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**“Mechanical Codes and Standards for
Movable Bridges”**

by

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Mechanical Codes and Standards

For Movable Bridge Design and Construction

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ABSTRACT

This paper presents an overview of the mechanical and material standards that are relevant to the design, fabrication and installation of mechanical equipment and systems for movable bridges. Codes and standards form the basis for quality control and quality assurance in construction. Among the project participants, the design engineer has full control over the selection and application of engineering standards. Adequately specifying the material requirements and the construction methods by referencing the relevant codes and standards greatly facilitates the construction process. It helps the Contractor in procuring the right materials and equipment, in fabricating and assembling the units, in installing the assemblies, and also in testing them. Beyond that the standards help Construction Inspectors in performing inspection and testing to ensure acceptability of work. Developing a clear understanding of applicable codes and standards by the Design Engineer and the Resident Engineer, as well as the Contractor, form the basis for quality surveillance in construction.

AASHTO, AREA, ASTM, AGMA, AWS, JIC, NFPA, SAE, ASME and ANSI standards applicable to mechanical aspects of movable bridge design and construction are analyzed and discussed. Different standards could be used to specify material requirements and to accomplish specific fabrication tasks, but the quality levels obtained in the application of these standards will vary. Calling out standards including supplementary requirements where applicable, makes construction requirements clear and specific, and helps avoid potential claims, disputes and delays in construction.

Mechanical Codes and Standards

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INTRODUCTION

The primary intent of codes and standards is to ensure safety and reliability in design, fabrication, construction, operation and maintenance of engineering systems. When adopted by reference in plans or specifications, they become part of the contract documents. They specify certain minimum requirements that a product, material, method, or procedure must meet for a particular application. Compliance with codes and standards form the basis for acceptance and rejection of materials, products or work in manufacturing and construction.

Codes are regulations, ordinances or statutory requirements of a governmental unit adopted and administered for the protection of public health, safety and welfare. Examples of codes include the Code of Federal Regulations (CFR), Florida Administrative Code (FAC) and local codes administered at the city or county levels. OSHA regulations, EPA regulations, Corps of Engineers and Coast Guard regulations, labor codes, licensing laws, building codes, plumbing codes, gas codes and all such regulations fall under this category.

Standards are developed by professional, industry, or trade associations with the intent of maintaining certain minimum criteria or requirements for materials, processes or products. In addition, the standards are intended to maintain uniformity in size, or in performance and operational characteristics, in order to facilitate interchangeability of products between manufacturers.

While codes are enforceable under the jurisdictional authority of the governmental entity, standards are enforceable to the extent they are referenced or adopted in a code or in a contract document.

CODES AND STANDARDS

Following the two primary standards applicable to the design and installation of mechanical equipment and systems, a fairly complete listing of codes standards relevant

to materials, components, appurtenances and fabrication and testing procedures is provided below.

1. American Association of State Highway and Transportation Officials
AASHTO Standard Specifications for Movable Highway Bridges
2. American Railway Engineering Association
AREA Manual for Railway Engineering Part 6 Movable Bridges

American Society for Testing and Materials (ASTM) Standards

A6	General Requirements for Rolled Structural Steel Plates, Shapes, and Sheet Piling and Bars, for Structural Use
A27	Steel Castings, Carbon, for General Application
A36	Carbon Structural Steel
A48	Gray Iron Castings
A53	Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
A106	Seamless Carbon Steel Pipe for High-Temperature Service
A108	Steel Bars, Carbon Cold-finished, Standard Quality
A123	Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
A125	Steel Springs, Helical, Heat-Treated
A148	Steel Castings, High Strength, for Structural Purposes
A153	Zinc Coating (Hot-Dip) on Iron and Steel Hardware
A167	Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
A193	Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
A194	Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service
A228	Steel Wire, Music Spring Quality
A240	Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels
A269	Seamless and Welded Austenitic Stainless Steel Tubing for General Service
A275	Test Method for Magnetic Particle Examination of Steel Forgings
A276	Stainless and Heat-Resisting Steel Bars and Shapes
A290	Carbon and Alloy Steel Forgings for Rings for Reduction Gears
A291	Steel Forgings, Carbon and Alloy, for Pinions, Gears and Shafts for Reduction Gears
A307	Carbon Steel Bolts and Studs, 60 ksi Tensile Strength
A311	Steel Bars, Carbon, Stress-Relieved, Cold-Drawn, Subject to Mechanical Property Requirements

