6.1 Plate and Structural Shapes. For fillet weld qualification only the following shall apply:

11.6.1.1 For fillet welds between members having a dihedral angle (Ψ) of less than 60°, Figure 5.4(A), the welder shall weld a groove weld test plate as required by 11.4. This qualification shall also be valid for joints having a dihedral angle (Ψ) of 60° and greater.

11.6.1.2 For joints having a dihedral angle (Ψ) of 60° or greater, but not exceeding 135°, the welder shall weld a test plate according to Option 1 or Option 2, depending upon the manufacturer's choice, as follows:

(1) **Option 1.** Weld a test plate in accordance with Figure 11.7.

(2) **Option 2.** Weld a soundness test plate in accordance with Figure 11.8.

11.6.2 Pipe or Tubing. For fillet weld qualification only the following shall apply:

AWS D15.1 Performance Qualification (Chapter 11)

11.6.2.1 For fillet welds in connections having a dihedral angle (Ψ) of less than 60°, qualification tests shall be as required by 11.5. The qualification shall also be valid for connections having a dihedral angle (Ψ) of 60° or greater.

11.6.2.2 For connections having a dihedral angle (Ψ) of 60° or greater, the welder shall weld test pipes in accordance with Figure 11.9.

11.7 Position of Test Welds (see Table 11.4)

11.7.1 Test Assemblies and Positions Required. Table 11.4 describes the type of test by assemblies and standard test positions that shall be taken to qualify a welder for the type of assembly and positions to be used for production welding of plate, pipe, or box tubing.

11.7.2 Standard Positions. See 10.4 for definitions.

11.7.3 Special Orientations. A manufacturer who does production welding in a special orientation may make test assemblies for performance qualification in that orientation. Such qualifications are valid only for the orientation actually tested.

AWS D15.1 Performance Qualification (Chapter 11)

11.8 Base Metal. The base metal used shall comply with the welding procedure used. When a welder is to be qualified to weld on austenitic stainless steel M-8 metal or nickel alloy M-41 metal, carbon steel plates of M-1 may be used for the performance test.

11.9 Joint Welding Procedure Specification. The welder shall comply with the requirements of a welding procedure specification qualified in accordance with this document. Weld cleaning shall be done in the same position as the welding position being qualified

11.10 Test Specimens

11.11 Method of Testing Specimens

AWS D15.1 Performance Qualification (Chapter 11)

11.12 Test Results Required

11.12.1 Visual Inspection. For acceptable qualification, the welded specimens shall conform to the requirements of 17.2 and Table 17.2, Class 1 for a minimum length of 6 in [150 mm]; minimum test plate length, with the exclusion of 1 in [25 mm] from each end.

11.12.2 Root, Face, and Side Bend Tests. The convex surface of the bend test specimen shall be visually examined for surface discontinuities. For acceptance, the surface shall contain no discontinuities exceeding the following dimensions:

11.12.3 Fillet Weld Break Test

11.12.4 Macroetch Test.

11.12.5 Radiographic Test. For acceptable qualification, the weld, as revealed by the radiograph, shall conform to the requirements of 17.3.

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11.13 Retests. In a case where a welder fails to meet the requirements of one or more test welds, a retest may be allowed under the following conditions:

11.13.1 An immediate retest may be made consisting of two test welds of each type on which the welder failed. All retest specimens shall meet all the specified requirements.

11.13.2 A retest may be made, provided there is evidence that the welder has had further training or practice. In this case, a complete retest (single test welds of each type) shall be made.

11.14 Period of Effectiveness. The welder's qualification as specified in this specification shall be considered as remaining in effect indefinitely unless either of the following applies:

11.14.1 The welder has not been engaged in the process of welding for which the welder was qualified by the Company for a period exceeding six months.

11.14.1.1 In the case described in 11.14.1, the requalification test need be made only in the 3/8 in [10 mm] thickness.

11.14.2 There is some specific reason to question a welder's ability.

AWS D15.1 Performance Qualification (Chapter 11)

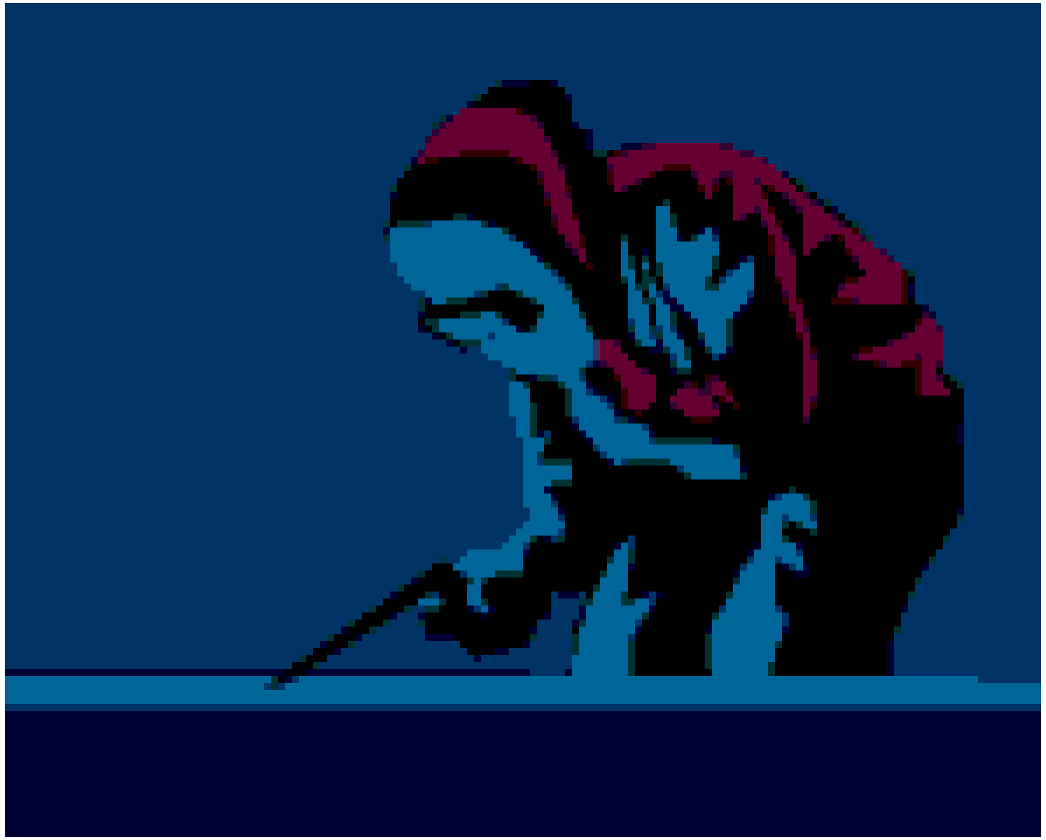
11.15 Records. Records of the test results shall be kept by the manufacturer and be available to those authorized to examine them. Records shall include:

11.15.1 Welder Qualification Record (see Sample Form D-4).

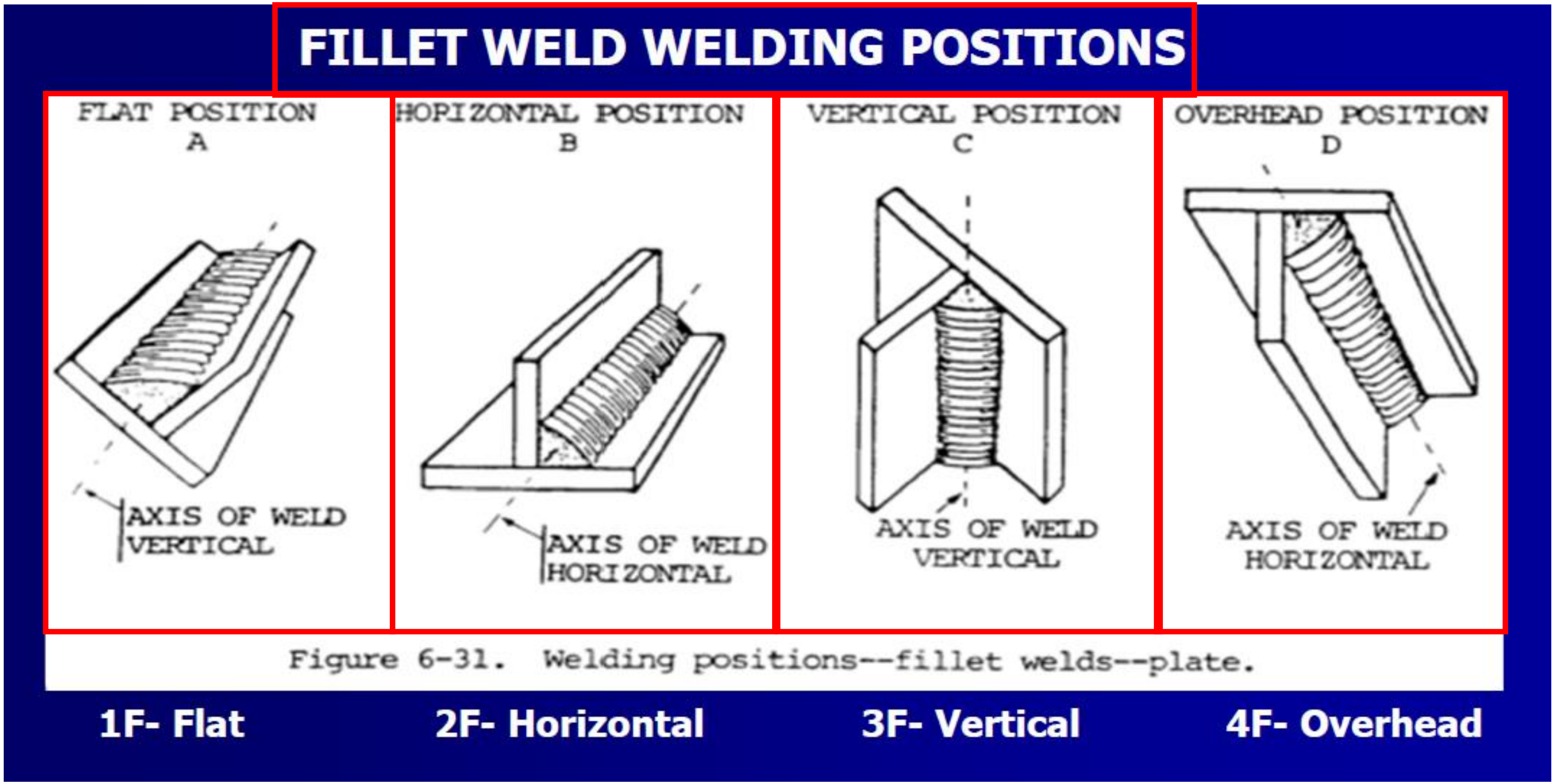
11.15.2 Supporting inspection and test reports.

Essential Variables:

- Process
- Position
- Material
- Joint Geometry
- Plate (Thickness)/Pipe (Diameter)



AWS D15.1 Performance Certification: Position



AWS D15.1 Performance Certification: Position

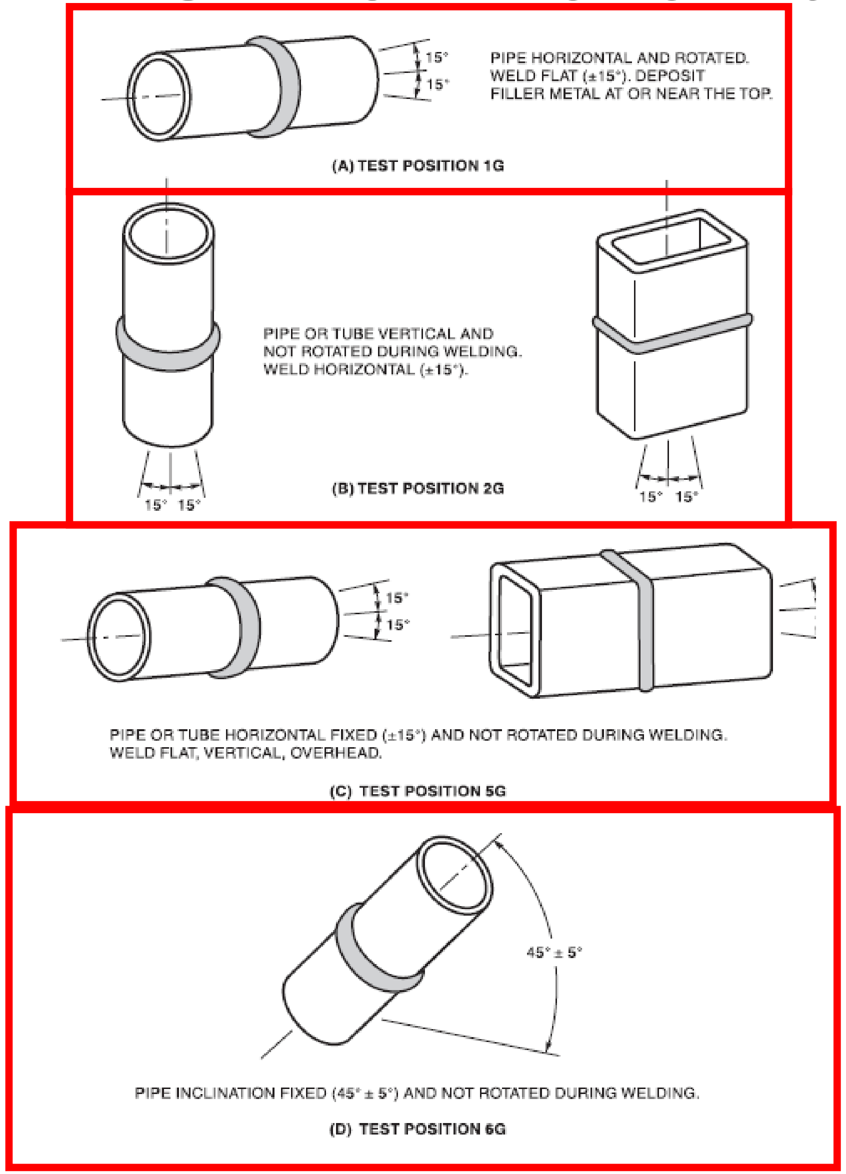


Figure 10.4—Positions of Test Pipe or Tubing for Groove Welds

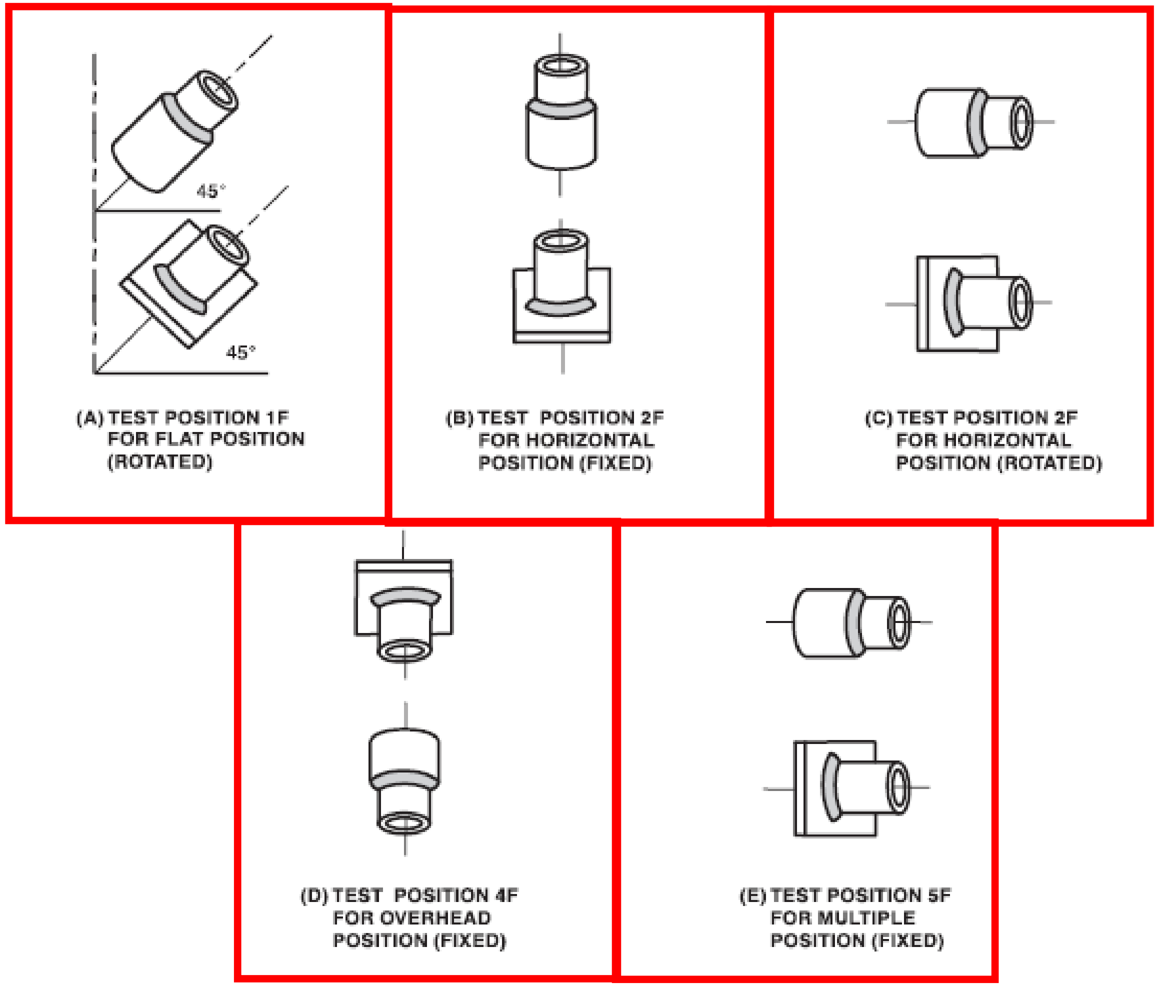


Figure 10.6—Test Positions for Fillet Welds (for Pipe and Tubing)

AWS D15.1 Performance Certification: Material Grouping

4.1 Base Metals. AWS B2.1/B2.1M, *Specification for Welding Procedure and Performance Qualification*, provides an extensive list of materials grouped into categories to minimize the number of qualification tests required. This in no way implies that materials in one group are interchangeable or equivalent for any given application. See Annex A for additional materials specific to this specification.

