MICHIGAN

DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION

FOR

**BRIDGE MACHINERY - GENERAL**

BRG:JST 1 of 24 APPR:REL:SCK:09-20-23

**a. Description.** This section applies to the detailed work to be performed on the bridge machinery. The bridge machinery includes the following systems: Operating Machinery and Tail Lock Machinery. The general requirements apply to all bridge machinery and are given here to avoid repetition. Also, the requirements of this section apply to the installation of electric motors, brakes, instrument drives, and limit switches to be mounted with the machinery, but supplied under separate items.

This project has Buy America Act requirements. Comply with these requirements as listed in the Project Special Provisions for providing machinery for this project.

1. Basis of Machinery Design. The design of new machinery conforms to the applicable requirements of the AASHTO LRFD Movable Highway Bridge Design Specifications 2nd Edition 2007 Revisions (hereinafter referred to as the AASHTO Standard), unless otherwise noted on the plans or stated herein.

2. Submittals. Submit manufacturer’s data and/or shop drawing data for all manufactured and purchased items of bridge machinery in accordance with the Special Provision for Shop Drawings and Other Submittals.

Include for each manufactured item the manufacturer's descriptive literature, drawings, diagrams, performance and characteristic curves, and catalog cuts; the manufacturer's name, trade name, catalog model or number, nameplate data, size, certified layout dimensions, capacity, specification reference, and applicable Federal and Military Specification references; and all other information necessary to establish contract compliance.

3. Shop Drawings. Show all parts completely detailed and dimensioned on the shop drawings. Submit all related component shop drawings when assembly drawings are submitted. State the grade and amount of finish machining, with all tolerances and allowances, and identify each part requiring a specific fit. Finished surfaces are defined by *ANSI/ASME B46.1, Surface Texture*, and fits are defined by *ANSI/ASME B4.1, Preferred Limits and Fits for Cylindrical Parts*, unless otherwise noted on the plans or stated herein. *ANSI/ASME B4.1* applies to fits for non-cylindrical parts.

Show proprietary items in outline form on the drawings. Indicate the method and sequence to be employed during assembly of bridge machinery and installation of necessary utilities support and service facilities. Show all external dimensions and clearances necessary for installation and operation of each item or furnish complete assembly diagrams showing each part contained within an assembly and the manufacturer’s part number assigned to each part. Provide a diagram sufficient to enable complete disassembly and reassembly of the item covered. In the event that any part is modified in any manner from the way it is described or delivered by its original manufacturer, deliver a drawing that details each modification and assign a unique part number to preclude the supply of replacement parts not modified in similar fashion. Provide assembly drawings of each item in addition to identifying and describing each internal part to contain: dimensions of all principal elements within the item; certified external dimensions affecting interfaces or installations; gross weight capacity and normal operating ratings; method and recommended type of lubrication, including location and type of fittings and provisions for adding, draining, and checking the level of each lubricant employed; inspection openings, seals, and vents; and details of all fasteners used to mount the equipment to its foundation.

Make a complete shop bill of materials for all machinery parts.

State the material and material specifications for each part. Give the designated numbers of specifications where *ASTM* specifications or any other standard specifications are used. Use abbreviations on the drawings to designate standard specifications for materials and workmanship as listed in subsection a.6.C, Codes and Standards, of this special provision. These abbreviations are used on the plans and within this special provision.

Furnish complete assembly and erection drawings. Include identifying marks and essential dimensions for locating each part or assembled unit with respect to the bridge structure or foundation. Use of mirror image or opposite hand erection drawings is prohibited.

Give a suitable title to each shop drawing to describe the parts detailed thereon and state by whom the internal quality control shop inspection will be performed.

A. Standard Compliance. Submit proof of conformance for applicable organizations such as, *ASME*, *UL*, *American Gas Association (AGA)*, and *American Refrigeration Institute (ARI)*, for all equipment or materials. The label or listing of the specified organization will be acceptable evidence. In lieu of the label or listing, submit a certificate from an independent testing organization, adequately equipped and competent to perform such services, and approved by the Engineer. The certificate must state that the item has been tested in accordance with the specified organization's test methods, and that the item conforms to the specified organization's standard or code.

B. Certified Test Reports. As used herein, certified test reports refer to reports of tests conducted on previously manufactured materials or equipment identical to that proposed for use.

C. Factory Tests. Factory tests refer to tests required to be performed on the actual materials or equipment proposed for use. Submit the results of all tests in accordance with the provisions of this contract for laboratory test results.

4. Operating and Maintenance Manuals.

A. General Requirements for Manuals. Furnish manuals containing descriptive material, catalog cuts with non-pertinent data blocked out, reduced shop drawings, and all information necessary for successful operation and maintenance of the bridge machinery systems. Any revisions required after the start-up period must be addressed by errata or addenda to the manuals.

Clearly print all submittals, data, drawings, diagrams, etc. so that all printed matter is accurate, distinct, and clearly legible. Illustrations are to be clear and printed matter, including dimensions and lettering on drawings, are to be legible. If reduced drawings are incorporated within the manuals, darken the original lines and letters as necessary to retain legibility of the drawings after reduction. Fold larger drawings to page size and insert in manuals.

Produce all printed matter, data, drawings, diagrams, etc., by methods that must offer permanence and durability. Use paper that is water resistant. No materials are to be used that will adversely affect this permanence and durability.

B. Contents of Manuals. Inscribe the following identification on the manual cover: the words “Bridge Machinery Operating and Maintenance Manual,” the name and location of the bridge, the contract number, the date, and the names of the Consultant and Contractor.

Include the names, addresses, and telephone numbers of each subcontractor installing the equipment and systems, as well as the local representatives for each item of equipment and system to be installed.

Provide a table of contents and assemble to conform to the table of contents with the tab sheets placed before instructions covering the subject.