A312	Seamless and Welded Austenitic Stainless Steel Pipes
A320	Alloy Steel Bolting Materials for Low-Temperature Service
A325	Structural Bolts, Steel, Heat-Treated, 120/105 ksi Minimum Tensile Strength
A354	Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners
A366	Steel, Sheet, Carbon, Cold-Rolled, Commercial Quality
A370	Test Methods and Definitions for Mechanical Testing of Steel Products
A388	Standard Practice for Ultrasonic Examination of Heavy Steel Forgings
A423	Seamless and Electric-Welded Low-Alloy Steel Tubes
A446	Steel Sheet, Hot-Dip Galvanized, Structural Quality
A449	Quenched and Tempered Steel Bolts and Studs
A485	High Hardenability Antifriction Bearing Steel
A488	Standard Practice for Steel Castings, Welding, Qualifications of Procedures and Personnel
A489	Carbon Steel Lifting Eyes
A490	Standard Specification for Heat-Treated Steel Structural Bolts, 150 ksi Minimum Tensile Strength
A501	Hot-Formed Welded and Seamless Carbon Steel Structural Tubing
A502	Structural Steel Rivets
A513	Electric-Resistance-Welded Carbon and Alloy Steel Mechanical Tubing
A519	Seamless Carbon and Alloy Steel Mechanical Tubing
A563	Carbon and Alloy Steel Nuts
A569	Steel, Carbon, Hot-Rolled Sheet and Strip, Commercial Quality
A572	High-Strength Low-Alloy Columbium-Vanadium Structural Steel
A574	Alloy Steel Socket-Head Cap Screws
A576	Steel Bars, Carbon, Hot-Wrought, Special Quality
A580	Stainless and Heat-Resisting Steel Wire
A582	Free-Machining Stainless and Heat-Resisting Steel Bars
A588	High-Strength Low-Alloy Structural Steel with 50 ksi Minimum Yield Point, to 4 inches Thick, (Weathering Steel or use A709, Grade 50W)
A609	Castings, Carbon, Low-Alloy, and Martensitic Stainless Steel, Standard Practice for Ultrasonic Examination Thereof
A653	Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
A663	Steel Bars, Carbon, Merchant Quality, Mechanical Properties
A666	Austenitic Stainless Steel, Sheet, Strip, Plate, and Flat Bar
A668	Steel Forgings, Carbon and Alloy, for General Industrial Use
A675	Steel Bars, Carbon, Hot-Wrought, Special Quality, Mechanical Properties
A687	High Strength Non-headed Steel Bolts and Studs
A706	Low-Alloy Steel Deformed Bars for Concrete Reinforcement
A707	Flanges, Forged, Carbon and Alloy Steel for Low-Temperature Service

A709	Carbon and High-Strength Low-Alloy Structural Steel Shapes, Plates, and Bars and Quenched-and-Tempered Alloy Structural Steel Plates for Bridges
A714	High-Strength Low-Alloy Welded and Seamless Steel pipe
A781	Castings, Steel and Alloy, Common Requirements, for General Industrial Use
A789	Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service
A802	Steel Castings, Surface Acceptance Standards, Visual Examination
A822	Seamless, Cold-Drawn Carbon Steel Tubing for Hydraulic System Service
A852	Quenched and Tempered Low-Alloy Structural Steel Plate with 70 ksi Minimum Yield Strength, to 4 inches Thick (Weathering Steel or use A709 Grade 70W)
A903	Steel Castings, Surface Acceptance Standards, Magnetic Particle and Liquid Penetrant Inspection
B22	Bronze Castings for Bridges and Turntables
B23	White Metal Bearing Alloys (commercially known as Babbitt Metal)
B100	Wrought Copper-Alloy Bearing and Expansion Plates and Sheets for Bridge and Other Structural Use
B43	Seamless Red Brass Pipe, Standard Sizes
B62	Composition Bronze or Ounce Metal Castings (for bronze fittings)
B438	Sintered Bronze Bearings, Oil Impregnated
B824	General Requirements for Copper Alloy Castings
D709	Laminated Thermosetting Materials
E94	Guide for Radiographic Testing
E165	Test Method for Liquid Penetrant Examination
E709	Guide for Magnetic Particle Examination
E1032	Method for Radiographic Examination of Weldments
F436	Hardened Steel Washers
F468	Nonferrous Bolts, Hexagonal Cap Screws, and Studs for General Use
F568	Carbon and Alloy Steel Externally Threaded Metric Fasteners
F959	Compressible-Washer-Type Direct Tension Indicators for use with Structural Fasteners (tensioning A325/A490 bolts)