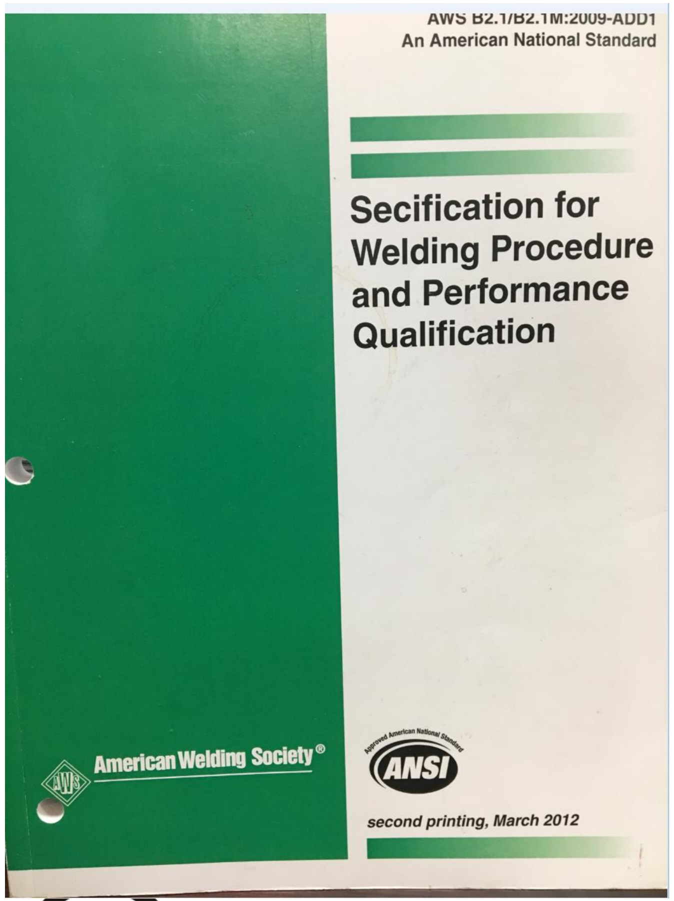


Table D.2 (Continued)
M-Number Listing of Base Metals—Nonferrous Alloys

Material Number	Standard	Base Metal Specification	Type, Grade, or Alloy Designation	UNS Number	Thickness or Diameter Limitations, in [mm]	Minimum Tensile/Yield Strength, ksi [MPa]	Product Form	Nominal Composition
Copper and Copper Base Alloys								
31	ASTM	B 395	Deoxidized High P Cu (DHP)	C12200	—	30/9 [207/62]	Seamless Tube	99.9Cu-0.027P
31	ASTM	B 395	Deoxidized As-Cu (DPA)	C14200	—	30/9 [207/62]	Seamless Tube	99.4Cu-0.3Ag-0.027P
31	ASTM	B 395	98.7 min Cu	C19200	—	30/9 [207/62]	Seamless Tube	98.7Cu-1Fe-0.025P
31	ASTM	B 543	Oxygen-Free Low P Cu (OFLP)	C10800	—	30/9 [207/62]	Welded Tube	99.95Cu-0.008P
31	ASTM	B 543	Deoxidized High P Cu (DHP)	C12200	—	30/9 [207/62]	Welded Tube	99.9Cu-0.027P
31	ASTM	B 543	97.0 min Cu	C19400	—	45/15 [310/103]	Welded Tube	97Cu-2.3Fe-0.08P
31	ASTM	B 819	Deoxidized High P Cu (DHP)	C12200	—	30/9 [207/62]	Seamless Tube	99.9Cu-0.027P
32	ASTM	B 21	Alloy A Naval Brass	C46400	≤1.00 [25] O.D.	54/20 [372/138]	Rod & Bar	60.5Cu-38Zn-0.75Sn
32	ASTM	B 21	Alloy A Naval Brass	C46400	>1.00 ≤2.00 [>25 ≤50]	52/20 [359/138]	Rod & Bar	60.5Cu-38Zn-0.75Sn
32	ASTM	B 21	Alloy A Naval Brass	C46400	>2.00 [50]	50/20 [345/138]	Rod & Bar	60.5Cu-38Zn-0.75Sn
32	ASTM	B 21	Alloy A Naval Brass	C46400	—	52/20 [359/138]	Shapes	60.5Cu-38Zn-0.75Sn
32	ASTM	B 43	Red Brass, 85%	C23000	—	40/12 [276/83]	Seamless Pipe	85Cu-15Zn
32	ASTM	B 111	Red Brass, 85%	C23000	—	40/12 [276/83]	Seamless Tube & Ferrule Stock	85Cu-15Zn
32	ASTM	B 111	Muntz Metal	C28000	—	50/20 [345/138]	Seamless Tube & Ferrule Stock	61Cu-38Zn
32	ASTM	B 111	Admiralty, A	C44300	—	45/15 [310/103]	Seamless Tube & Ferrule Stock	71.5Cu-28Zn-1Sn-0.04Ag
32	ASTM	B 111	Admiralty, B	C44400	—	45/15 [310/103]	Seamless Tube & Ferrule Stock	71.5Cu-28Zn-1Sn-0.06Sb

AWS D15.1 Performance Qualification (Chapter 11)

Table 11.1
Performance Qualification—Limitation of Essential Variables

	Welders[a, b]	Welding Operators	Tack Welders
(1) To a process not qualified (GMAW-S is considered a separate process)	X	X	X
(2) A change from a ferrous to a nonferrous base metal or vice versa	X	X	
(3) A change in an "M" number of nonferrous materials (a change involving only aluminum alloys is exempt)	X	X	X
(4) To an SMAW electrode with an F-number (see Table 11.2) higher than the WPQR electrode F-number	X		X
(5) To a position not qualified	X	X	X
(6) To a diameter or thickness not qualified	X	X	
(7) To a vertical welding progression not qualified (uphill or downhill)	X		
(8) The omission of backing (if used in the WPQR test)[c]	X	X	
(9) To multiple electrodes but not vice versa.		X	

[a] Welders qualified for GMAW, FCAW, or GTAW shall be considered as qualified welding operators in the same process(es) and subject to the welder essential variable limitations.
[b] A welder is qualified for plug, slot, and buildup welding by a complete penetration groove weld test.
[c] Double-welded groove joints are considered welding with backing.

AWS D15.1 Performance Qualification (Chapter 11)

Table 11.2
Electrode Classification Groups for Welder and Tack Welder Qualification

F Number	AWS A5.1/A5.1M, A5.4/A5.4M, and A5.5/A5.5M Electrode Classification[a]
F1	EXX20, EXX20-X, EXX24, EXX27-X, EXX28
F2	EXX12, EXX13, EXX13-X, EXX14
F3	EXX10, EXX10-X, EXX11, EXX11-X
F4	EXX15, EXX15-XX, EXX16, EXX16-XX, EXX18, EXX18-XX, EXX48, EXX45-X
F5	EXXX(X)-15, EXXX(X)-16, EXXX(X)-17

[a] The letters "XX" used in the classification designation in this table for F1 through F4 electrodes stands for the various strength levels (60 ksi, 70 ksi, 80 ksi, 90 ksi, 100 ksi, and 120 ksi [414 MPa, 483 MPa, 551 MPa, 620 MPa, 690 MPa, and 827 MPa]) of deposited weld metal. AWS A5.5/A5.5M, *Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding*, requires composition designations such as EXX18-XX where "-XX" indicates a chemical composition. The letters "XXX(X)" used in the classification for F5 electrodes stands for the various metal alloys of the electrode.

AWS D15.1 Performance Certification: Process

Table W.9 F-Numbers for steel filler metals—grouping of electrodes and welding rods for qualification

F-No.	AWS Specification No.	AWS Classification No.
1	A-5.1 and 5.5	EXX20, EXX24, EXX27, EXX28
2	A-5.1 and 5.5	EXX12, EXX13, EXX14
3	A-5.1 and 5.5	EXX10, EXX11
4	A-5.1 and 5.5	EXX15, EXX16, EXX18, EXX48
4	A-5.4 other than austenitic	EXX15, EXX16
5	A-5.4 (austenitic)	EXX15, EXX16
6	A-5.17	FXX-EXX
6	A-5.9	ERXX
6	A-5.18	ERXXS-X
6	A-5.20	EXXT-X
6	A-5.22	EXXXT-X
6	A-5.23	FXX-EXXX-X, FXX-ECXXX-X, and FXX-EXXX-XN, FXX-ECXXX-XN
6	A-5.28	ER-XXX-X and E-XXX-X
6	A-5.29	EXXTX-X

AWS D15.1 Performance Qualification (Chapter 11)

Table 11.3
Number and Type of Specimens and Range of Thickness Qualified—Welder and Welding Operator Qualification[h]

1. Test on Plate[i]

Type of Weld	Thickness of Test Plate (T) as Welded, in [mm]	Visual Screening Inspection	Number of Specimens: Bend Tests[j] Face	Root	Side	T-Joint Break	Macroetch Thickness Test	Qualified, in [mm]
Groove[g]	T ≤ 3/8 [10]	Yes	1	1	—	—	—	1/8 [3]–2T[c]
Groove[g]	3/8 ≤ T < 1/2 [10 ≤ T < 13]	Yes	—	—	2	—	—	1/8 [3]–2T[c, d]
Groove[g]	1/2 [13] or over	Yes	—	—	2	—	—	1/8 [3]–Unlimited[c]
Fillet Option 1[a]	3/16–1/2 [5–13]	Yes	—	—	—	1	1	1/8 [3]–Unlimited
Fillet Option 2[b]	3/8 [10]	Yes	—	2	—	—	—	1/8 [3]–Unlimited

AWS D15.1 Performance Qualification (Chapter 11)

2. Test on Pipe

Type of Weld	Outside Diameter, in [mm]	Number of Specimens: All Positions Except 5G and 6G Only – Face Bend[j]	Root Bend[j]	Side Bend[j]	Number of Specimens: 5G and 6G Positions Only – Face Bend[j]	Root Bend[j]	Side Bend[j]	Macro and Break	Outside Diameter Qualified, in [mm]	Plate, Pipe, or Tube Wall Thickness Qualified, in [mm] – Min.	Max.
Groove	<0.625 [16]	1	1	—	e	e	—	—	≥ Diameter welded	T/2	2T[c]
Groove	0.625 to ≤2-7/8 [16 to ≤73]	1	1	—	2	2	—	—	≥0.625 [16]	T/2	2T[c]
Groove	>2-7/8 [73]	1	1	—	2	2	—	—	≥ Diameter welded	T/2	2T[c, k]
Fillet Option 3[f]	<0.625 [16]	—	—	—	—	—	—	1	≥ Diameter welded	1/8 [3]	Unlimited
Fillet Option 3[f]	0.625 to ≤2-7/8 [16 to ≤73]	—	—	—	—	—	—	1	≥0.625 [16]	1/8 [3]	Unlimited
Fillet Option 3[f]	>2-7/8 [73]	—	—	—	—	—	—	1	≥ Diameter welded	1/8 [3]	Unlimited

See Figure 11.7.
See Figure 11.8.
Also qualifies for welding fillet welds of all sizes on material of 1/8 in [3 mm] to unlimited thickness for the positions qualified in Table 11.4.
T max for welding operator qualifications.
Radiographic examination required.
See Figure 11.9.
Qualification for butt joint groove welds in plate also qualifies for box tubing (and vice versa) for the positions qualified in Table 11.4.
T = Thickness of test coupon.
Qualifies to weld pipe over 24 in [610 mm] in diameter.
Radiographic examination of welder and welder operator test plate may be made in lieu of the bend test (see 11.11.4 and 12.7).
T ≥ 1/2 in [13 mm] thickness qualifies unlimited thickness for plate and pipe.

AWS D15.1 Performance Qualification (Chapter 11)

Table 11.4
Welder and Welding Operator Qualification—Type and Position Limitation[a]

Qualification Test[b]		Production Weld Type and Position Qualified[c]			
		Plate, Structural Shapes, Box Tubing, and Pipe over 24 in [610 mm] in Diameter		Pipe 24 in [610 mm] and Under in Diameter	
Weld Type	Position	Groove	Fillet	Groove	Fillet[e]
Plate-Groove	1G	F	F, H	—	F, H
	2G	F, H	F, H	—	F, H
	3G	F, V	F, V	—	F, V
	4G	F, OH	F, OH	—	F, OH
	2G, 3G and 4G[d]	All	All	—	All
Plate-Fillet[d]	1F	—	F	—	F
	2F	—	F, H	—	F, H
	3F	—	F, V	—	F, V
	4F	—	F, OH	—	F, OH
	2F, 3F and 4F	—	All	—	All

AWS D15.1 Performance Qualification (Chapter 11)

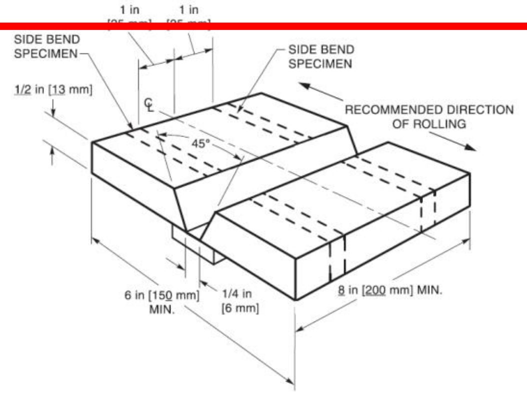
Weld Type	Position	Groove	Fillet	Groove	Fillet[e]
Pipe-Groove 24 in [610 mm] and under in diameter	1G Rotated	F, H	F, H	F	F, H
	2G	F, H	F, H	F, H	F, H
	5G	F, V, OH	F, V, OH	F, V, OH	F, V, OH
	6G	All	All	All	All
	2G and 5G	All	All	All	All
Pipe-Fillet 24 in [610 mm] and under in diameter	1F Rotated	—	F	—	F
	2F/2FR	—	F, H	—	F, H
	4F	—	F, OH	—	F, OH
	5F	—	All	—	All

[a] For thickness and diameter range qualified, see Table 11.3.
[b] For welding test positions, see Figures 10.3 through 10.6.
[c] For production welding positions, see Figures 10.1 and 10.2; F = flat, H = horizontal, V = vertical, OH = overhead.
[d] Not applicable for connections having a angle of less than 60° (see 11.6.2.1 and 12.3.5.1).
[e] For brake pipe welding, see 6.15 and AAR S-402.
[f] Includes socket welded fittings.

AWS D15.1 Performance Qualification (Chapter 11)

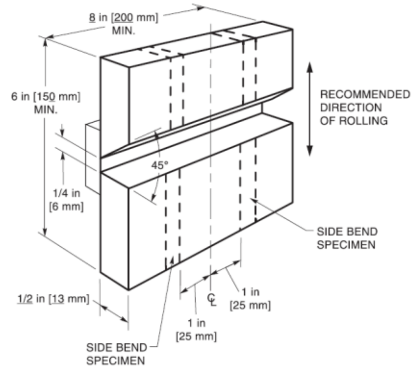
Table 11.5
Maximum Reinforcement—Pipe Welds

Pipe Wall Thickness, in [mm]	Reinforcement, Max., in [mm]
3/8 [10] or less	3/32 [2.5]
Over 3/8 to 3/4 [10 to 19] incl.	1/8 [3]
Over 3/4 [19]	3/16 [5]



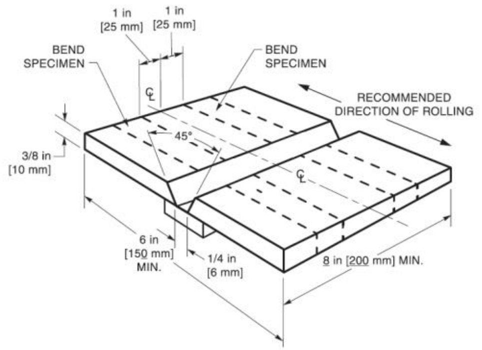
Notes:
1. When radiography is used for testing, no tack welds shall be in the test area.
2. The backing thickness shall be 1/4 in [6 mm] min. to 3/8 in [10 mm] max.; width of backing shall be 3 in [75 mm] min. when not removed for radiography, otherwise 1 in [25 mm] min.

Figure 11.1—Test Plate for Unlimited Thickness Welder Qualification



Notes:
1. When radiography is used for testing, no tack welds shall be in the test area.
2. The backing bar thickness shall be 1/4 in [6 mm] min. to 3/8 in [10 mm] max.; width of backing shall be 3 in [75 mm] min. when not removed for radiography, otherwise 1 in [25 mm] min.

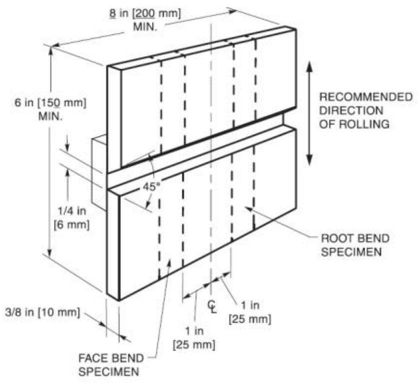
Figure 11.2—Test Plate for Unlimited Thickness Horizontal Position—Welder Qualification



Notes:
1. When radiography is used for testing, no tack welds shall be in test area.
2. The backing thickness shall be 1/4 in [6 mm] min. to 3/8 in [10 mm] max.; backing width shall be 3 in [75 mm] min. when not removed for radiography, otherwise 1 in [25 mm] min.
3. See Figure 10.13 or 10.14 for the appropriate specimen dimensions.

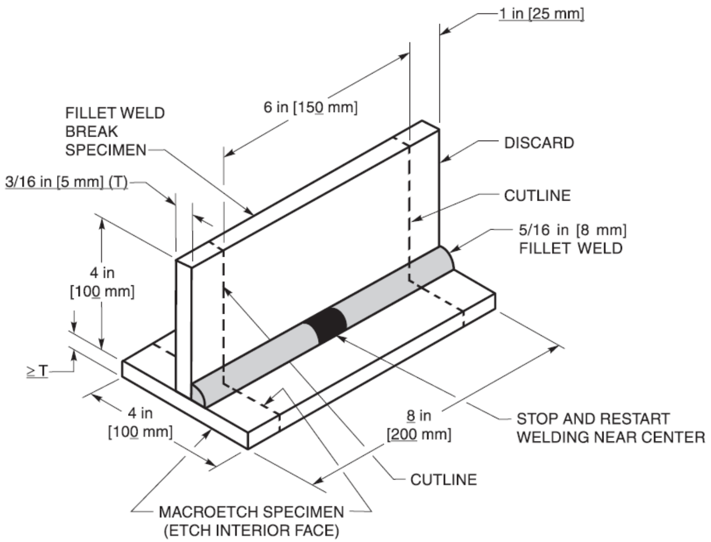
Figure 11.3—Test Plate for Limited Thickness—Welder Qualification

AWS D15.1 Performance Qualification (Chapter 11)



Notes:
1. When radiography is used for testing, no tack welds shall be in test area.
2. The backing thickness shall be 1/4 in [6 mm] min. to 3/8 in [10 mm] max.; backing width shall be 3 in [75 mm] min. when not removed for radiography, otherwise 1 in [25 mm] min.
3. See Figure 10.13 or 10.14 for the appropriate specimen dimensions.

Figure 11.4—Test Plate for Limited Thickness Horizontal Position—Welder Qualification



Note: Plate dimensions are minimum.

Figure 11.7—Fillet-Weld-Break and Macroetch Test Plate Welder and Welding Operator Qualification—Option 1

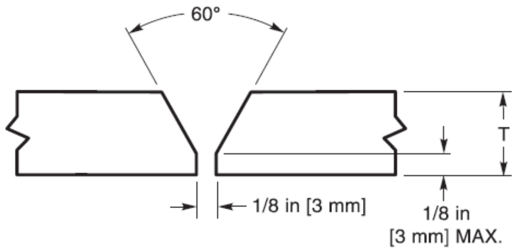
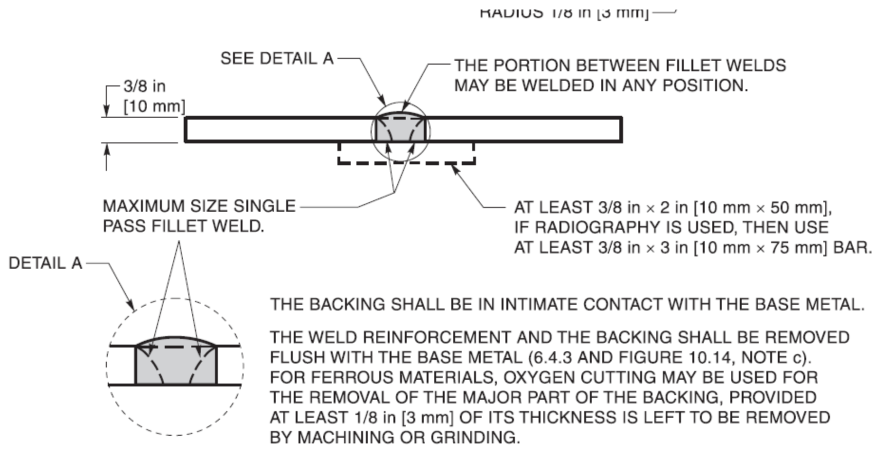


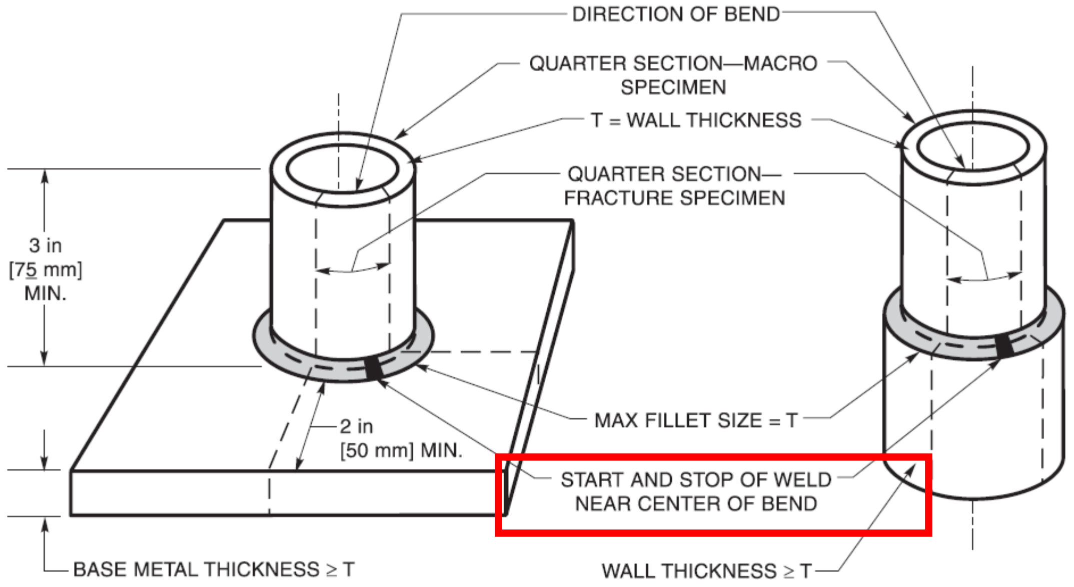
Figure 11.5—Tubular Butt Joint— Welder Qualification without Backing

AWS D15.1 Performance Qualification (Chapter 11)



Note: Either pipe-to-plate or pipe-to-pipe may be used as shown.