Include the following in the manual as a minimum: a system layout showing all machinery components and equipment with data to explain detailed operation and control of each component; a control sequence describing the operation; a detailed description of the function of each principal component of the system; the procedure for operation; installation instructions; maintenance and overhaul instructions; lubrication schedule to include type, grade, temperature range, and frequency; safety precautions, diagrams, and illustrations; test procedures; performance data; and parts lists. The parts lists for equipment must indicate the sources of supply, recommended spare parts, and the service organization that is reasonably convenient to the bridge site.

Include manufacturer’s standard publications provided that particular literature covers information and data specific to the equipment actually furnished.

Include information for trouble-shooting the bridge machinery. List behavioral warning signs, possible problems, and potential solutions; incorporate each into the manual for each principal piece of equipment.

Include detailed steps for cursory and in-depth inspections that should be performed annually and biennially, respectively.

Complete the manuals in all respects for all equipment, controls, accessories, and associated appurtenances provided.

C. Materials for Manuals. Bind the operating and maintenance manuals in heavy-duty, nickel-plated three-hole binders with three trigger positions: lock, unlock and open. Use binders that have metal hinges. Use a locking mechanism that allows sheets to lie flat (i.e. channel lock). Use covers made of stiff, heavy-duty plastic or other approved material. Binder type must be either elliptical ring, round ring, screw post, or post with channel lock, as directed by the Engineer.

Bind the printed material into each book between rigid covers. Use instruction books containing drawings that measure 8.5 by 11 inches to minimize excessive folding and to allow for ease of use. Neatly title the books with a descriptive title, the name of the project, the location, the year of installation, the name of the manufacturer, the engineering firm, and the Contractor. Provide legible copies of drawings in black on white background. Submit the arrangements of the books, the method of binding, and the material to be included to the Engineer for approval.

Use 8.5 by 11inch, 20 pound, copy paper, acid-free punched paper that is a quality suitable for archival use. The punched holes, each with a minimum diameter of 5/16 inch, are to be reinforced with plastic or cloth to the standard three-hole spacing.

For foldout diagrams and illustrations, reinforce all holes (5/16-inch minimum diameter) with plastic or cloth to standard three hole spacing.

D. Sequence of Submittals for Manuals. Submit two copies of sample formats and outlines of contents in draft form 60 days prior to the earliest: of final inspection, acceptance tests, or return of the span operation to the Department. Show proposed methods of binding, methods of printing, and reproduction.

Submit two copies of complete manual in final form 15 days prior to final inspection, acceptance tests, or return of the span operation to the Department.

Submit four hard copies and electronic copies in PDF format, of approved manual 10 days after final inspection and acceptance tests. One of the four hard copies will become the property of the Consultant; the remaining copies will become the property of the Department.

5. Posted Operating Instructions. Provide operating instructions (approved by the Engineer) for each system and each principal piece of equipment for the use of operation and maintenance personnel. Include diagrams showing the complete layout of the entire system framed under acrylic plastic or in approved laminated plastic and posted where directed by the Engineer. Post printed operating instructions for each principal piece of equipment including proper adjustment, operation, lubrication, safety precautions, procedures in the event of equipment failure, and any other necessary items of instruction as recommended by the manufacturer of the unit. Attach to or post adjacent to the piece of equipment. Use weather-resistant materials when producing operating instructions, or suitably enclose the instructions for protection from the weather. Do not mount operating instructions in direct sunlight. Secure operating instructions to prevent easy removal or peeling.

6. Quality Assurance.

A. Standard Products. Provide materials and equipment that are essentially the standard catalogued products of manufacturers regularly engaged in production of such materials or equipment and are manufacturer's latest standard design that complies with the specification requirements. Provide materials and equipment that are essentially duplicate items that have been in satisfactory commercial or industrial use at least 2 years prior to bid opening. Where two units of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the system need not be the products of the same manufacturer. Provide the manufacturer's name and address and the model and serial number on a nameplate, securely affixed in a conspicuous place for each major component. The nameplate of the distributing agent will not be acceptable.

B. Manufacturer’s Recommendations. Where installation procedures or any part thereof are required to be in accordance with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations are to be furnished to the Engineer prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material. Provide as part of the work all special machining and installation required by the component manufacturer.

C. Codes and Standards. All work under machinery pay items must comply with all applicable requirements of the latest edition of codes and standards issued by, but not limited to, the following organizations and publications, whose abbreviations used in this special provision are as shown:

American Association of State Highway and Transportation Officials - AASHTO

American Bearing Manufacturers Association - ABMA

American Gear Manufacturers Association - AGMA

American Iron and Steel Institute - AISI

American National Standards Institute - ANSI

American Society for Testing and Materials - ASTM

American Welding Society - AWS

National Lubricating Grease Institute - NLGI

Society of Automotive Engineers - SAE

Steel Structures Painting Council - SSPC

Meet the work requirements of all other codes and standards as specified elsewhere in this special provision. Where codes and standards are mentioned for any pay item, it is intended to call particular attention to them; it is not intended that any other codes and standards be omitted if not mentioned.

D. Qualifications, Personnel, and Facilities. For the fabrication, installation, aligning, cleaning, lubricating, testing, and all other work required by bridge machinery pay items, use adequate numbers of skilled, trained, and experienced mechanics, millwrights, and service personnel who are thoroughly familiar with the requirements and methods specified for the proper execution of work.

For the installation, aligning, and fastening of bridge machinery, use adequate numbers of skilled, trained, and experienced millwrights with at least two prior movable bridge jobs as past experience. Submit the experience of the crew members proposed for installing the machinery that will be performing the work to the Engineer for review and approval.

Equip mechanics, millwrights, and service personnel with all necessary instruments to assure that related components have been provided within acceptable tolerances, and to make all necessary adjustments for attaining the specified ratings.

E. Rules, Regulations, and Ordinances. Assure that work complies with all applicable federal, state, and local rules, regulations, and ordinances.