American Welding Society (AWS) Standards

A2.4	Symbols for Welding and Nondestructive Testing
A3.0	Standard Welding Terms and Definitions
A5.5	Specifications (moisture test, etc.)
A5.17/23	Filler Metal Specifications (chemical analysis)
B1.10	Guide for Nondestructive Inspection of Welds
B1.11	Guide for the Visual Inspection of Welds

B4.0	Mechanical Testing of Welds, Standard Methods
D1.1	Structural Welding Code Steel
D1.5	Bridge Welding Code
D11.2	Guide for Welding Iron Castings

American National Standards Institute (ANSI) Standards

B1.1	Unified Screw Threads
B1.13	Metric Screw Threads
B1.20.3	Dryseal Pipe Threads
B2.1	Taper Pipe Threads
B4.1	Preferred Limits and Fits for Cylindrical Parts
B4.2	Preferred Metric Limits and Fits
B16.11	Forged Steel Fittings, Socket Welding and Threaded
B17.1	Keys and Keyseats
B18.2.1	Square and Hexagonal Bolts and Screws
B18.2.2	Square and Hexagonal Nuts
B18.2.3	Metric Hexagonal Bolts, Screws and Cap Screws
B18.2.4	Metric Hexagonal Nuts
B18.3	Socket, Cap, Shoulder and Set Screws
B18.8.1	Clevis Pins and Cotter Pins
B18.21.1	Lock Washers
B18.22.1	Plain Washers
B31.1	Hydraulic Line Seamless Steel Pipe
B32.4	Preferred Series of Sizes and Tolerances for Metric Sizes
B46.1	Surface Texture
B93.10	Static Pressure Rating Methods of Square Head Fluid Power Cylinders
Y1.1	Abbreviations for Use on Drawings and in Text
Y14	Drafting Practices
Y14.5	Dimensioning and Tolerancing
Y32.10	Graphic Symbols for Fluid Power Diagrams

Joint Industrial Council (JIC) Hydraulic Standards

H1.10	Hydraulic Control Circuit and Piping Diagrams
H1.11	Specifications
H1.12.3	As-Built Changes (record drawings)
H1.12.4	O & M Manual Hydraulic Equipment
H2.7	Servo Valve Pump Actuators
H3	Requirements for Hydraulic System Controls
H4	Requirements for Fluid Motors

H5	Requirements for Pumps
H7	Requirements for Filtration of Hydraulic Fluid
H8	Requirements for Valves
H9	Requirements for Accumulators
H10	Requirements for Heat Exchangers
H11	Requirements for Piping, Fittings and Manifolds/Piping Systems
H12	Requirements for Seals and Sealing Devices
H13	Safety Requirements

National Fluid Power Association (NFPA) Standards

T2.24.1	Hydraulic Fluid Power Installation and Systems Standard - Systems Standard for Stationary Industrial Machinery
T3.9.17	Hydraulic Fluid Power - Positive Displacement Pumps - Method of Testing and Presenting Basic Performance Data
T3.10.8.8	Hydraulic Fluid Power - Filters - Multi-Pass Method for Evaluating Filtration Performance
T3.16.2	Requirements for Non-Integral Industrial Fluid Power Hydraulic Reservoirs
T3.16.3	Requirements for Non-Integral Industrial Fluid Power Hydraulic Power Units