Figure 11.8—Fillet Weld Root-Bend Test Plate Welder and Welding Operator Qualification—Option 2



Note: Either pipe-to-plate or pipe-to-pipe may be used as shown.

Figure 11.9—Fillet Weld on Pipe—Welder and Welding Operator Qualification—Option 3

AWS D15.1 Performance Qualification (Chapter 11)

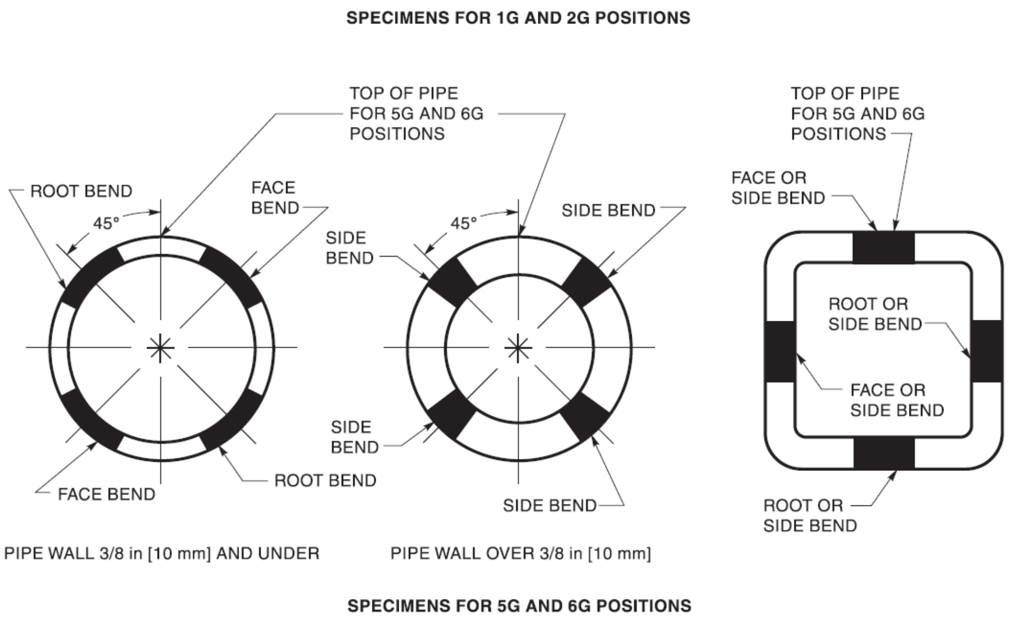
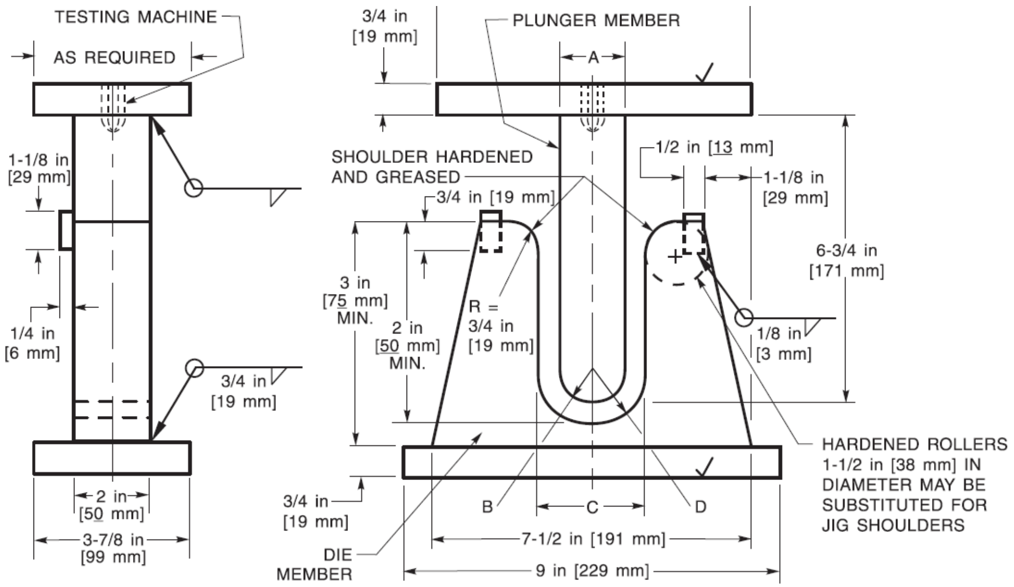


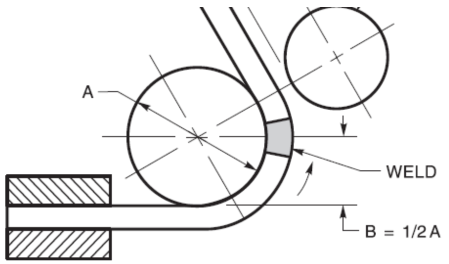
Figure 11.10—Location of Test Specimens on Welded Test Pipe and Square or Rectangular Tubing—Welder Qualification



Source: Adapted from AWS B4.0:2016, *Standard Methods for Mechanical Testing of Welds*, Figure 6.2, American Welding Society.

Material[a]	Thickness of Specimen, in [mm]	A, in [mm]	B, in [mm]	C, in [mm]	D, in [mm]
M-No. 23 to M-No. 2X, M-No. 2X with F-No. 23	1/8 [3] t = 1/8 [3] or less	2-1/16 [53] 16-1/2t	1-1/32 [26] 8-1/4t	2-3/8 [60] 18-1/2t + 1/16 [1.5]	1-3/16 [30] 9-1/4t + 1/32
M-No. 11; M-No. 25 welded to M-No. 21 or M-No. 22 or M-No. 25; Steel over 90 ksi [620 MPa] yield	3/8 [10] t = 3/8 [10] or less	2-1/2 [64] 6-2/3t	1-1/4 [32] 3-1/3t	3-3/8 [86] 8-2/3t + 1/8 [3]	1-11/16 [43] 4-1/3t + 1/16 [1.5]
[illegible]	3/8 [10]	3 [75]	1-1/2 [38]	3-7/8 [98]	1-15/16 [49]

AWS D15.1 Performance Qualification (Chapter 11)



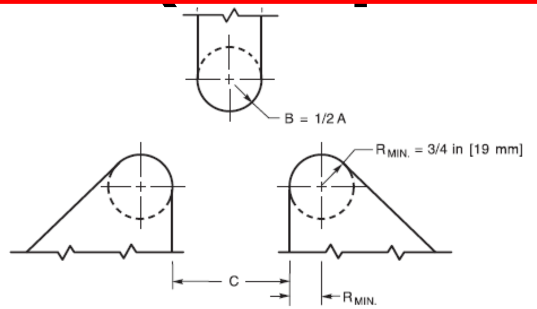
Source: Adapted from AWS B4.0:2016, *Standard Methods for Mechanical Testing of Welds*, Figure 6.3, American Welding Society.

Material[a]	Thickness of Specimen, in [mm]	A, in [mm]	B, in [mm]
M-No. 23 to M-No. 2X, M-No. 2X with F-No. 23; Al alloy	1/8 [3] t = 1/8 [3] or less	2-1/16 [52] 16-1/2t	1-1/32 [27] 8-1/4t
M-No. 11; M-No. 25 to M-No. 21 or M-No. 22 or M-No. 25 Steel over 90 ksi [620 MPa] yield	3/8 [10] t = 3/8 [10] or less	2-1/2 [64] 6-2/3t	1-1/4 [32] 3-1/3t
7005 Al alloy	3/8 [10] t = 3/8 [10] or less	3 [77] 8t	1-1/2 [38] 4t
Steel over 50 ksi to 90 ksi [345 MPa to 620 MPa] yield	3/8 [10] t = 3/8 [10] or less	2 [50] 5-1/3t	1 [25] 2-2/3t
All others	3/8 [10] t = 3/8 [10] or less	1-1/2 [38] 4t	3/4 [19] 2t

[a] "X" refers to 1, 2, 3, or 5, as applicable.

Notes:
1. Dimensions not shown are the option of the designer. The essential consideration is to have adequate rigidity so that the jig parts cannot spring.
2. The specimen shall be firmly clamped on one end so that there is no sliding of the specimen during the bending operation.
3. Test specimens shall be removed from the jig when the outer roll has been removed 180° from the starting point.
4. Dimensions A and B shall have a tolerance of +1/16 in [1.5 mm] (11.11.1).

Figure 11.12—Guided-Bend Wraparound Jig



Source: Adapted from AWS B4.0:2016, *Standard Methods for Mechanical Testing of Welds*, Figure 6.1, American Welding Society.

Material[a]	Thickness of Specimen, in [mm]	A, in [mm]	B, in [mm]	C, in [mm]
M-No. 23 to M-No. 2X, M-No. 2X with F-No. 23; Al alloy	1/8 [3] t = 1/8 [3] or less	2-1/16 [52] 16-1/2t	1-1/32 [26] 8-1/4t	2-3/8 [60] 18-1/2t + 1/16
M-No. 11; M-No. 25 to M-No. 21 or M-No. 22 or M-No. 25 Steel over 90 ksi [620 MPa] yield	3/8 [10] t = 3/8 [10] or less	2-1/2 [64] 6-2/3t	1-1/4 [32] 3-1/3t	3-3/8 [86] 8-2/3t + 1/8
7005 Al alloy	3/8 [10] t = 3/8 [10] or less	3 [75] 8t	1-1/2 [38] 4t	3-7/8 [98] 10t + 1/8
Steel over 50 ksi to 90 ksi [345 MPa to 620 MPa] yield	3/8 [10] t = 3/8 [10] or less	2 [50] 5-1/3t	1 [25] 2-2/3t	2-7/8 [73] 7-2/3t
All others	3/8 [10] t = 3/8 [10] or less	1-1/2 [38] 4t	3/4 [19] 2t	2-3/8 [60] 6t + 1/8

[a] "X" refers to 1, 2, 3, or 5, as applicable.

Notes:
1. The weld and heat-affected zone in the case of a transverse-weld bend specimen shall be completely within the bend portion of the specimen after testing.
2. Either hardened and greased shoulders or hardened rollers free to rotate shall be used.
3. The shoulders or rollers shall have a minimum bearing surface of 2 in [50 mm] for placement of the specimen. The rollers shall be high enough above the bottom of the jig so that the specimens will clear the rollers when the ram is in the low position.
4. The ram shall be fitted with an appropriate base and provision made for attachment to the testing machine, and shall be a sufficiently rigid design to prevent deflection and misalignment while making the bend test. The body of the ram may be less than the dimensions shown in column A.
5. If desired, either the rollers or the roller supports may be made adjustable in the horizontal direction so that specimens of t thickness may be tested on the same jig.
6. The roller supports shall be fitted with an appropriate base designed to safeguard against deflection or misalignment and equipped with means for maintaining the rollers centered midpoint and aligned with respect to the ram.
7. Dimensions A, B, and C shall have a tolerance of +1/16 in [1.5 mm] (11.11.1).

Figure 11.13—Guided-Bend Roller Jig

AWS D15.1 Performance Qualification (Chapter 11)

- Process
- Material (M Number)
- Position
- Plate/Pipe (Thickness and Diameter)
- Joint Geometry
- Electrode (F# for SMAW)
- 6-Month Continuity
- Eye-Exam

Welding Operator Qualification (Chapter 12)

12. Welding Operator Qualification

12.1 General. The qualification tests described in this section are specifically devised tests to determine a welding operator's ability to produce sound welds. The qualification tests are not intended to be used as guides for welding during actual construction. The latter shall be performed in accordance with the requirements of the welding procedure specification.

12.2 Limitation of Variables. Any change from the limitations in Table 11.1 shall require separate qualification.

12.2.1 Welders qualified using GMAW, FCAW, or GTAW shall be considered as qualified welding operators in the same process(es), subject to the same essential variable limitations of 12.2 and provided that there is sufficient evidence that the welders have received training and have demonstrated their ability to produce satisfactory production welds.

12.3 Qualification Tests Required for Welding Operators

12.3.1 The welding operator qualification test shall utilize a joint design in accordance with an approved welding procedure specification. Figure 12.1 cites a suggested plate groove weld test design. Except for GMAW short circuiting transfer mode, the welding operator may instead be qualified by radiography of the initial 15 in [381 mm] of a production groove weld. The material thickness range qualified shall be that shown in Table 11.3.

12.3.2 The welding operator who makes a complete joint penetration groove weld procedure qualification test in plate that meets the requirements is thereby qualified for that process and test position for plate of thickness given in Tables 11.3 and 11.4.

12.3.3 The welding operator who makes a complete joint penetration groove weld procedure qualification test in pipe or tubing that meets the requirements is thereby qualified for that process and test position for pipe or tubing. The pipe diameter and wall thickness range qualified for shall be that shown in Table 11.3. This qualifies the welding operator for welding groove and fillet welds in plate, pipe, or tubing as shown in Table 11.4.

12.3.4 Qualification of a welding operator on plate in the 1G (flat), or 2G (horizontal) position shall qualify the welding plate operator for welding pipe or tubing over 24 in [610 mm] in diameter for the position qualified, except that qualification in the 1G position also qualifies for the fillet welding of plate in the flat and horizontal positions, and qualification in the 2G position also qualifies for groove welding of plate in the flat position, and for fillet welding of plate in the flat and horizontal positions.

Welding Operator Qualification (Chapter 12)

12.9 Retests. If a welding operator fails to meet the requirements of one or more test welds, a retest may be allowed under the following conditions:

12.9.1 An immediate retest may be made consisting of two test welds of each type on which the welding operator failed. All specimens shall meet all the requirements specified for such welds.

12.9.2 A retest may be made provided there is evidence that the welding operator has had further training or practice. In this case, a complete retest (single test welds of each type) shall be made.

12.10 Period of Effectiveness. The welding operator's qualification specified in Clause 12 shall be considered as remaining in effect indefinitely unless one of the following applies:

12.10.1 The welding operator is not engaged in the given process of welding for which the operator is qualified for a period exceeding six months.

12.10.2 There is some specific reason to question the welding operator's ability.

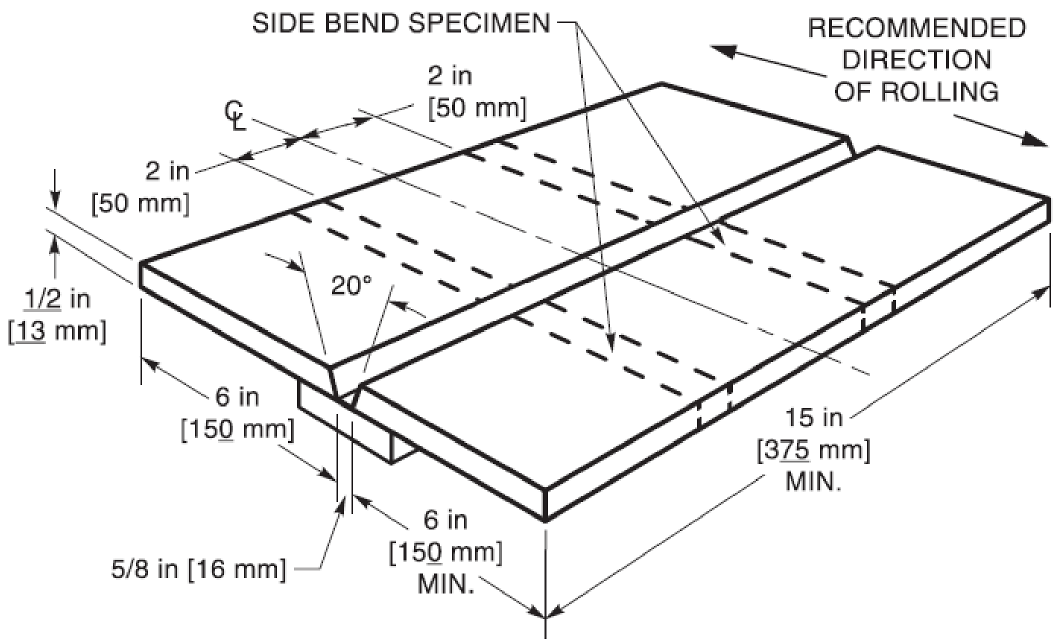
12.11 Records. Records of the test results shall be kept by the manufacturer and be available to those authorized to examine them. Records shall include:

12.11.1 Welding Operator Qualification Record (see sample in Annex D).

12.11.2 Supporting inspection and test reports.

12.12 Flash Welding Operator Qualification. Each welding operator shall be tested by welding a test coupon following any WPS. The welded test coupon shall be cut into strips, visually examined, and bend tested in accordance with 10.12.2. Polishing and examination of a cross-section is not required. Qualification following any flash welding WPS qualifies the operator to follow all flash welding WPSs.

Welding Operator Qualification (Chapter 12)



Notes:
1. When radiography is used for testing, no tack welds shall be in test area.
2. The joint configuration of a qualified groove weld procedure may be used in lieu of the groove configuration shown here.
3. The backing bar thickness shall be 3/8 in [10 mm] min. to 1/2 in [13 mm] max.; backing bar width shall be 3 in [75 mm] min. when not removed for radiography, otherwise 1-1/2 in [38 mm].
4. See Figure 10.13 or 10.14 for the appropriate specimen dimensions.

Figure 12.1—Test Plate for Unlimited Thickness—Welding Operator Qualification

Tack Welder Qualification (Chapter 13)

13.3 Qualification Tests Required. A tack welder shall be qualified by one test plate made in each position in which he or she is to tack weld. The tack welder shall make a 1/4 in [6 mm] maximum size tack weld approximately 2 in [51 mm] long on the fillet-weld-break specimen as shown in Figure 13.1.

13.6 Method of Testing Specimens. A force shall be applied to the specimen as shown in Figure 13.2 until rupture occurs. The force may be applied by any convenient means. The surface of the weld and of the fracture shall be examined visually for defects.

13.7 Test Results Required

13.7.1 The tack weld shall present a reasonably uniform appearance and shall be free of overlap, cracks, and undercut exceeding 1/32 in [0.8 mm]. There shall be no porosity visible on the surface of the tack weld.

13.7.2 The fractured surface of the tack weld shall show fusion to the root, but not necessarily beyond, and shall exhibit no incomplete fusion to the base metal nor any inclusion or porosity larger than 3/32 in [2.5 mm] in greatest dimension.

13.7.3 A tack welder who passes the fillet-weld-break test shall be eligible to tack weld all types of joints for the process and in the position in which the tack welder has qualified.

Tack Welder Qualification (Chapter 13)

13.3 Qualification Tests Required. A tack welder shall be qualified by one test plate made in each position in which he or she is to tack weld. The tack welder shall make a 1/4 in [6 mm] maximum size tack weld approximately 2 in [51 mm] long on the fillet-weld-break specimen as shown in Figure 13.1.

13.9 Period of Effectiveness. A tack welder who passes the qualification test shall be considered eligible to perform tack welding indefinitely in the positions and with the process for which the tack welder is qualified unless there is some specific reason to question the ability of the tack welder. In such case, the tack welder shall be required to demonstrate an ability to make sound tack welds by again passing the prescribed tack welding test.