F. Substitutions. The terms "approved equal," "of equal quality," and "or equal" which appear on the plans and in this special provision, are intended to allow the Contractor to substitute other manufacturers and model numbers of products of equal quality and rating for those specified.

Prior to the Contractor's ordering of any substitute product, obtain in writing the Engineer's approval of the equivalence of the substitute product. The acceptance of the substitute product is at the sole discretion of the Engineer who will establish the basis for equivalence and will review the quality of the materials and products described in detail on the submitted shop drawings and product data.

The Engineer will "Approve" or "Revise and Resubmit" substitute material. Upon return of a shop drawing showing rejection, resubmit the shop drawing showing the specified product. Rejection will not in any way result in any increase in the contract price.

Approval by the Engineer of any substitute product submitted by the Contractor does not relieve the Contractor of responsibility for the proper operation, performance, or functioning of that product.

A manufacturer’s name and catalog part number specifying a particular product, whether in this special provision or on the plans, is so specified to establish quality, configuration, and arrangement of parts. An equivalent product made by another manufacturer may be substituted for the specified product subject to the approval of the Engineer; however, the Contractor will make all necessary changes required by the substitution in related machinery and structural, architectural, and electrical parts, at no increase in the contract price.

If any departures from the plans or this special provision are deemed necessary by the Contractor, submit details of such departures and the reasons therefore, as soon as practicable for approval. Make no such departures without approval by the Engineer.

**b. Materials**.

1. Steel Castings. Before any work is started, the manufacturer must communicate with the Engineer to arrange for inspections and tests. Notify the Engineer not less than 2 weeks prior to the start of work so that a representative of the Engineer may be present.

Take all necessary precautions to fabricate the castings true to pattern in form and dimensions, free of pouring faults, cracks, cold shuts, blow holes and other defects in positions affecting their strength and value for the service intended.

Clean all castings free of loose scale and sand; remove all fins, seams, gates, risers, and other irregularities. Ensure all unfinished edges of castings are neatly cast with rounded corners and all inside angles must have ample fillets.

Visually examine all castings in accordance with *ASTM A802*, meeting visual inspection acceptance criteria Level II. Castings that do not pass this test may be rejected. Submit test results, whether positive or negative, to the Engineer. Test records meeting Level III may be considered for weld repair, provided the manufacturer submits a procedure to the Engineer for review and approval that the Engineer approves.

Ensure all castings that have solid sections 2 inches thick or greater and all fracture critical members are ultrasonically tested in accordance with *ASTM A609/A609M, Method A*, meeting Quality Level 2. Castings that do not pass this test may be rejected. Submit test results, whether positive or negative, to the Engineer. Test records meeting Quality Level 3 may be considered for weld repair, provided the manufacturer submits a procedure to the Engineer for review and approval that the Engineer approves.

Ensure all casting surfaces are magnetic particle examined in accordance with *ASTM E125*, meeting the following acceptable levels of discontinuities:

Type I Cracks/Hot Tears 1/4 inch, maximum

Type II Shrinkage Degree 3

Type III Inclusions Degree 3

Type IV Chaplets Degree 2

Type V Porosity Degree 1

Submit test results, whether positive or negative, to the Engineer. All surface discontinuities may be considered for weld repair, provided the manufacturer submits a procedure to the Engineer for review and approval that the Engineer approves.

All repair procedures must include details of the areas to be repaired and a means to qualify the repair method. Ensure approved repair procedures are performed prior to final heat treatment, so that no weld repairs are needed after final machining. In addition, ensure all surface defects removed by machining are performed prior to final heat treatment.

Ensure all castings that fail to meet the established acceptance criteria and considered rejected are replaced, at the Contractors expense, with new castings.

2. Bronze Castings. All bronze castings must meet the requirements of *ASTM B22/B22M* and be Copper Alloy Unified Numbering System (UNS) No. C91100 unless otherwise indicated or approved by the Engineer.

3. Forgings. All carbon and alloy steel forgings must meet the requirements of *AASHTO M102M/M102* (*ASTM A668/A668M*) unless otherwise indicated or approved by the Engineer.

Ensure all forgings are reduced to size from a single bloom or ingot until homogeneity is secured. The blooms or ingots, from which shafts or pins are to be made, must have a cross-sectional area at least three times that required after finishing. Perform all forging at no less than a red heat.

4. Shafting and Pins. Fabricate all shafts in conformance to tolerances in *ASTM A29/A29M* unless otherwise indicated. Turned, ground, and polished shafting straightness tolerances are to be up to 0.002 inch per foot for shafts up to and including 1½ inches in diameter, and up to 0.003 inch per foot for shafts over 1½ inches in diameter.

Accurately finish all shafts and pins round, smooth, and straight and when turned to different diameters, round fillets at the shoulders. Bore lengthwise through the center (to a diameter approximately 1/5 the smallest body diameter) for each shaft or pin having a uniform diameter of more than 8 inches and each shaft or pin having several diameters, of which the smallest is more than 8 inches.

As required lengths are reached, fabricate each end of all shafts with a 60-degree lathe center, with a clearance hole at the exact center of the shaft. Prepare the ends of the shafts that have a hole bored lengthwise through the center for the attachment of a centering device equivalent to the lathe center. All such devices are furnished as part of the work. All such devices are to fit within the shaft ends such that the bore and lathe center are concentric to within 0.002 inch.

Where it is required on the plans that stepped shafts have fillets blended in smoothly to adjacent surfaces without tool marks or scratches, machine the surfaces to an *ANSI* maximum roughness of 63 micro inches, unless otherwise required herein or on the plans to have a finer finish.

Fabricate all cold-finished shafting that is the type and grade of the steel shown on the plans, test for its mechanical properties, and submit a test certificate to the Engineer. Fabricate each cold-finished shaft free from camber. Test each to ensure rotation and that each runs without vibration, noise, or chatter at all speeds up to and including the maximum rated speed.