Society of Automotive Engineers (SAE) Standards

J476	Dryseal Pipe Threads
J512	Automotive Tube Fittings
J514	Hydraulic Tube Fittings
J515	Hydraulic O-Rings
J516	Hydraulic Hose Fittings
J517	Hydraulic Hose
J518	Hydraulic Flanged Tube, Pipe, and Hose Connections, 4-Bolt Split Flange Type
J524	Seamless Low Carbon Steel Tubing Annealed for Bending and Flaring
J525	Welded and Cold Drawn Low Carbon Steel Tubing Annealed for Bending and Flaring
J526	Welded Low Carbon Steel Tubing — for general automotive applications
J528	Seamless Copper Tube (comparable to ASTM B75)
J530	Automotive Pipe Fittings (low and medium pressures)
J533	Flares for Tubing

J534	Lubrication Fittings
J962	Formed Tube Ends for Hose Connections (low pressure applications)
J1065	Pressure Ratings for Hydraulic Tubing and Fittings
J1273	Selection, Installation, and Maintenance of Hose and Hose Assemblies
J1453	Fittings - O-Ring Face Seal

American Society of Mechanical Engineers (ASME) Standards

Section II Part A	Ferrous Material Specifications
Section II Part B	Non-Ferrous Material Specifications
Section II Part C	Specifications for Welding Rods, Electrodes and Filler Metals
Section VIII	Pressure Vessels
Section IX	Welding and Brazing Qualifications

American Gear Manufacturers' Association (AGMA) Standards

201	Tooth Proportions for Coarse-Pitch Involute Spur Gears
203	Fine-Pitch On-Center Face Gears for 20 degree Involute Spur Pinions
207	Tooth Proportions for Fine-Pitch Involute Spur Gears and Helical Gears
210.02	Surface Durability Stress
220.02	Bending Stress (fillet tensile stress)
250.03	Lubrication of Industrial Enclosed Gear Drives
374	Design for Fine Pitch Worm Gearing
390	Gear Classification Handbook
390.03	Recommended Backlash Range for Gearing
	Total Composite Tolerances
	Tooth-Contact Pattern Evaluation
420.24	Spur, Helical and Spiral-Bevel Gear Drives
1012-F90	Gear Nomenclature, Definition of Terms with Symbols
2000-A88	Gear Classification and Inspection Handbook
2001-C95	Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth
2005-B88	Design Manual for Bevel Gears
6001-C88	Design and Selection of Components for Enclosed Gear Drives
6010-E88	Standard for Spur, Helical, Herringbone, and Bevel Enclosed Drives
9001-A86	Lubrication of Flexible Couplings
9005-A94	Industrial Gear Lubrication

Miscellaneous Codes and Standards

1. Code of Federal Regulations

29 CFR Part 1910 General Safety and Health Regulations as Applicable to Construction
29 CFR Part 1926 Safety and Health Regulations for Construction

2. Federal Specifications

FS RR-S-550 - Sockets for Wire Ropes
FS QQ-C-320C - Stainless Steel Rods (chrome plated)
FS QQ-Z-325C - Plating of Anchorage Components

3. Military Specifications

MIL-S-22499 High Brass, Liners

4. Anti-Friction Bearing Manufacturers' Association

AFBMA Standard 9 - Rating Life and Static Load Rating
Standards for Bearing Designation, Bearing Tolerances, etc.

5. National Lubricating Grease Institute

NLGI Lubricating Grease Guide
Grease Grades 0 (softest) through 6 (stiffest block grease) based on consistency

6. American Concrete Institute

ACI 349, Appendix B, Section B.7 - Steel Embedments (anchor bolts)

7. Steel Structures Painting Council

SSPC Manual, Volume 2 - Cleaning and Painting

8. Research Council on Structural Connections

RCSC Specifications for Structural Joints using A325 and A490 bolts

9. American Institute of Steel Construction

AISC Code of Standard Practice (payment on unit price contracts)

CONCLUSION

Codes and standards form the basis for specification development and quality assurance in construction. The codes are administered to protect public health, safety and welfare, and compliance with them is mandatory. However, the standards go a step further to ensure quality, reliability and uniformity in engineering. But the standards apply only when they are referenced in the specifications, or adopted by reference in a code or a contract document.

The primary responsibility for proper application and interpretation of Codes and Standards lies with the Design Engineer. Once referenced in the construction specifications, the Contractor and the Inspector can assure compliance with the requirements of, or the recommendations in, the adopted documents. Knowledge of the relevant codes and standards and their competent use by the project participants is key to ensuring quality and to avoiding disputes and delays in construction.