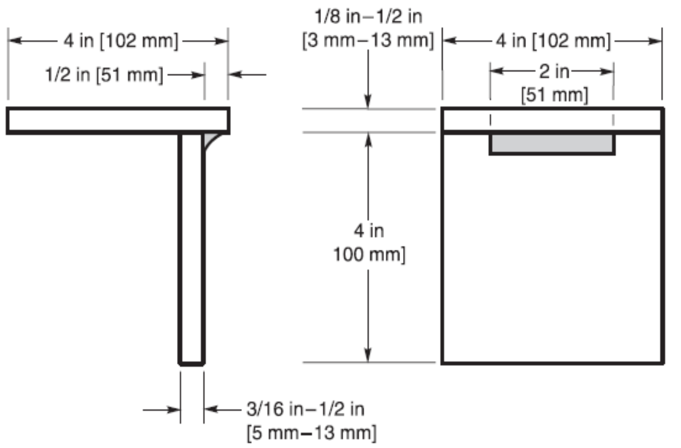


Figure 13.1—Fillet-Weld-Break Specimen—Tack Welder Qualification

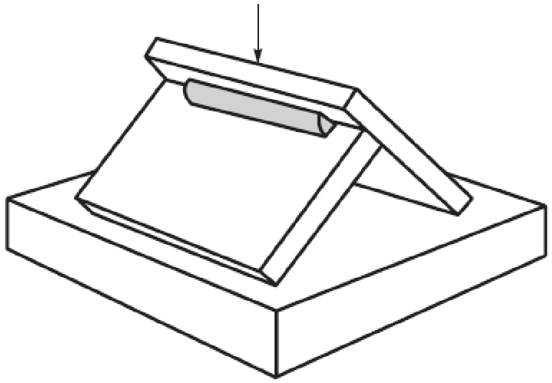


Figure 13.2—Method of Rupturing Specimen—Tack Welder Qualification

Inspection – General Requirements (~~Chapter 14~~)

14. Inspection—General Requirements

14.1 Manufacturer's Responsibility. The company performing welding is responsible for inspection.

14.2 Designated Inspector

14.2.1 When so assigned by the company, the welder or welding operator may function as the designated inspector.

14.2.2 The Designated Inspector shall be adequately trained and qualified to perform all of the assigned duties. There shall be documented evidence of training received. For other than visual inspection, personnel qualifications shall be in accordance with 15.2.

Inspection – General Requirements (~~Chapter 14~~)

14.3 Fabrication Inspection

14.3.1 Inspection of Drawings and Specifications. The Designated Inspector shall verify that welding is being done in accordance with 5.5, and all applicable drawings and specifications.

14.3.2 Inspection of Consumables. The Designated Inspector shall verify that welding is being done using consumables in accordance with 5.6.

14.3.3 Inspection of Workmanship. The Designated Inspector shall verify that welding is being done meeting workmanship requirements given in Clause 6.

14.3.4 Inspection of Welding Procedure Specifications. The Designated Inspector shall verify that welding is being done in compliance with written welding procedure specifications that are either prequalified in accordance with Clauses 7 and 8, or have been qualified in accordance with Clause 10.

14.3.5 Inspection of Welders, Welding Operators, and Tack Welders. The Designated Inspector shall verify that welding is being done using welders, welding operators, or tack welders who have been qualified in accordance with Clause 11, 12, or 13.

Inspection – General Requirements (Chapter 14)

14.3.6 Inspection of Weld Size and Location. The Designated Inspector shall make sure that the size, location, and length of all welds meet the specified requirements. Unspecified welds shall not be added without the approval of the Fabricator's Engineer.

14.3.7 Visual Inspection of Completed Welds. All completed welds shall be visually inspected by the Designated Inspector for compliance in 17.2.

14.3.8 Documentation. Designated Inspectors shall document acceptance of all welds as required by industry standards and contractual agreements (individual welds or assemblies).

14.4 Verification Inspection. Verification inspection and testing are the prerogatives of the purchaser who may perform this function or, when provided in the contract, waive independent verification, or stipulate that both inspection and verification shall be performed by the company. The Verification Inspector is the duly designated person who acts for and in behalf of the purchaser on all inspection and quality matters within the scope of the contract documents.

Inspection – General Requirements (Chapter 14)

14.4.1 The Verification Inspector shall be guided by but is not limited to the following:

14.4.1.1 The Verification Inspector has the authority to ascertain that all fabrication welding is performed in accordance with requirements of this specification or contract documents exceeding those requirements.

14.4.1.2 The Verification Inspector, where possible, shall be furnished with complete detailed drawings showing the size, type, and location of all welds to be made. This Inspector shall also be furnished with the portion of the contract documents that describes material and quality requirements for the products to be fabricated, assembled, or repaired.

14.4.1.3 The Verification Inspector shall be notified in advance of the start of operations subject to inspection and verification.

14.4.2 Inspection of Materials. The Verification Inspector may ascertain that only materials conforming to the requirements of this specification are used.

Inspection – General Requirements (Chapter 14)

14.4.3 Inspection of Welding Procedure Qualification and Equipment

14.4.3.1 The Verification Inspector may ascertain that all welding procedures are prequalified and covered by a welding procedure specification or are qualified in accordance with Clause 10.

14.4.3.2 The Verification Inspector may inspect the welding equipment to be used for the work to make certain that it conforms to the requirements of 6.1.2.

14.4.4 Inspection of Welder, Welding Operator, and Tack Welder

14.4.4.1 The Verification Inspector may ascertain that the welding is performed only by welders, welding operators, and tack welders who are qualified in accordance with the requirements of Clause 11, 12, or 13, as applicable.

14.4.4.2 When the quality of a welder's, welding operator's, or tack welder's work appears to be below the requirements of this specification, the Verification Inspector may require the welder, welding operator, or tack welder to demonstrate an ability to produce sound welds by means of a simple test, such as the fillet weld break test, or by requiring complete requalification in accordance with the subclauses pertaining to retest for Welders, Welding Operators, and/or Tack Welders, as applicable.

14.4.4.3 The Verification Inspector may require requalification of any welder or welding operator who has not used the process for which the welder or welding operator has been qualified for a period exceeding six months.

14.4.4.4 The Verification Inspector may require repairs to welds found not conforming to specifications or approved drawings.

Inspection – General Requirements (Chapter 14)

14.4.5 Inspection of Work and Records

14.4.5.1 The Verification Inspector may ascertain that the size, length, and location of all welds conform to the requirements of this specification and to the detail drawings and that no unspecified welds have been added without approval of the Engineer.

14.4.5.2 The Verification Inspector may ascertain that only welding procedure specifications are employed that meet the provisions of 9.1 or are qualified in accordance with Clause 10.

14.4.5.3 The Verification Inspector may ascertain that if electrodes are used, they are used only in the positions and with the type of welding current and polarity for which they are classified.

14.4.5.4 The Verification Inspector may, at suitable intervals, observe the technique and performance of each welder, welding operator, and tack welder to make certain that the applicable technique requirements are met.

14.4.5.5 At suitable intervals, the Verification Inspector may examine the work to make certain that it meets the requirements of this specification. Size and contour of welds shall be measured with suitable gages. Visual inspection for cracks in welds and base metal and other discontinuities should be aided by a strong light, magnifiers, or such other devices as may be found helpful.

NDE – General Requirements (Chapter 15)

15. NDE General Requirements

15.1 Nondestructive Examination. The limitations and complementary use of each method are explained in the latest edition of AWS B1.10M/B1.10, *Guide for the Nondestructive Examination of Welds*. As an alternative to the NDE procedures, techniques, and personnel qualification requirements of this section, AAR MSRP C-III, Appendix T, may be utilized.

15.1.1 Welds tested nondestructively that do not meet the requirements of this specification shall be repaired by the methods permitted by 6.5.

15.2 Personnel Qualifications. For other than visual inspection, personnel performing nondestructive examination shall be qualified in accordance with a written practice modeled after the American Society for Nondestructive Testing Recommended Practice SNT-TC-1A or other mutually agreed upon practices.

15.2.1 Exemption of QC1 Requirements. Personnel performing NDT under the provisions of 15.2 need not be qualified and certified under the provisions of AWS QC1.

15.2.2 Vision Requirements. All Personnel performing visual examination per this standard shall be examined to ensure they have natural or corrected near-distance visual acuity in at least one eye such that the individual is capable of reading a Jaeger Number 2 test chart or equivalent at a distance of not less than 12 in [300 mm]. The examination shall be valid for a period of one (1) year.

NDE – Methods (Chapter 16)

16. NDE Methods

16.1 Radiographic Testing of Groove Welds. When radiographic testing is used, the procedure and technique shall be in accordance with the following, and the acceptance criteria in accordance with 17.3:

16.1.1 General Requirements

16.1.1.1 Butt Joints. The procedures and standards set forth in 16.1.1.2 govern radiographic testing of welds when such inspection is required by the contract documents. The requirements listed herein are specifically for testing groove welds in butt joints in plate, shapes, and bars by X-ray or gamma ray sources. The methodology shall conform to ASTM E94, *Guide for Radiographic Testing*, ASTM E747, *Standard Method for Design, Manufacture and Material Grouping Classification of Wire Image Quality Indicators (IQI) Used for Radiography*, and ASTM E1032, *Standard Test Method for Radiographic Examination of Weldments*, except as provided herein.

16.1.1.2 Variations

16.1.2 Examination, Report, and Disposition of Radiographs

16.1.3 Acceptability of Welds. Welds shown by radiographic testing to have discontinuities prohibited by Figures 16.1, 16.2, 16.3, 16.4, and 16.5 shall be repaired in accordance with 6.5.

NDE – Methods (Chapter 16)

16.2 Ultrasonic Testing of Groove Welds. When ultrasonic testing is used, the procedure and technique shall be in accordance with AWS D1.1/D1.1M, Ultrasonic Testing (UT) of Groove Welds. As an alternative, a written procedure that meets the requirements of AWS D1.1/D1.1M, UT Examination of Welds by Alternative Techniques, or the latest addendum of ASME *Boiler and Pressure Vessel Code*, Section V, may be used. UT inspection flaw size evaluation shall be in accordance with 16.2.5. Acceptance criteria shall be in accordance with 17.4. When ultrasonic testing of aluminum is required by contract, the testing procedure and acceptance criteria shall be specified.

16.2.3 Base Metal.

16.2.4 Extent of Testing

16.2.5 UT Inspection Flaw Size Evaluation

16.2.5.1 The length of flaws shall be determined in accordance with this procedure. Each discontinuity shall be accepted or rejected on a basis of its indication rating and its length in accordance with Table 17.3.

NDE – Methods (Chapter 16)

16.2.6 Preparation and Disposition of Reports

16.2.6.1 A report form that clearly identifies the work and the area of inspection shall be completed by the ultrasonic inspector at the time of inspection. The report form for welds that are acceptable need only contain sufficient information to identify the weld, the inspector's signature, and the acceptability of the weld. An example of such a form is shown in Annex D, Form D-7.

16.2.6.2 Before a weld subject to ultrasonic testing by the manufacturer for the purchaser is accepted, all report forms pertaining to the weld, including any that show unacceptable quality prior to repair, shall be made available to the inspector.

16.2.6.3 A full set of completed report forms of welds subject to ultrasonic testing by the manufacturer for the Owner, including any that show unacceptable quality prior to repair, shall be delivered to the Owner upon completion of the work. The manufacturer's obligation to retain ultrasonic reports shall cease (1) upon delivery of this full set to the Owner, or (2) one full year after completion of the manufacturer's work, provided that the Owner is given prior written notice.

NDE – Methods (Chapter 16)

16.3 Liquid Penetrant Testing of Welds. When liquid penetrant inspection is used, the inspection shall be in accordance with a written procedure that meets the requirements of ASTM E165, *Practice for Liquid Penetrant Inspection Method*, and shall be evaluated on the basis of the relevant portions of the acceptance criteria of 17.2. For aluminum welds, liquid penetrant testing shall not be used for intermediate passes of multipass welds.

16.4 Magnetic Particle Testing of Welds. When magnetic particle inspection is used, the inspection shall be in accordance with a written procedure that meets the requirements of ASTM E709, *Practice for Magnetic Particle Examination*, and shall be evaluated on the basis of the relevant portions of the acceptance criteria of 17.2.

NDE – Methods (Chapter 16)

Legend for Figures 16.1, 16.2, and 16.3

Dimensions of Discontinuities

B = Maximum allowed dimension of a radiographed discontinuity.

L = Largest dimension of a radiographed discontinuity.

L' = Largest dimension of adjacent discontinuities.

C = Minimum clearance measured along the longitudinal axis of the weld between edges of porosity or fusion-type discontinuities (larger of adjacent discontinuities governs), or to an edge or an end of an intersecting weld.

C_1 = Minimum allowed distance between the nearest discontinuity to the free edge of a plate or tubular, or the intersection of a longitudinal weld with a girth weld, measured parallel to the longitudinal weld axis.

W = Smallest dimension of either of adjacent discontinuities.

Material Dimensions

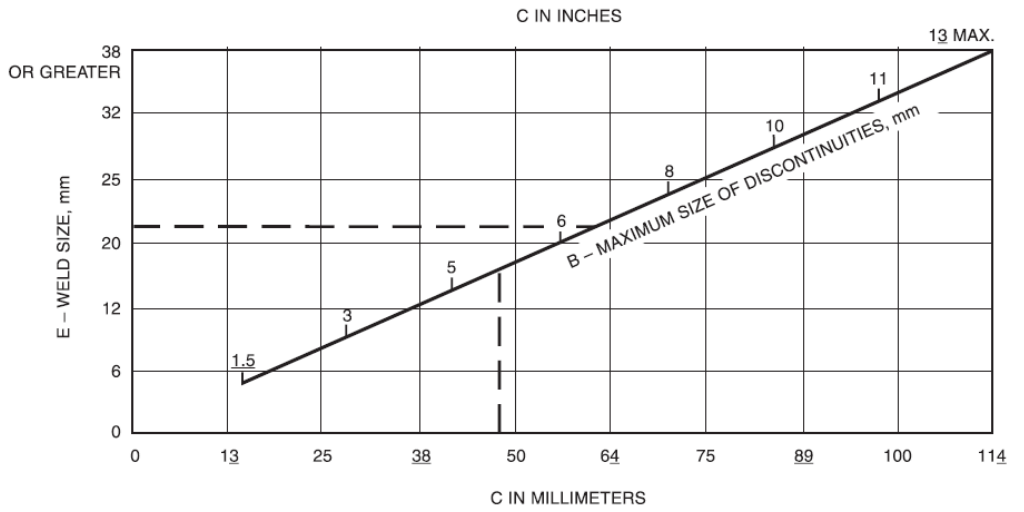
E = Weld size.

T = Plate or pipe thickness for CJP groove welds.

Definitions of Discontinuities

- An elongated discontinuity shall have the largest dimension (L) exceed 3 times the smallest dimension.
- A rounded discontinuity shall have the largest dimension (L) less than or equal to 3 times the smallest dimension.
- A cluster shall be defined as a group of nonaligned, acceptably-sized, individual adjacent discontinuities with spacing less than the minimum allowed (C) for the largest individual adjacent discontinuity (L'), but with the sum of the greatest dimensions (L) of all discontinuities in the cluster equal to or less than the maximum allowable individual discontinuity size (B). Such clusters shall be considered as individual discontinuities of size L for the purpose of assessing minimum spacing.

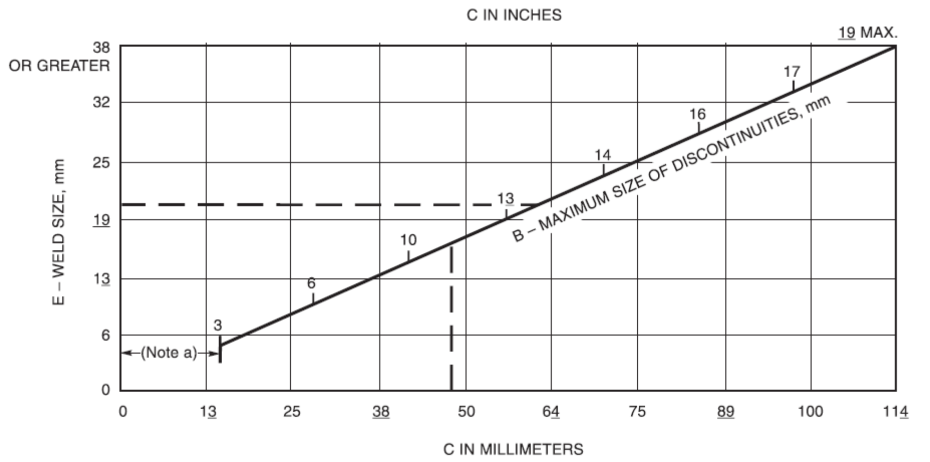
NDE – Methods (Chapter 16)



Notes:
1. To determine the maximum size of discontinuity allowed in any joint or weld size, project E horizontally to B.
2. To determine the minimum clearance allowed between edges of discontinuities of any size greater than or equal to 3/32 in [2.5 mm], project B vertically to C.
3. See Legend on page 147 for definitions.

Source: AWS D1.1/D1.1M:2006, *Structural Welding Code—Steel*, Figure 6.4, American Welding Society.

Figure 16.1—Weld Quality Requirements for Discontinuities Occurring in Cyclically Loaded Nontubular Tension Welds (Limitations of Porosity and Fusion Discontinuities)



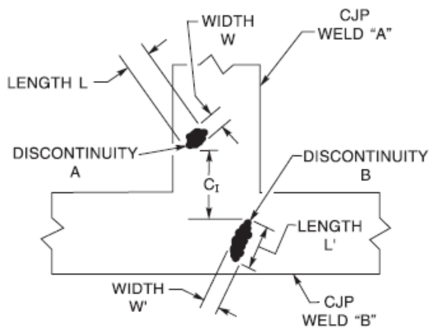
[a] The maximum size of a discontinuity located within this distance from an edge of plate shall be 1/8 in [3 mm], but a 1/8 in [3 mm] discontinuity shall be 1/4 in [6 mm] or more away from the edge. The sum of discontinuities less than 1/8 in [3 mm] in size and located within this distance from the edge shall not exceed 3/16 in [5 mm]. Discontinuities 1/16 in [1.5 mm] to less than 1/8 in [3 mm] shall not be restricted in other locations unless they are separated by less than 2 L (L being the length of the larger discontinuity); in which case, the discontinuities shall be measured as one length equal to the total length of the discontinuities and space and evaluated as shown in Figure 16.2.

Notes:
1. To determine the maximum size of discontinuity allowed in any joint or weld size, project E horizontally to B.
2. To determine the minimum clearance allowed between edges of discontinuities of any size, project B vertically to C.
3. See Legend on Page 147 for definitions.

Source: AWS D1.1/D1.1M:2006, *Structural Welding Code—Steel*, Figure 6.5, American Welding Society.