Use turned, ground, and polished commercial shafting of the grade specified where shown on the plans.

5. Fasteners. All bolts, either for connecting machinery parts to each other or to supporting members are categorized as one of the following types:

• Finished body, high-strength bolts

• High strength turned bolts, turned cap screws, and turned studs

Ensure all high-strength bolts shown on the plans are finished body, high-strength bolts unless otherwise noted.

Finished body high-strength bolts are to meet the requirements of *ASTM A449*. High-strength bolts must have finished bodies and regular hexagonal heads. Holes for high-strength bolts are to be individually reamed for a clearance of not more than 0.010 inch larger than the actual diameter of individual bolts for that hole.

Furnish high strength turned bolts, turned cap screws, and turned studs with turned shanks, cut threads, and finished washer-faced heavy hexagonal heads. Furnish high strength turned bolts, turned cap screws, and turned studs meeting the requirements of *ASTM A449*. For the finished shank of all turned bolts, turned cap screws and turned studs, use 1/16 inch larger in diameter than the diameter of the thread. Determine the head and nut dimensions based on the thread diameter. For the shanks of all turned fasteners, use an *ANSI Class LC6* fit in the finished holes in accordance with *ANSI/ASME B4.1*. Fully detail turned fasteners on shop drawings.

Ensure dimensions of all bolt heads, nuts, and hexagonal head cap screws are in accordance with *ANSI/ASME B18.2.1, Square and Hex Bolts and Screws,* and *ANSI/ASME B18.2.2, Square and Hex Nuts.*

Furnish heavy series heads and nuts for turned bolts, turned cap screws, and turned studs.

Ensure dimensions of socket-head cap screws, socket flat-head cap screw, and socket-set screws are in accordance with *ANSI B18.3, Socket Cap, Shoulder, and Set Screws*. Unless otherwise called for on the plans or specified herein, make the screws of heat-treated alloy steel, cadmium-plated, and furnish with a self-locking nylon pellet embedded in the threaded section. Set screws are to be of the headless, safety type with threads of the coarse thread series and having cup points. Do not use set screws to transmit torsion nor as the fastening or stop for any equipment that contributes to the stability or operation of the bridge.

Fabricate all threads for bolts, nuts, and cap screws in accordance with the course thread series having a Class 2 tolerance for bolts and nuts or Class 2A tolerance for bolts and Class 2B tolerance for nuts in accordance with the *ANSI/ASME B1.1, Unified Inch Screw Threads*.

Spot face all bolt holes through unfinished surfaces for the head and nut, square with the axis of the hole.

Unless otherwise called for, sub-drill all bolt holes in the machinery parts for connecting these parts to the supporting steel work at least 1/4 inch smaller in diameter than the bolt diameter and ream assembled for the proper fit at assembly or at erection with the steel work after the parts are correctly assembled and aligned.

Furnish positive locks of an approved type for all nuts, except those on *ASTM A449* bolts. Furnish tempered steel in accordance with the *SAE* regular dimensions for lock washers, where applicable. Use materials that meet the *SAE* tests for temper and toughness.

Furnish a hardened plain washer at each end of high-strength bolts meeting the requirements of *ASTM F436/F436M*.

Furnish cotters in accordance with the *SAE* standard dimensions and made of half-round stainless-steel wire, *ASTM A276/A276M, Type 316*.

In addition to meeting all applicable material, machining and production specifications, visually inspect all fasteners during installation. Replace any fastener found to have defects or conditions that will not allow them to be properly installed with new fasteners meeting the contract plans and specifications as part of the work at no additional cost to the contract.

Use only fasteners manufactured in the United States with the property class and source identification appearing on the top of head.

6. Keys and Keyways. Furnish keys and keyways in accordance with the dimensions and tolerances for square and rectangular keys of *ANSI B17.1, Keys and Keyseats*, meeting the requirements of Class 2 for parallel keys fits, unless otherwise specified. Furnish keys with chamfers on the outside corners and keyways with fillet radii on the inside corners as suggested by the *ANSI* Standard.

Effectively hold all keys in place, preferably by setting them into closed-end keyways milled into the shaft. Round the ends of all such keys to a half circle equal to the width of the key. If two keys are used in a hub, locate the keys 120 degrees apart and in line with wheel arms where practicable.

Furnish keys that are machined from alloy steel forgings, *ASTM A668/A668M, Class K* unless otherwise specified herein or on the plans. Orient the key lengths parallel to the metal flow during the hot working operation.

7. Sleeve Bearings and Bushings. Fit all split bearings mated to the other half as shown on the plans. Accurately machine the surface between the cap and base. Secure all caps to the bases with high strength turned bolts and double nuts. Furnish all caps and bases with double-flanged bronze bushings securely held against changing position under load by hexagonal-head, steel cap screws, unless otherwise shown on the plans. Fit all bushings to the inside bore and end faces of the base and cap, with an *ANSI Class LC1* clearance and location fit, and fit the shaft journals, with an *ANSI Class RC6* running fit. Furnish all caps with a tapped hole for lifting eyebolt.

Furnish pillow block steel housings capable of withstanding the design radial and axial loads in any direction and angle of operation, including uplift. Furnish housings and bearings designed to withstand a 200 percent overload. Cast bases without mounting holes. Sub-drill mounting holes from the solid and final drill and ream with supporting steel work. Furnish seals that retain the lubricant and exclude water and debris. Furnish high-strength steel cap bolts for pillow blocks. Use cap and cap bolts capable of resisting the rated bearing load as an uplift force. Furnish pillow block base connecting bolts meeting the requirements of *ASTM A193/A193M, Grade B7*.