Figure 16.2—Weld Quality Requirements for Discontinuities Occurring in Cyclically Loaded Nontubular Compression Welds (Limitations of Porosity or Fusion-Type Discontinuities)

NDE – Methods (Chapter 16)



KEY FOR FIGURE 6.6, CASES I, II, III, AND IV

WELD A = LONGITUDINAL TUBULAR CJP GROOVE WELD
WELD B = TUBULAR GIRTH CJP GROOVE WELD

DISCONTINUITY A = ROUNDED OR ELONGATED DISCONTINUITY LOCATED IN WELD A
DISCONTINUITY B = ROUNDED OR ELONGATED DISCONTINUITY LOCATED IN WELD B

L AND W = LARGEST AND SMALLEST DIMENSIONS, RESPECTIVELY, OF DISCONTINUITY A
L' AND W' = LARGEST AND SMALLEST DIMENSIONS, RESPECTIVELY, OF DISCONTINUITY B

E = WELD SIZE
C_I = SHORTEST DISTANCE PARALLEL TO THE WELD A AXIS, BETWEEN THE NEAREST DISCONTINUITY EDGES

CASE I DISCONTINUITY LIMITATIONS[a]

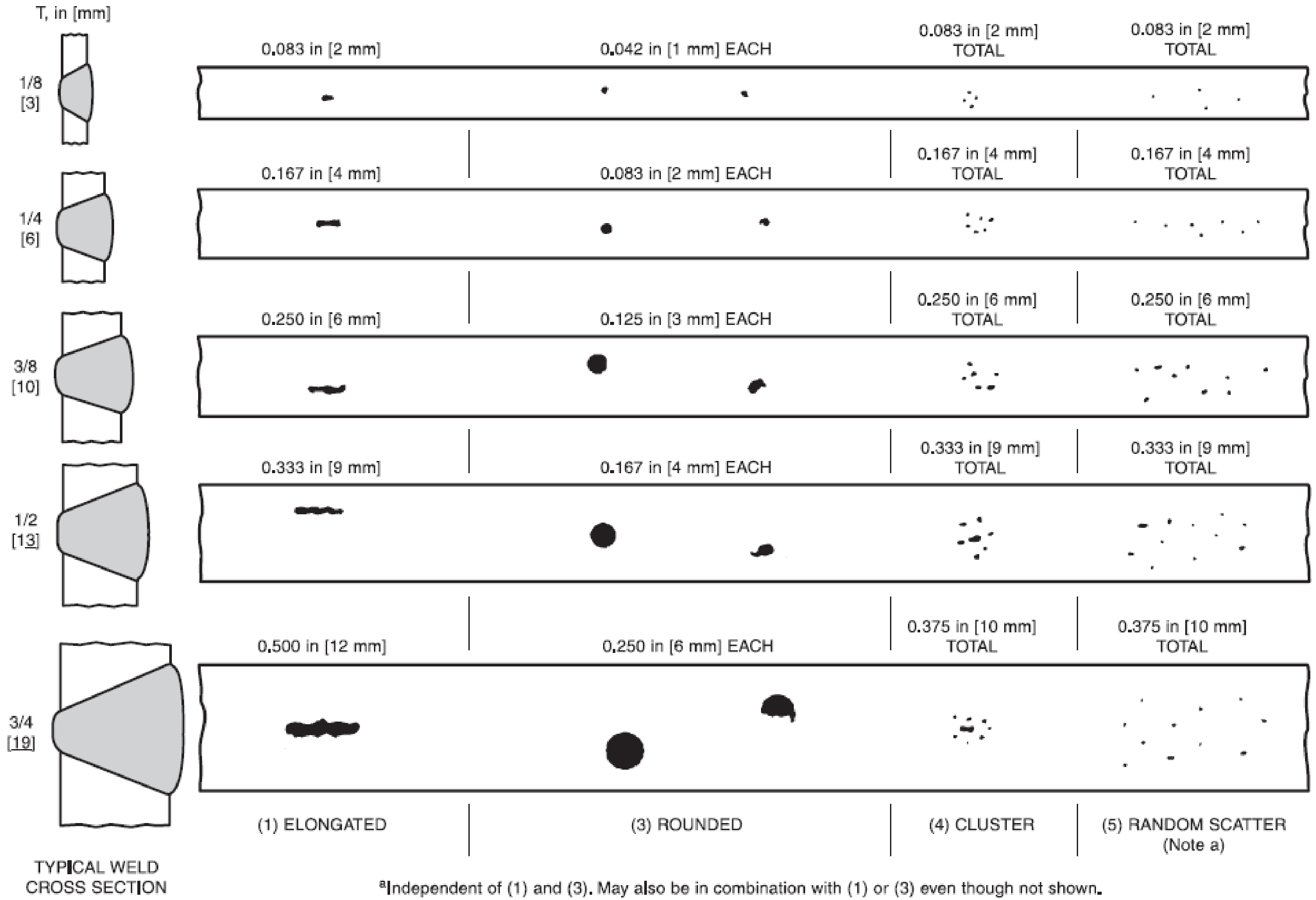
DISCONTINUITY DIMENSION	LIMITATIONS	CONDITIONS
L	< E/3, ≤ 1/4 in [6 mm]	E ≤ 2 in [50 mm]
	≤ 3/8 in [10 mm]	E > 2 in [50 mm]
C_I	≥ 3L	(A) ONE DISCONTINUITY ROUNDED, THE OTHER ROUNDED OR ELONGATED[a] (B) L ≥ 3/32 in [2.5 mm]

[a] The elongated discontinuity may be located in either the longitudinal or girth weld. For the purposes of this illustration, discontinuity B was located in the girth weld.

Case I—Discontinuity at Weld Intersection

Figure 16.3 (Continued)—Weld Quality Requirements for Elongated Discontinuities as Determined by RT of Tubular Joints

NDE – Methods (Chapter 16)



[a]Independent of (1) and (3). May also be in combination with (1) or (3) even though not shown.

Source: AWS D1.1/D1.1M:2006, *Structural Welding Code—Steel*, Figure 6.2, American Welding Society.

Figure 16.4—Maximum Acceptable RT Images

Acceptance Criteria (Chapter 17)

17. Acceptance Criteria

17.1 Temporary Welds. Welds that are to be removed are not subject to visual inspection acceptance criteria. When welds are removed, the surface shall be made flush with the original surface.

17.2 Visual Inspection Acceptance Criteria

17.2.1 Cracks shall not be permitted (see 8.7.1 for Side Frame Column Guide wear plate welding).

17.2.2 Incomplete fusion shall not be permitted.

17.2.3 Craters. See Table 17.1.

17.2.4 Weld profiles shall be in accordance with 6.4.

17.2.5 Undercut and porosity shall conform to the limits of the applicable class shown in Table 17.2.

17.2.6 Weld size of fillet welds shall not be below the specified size by more than 1/32 in [0.8 mm] except that fillet welds over 3/16 in [5 mm] may be 1/16 in [1.5 mm] undersize for up to 10% of the length of the weld.

17.2.7 Spatter shall not be permitted in areas where it would interfere with the function, inspection, or corrosion protection of the member.

Acceptance Criteria (Chapter 17)

17.3 Radiographic Inspection Acceptance Criteria

17.3.1 Welds that are subject to radiographic inspection in addition to visual inspection shall have no cracks or incomplete fusion. CJP welds shall have no incomplete joint penetration.

17.3.2 Welds shall be unacceptable if inspection shows individual discontinuities (tungsten inclusions shall be considered porosity) having a greatest dimension greater than those allowed by Figure 16.1, 16.2, or 16.3, as applicable, or showing greater dimensions than those shown in Figure 16.4 or 16.5, as applicable.

17.4 Ultrasonic Inspection Acceptance Criteria. Welds that are subject to ultrasonic inspection shall be acceptable if they meet the acceptance criteria of Table 17.3.

17.5 Liquid Penetrant Acceptance Criteria. Welds that are subject to liquid penetrant inspection shall be evaluated on the basis of the relevant portions of the acceptance criteria in 17.2.

17.6 Magnetic Particle Acceptance Criteria. Welds that are subject to magnetic particle inspection shall be evaluated on the basis of the relevant portions of the acceptance criteria in 17.2.

Acceptance Criteria (Chapter 17)

Table 17.1
Weld Crater Limitations

Material	Weld Type and Size	Allowable Crater Depth
Steel	Fillet < 3/16 in [5 mm]	1/32 in [0.8 mm] max.[a]
	Fillet 3/16 in [5 mm] and larger	1/16 in [1.5 mm] max.[a]
	Groove < 1/2 in [13 mm]	1/32 in [0.8 mm] max.[a]
	Groove 1/2 in [13 mm] and larger	1/16 in [1.5 mm] max.[a]
Aluminum	Fillet or Groove—All sizes	None—All craters shall be filled

[a] Crater depths in excess of these limits shall be filled.

Table 17.2
Undercut and Porosity Limitations

	Quality Level	
	Class 1 Weld[a]	Class 2 Weld[b]
Undercut:	Less than 1/64 in [0.5 mm]	1/32 in [0.8 mm] or 12-1/2% of the material thickness, whichever is less.
Porosity:	No more than one pore in each 4 in [100 mm] of weld. No pore exceeding 3/32 in [2.5 mm] diameter.	No single pore exceeding 3/32 in [2.5 mm] diameter. Sum of the diameters of pores shall not exceed 3/8 in [10 mm] in any linear inch [25 millimeters] of weld and shall not exceed 3/4 in [19 mm] in any 12 linear inches [300 linear millimeters].

[a] All Class 1 welds shall be specified on the drawing.
[b] All other welds shall be considered to be in Class 2 unless otherwise specified in the drawing.

Acceptance Criteria (Chapter 17)

Table 17.3
Ultrasonic Inspection Acceptance—Rejection Criteria

Flaw Severity	Weld Thickness, in [mm] and Search Unit Angle										
	5/16 to 3/4 [8 to 19]	>3/4 to 1-1/2 [>19 to 38]	>1-1/2 to 2-1/2 [>38 to 64]			>2-1/2 to 4 [>64 to 100]			>4 to 8 [>100 to 200]		
Class	70°	70°	70°	60°	45°	70°	60°	45°	70°	60°	45°
A	+5 and lower	+2 and lower	–2 and lower	+1 and lower	+3 and lower	–5 and lower	–2 and lower	0 and lower	–7 and lower	–4 and lower	–1 and lower
B	+6	+3	–1 0	+2 +3	+4 +5	–4 –3	–1 0	+1 +2	–6 –5	–3 –2	0 +1
C	+7	+4	+1 +2	+4 +5	+6 +7	–2 to +2	+1 +2	+3 +4	–4 to +2	–1 to +2	+2 +3
D	+8 and up	+5 and up	3 and up	+6 and up	+8 and up	+3 and up	+3 and up	+5 and up	+3 and up	+3 and up	+4 and up

Notes:
1. Class B and C flaws shall be separated by at least 2L, L being the length of the longer flaw, except that when two or more such flaws are not separated by at least 2L, but the combined length of flaws and their separation distance is equal to or less than the maximum allowable length under the provision of Class B or C, the flaw shall be considered a single acceptable flaw.
2. Class B and C flaws shall not begin at a distance less than 2L from weld ends carrying primary tensile stress, L being the flaw length.

Class A (large flaws)
Any indication in this category shall be rejected (regardless of length).

Class B (medium flaws)
Any indication in this category having a length greater than 3/4 in [19 mm] shall be rejected.

Class C (small flaws)
Any indication in this category having a length greater than 2 in [51 mm] shall be rejected.

Class D (minor flaws)
Any indication in this category shall be accepted regardless of length or location in the weld.

Scanning Levels	
Sound Path, in[a] [mm[a]]	Above Zero Reference, dB
to 2-1/2 [64]	14
>2-1/2 to 5 [>64–125]	19
>5 to 10 [>125–250]	29
>10 to 15 [>250–375]	39

[a] This column refers to sound path distance, NOT material thickness.

Requirements for Welding Sheet Metal (Chapter 18)

18. Requirements for Welding Sheet Metal

This clause is applicable for welds made on base metal thinner than 1/8 in [3 mm] (see 9.1.5). The provisions of Clauses 5 through 17 apply to these materials, except as noted below.

18.1 Design of Welded Joints

18.1.1 General. Welded connections may be made using groove welds, arc spot or arc seam welds, lap, T or corner fillet welds, and single-flare-bevel or single-flare-V-groove welds as shown in Figures 18.1 through 18.8.

18.1.2 Square Grooves. Square grooves shall be used in butt joints with the welding preferably done in the flat position. Root opening (gap) conditions shall be as shown in Figure 18.1.

Requirements for Welding Sheet Metal (Chapter 18)

18.1.3 Arc Spot Welds. Arc spot welds through one or two thicknesses of base metal onto a supporting member as shown in Figure 18.2 shall be made in the position qualified. For sheets thinner than 0.028 in [0.5 mm], a washer, as shown in Figure 18.3 shall be used to prevent burn back. The weld metal shall have a diameter of at least 3/8 in [10 mm] on the supporting structural member.

The minimum distance(s) from the center of an arc spot weld to any edge of the sheet material shall be as follows:

$$e\,min = \frac{P}{0.5F_u t} \quad \text{for } \frac{Fu}{FY} \geq 1.15 \qquad \text{(Eq. 2)}$$

or

$$e\,min = \frac{P}{0.45F_u t} \quad \text{for } \frac{Fu}{FY} < 1.15 \text{ but not less than } 1.5d \qquad \text{(Eq. 3)}$$

(See Figure 18.4)

where

P = force transferred by the arc spot or arc slot weld
F_u = specified minimum ultimate tensile strength of base metal (ksi)
FY = specified yield strength of base metal
t = thickness of base metal exclusive of thickness of coating for single sheet or combined thickness of base metal for double sheet
$e\,min$ = minimum distance from center of the arc spot or arc slot weld to the edge of the top sheet

NOTE: Formulas for U.S. standards only. Convert e min to SI Units after final calculation.

Requirements for Welding Sheet Metal (Chapter 18)

18.1.4 Single-Flare-Bevel-Groove Welds. The minimum length shall be 3/4 in [19 mm] (see Figure 18.7) unless otherwise specified on the drawing or dictated by part size.

18.1.5 Plug and Slot Welds. The effective area shall be the minimal area of the hole or slot in the plane of the faying surface.

18.1.6 Fillers. Filler shall be used only with approval by the Fabricator's Engineer and Owner's Engineer. When used, fillers shall conform to the requirements of 5.5.3.

18.2 Joint and Procedure Qualification for Welding Sheet Metal. Joints and welding procedure specifications for base metals less than 1/8 in [3 mm] thick, that are qualified under the provisions of AWS B2.1/B2.1M, are considered qualified under this specification. All other cases shall be qualified in accordance with 18.2.1.

18.2.1 WPS Requirements. WPSs shall be qualified for any change in process and essential variables as listed in Table 18.1.

18.2.2 Number of Tests, Methods of Testing, and the Results Required for the Qualification of Arc Welding Procedure Specifications

18.2.2.1 Groove and Fillet Welds

(1) Two rectangular pieces of material to be tested, at a minimum of 4 in [100 mm] wide and long, shall be welded. The weld shall be a minimum of 4 in [100 mm] long (see Figure 18.11). Weldments and tests shall be in accordance with Table 18.2.

Requirements for Welding Sheet Metal (Chapter 18)

18.2.2 Number of Tests, Methods of Testing, and the Results Required for the Qualification of Arc Welding Procedure Specifications

18.2.2.1 Groove and Fillet Welds

(1) Two rectangular pieces of material to be tested, at a minimum of 4 in [100 mm] wide and long, shall be welded. The weld shall be a minimum of 4 in [100 mm] long (see Figure 18.11). Weldments and tests shall be in accordance with Table 18.2.

(2) The weld shall meet the following visual inspection requirements:

(a) no incomplete fusion;

(b) no incomplete joint penetration;

(c) face/root reinforcement or convexity shall not exceed 50% of the thickness of the thinner member;

(d) no more than one visible pore or inclusion in any 1 in [25 mm] of weld. The size of any pore or inclusion shall not exceed 0.25T, where T is the thickness of the thinner member;

(e) no undercut exceeding 0.15T; and

(f) no cracks.

Requirements for Welding Sheet Metal (Chapter 18)

(3) After the test joints have been made, they shall be bent back upon themselves completely, the axis of the bend being parallel to the axis of the weld (see Figure 18.9). In case of a joint welded from one side only, the root of the weld shall be on the face of the bend.

(4) A weld shall be considered satisfactory if:

(a) no cracks are evident after bending except in the first and last 0.5 in [13 mm] of the weld;

(b) the weld has not fractured at the root; and

(c) there is no evidence of incomplete fusion.

(5) Cracks in the base metal shall not be cause for weld rejection.

18.2.2.2 Arc Spot Welds. The company shall establish a welding procedure specification for each single and double thickness of sheet to be arc spot welded to a supporting member. Two welded assemblies shall be tested. First multiple rectangular pieces, 2-1/2 in [64 mm] or wider, shall be clamped as shown in Figure 18.2. Then the welder shall make an arc spot weld of the diameter required for procedure qualification, producing a nugget not less than 3/8 in [10 mm] in diameter. The crater of the spot weld shall be filled and 1/32 in [0.8 mm] minimum reinforcement provided.

Requirements for Welding Sheet Metal (Chapter 18)

(1) Appearance of the weld shall be in accordance with the requirements of 17.2.

(2) After the weld has cooled, the projecting part of the sheet shall be struck repeatedly with a hammer, as shown in Figure 18.10 until the failure occurs. The diameter of the weld nugget remaining shall be measured for the required minimum diameter as shown in Figure 18.2. If such minimum diameter has not been obtained or if the weld is otherwise not satisfactory, the welding current shall be adjusted and the test repeated until all requirements are met.

(3) The qualification of an arc spot weld between a single sheet, or multiple sheets and a supporting member shall qualify for the position tested.

(4) A change in one of the following essential variables, exceeding the requirements of Table 18.1, shall require requalification:

(a) For all welding processes a change in base metal, weld size, filler metal "F" number, or position of welding.

(b) For gas metal arc or flux cored arc welding, a change in welding current, shielding gas, or wire feed rate.

18.2.2.3 Stud Welding. When qualifying studs to be forced through sheet steels onto structural members, the sheet steel shall be placed tightly against the structural member. The workmanship requirements of 6.13 shall apply.

Requirements for Welding Sheet Metal (Chapter 18)

18.3 Records. Records of the test results shall be kept by the manufacturer and be available to those authorized to examine them. Records shall include:

18.3.1 Welding Procedure Specification (WPS) listing essential variables (see Annex D).

18.3.2 Procedure Qualification Records (PQR) used to qualify the welding procedure (see Annex D).

18.3.3 Supporting inspection and test reports.

Requirements for Welding Sheet Metal (Chapter 18)

Table 18.1
Essential and Non-Essential Variables[a] for Inclusion in WPS
FCAW, GMAW, GTAW, and SMAW (See 18.2.1)

Essential Variable Changes Requiring Requalification:	Process			
	FCAW	GMAW	GTAW	SMAW
Joint Design				
(1) A change in joint design type from one of the below to another type:	X	X	X	X
(a) Square or V groove				
(b) Fillet				
(c) Flare Bevel or Flare V				
(2) A change in groove joint design that results in:	X	X	X	X
(a) An increase in root opening of more than 25%				
(b) The omission, but not addition, of backing material or back welding				
(c) The addition or omission of consumable inserts				
(d) The omission or inclusion of a spacer strip				
(e) The omission but not inclusion of backgouging				
(3) For plug and slot welds:	X	X	X	X
(a) A decrease in the specified slot width or hole diameter to less than material thickness +0.25 in [+6.35 mm] of the material with the hole or slot				
(b) A change in the depth (Material Thickness) of the slot or hole of more than 50%				
(c) A decrease in thickness of the specified backing base metal of more than 50%				

Requirements for Welding Sheet Metal (Chapter 18)

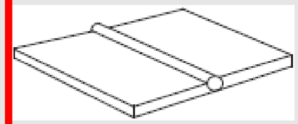
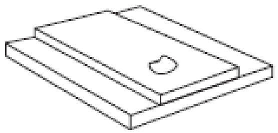
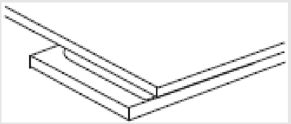
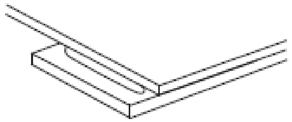
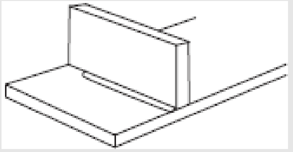
	FCAW	GMAW	GTAW	SMAW
Base Metal				
(4) A change from one "M" number to another "M" number or to an unlisted base metal, unless the unlisted base metal can be shown to have mechanical properties in the same range and a similar chemical composition within the same range as verified by the Fabricator's Engineer	X	X	X	X
(5) A change in the type of coating material, or the addition, but not the deletion of coating material on the base metal. (*NOTE: Anti-spatter compound is not considered a coating material.*)	X	X	X	X
(6) A change in base metal thickness of more than 50%	X	X	X	X
Filler Metals				
(7) A change in electrode classification (e.g., change from E7018-1 to E7018, ER70S-3 to ER70S-6, E71T-1 to E71T-5, ER4043 to ER5554	X	X	X	X
(8) A change in tungsten electrode type per AWS A5.12M/A5.12	—	—	X	—
(9) A change in the diameter of the electrode	X	X	X	X
(10) A change of more than 1/16 in [1.6 mm] in the diameter of filler wire	—	—	X	—
(11) The addition or deletion of filler metal	—	—	X	—

Requirements for Welding Sheet Metal (Chapter 18)

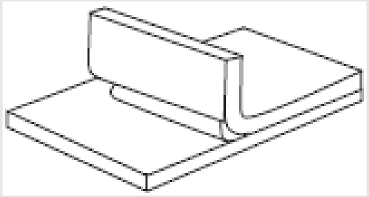
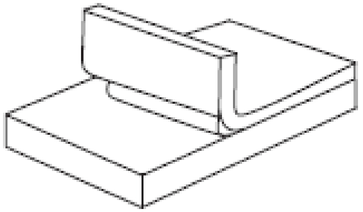
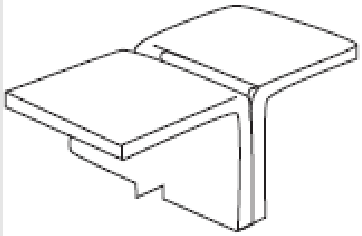
	FCAW	GMAW	GTAW	SMAW
Process Parameters				
(12) A change in current or polarity	X	X	X	X
(13) A change in amperage or voltage of more than 25%	X	X	X	X
(14) A change of more than 25% of the qualified mean travel speed—Aluminum only	X	X	X	X
(15) A change in mode of metal transfer	—	X	—	—
Shielding Gas				
(16) A change from a single gas to any other gas or to a mixture of gases or a change in the specified percentage composition of gas mixture	X	X	X	—
(17) The omission but not inclusion of backing gas	X	X	X	—
Preheat and Interpass Temperature				
(18) A decrease of more than 50°F [28°C] but not below 32°F [0°C]	X	X	X	X
(19) For a preheat temperature of 32°F [0°C], or lower, the test temperature is the minimum preheat temperature.	X	X	X	X
Technique				
(20) A change in the position of welding, as defined in Figures 10.1 and 10.2, except as permitted by Table 11.4				
(21) In vertical welding, changes in progression for any pass from upward to downward or vice versa.	X	X	X	X

Requirements for Welding Sheet Metal (Chapter 18)

Table 18.2
Procedure Qualification Tests

Test Assemblies as Shown are:	Type of Welded Joint Tested	Number of Tests Required for Each Welding Position and Thickness[a]	Type of Test	Qualifies for:
	Square or V groove butt joint, sheet to sheet, with any position	2	Bend	Square and V groove butt joint, sheet to sheet
	Arc spot weld, sheet to supporting member	2	Twist	Arc spot weld and arc seam weld, sheet to supporting member
	Fillet welded lap joint	2	Bend	Fillet welded lap joint, sheet to sheet, or sheet to supporting member, any position
	Fillet welded lap joint, sheet to supporting member	2	Bend	Fillet welded lap joint, sheet to supporting member
	Fillet welded T-joint, sheet to sheet	2	Bend	Fillet welded T- or lap or lap joint, sheet to sheet, or sheet to supporting member

Requirements for Welding Sheet Metal (Chapter 18)

Test Assemblies as Shown are:	Type of Welded Joint Tested	Number of Tests Required for Each Welding Position and Thickness[a]	Type of Test	Qualifies for:
	Flare bevel, sheet to sheet	2	Bend	Flare-bevel-groove weld, sheet to sheet, or sheet to supporting member or flare V-groove weld, sheet to sheet
	Flare bevel, sheet to supporting member	2	Bend	Flare-bevel-groove weld, sheet to supporting member
	Flare-V, sheet to sheet	2	Bend	Flare-V-groove weld, sheet to sheet or flare-bevel-groove weld, sheet to sheet, or sheet to supporting member

[a] Within the limits of essential variables.

Requirements for Welding Sheet Metal (Chapter 18)

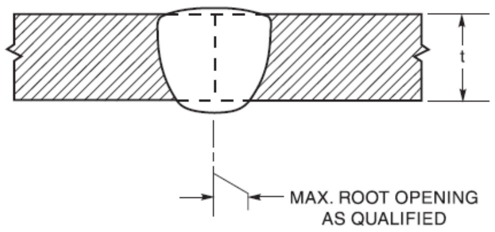
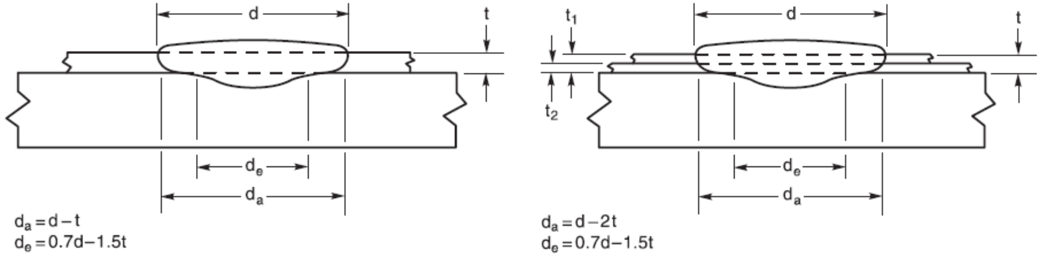


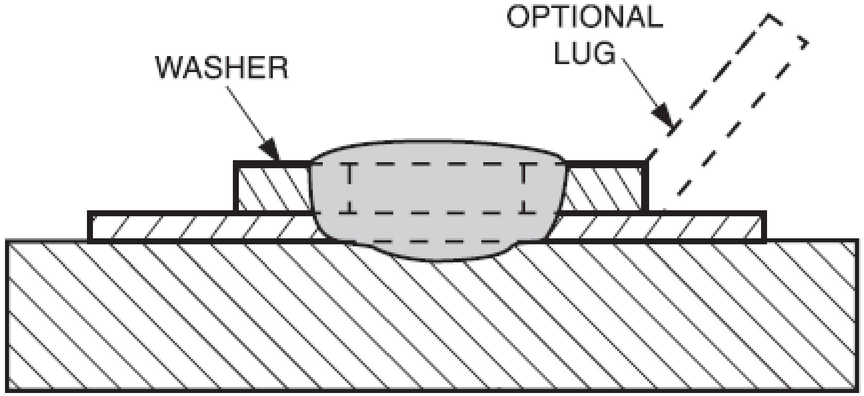
Figure 18.1—Square-Groove Weld in Butt Joint



(A) SINGLE THICKNESS OF SHEET

(B) DOUBLE THICKNESS OF SHEET

Figure 18.2—Arc Spot Welds



Note: e = d.

Figure 18.3—Arc Spot Weld Using Washer

Requirements for Welding Sheet Metal (Chapter 18)

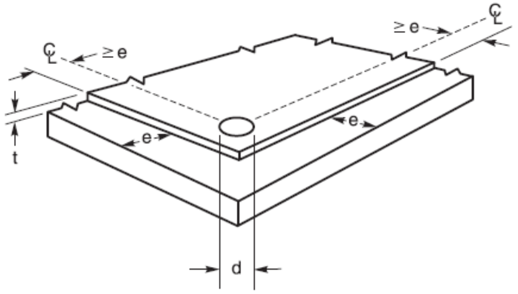


Figure 18.4—Edge Distances for Arc Spot Welds

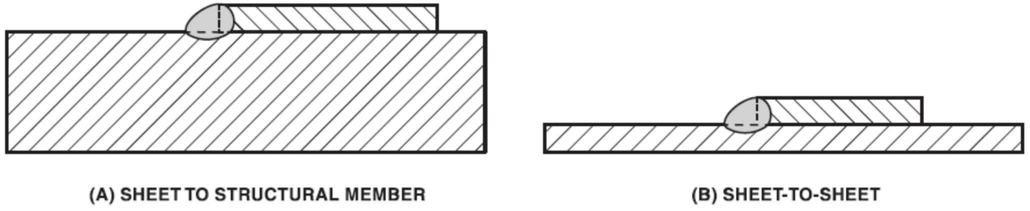


Figure 18.5—Lap-Fillet Welds

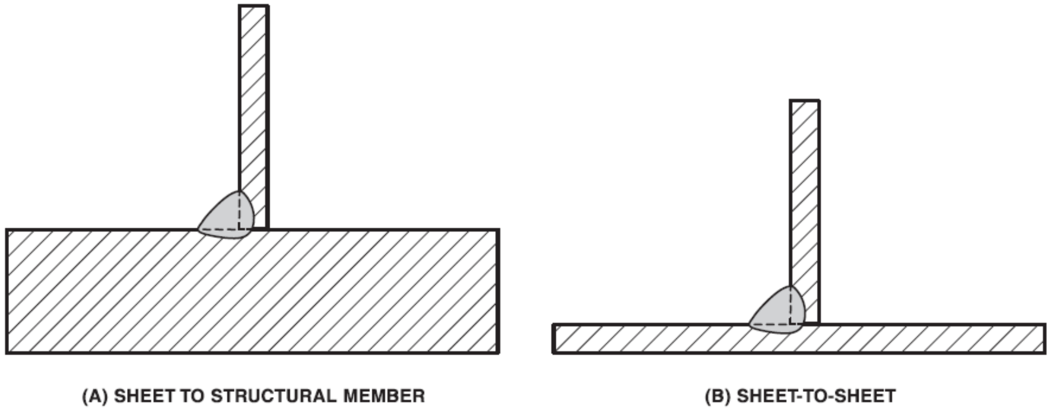


Figure 18.6—Fillet Welds in T-Joints

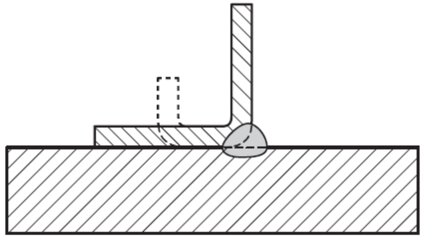


Figure 18.7—Single-Flare-Bevel-Groove Weld—Horizontal

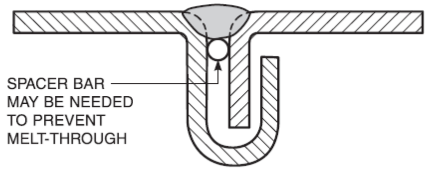


Figure 18.8—Single-Flare-V-Groove Weld—Flat

Requirements for Welding Sheet Metal (Chapter 18)

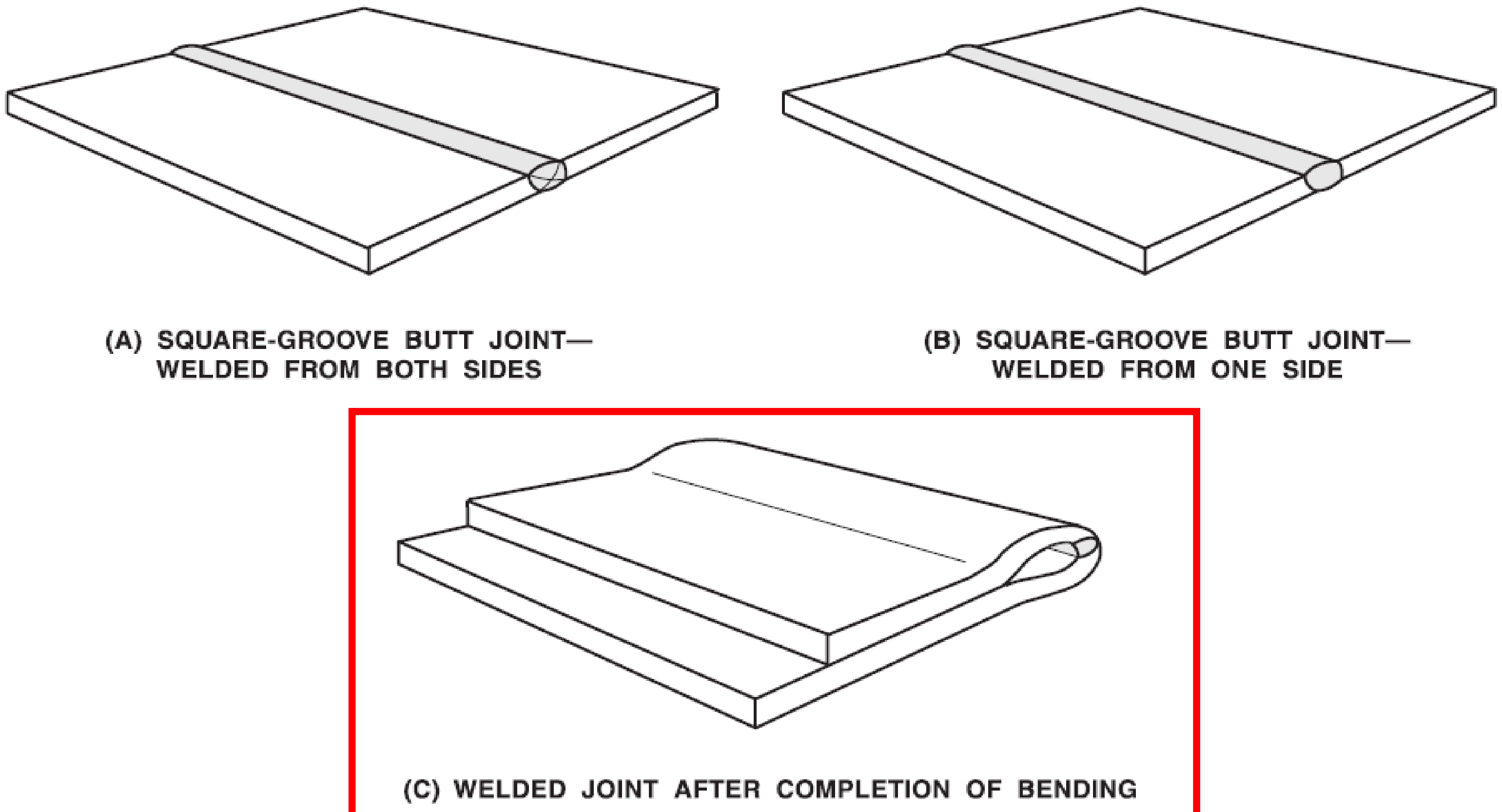


Figure 18.9—Square-Groove Butt Joints

Requirements for Welding Sheet Metal (Chapter 18)

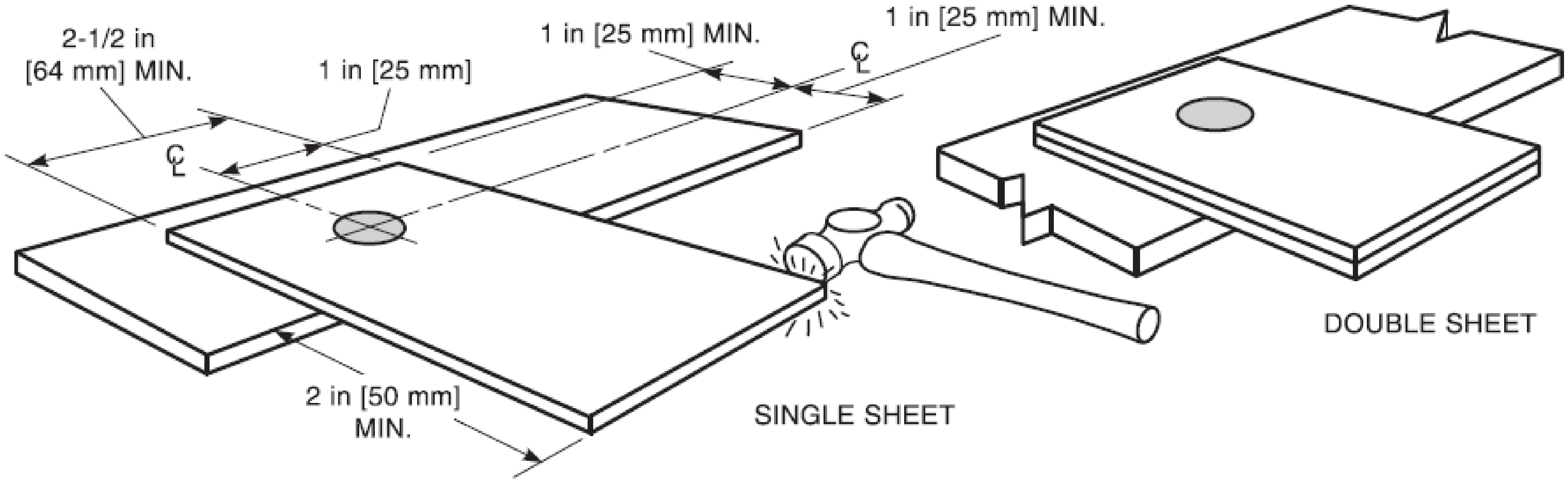


Figure 18.10—Test for Arc Spot Weld

Requirements for Welding Sheet Metal (Chapter 18)

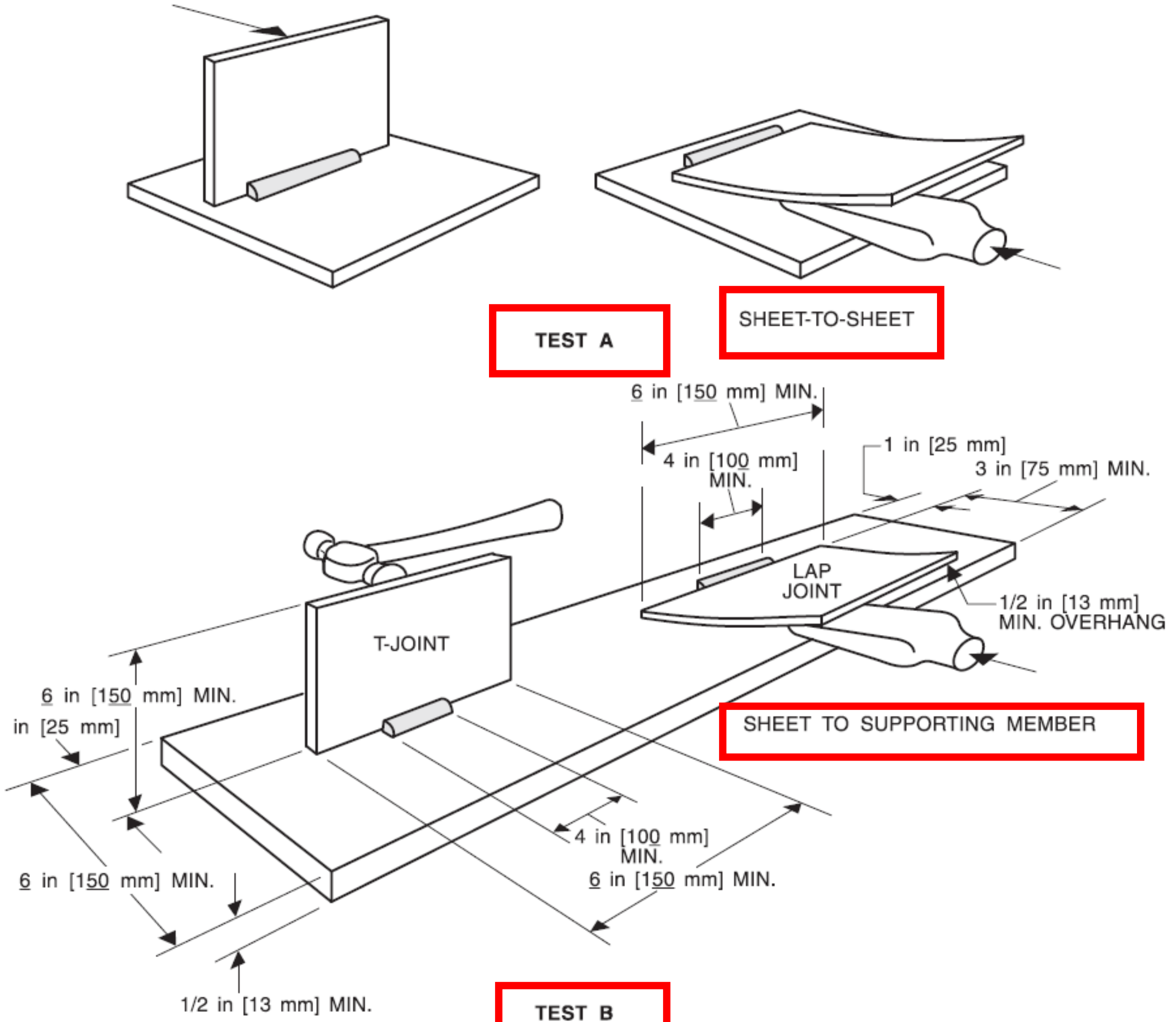


Figure 18.11—Fillet Weld Test Assembly

Requirements for Welding Sheet Metal (Chapter 18)