Finish bore bushings for split bearings with the caps in place and with 1/4 inch thick rolled bronze or brass liners. Furnish liners with laminated construction where at least 1/8 inch of the liner thickness is capable of adjustment in increments of 0.003 of an inch. Cut the edges of the liners toward the shaft journal to fit the shaft shoulder fillets where they occur and are cut square and flush with the bushing flange if there is no change in shaft diameter. Except for a short distance from each end, cut back the inside edges of the liners to form a grease groove along the shaft. Drill all bolt holes through the liners.

Furnish spiral grease grooves for each half bushing of split bearings. Connect the groove at the ends of the liner grooves and intersect at the center of each half bushing, unless otherwise shown on the plans. Precision machine-cut and smooth all grease grooves. Round the corners of all grooves to a radius of not more than half the width of the groove.

8. Roller Bearings. Size anti-friction bearings for a B-10 life of 40,000 hours as defined by *ABMA* for the ratings shown on the plans.

Machine all pins, shafts and attachments to the dimensions and tolerances specified by the bearing manufacturer.

Furnish pillow block bearings, adapter mounted, self-aligning expansion and non-expansion types, as called for on the plans. Furnish cast steel housings capable of withstanding the design radial load in any direction, including uplift. Cast bases without mounting holes. Sub-drill mounting holes from the solid and final ream with supporting steel work. Furnish seals that retain the lubricant and exclude water and debris. Furnish high-strength steel cap bolts for pillow blocks. Use cap and cap bolts capable of resisting the rated bearing load as an uplift force.

9. Shaft Journals. Accurately turn all journal bearing areas on shafts and pins. Grind and polish the journal surface and adjoining shoulder fillets to an *ANSI* maximum roughness of 8 micro inches, leaving no trace of tool marks or scratches.  Finish journal diameters to the limits of an *ANSI Class RC6* running fit.

10. Open Gearing. Furnish spur gears with 20 degree full-depth, involute cut teeth in accordance with the proportions of the *ANSI/AGMA 201.02, Tooth Proportions for Coarse-Pitch Involute Spur Gears*, unless otherwise specified herein or shown on the plans. Furnish a suitable root radius and backlash for all teeth.

Cut the teeth of all gears from solid rims or blanks. Finish the sides and peripheries of all gears and pinions and scribe the pitch circle on both sides not less than 0.02 inch deep with a U-pointed tool. Ensure the working surfaces of all gear teeth are true to the proper outline, accurately spaced on the true pitch circle, exceptionally smooth, and free from planing or milling-cutter ridges. Remove cutter burrs from all edges of the teeth, and round the top edges of all teeth to a 1/32-inch radius.

Except as otherwise provided herein or on the plans, cut and mount all gears to meet the requirements for accuracy of *ANSI/AGMA 2000-A88, Gear Classification and Inspection Handbook*. State the *AGMA* quality number on the applicable shop drawings. Conform open gearing to *AGMA Quality No. 9* or higher.

11. Enclosed Speed Reducers. Furnish speed reducers that are based on standard models from one manufacturer, with sizes, ratios, and construction details as shown on the plans.

Design speed reducers to meet all requirements of *ANSI/AGMA 6010-F97*, and to be manufactured in accordance with the requirements of *AGMA* and given nameplates with the following information:

• Size

• Ratio

• Service Power Rating

• High Speed Shaft Revolutions Per Minute

• Service Factor

• Lubrication Specification

Ensure gear teeth are through-hardened and conform to *AGMA Quality No. 9* or higher. Do not furnish case-hardened gears to drive bridge machinery.

Furnish gears that are either spur, helical, herringbone, or bevel teeth; bearings that are antifriction type; and housings that have steel castings or welded steel plates, where stress is relieved. Sand blast clean the inside of the housings prior to assembly and also protect from rusting. Furnish exact ratios where specified.

The primary differential reducers to be based on a proven design. Differential design to include if one output shaft locked and all the dynamic torque and speed goes to the other shaft.

The primary reducer is to have a 1 to 1 ratio right angle auxiliary input as shown on the plans. The auxiliary input shaft, gearing, shafting and bearings are to be designed to the same requirements of the main motor shaft.

Gearing that transmits torque through a shaft and is not integral with the shaft, must be provided with suitable keyways and keys to transmit the design torque and withstand momentary overloads. Avoid shear of bolts, as a means to transmit torque inside the gear box. Minimize fasteners inside the gear box and use suitable means to prevent any fasteners inside the box from becoming loose.

Furnish speed reducers able to withstand a momentary overload equal to 3 times the rated full load torque of the driving motor(s) without any component reaching 75 percent of its yield strength.

Proportion pinions so that the root diameter of the pinion is not smaller in diameter than the diameter of the journals for the pinion shaft.

Furnish automatic lubrication of the gears and bearings when the unit is in operation.

It is preferable that a bath lubrication system be utilized. In a bath lubrication system, all components in the speed reducer that require, or feed lubrication are partially submerged in an oil bath.

When the configuration of gears and bearings prevents bath lubrication, a splash lubrication system should be used. Use splash lubrication systems that furnish continuous proper lubrication for all gears and bearings. Oil feed troughs may be used to supply oil to bearings and gears that are above the bath. Design splash lubrication systems such that equal lubrication is supplied to each internal component for both directions of operation.

If a pressurized lubrication system is required for the reducer, furnish a redundant lubrication system that operates at all times when the primary system is functioning.

Furnish grease-lubricated reducer bearings with separate fill and purge fittings when oil splash is not practical, readily accessible after installation of reducer. Furnish the grease-lubricated reducer bearings with internal seals between the bearing housing and reducer cavity, preventing grease and gear oil from interacting.

Furnish mechanical-type oil seals as the bearing shaft ring seals on shaft extensions to compensate for wear.

Conform shaft extensions for the various reducers to the arrangement, lengths, and diameters shown on the plans. Shrink fit couplings on the shafts in the shop.

Furnish inspection ports on reducers for inspection of all gears, bearings, and other internal devices. Position the ports above the oil level, if practicable, so that oil draining is not required for inspection. Size the port such that minor repairs could be made to reducers without requiring housing disassembly. Provide seals that properly seal the ports and do not require replacement when ports are opened.