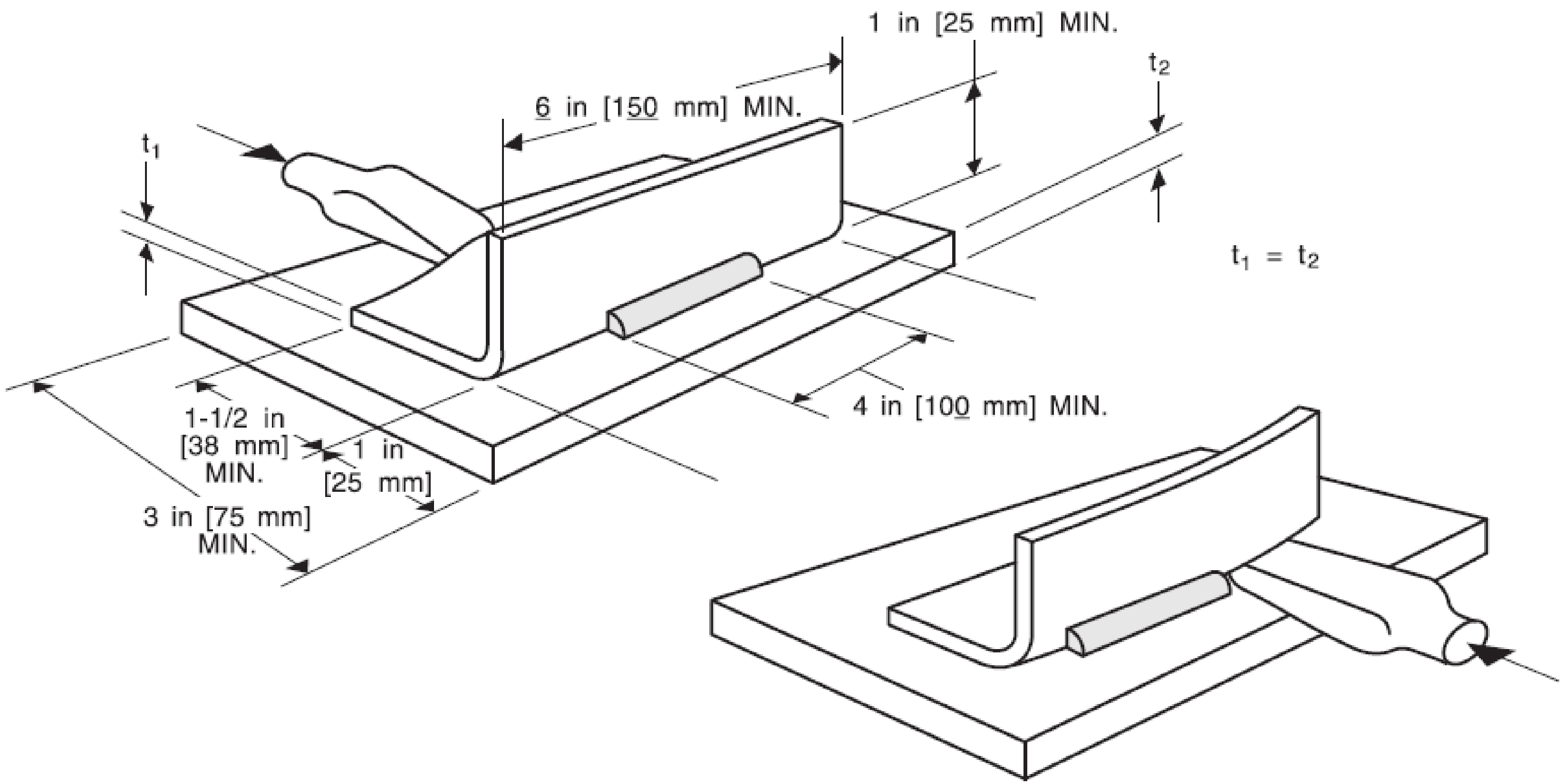


Figure 18.12—Standard Test Assembly for Flare-Bevel-Groove Welds; Test C—Sheet-to-Sheet

Requirements for Welding Sheet Metal (Chapter 18)

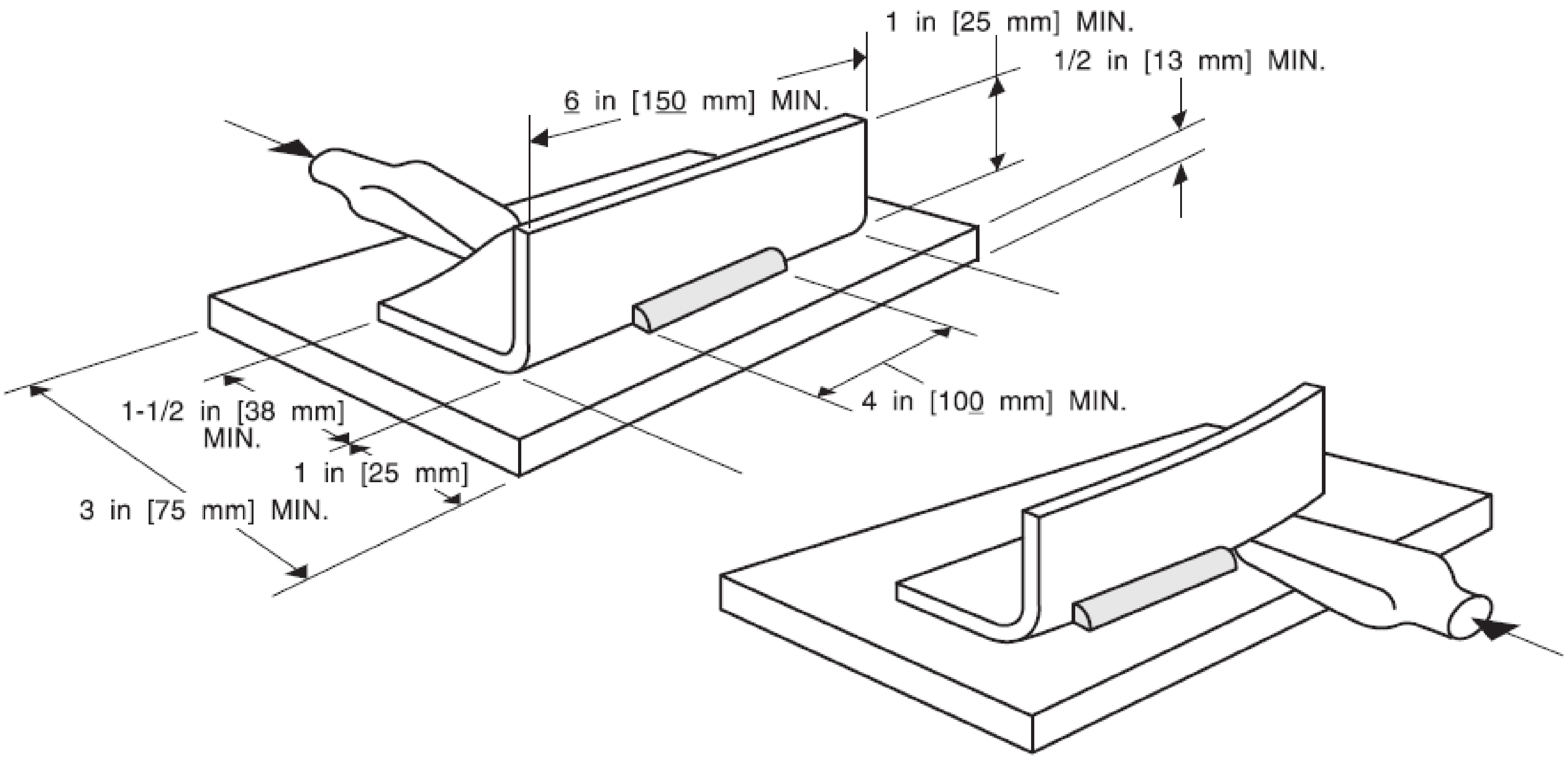


Figure 18.13—Standard Test Assembly for Flare-Bevel-Groove Weld; Test D—Sheet-to-Supporting Plate

Welder, Welding Operator, and Tack Welder Qualification –Carbon, Low Alloy, and Stainless Steel Sheet Metals (Chapter 19)

For welding on base metals less than 1/8 in [3 mm], the following qualification requirements apply:

19.1 General. The qualification tests described herein are specially devised tests to determine the welder's ability to produce sound welds. The qualification tests, shown in Table 19.2, shall be performed in accordance with the requirements of the procedure specification (see Form D-14A). These tests are not intended to be used as a guide during actual construction.

19.2 Limitation of Variables. The welder shall be required to qualify in each process to be used and for any change in the variables in each process as indicated in Table 19.1.

19.2.1 A qualified welding procedure specification shall be used for welder qualification. The number and type of test assemblies, the method of testing, and the test results shall be per Table 19.2.

19.2.2 The welder who completes a successful procedure qualification shall be considered qualified for the welding process within the parameters of Table 19.1 based on the Procedure Qualification Record.

19.2.3 For acceptance criteria refer to the applicable subclauses of 18.2.

Welder, Welding Operator, and Tack Welder Qualification –Carbon, Low Alloy, and Stainless Steel Sheet Metals (Chapter 19)

19.3 Retests

19.3.1 In case a welder, welding operator, or tack welder fails to meet the requirements of one or more weld tests, a retest may be allowed. A retest shall be made consisting of one test specimen of each type which the welder, welding operator, or tack welder, failed. It is recommended that additional documented training be given prior to the retest.

19.3.2 The performance test may be terminated at any stage of the testing procedure whenever it becomes apparent to the supervisor conducting the tests that the welder, welding operator, or tack welder, does not have the required skill to produce satisfactory results.

19.4 Period of Effectiveness. Qualification shall be considered as remaining in effect indefinitely unless (1) the welder, welding operator, or tack welder has not engaged in a given process of welding for which the welder is qualified for a period exceeding six months, or (2) there is some specific reason to question the welder, welding operator, or tack welder's ability.

19.5 Records Records of the test results shall be kept by the manufacturer and shall be available to those authorized to examine them. Records shall include;

19.5.1 Welder Qualification Record listing essential variables (see Form D-14A).

19.5.2 Supporting inspection and test reports.

Welder, Welding Operator, and Tack Welder Qualification –Carbon, Low Alloy, and Stainless Steel Sheet Metals (Chapter 19)

Table 19.1
Limitation of Variables for Welder Qualification
FCAW, GMAW, GTAW, and SMAW (See 19.2)

Essential Variable Changes Requiring Requalification:	Process			
	FCAW	GMAW	GTAW	SMAW
Joint Design				
(1) A change in joint design type from one of the below to another type:	X	X	X	X
(a) Groove				
(b) Fillet, Plug, or Slot				
(c) Flare Bevel or Flare V				
(2) The omission, but not addition, of backing material	X	X	X	X

Welder, Welding Operator, and Tack Welder Qualification –Carbon, Low Alloy, and Stainless Steel Sheet Metals (Chapter 19)

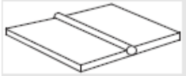
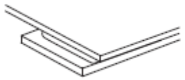
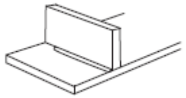
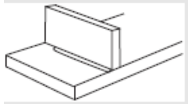
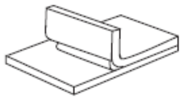
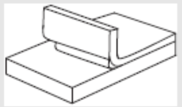
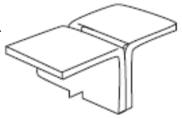
	FCAW	GMAW	GTAW	SMAW
Base Metal				
(3) A change from ferrous to nonferrous or vice-versa	X	X	X	X
(4) A change in the "M" number of nonferrous materials (a change involving only aluminum alloys is exempt)	X	X	X	X
(5) A change in base metal thickness of more than 50% from that qualified	X	X	X	X
(6) A change in coated sheet steel-to-coated sheet steel or coated sheet steel-to-sheet steel with another coating	X	X	X	X
Filler Metals				
(7) A change in electrode "F" number to a higher "F" number as identified in Table 11.2	—	—	—	X
(8) A change in tungsten electrode type per AWS A5.12M/A5.12	—	—	X	—
(9) A change of more than 1/32 in [0.8 mm] in the diameter of the electrode	X	X	X	X
(10) A change of more than 1/32 in [0.8 mm] in the diameter of filler wire	—	—	X	—
(11) The addition or deletion of filler metal	—	—	X	—

Welder, Welding Operator, and Tack Welder Qualification –Carbon, Low Alloy, and Stainless Steel Sheet Metals (Chapter 19)

	FCAW	GMAW	GTAW	SMAW
Process Parameters				
(12) A change in mode of metal transfer	—	X	—	—
Shielding Gas				
(13) A change from a gas containing more than 85% Argon to a gas containing less than 85% Argon, or vice-versa	—	X	—	—
Technique				
(14) The omission, but not inclusion, of backgouging	X	X	X	X
(15) A change in position of welding except as permitted by Table 19.2	X	X	X	X
(16) In vertical welding, changes in progression for any pass from upward to downward or vice-versa	X	X	X	X

Welder, Welding Operator, and Tack Welder Qualification –Carbon, Low Alloy, and Stainless Steel Sheet Metals (Chapter 19)

Table 19.2
Welder Qualification Tests
(See Clause 18 for Testing and Acceptance)

Test Assemblies as Shown are:	Type of: Welded Joint	Type of: Welding Position	Qualifies for: Welding Position	Qualifies for: Type of Welded Joint	Number of Tests	Type of Test
	Groove joint, sheet to sheet	F H V OH	F F, H F, V F, OH	All groove joints	2	Bend
	Fillet welded lap joint, sheet to sheet	F H V OH	F F, H F, V F, OH	All fillet joints	2	Bend
	Fillet welded lap joint, sheet to supporting member	F H V OH	F F, H F, V F, OH	All fillet joints	2	Bend
	Fillet welded T-joint, sheet to sheet	F H V OH	F F, H F, V F, OH	All fillet joints	2	Bend
	Fillet welded T-joint, sheet to supporting member	F H V OH	F F, H F, V F, OH	All fillet joints	2	Bend
	Flare-bevel, sheet to sheet	F H V OH	F F, H F, V F, OH	All flare-bevel-groove and flare-V-groove joints	2	Bend
	Flare-bevel, sheet to supporting member	F H V OH	F F, H F, V F, OH	All flare-bevel-groove and flare-V-groove joints	2	Bend
	Flare-V sheet to sheet	F H V OH	F F, H F, V F, OH	All flare-bevel-groove and flare-V-groove joints	2	Bend

20. Technique and Workmanship for Welding Sheet Metal

20.1 Surfaces to be welded shall be smooth, uniform, and free from fins, tears, cracks, or other imperfections which would adversely affect the quality or strength of the weld.

20.2 Surfaces to be welded and surfaces adjacent to a weld shall also be free from loose or thick scale, slag, rust, moisture, grease, or other foreign material that would prevent proper welding or produce objectionable fumes.

20.3 Mill scale that withstands vigorous wire brushing, a thin rust inhibitive coating, a galvanized coating, or an anti-spatter compound may remain.

20.3.1 Welding shall not be done when surfaces are wet or exposed to rain, sleet, snow, or high wind. Additionally, for carbon and low-alloy steel base metals, the ambient and base metal temperatures shall be at least 32°F [0°C]. For the welding of aluminum base metals, the ambient and base metal temperatures shall be at least 50°F [10°C].

20.3.2 If temperatures are below those required by 6.1.3 and 6.1.4, preheating shall be required to achieve the minimum base metal temperature. The ambient temperature shall be not less than 50°F [10°C] without adequate preheating prior to welding.

20.4 Joint details shall be arranged to provide the most favorable position for welding (see Figures 10.1 and 10.2 for a definition of welding positions).

21. Inspection of Welding Procedure Qualification and Equipment for Welding Sheet Metal

21.1 The Verification Inspector may ascertain that all welding procedures are qualified and covered by a welding procedure specification in accordance with Clause 9, 18.2.1, or 18.2.2, as applicable.

21.2 The Verification Inspector may inspect the welding equipment to be used for the work to make certain that it conforms to the requirements of 6.1.2.

21.3 The Verification Inspector may ascertain that the welding is performed only by welders, welding operators, and tack welders who are qualified in accordance with the requirements of Clause 11, 12, or 13, for material thicknesses 1/8 in [3 mm] and above. For material thicknesses less than 1/8 in [3 mm], the requirement of Clauses 19 and 20 shall apply.

22. Weld Details—Sheet Metal

Materials thinner than 1/8 in [3 mm] shall comply with the requirements listed for 1/8 in [3 mm] and thicker except as noted below:

22.1 Groove Welds (Butt Joints). Root openings of groove welds shall be in accordance with the requirements of Figure 18.1.

22.2 Fillet Welds. Root openings of fillet welds forming a T- or lap joint shall not exceed 0.5 times the thickness of the thinner member.

23. Sheet Metal Weld Quality—Visual Inspection Acceptance Criteria

The cumulative length of undercut shall be no longer than L/8, where L is the specified length of the weld, or in the case of arc spot welds, the circumference, provided fusion exists between the weld metal and base metal. Depth of undercut is not a subject of inspection and need not be measured. Melt-through that results in a hole is unacceptable.

Annex A (Normative)

Alternate Base Material Specifications (Steel)

This annex is part of this standard and includes mandatory elements for use with this standard.

This annex provides M numbers and group numbers for steels used in the railroad industry that may or may not be included in AWS B2.1/B2.1M.

Table A.1
Numerical Indexing of Base Material Specifications (Steel)

Standard	Base Metal Specification	M No.	Group No.	Type, Grade, or Alloy	UNS Number	Type of Base Metal
ASTM	A436	2F	—	All		
ASTM	A439	2G	—	All		
ASTM	A744	8	1	TP304L	S30403	Note a
ASTM	A744	8	1	TP316L	S30603	Note a
ASTM	A744	8	1	TP317L	S30703	Note a
ASTM	A744	8	1	TP321	S32103	Note a
ASTM	A744	8	1	TP347	S34703	Note a
AAR	M201	1	1	Grade A		
AAR	M201	1	2	Grade B		
AAR	M201	1	3	Grade B+		
AAR	M201	1	4	Grade C		
AAR	TC128	10C	1	Grade B		

[a]As Welded Wrought Fittings

Annex B (Informative)

Filler Metal Classifications

This annex is not part of this standard but is included for informational purposes only.

Table B.1
Grouping of Welding Electrodes and Rods for Qualification

F-No.	AWS Specification	AWS Classification
	Steel and Steel Alloys	
1	A5.1/A5.1M	EXX20, EXX22, EXX24, EXX27, EXX28
1	A5.4/A5.4M	EXXX(X)-26
1	A5.5/A5.5M	EXX20-X, EXX27-X
2	A5.1/A5.1M	EXX12, EXX13, EXX14, EXX19
2	A5.5/A5.5M	E(X)XX13-X
3	A5.1/A5.1M	EXX10, EXX11
3	A5.5/A5.5M	E(X)XX10-X, E(X)XX11-X
4	A5.1/A5.1M	EXX15, EXX16, EXX18, EXX18M, EXX48
4	A5.4/A5.4M other than austenitic and duplex	EXXX(X)-15, EXXX(X)-16, EXXX(X)-17
4	A5.5/A5.5M	E(X)XX15-X, E(X)XX16-X, E(X)XX18-X, E(X)XX18M, E(X)XX18M1
5	A5.4/A5.4M austenitic and duplex	EXXX(X)-15, EXXX(X)-16, EXXX(X)-17

Table B.1
Grouping of Welding Electrodes and Rods for Qualification

F-No.	AWS Specification	AWS Classification
6	A5.2/A5.2M	All classifications
6	A5.9/A5.9M	All classifications
6	A5.17/A5.17M	All classifications
6	A5.18/A5.18M	All classifications
6	A5.20/A5.20M	All classifications
6	A5.22/A5.22M	All classifications
6	A5.23/A5.23M	All classifications
6	A5.25/A5.25M	All classifications
6	A5.26/A5.26M	All classifications
6	A5.28/A5.28M	All classifications
6	A5.29/A5.29M	All classifications
6	A5.30/A5.30M	INMs-X, IN5XX, IN3XX(X)

Table B.2
AWS A5.36/A5.36M Retained Flux Cored and Metal Cored Electrode Classifications with Fixed Requirements[a]

Electrode Type	Classification Designation[b]	Shielding Gas[c]	Weld Deposit Requirements (As-Welded)	Deposit Composition[d]
Flux Cored	E7XT-1C [E49XT-1C]	C1	Tensile Strength: 70–95 ksi [490–670 MPa] Minimum Yield Strength: 58 ksi [390 MPa] Min. Charpy Impact: 20 ft·lbf@ 0°F [27 J@–20°C] Minimum % Elongation: 22%	CS1
	E7XT-1M [E49XT-1M]	M21[g]		
	E7XT-5C [E49XT-5C]	C1	Tensile Strength: 70–95 ksi [490–670 MPa] Minimum Yield Strength: 58 ksi [390 MPa] Min. Charpy Impact: 20 ft·lbf @ –20°F [27 J @ –30°C] Minimum % Elongation: 22%	
	E7XT-5M [E49XT-5M]	M21[g]		
	E7XT-9C[e] [E49XT-9Ce]	C1		
	E7XT-9M[e] [E49XT-9Me]	M21[g]		
	E7XT-6 [E49XT-6]	None (Self-Shielded)	Tensile Strength: 70–95 ksi [490–670 MPa] Minimum Yield Strength: 58 ksi [390 MPa] Min. Charpy Impact: 20 ft·lbf @ –20°F [27 J @–30°C] Minimum % Elongation: 22%	CS3
	E7XT-8 [E49XT-8]			
	E7XT-11 [E49XT- 11]		Tensile Strength: 70–95 ksi [490–670 MPa] Minimum Yield Strength: 58 ksi [390 MPa] Minimum % Elongation: 20%[f] Charpy Impact not specified	
	E7XT-12C[e] [E49XT-12Ce]	C1	Tensile Strength: 70–90 ksi [490–620 MPa] Minimum Yield Strength: 58 ksi [390 MPa] Min. Charpy Impact: 20 ft·lbf @ –20°F [27 J @–30°C] Minimum % Elongation: 22%	CS2
	E7XT-12M[e] [E49XT-12Me]	M21[g]		
	E70T-4 [E490T-4]	None (Self-Shielded)	Tensile Strength: 70–95 ksi [490–670 MPa] Minimum Yield Strength: 58 ksi [390 MPa] Min. Charpy Impact: Not Specified Minimum % Elongation: 22%	CS3
	E7XT-7 [E49XT-7]			
Single Pass Flux Cored	E7XT-14 [E49XT-14]	Not Specified	Minimum Tensile Strength: 70 ksi [490 MPa] Single Pass Electrode: Yield, % Elongation and Charpy notch toughness not specified. For the E7XT-GS [E49XT-GS] electrodes the usability characteristics, positionality, polarity, and shielding gas (if any) are as agreed upon between the purchaser and supplier.	Not Specified
	E7XT-GS [E49XT-GS]			
Metal Cored	E70C-6C [E49C-6C]	C1	Tensile Strength: 70 ksi minimum [490 MPa] Minimum Yield Strength: 58 ksi [390 MPa] Min. Charpy Impact: 20 ft·lbf @ –20°F [27 J @ –30°C] Minimum % Elongation: 22%	CS1
	E70C-6M [E49C-6M]	M21[g]		

Table B.3
AWS A5.36/A5.36M Tension Test Requirements

Tensile Strength Designator		Single Pass Electrodes	For A5.36 Multiple Pass Electrodes U.S. Customary Units			For A5.36M Multiple Pass Electrodes International System of Units (SI)		
U.S. Customary Units	International System of Units (SI)	Minimum Tensile Strength ksi [MPa]	Tensile Strength (ksi)	Minimum Yield Strength[a] (ksi)	Minimum Percent Elongation	Tensile Strength [MPa]	Minimum Yield Strength[a] [MPa]	Minimum Percent Elongation
6	43	60 [430]	60–80	48	22	430–550	330	22
7	49	70 [490]	70–95[c]	58	22	490–660[c]	400	22
8	55	80 [550]	80–100	68	19	550–690	470	19
9	62	90 [620]	90–110	78	17	620–760	540	17
10	69	100 [690]	100–120	88	16	690–830	610	16
11	76	110 [760]	110–130	98	15[d]	760–900	680	15[d]
12	83	120 [830]	120–140	108	14[d]	830–970	740	14[d]
13	90	130 [900]	130–150	118	14[d]	900–1040	810	14[d]

[a] Yield strength at 0.2% offset.
[b] In 2 in [50 mm] gauge length when a 0.500 in [12.5 mm] nominal diameter tensile specimen and nominal gauge length to diameter ratio of 4:1 specified in the Tension Test section of AWS B4.0) is used. In 1 in [25 mm] gauge length when a 0.250 in [6.5 mm] nominal diameter tensile sp men is used as permitted for 0.045 in [1.2 mm] and smaller sizes of the E71T11-AZ-CS3 [E491T11-AZ-CS3].
[c] The maximum tensile strength shall be 90 ksi [620 MPa] for carbon steel electrodes with a T12 usability designator depositing a CS2 composition.
[d] Elongation requirement may be reduced by one percentage point if the tensile strength of the weld metal is in the upper 25% of the tensile strength range.

Source: Adapted from AWS A5.36/A5.36M:2016, *Specification for Carbon and Low-Alloy Steel Flux Cored Electrodes for Flux Cored Arc Welding and Metal Cored Electrodes for Gas Metal Arc Welding*, Table 1, American Welding Society.

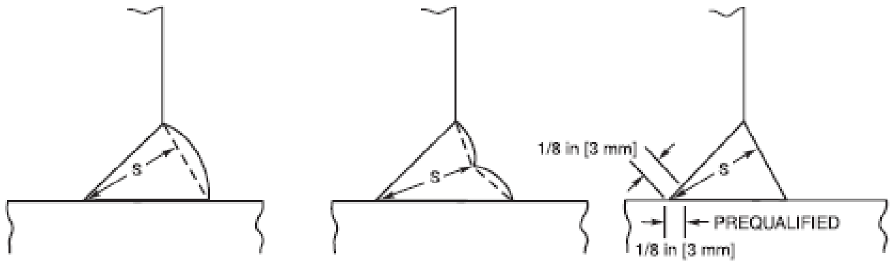
Table B.4
AWS A5.36/A5.36M Charpy Impact Test Requirements

A5.36 Requirements U.S. Customary Units			A5.36M Requirements International System of Units (SI)		
Impact Designator[a, b]	Maximum Test Temperature[c, d] (°F)	Minimum Average Energy Level	Impact Designator[a, b]	Maximum Test Temperature[c, d] (°C)	Minimum Average Energy Level
Y	+68	20 ft·lbf	Y	20	27 Joules
0	0		0	0	
2	–20		2	–20	
4	–40		3	–30	
5	–50		4	–40	
6	–60		5	–50	
8	–80		6	–60	
10	–100		7	–70	
15	–150		10	–100	
Z	No Impact Requirements		Z	No Impact Requirements	

Annex C (Informative)

Effective Weld Size—Special Cases

This annex is not part of this standard but is included for informational purposes only.



C1. Combination Partial Penetration Groove Weld and Fillet Weld

The effective weld size (S) is the minimum distance from the weld root to the face of the diagrammatic weld, with a reduction of 1/8 in [3 mm] as required by 7.1.1, less any convexity.

C2. Required Leg Sizes of Fillet Welds in Skewed T-Joints

Table C.1 is a tabulation showing equivalent leg size factors for the range of dihedral angles (Ψ) between 60° and 135°, assuming no root opening (R). Root openings 1/16 in [1.5 mm] or greater, but not exceeding 3/16 in [5 mm] shall be added directly to the equivalent leg size (W_E). The required leg size (W_R) for fillet welds in skewed T-joints is calculated using the equivalent leg size factor for a given dihedral angle (Ψ), as shown in the example.

EXAMPLE:
(U.S. Customary Units)

Given: Skewed T-joint angle, 75°; root opening, 1/16 in
Required: Strength equivalent to 90° fillet weld of size: 5/16 in
Procedure: (1) Factor for 75° from Table C.1 = 0.86
(2) Equivalent leg size, W_E, of skewed joint, without root opening: $W_E = 0.86 \times 0.313 = 0.269$ in
(3) With root opening: 0.063 in
(4) Required leg size, W_R, of skewed fillet weld: [Step (2) + (3)] $W_R = 0.332$ in
(5) Rounding up to a practical dimension: $W_R = 3/8$ in

Annex D (Informative)

Sample Report Forms

This annex is not part of this standard but is included for informational purposes only.

PREQUALIFIED WELDING PROCEDURE SPECIFICATION (WPS)

Material specification ______
Welding process ______
Manual or machine ______
Position of welding ______
Filler metal specification ______
Filler metal classification ______
Flux ______
Weld metal grade* ______
Shielding gas ______ Flow rate ______
Single or multiple pass ______
Single or multiple arc ______
Welding current ______
Polarity ______
Welding progression ______
Root treatment ______
Preheat and interpass temperature ______
Postweld Heat Treatment ______ None ______
*Applicable only when filler metal has no AWS classification.

WELDING PROCEDURE

Pass No.	Electrode Size	Electrical Characteristics		Travel Speed	Joint Detail
		Amperes	Volts		

This procedure may vary due to fabrication sequence, fit-up, pass size, etc., within the limitation of variables given in AWS D15.1: (______ (year)), *Railroad Welding Specification for Cars and Locomotives.*

Procedure no. ______ Manufacturer or Contractor ______
Revision no. ______ Authorized by ______
Form D-1 Date ______

PROCEDURE QUALIFICATION RECORD (PQR)

PROCEDURE SPECIFICATION

Material specification ____________

Welding process ____________

Manual or machine ____________

Position of welding ____________

Filler metal specification ____________

Filler metal classification ____________

Weld metal grade* ____________

Shielding gas ________ Flow rate ________

Single or multiple pass ____________

Single or multiple arc ____________

Welding current ____________

Welding progression ____________

Preheat temperature ____________

Postheat treatment ____________

Welder's name ____________

*Applicable when filler metal has no AWS classification.

GROOVE WELD TEST RESULTS

Tensile strength, psi

1. ____________
2. ____________

Guided-bend tests (2 root-, 2 face-, or 4 side-bend)

Root	Face
1. ________	1. ________
2. ________	2. ________

Radiographic-ultrasonic examination

RT report no. ____________

UT report no. ____________

VISUAL INSPECTION

Appearance ____________

Undercut ____________

Piping porosity ____________

Test date ____________

Witnessed by ____________

FILLET WELD TEST RESULTS

Minimum size multiple pass Macroetch	Maximum size single pass Macroetch
1. ______ 2. ______	1. ______ 3. ______
3. ______	2. ______

All-weld-metal tension test

Tensile strength, psi ____________

Yield point/strength, psi ____________

Elongation in 2 in, % ____________

Laboratory test no. ____________

WELDING PROCEDURE

Pass No.	Electrode Size	Electrical Characteristics		Travel Speed	Joint Detail
		Amperes	Volts		

We, the undersigned, certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of AWS D15.1: (________ (year)), *Railroad Welding Specification for Cars and Locomotives.*

Procedure no. ____________ Manufacturer or Contractor ____________

Revision no. ____________ Authorized by ____________

Form D-2 Date ____________

TEST QUALIFIED WELDING PROCEDURE SPECIFICATION (WPS)

Qualified by procedure qualification no. ____________________

Material specification ____________________

Welding process ____________________

Manual or machine ____________________

Position of welding ____________________

Filler metal specification ____________________

Filler metal classification ____________________

Flux ____________________

Weld metal grade* ____________________

Shielding gas ____________________ Flow rate ____________________

Single or multiple pass ____________________

Single or multiple arc ____________________

Welding current ____________________

Polarity ____________________

Welding progression ____________________

Root treatment ____________________

Preheat and interpass temperature ____________________

Postweld Heat Treatment ____________________

*Applicable only when filler metal has no AWS classification.

WELDING PROCEDURE

Pass No.	Electrode Size	Electrical Characteristics		Travel Speed	Joint Detail
		Amperes	Volts		

This procedure may vary due to fabrication sequence, fit-up, pass size, etc., within the limitation of variables given in AWS D15.1: (__________), *Railroad Welding Specification for Cars and Locomotives.*
(year)

Procedure no. ____________________ Manufacturer or Contractor ____________________

Revision no. ____________________ Authorized by ____________________

Form D-3 Date ____________________

WELDER AND WELDING OPERATOR QUALIFICATION RECORD

Welder or welding operator's name ______ Identification no. ______

Welding process ______ Manual ______ Semiautomatic ______ Machine ______

(Flat, horizontal, overhead, or vertical—if vertical, state whether upward or downward.)

In accordance with procedure specification no. ______

Material specification ______

Diameter and wall thickness (if pipe)—otherwise, joint thickness ______

Thickness range this qualifies ______

FILLER METAL

Specification no. ______ Classification ______ F-no. ______

Describe filler metal (if not covered by AWS specification) ______

______

Is backing strip used? ______

Filler metal diameter and trade name ______

______

Flux for submerged arc or gas for gas metal arc or flux cored arc welding ______

VISUAL INSPECTION

Appearance ______ Undercut ______ Piping porosity ______

Guided Bent Test Results

Type	Result	Type	Result

Test conducted by ______

per ______

Laboratory test no. ______

Test date ______

Fillet Test Results

Appearance ______

Fracture test root penetration ______

Fillet size ______

Macroetch ______

(Describe the location, nature, and size of any crack or tearing of the specimen.)

Test conducted by ______

per ______

Laboratory test no. ______

Test date ______

RADIOGRAPHIC TEST RESULTS

Film Identification	Results	Remarks	Film Identification	Results	Remarks

Test witnessed by ______

per ______

Laboratory test no. ______

Test date ______

We, the undersigned, certify that the statements in this record are correct and that the test welds were prepared and tested in accordance with the requirements of AWS D15.1: (______), *Railroad Welding Specification for Cars and Locomotives.*
(year)

Manufacturer or Contractor ______

Authorized by ______

Date ______

Form D-4

Annex E (Informative)

Gage Thickness of Sheet Metal and Aluminum Filler Alloy Selection Guide

Table E.1
Hot-Rolled and Cold-Rolled Sheet Metal

Manufacturer's Standard Gage Number	Thickness Equivalent in [mm]
3	0.2391 [6.07]
4	0.2242 [5.70]
5	0.2092 [5.31]
6	0.1943 [4.94]
7	0.1793 [4.55]
8	0.1644 [4.18]
9	0.1495 [3.80]
10	0.1345 [3.42]
11	0.1196 [3.04]
12	0.1046 [2.66]
13	0.0897 [2.28]

Annex E (Informative)

Gage Thickness of Sheet Metal and Aluminum Filler Alloy Selection Guide

Table E.2
Galvanized Sheet Metal

Galvanized Sheet Gage Number	Thickness Equivalent in [mm]
8	0.1681 [4.27]
9	0.1532 [3.90]
10	0.1382 [3.51]
11	0.1233 [3.13]
12	0.1084 [2.75]
13	0.0934 [2.37]
14	0.0785 [1.99]
15	0.0710 [1.80]
16	0.0635 [1.61]

Annex E (Informative)

Gage Thickness of Sheet Metal and Aluminum Filler Alloy Selection Guide

Table E.3[a, b] (Continued)
Guide to the Choice of Filler Metal for General Purpose Welding of Aluminum

Base Metal	5154 5254[c9]	5086	5083	5052 5652[c9]	5005 5050	3004 Alclad 3004	2219	2014 2036	1100 3003 Alclad 3003
1060, 1070, 1080, 1350	ER5356[c3, c4]	ER5356[c4]	ER5356[c4]	ER4043[c2, c4]	ER1100[c2, c3]	ER4043[c2, c4]	ER4145[c2, c3]	ER4145	ER1100[c2, c3]
1100, 3003, Alclad 3003	ER5356[c3, c4]	ER5356[c4]	ER5356[c4]	ER4043[c2, c4]	ER1100[c2, c3]	ER4043[c2, c4]	ER4145[c2, c3]	ER4145	ER1100[c2, c3]
2014, 2036	—	—	—	—	ER4145	ER4145	ER4145[c5]	ER4145[c5]	
2219	ER4043	—	—	ER4043[c2]	ER4043[c1, c2]	ER4043[c1, c2]	ER2319[c1]		
3004, Alclad 3004	ER5356[c6]	ER5356[c4]	ER5356[c4]	ER5356[c3, c6]	ER5356[c6, c3]	ER5356[c3, c6]			
5005, 5050	ER5356[c6]	ER5356[c4]	ER5356[c4]	ER5356[c3, c4]	ER5356[c3, c6]				
5052, 5652[c9]	ER5356[c6]	ER5356[c4]	ER5356[c4]	ER5654[c3, c6, c9]					
5083	ER5356[c4]	ER5356[c4]	ER5183[c4]						
5086	ER5356[c4]	ER5356[c4]							
5154, 5254[c9]	ER5654[c6, c9]								

Annex F (Informative)

Macroetch Procedures

Annex G (Informative)

Requesting an Official Interpretation on an AWS Standard

Annex H (Informative)

Informative References

This annex is not part of this standard but is included for informational purposes only.

AAR *Manual of Standards and Recommended Practice, Section C-III, Specification for Tank Cars, M-1002*.

ASME *Boiler and Pressure Vessel Code*, Section VIII.

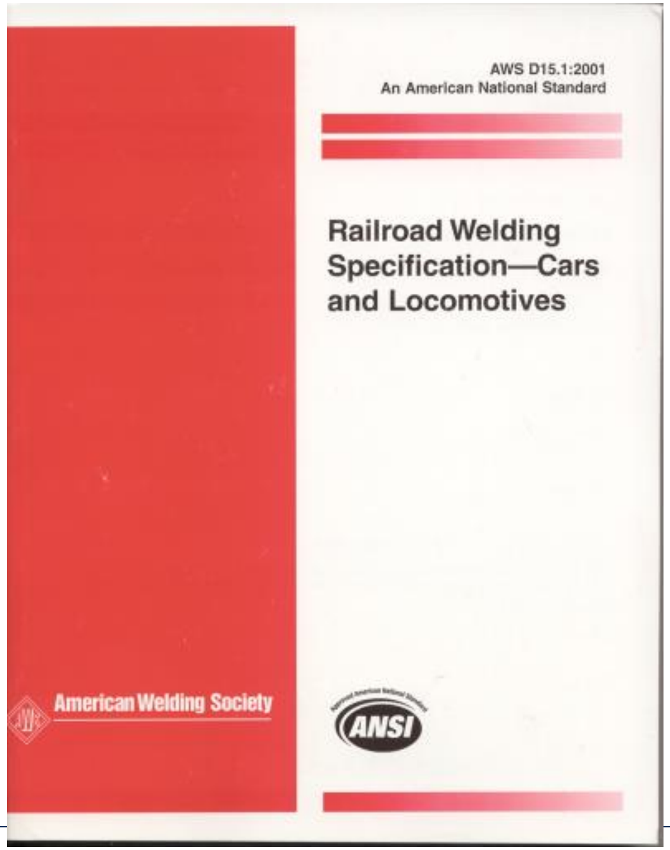
AWS C4.6M (ISO 9013), *Thermal Cutting—Classification of Thermal Cuts—Geometric Product Specification and Quality Tolerances*, American Welding Society.

AWS C5.3, *Recommended Practices for Air Carbon Arc Gouging and Cutting*, American Welding Society.

AWS C5.4, *Recommended Practices for Stud Welding*, American Welding Society.

List of AWS Documents on Railroad Welding

Designation	Title
D15.1/D15.1M	*Railroad Welding Specification for Cars and Locomotives*
D15.2/D15.2M	*Recommended Practices for the Welding of Rails and Related Components for Use by Rail Vehicles*



Thank you for Participating!

Questions ?

Thank you!

AAR Quality Assurance
55500 DOT Road
Pueblo, Colorado 81001
www.aar.com