Furnish reducers equipped with moisture trap breathers, oil fills, break proof glass oil level indicators, drains, and inspection ports.

Position moisture-trap breathers above maximum oil levels in all positions of the reducer during operation, with piping entering the unit at the highest point possible. Do not mount breathers in bearing caps.

Mount oil level indicators in locations that can be easily viewed by maintenance crews. Graduate the sight glass on reducers in which the oil level varies by more than 1/2 inch per 50 °F temperature change. Vent the indicator back to the case. Furnish sight glasses made of rugged construction and protected against breakage.

Locate oil drains at the lowest point possible. Furnish a drain with a hand operated lever which can be locked in the closed position.

Position oil sampling cocks in accessible positions on the reducers with two sampling cocks on each, one located at the lowest level of oil and one just below the upper oil level.

Furnish speed reducers with details for oil expansion due to churning and temperature change.

Ensure base plates/feet for the reducers are large enough to give unobstructed access for drilling and reaming the mounting holes from above the unit. For the primary and secondary reducers, the mounting feet are to be custom and be coordinated with structural supports. Detail and coordinate the reducer mounting with supports. Design bolting of the reducers to support to withstand normal and momentary overload torque conditions.

Size and detail the gear housing for reducers on the movable span to complement lubrication to gearing and bearings in all bridge operation positions.

Submit for the Engineer’s approval, a certified print of each speed reducer showing as a minimum the following:

• All external mounting dimensions including shaft sizes, bores, and keyways as required.

• Internal drawings showing each reducer component with part numbers.

• The ratings that will appear on the nameplate.

• Location of all lubricant connections.

• Lubrication recommendations.

Submit for the Engineer’s approval, computerized calculations showing conformity to the requirements of the *AGMA Standard* specified. Ensure the reducer design calculations are made available to the Department prior to construction of the unit.

12. Hubs and Bores. Finish the hubs of all gears, wheels, and couplings on both faces; polish the area where the hub face performs the function of a collar to prevent shaft movement. Bore the hubs concentric with the rims of gears and wheels or with the outside of the couplings. Furnish all hubs to have an *ANSI Class FN2* medium shrink fit on the shafts, unless otherwise specified.

13. Shims. As shown on the plans, furnish stainless steel shims required for leveling and aligning of equipment; neatly trim to the dimensions of the assembled parts and drill for all bolts that pass through the shims. Use shims that are Stainless Steel meeting *ASTM A240/A240M, Type 304*. To prevent distortion of the shims, do not punch the bolt holes at the machine shop. Instead, pre-drill the shim holes 1/4 inch larger in diameter than the permanent fasteners shank. For shims greater than 1/2 inch, include one solid plate of thickness equal to 1/2 inch less than total shim thickness.

Furnish tapered shims as needed to secure final alignment and full bearing of components on their supports, as necessary as part of the work, at no additional cost to the contract.

Furnish fully dimensioned shims as shown and detailed on the shop drawings. Shims with open side or U-shaped holes for bolts will not be permitted. Shims will have a minimum of two holes for bolts.

Unless otherwise shown on the plans, furnish shim pack containing shims of decreasing thickness from full depth down to 0.010-inch, plus 2-0.005-inch shims. For example, a 0.5-inch shim pack would consist of the following shim thickness 0.500, 0.250, 0.125, 0.060, 0.040, 0.020, 0.010, 2-0.005-inch for a total of 9 shims.

14. Welding. Perform welding required for machinery in accordance with the requirements of the *AASHTO/AWS D1.5, Bridge Welding Code* (AWS D1.5). Stress relieving will be required prior to machining.

Furnish welding joint sizes and details as shown on the shop drawings. For required multi-pass welds, submit welding procedures with shop drawings.

Ensure distortion during fabrication is kept to a minimum by the use of welding fixtures and proper welding procedures.

For all welds used to fabricate machinery, completely test by ultrasonic inspection per AWS D1.5 for compression welds unless otherwise noted. Perform all machining after welding and stress relieving.

15. Machinery Guards. Furnish machinery guards for all moving parts readily accessible to personnel, including, but not restricted to the following:

• Couplings (including, but not limited to: C2A, C2B, C3, C5)

• Floating Shafts

• Open gears

• Unused shaft extensions

• Brakes

• Instrument drives and limit switches

• Clutches

Machinery guards are not required for the rack segments and main pinions. Construct machinery guards to comply with the applicable requirements of *ANSI B15.1, Safety Standard for Mechanical Power Transmission Apparatus*.

Unless otherwise shown or specified, construct all machinery guards with stainless steel with minimum thickness of No. 12 Gauge (0.1046 inch). Furnish guards that require no disassembly of any machinery component.

Furnish machinery guards with removable hinged or bolted covers for access to lubrication fittings enclosed by the guard. Furnish phenolic nameplates on these covers with lubrication instructions.

Furnish warning label to adhere to stainless steel machinery guard.

16. Flexible Couplings. Furnish couplings of the type shown on the plans, which includes grid type, gear type, and others as needed.

In general, furnish couplings that are finish-bored and have keyways cut by the coupling manufacturer to dimensions and tolerances established on the shop drawings then ship to the manufacturers of the various components for shop installation on the shafts.

Furnish grid-type, self-aligning, fully flexible, torsionally flexible couplings to connect electric motors to machinery components. Furnish grid-type couplings with steel hubs, alloy steel grids, and steel or aluminum covers. Furnish all couplings with shrouded bolts.

Furnish gear-type, self-aligning, full-flexible couplings or semi-flexible couplings with floating shafts to connect all machinery components, except where other types of couplings are called for on the plans. Furnish all couplings with shrouded bolts. Make the gear-type couplings of forged steel having curved face teeth and providing for at least a ±3/4-degree misalignment per gear mesh.

Furnish special couplings as shown on the plans.

Furnish couplings that are standard products of an established manufacturer.

17. Lubrication.

A. Lubrication Fittings. Use national pipe straight (NPS) 1/4 giant button head fittings, unless otherwise shown on the plans. Where required, furnish stainless steel seamless pipe to connect fittings to housings, allowing grease to discharge directly through the housing, shims, bushing, and into the grease grooves for distribution. Locate all grease fittings for convenient greasing, and if necessary, connect the points requiring lubrication from convenient lubrication stations by NPS 1/4 stainless steel seamless pipe – schedule 80 with stainless steel threaded pipe fittings – 3000 psi. Meet *ASTM A312/A312M* and *ASTM A182/A182M* for all stainless-steel pipe and fittings, respectively. Keep all pipe extensions as short as practical; securely support the pipe extensions at fittings and at intermediate points and locate so that they are protected from injury. Install only lubricating equipment that meets the included requirements and is in new condition.

Do not use more than two sizes of fittings. Use the large size wherever possible; use the smaller size for motor bearings and other small devices. Use pressure fittings rated at a minimum of 3,000 psi. Furnish fittings that contain a steel check valve that will receive grease and close against back pressure.

Immediately after the completion of fabrication, plug all fitting locations until components are installed and regular lubrication is started. At that time, replace the plugs with proper grease fittings. During installation, lubricate all rotating and sliding parts of the machinery and fill all gear reducers, bearing housings, and flexible couplings with lubricants indicated on approved lubrication charts. On plain bearings lubricate both contact surfaces with approved lubricant during assembly of the bearing components.

B. Lubrication Charts. Furnish three copies (on mylar) of lubrication charts showing the location of all lubricating fittings and other points of the mechanical and electrical equipment which require lubrication of any kind; show the kind of lubricant to be used at each point; and document the frequency of lubrication. Frame the charts under acrylic in neat wooden frames, and place as directed by the Engineer. Furnish one Universal Serial Bus (USB) Flash Drive containing PDF images of the lubrication charts.

For each machinery component, store all related maintenance and lubrication literature in a heavy-bound binder, which is to be kept in the control house. Furnish one USB Flash Drive containing PDF image(s) of this information.

18. Tools and Equipment. Furnish the following tools and lubrication equipment:

A. One 60-inch by 24-inch by 78-inch extra-heavy-duty steel tool storage cabinet with four shelves, hinged doors and a heavy-duty padlock. Furnish steel that has a minimum 12-gauge thickness except shelves may be 14 gauge. Locate storage cabinet as directed by the Engineer.

B. Two hand lubrication guns, screw type, 12-ounce capacity, for each size lube fitting used.

C. One loader pump for 25-pound capacity pail for each type gun furnished.

D. One grease transfer pump complete with hose and fittings for 120-pound drum.

E. One 1-Ton hand chain hoist with a minimum lift of 15 feet equal to Coffing Model LHH-1B15 or similar hoist as manufactured by Harrington Hoists, Inc.; Yale hoist as manufactured by Columbus McKinnon Industrial Products GmbH; or approved equal.

F. Two of any size wrench and special tools or special lubrication equipment necessary to service machinery components actually installed in the bridge, which are not otherwise specified.

19. Spare Parts. Furnish a complete list of each and every shaft and coupling seal used at the job, including current part number and manufacturer of each seal furnished plus sufficient generic description and dimensions to order seals in the future when current models/manufacturers may no longer be identifiable.

In addition to the spare parts described under other items, frunish the following spare parts:

• One grid of each grid-type coupling.

• One complete set of gaskets for every flexible coupling.

• Five fittings of each different type and size used.

**c. Construction.**

1. Shop Fabrication. To permit inspection, give 14 days’ notice to the Engineer before the beginning of work at foundries, forge, and machine shops. Notify the Engineer of the location(s) where the order(s) have been placed prior to casting, forging, or machining any materials.

Furnish all facilities for the inspection of material and workmanship in the foundries, forge, and machine shops. Allow free access to necessary parts of the premises to the Inspector designated by the Engineer. Work done while the Inspector has been refused access or presented in a manner that prevents adequate inspection will automatically be rejected.

The Inspector will have the authority to reject materials or workmanship, which do not fulfill the requirements of this special provision.

Inspection at the foundries, forge, and machine shops is intended as a means of facilitating the work and avoiding errors. It is expressly understood that inspection will not relieve the Contractor from any responsibility in regard to imperfect material or workmanship and the necessity for replacing defective materials or workmanship, which are delivered to the job site.

Furnish the Engineer with a copy of all orders covering work performed by subcontractors or suppliers.

Unless otherwise provided, furnish without additional cost to the Department test specimens as required, and all labor, testing machines, tools, and equipment necessary to prepare the specimens and to make the physical tests and chemical analyses required by material specifications, all of which are to be furnished by and/or performed by the Contractor. Furnish a copy of all test reports and chemical analyses to the Engineer.

The acceptance of any material or finished parts by the Engineer are to be a bar to their subsequent rejection if found defective. Ensure rejected material and workmanship is replaced or made acceptable by the Contractor at no additional cost to the Department.

2. Shop Inspection and Testing. Assemble machinery components to verify their correct fit prior to shipment. Ensure measurements required for each assembly are as shown on the plans and/or described in the individual pay items.

Shop test each reducer by running it at no load and at the normal operating speed for at least 1 hour in each direction in both the horizontal (0 degree) and raised (74 degrees) positions (4 hours total continuous operation). During the raised position test, orient the reducers to match how they will be mounted and raised on the bridge. Also include testing of the differential in the horizontal (0 degrees) position (2-hour total continuous operation). This requires locking one output shaft and spinning the other shaft 30 minutes in each direction and then switch the locked shaft and the shaft being spun for another 30 minutes each direction. Ensure this test is performed in the presence of a representative of the Engineer. Perform the test runs with the reducers filled to the dipstick mark, with new oil of the viscosity the manufacturer recommends on his lubrication chart for normal operation. Immediately before the start of the test, and at 15-minute intervals, thereafter, make the following measurements and observations and record and submit with the certificate of compliance:

• Temperature of ambient air

• Temperature of oil near bottom of crankcase

• Surface temperature of each shaft extension adjacent to shaft seal

• Sound level at point above and 3 feet distant from center of unit

• External leak check

During this test the temperature of the oil is to rise no more than 30 °F from ambient and no shaft is to experience a temperature rise of more than 40 °F from the ambient. The noise level of the reducer is not to exceed 90 dB with the microphone held 3 feet from the reducer housing.

During testing, check each speed reducer for unusual noise (thumping or any non-uniformity), excessive bearing clearance, and other unusual operating characteristics. The units are to operate smoothly and without excessive vibration or temperature rise. Record and correct all malfunctions, and retest the units, if necessary, before release from the manufacturer’s shop. After the unit has passed the test, submit a Certificate of Compliance to the Engineer.

Demonstrate the proper operation of the lubricating system during the shop test. In addition to the test specified above, demonstrate the proper distribution of load on the gear teeth by the application of tooth bluing liquid and a documented report containing digital photographs, to be submitted with the Certificate of Compliance.

Additional testing of speed reducers may be specified in the Special Provision for Operating Machinery.

3. Defective Material and Workmanship. All machinery rejected during inspection and testing, that is not made acceptable, is to be removed from the work site and replaced at Contractor’s expense.

Delays resulting from the rejection of material, equipment or work is not to be the basis of any claim.

Correct, at Contractor’s expense, all defects found during the guarantee period resulting from faulty material, components, workmanship, or installation.

4. Delivery and Storage.

A. Protection for Shipment. Clean machinery parts of dirt, chips, grit, and all other injurious materials and coat all unpainted surfaces with a corrosion-inhibiting preservative prior to shipping.

Finished metal surfaces and unpainted metal surfaces that would be damaged by corrosion are to be coated as soon as practicable after finishing with a rust-inhibiting preservative. With the exception of unfinished metal surfaces inside of gear reducers, remove this coating prior to operation and from all surfaces prior to painting after erection.

Any interface between stainless steel or aluminum and structural steel is to receive an Engineer-approved coat of zinc-rich primer prior to assembly.

Completely protect machinery parts from weather, dirt, and all other injurious conditions during manufacture, shipment, and storage.

Protect shaft journals that are shipped disassembled from their bearings during shipment and before erection by a packing of oil-soaked rags secured in place by burlap and covered with heavy metal thimbles or heavy timber lagging securely attached. Take every precaution to ensure that the bearing surfaces are not damaged and that all parts arrive at their destination in satisfactory condition.

Mount assembled units on skids or otherwise crate for protection during handling and shipment.

B. Package and Deliver Spare Parts. Protect spare parts for shipment and prolonged storage by coating, wrapping, and boxing.

Durably tag or mark all spare parts with clear identification showing the designation used on the approved shop drawing.

Clearly mark on the outside of the boxes for spare parts showing their contents. Deliver spare parts to a location designated by the Department.

C. Guarantee and Warranties. Manufacturers’ warranties or guarantees on equipment, materials, or products purchased for use on the Contract are to be consistent with those provided as customary trade practice, obtained by the Contractor, and upon acceptance of the contract. The Contractor will assign to the Department all manufacturers’ warranties or guarantees on all such equipment, material, or products furnished for or installed as part of the contract.

The Contractor will warrant the satisfactory in-service operation of the mechanical equipment, material, products, and related components. This warranty extends for a period of 1 year following the date of final acceptance of the project.

5. Erection. Submit calculations for each stage of construction, and drawings and procedures detailing the intended scheme for installing all machinery. Machinery installation is done in a coordinated manner to ensure all the machinery components fit the adjacent material furnished under other items.

A. Alignment and Bolting. Start the order of assembly and alignment of bridge machinery at the final driven components and work back to the prime mover. To achieve proper alignment of mating components prior to final reaming and fastening, limit the finality of some staged machinery installations which are prior to completion of the final installation.

Align all open gearing such that backlash is within tolerance and at least the center 50 percent of the effective face width of each pair of meshing teeth is in contact throughout the full range of movement. The cross mesh should not exceed 0.01 inch per 10 inches face width. Submit all open gear measurements to the Engineer for review and approval. The measurements are to include backlash, cross-mesh alignment, tooth valley gap, and face contact. Submit to the Engineer for approval the type of bluing or lubricant to be used for face contact measurements prior to taking any measurements. Perform the measurements at a minimum of eight equally spaced span positions ranging from fully open to fully closed.

Match-mark all parts of the machinery for proper assembly and correct orientation. Before final drilling or reaming, adjust all parts to exact alignment by means of shims. Furnish tapered shims as necessary. Include installation, alignment, and shimming of the electric motors and devices such as limit switches and encoders, with the machinery for such erection. After final alignment and bolting, all parts must operate smoothly.

Do not operate the span via the bridge machinery until all components are installed, in final alignment, and bolted as approved by the Engineer.

In general, after final alignment of machinery, drill bolt holes into the structural steel from the solid for connecting machinery. For erection and alignment of machinery, use sufficient erection holes, sub-drilled 1/4 inch undersize for undersized temporary bolts. As the machinery is aligned in its final position, drill full-size holes for the remaining bolts, or sub-drill and ream; install the full-size bolts; and remove the temporary bolts. Ream full-size the undersized holes (used for temporary bolts) and install full-size bolts.

Drill and ream assembled bolt holes in structural steel and machinery components (with shims in place correctly positioned with respect to the component base and bolt pattern) to assure accurate alignment of the hole and accurate clearance over the entire length of the bolt within the specified limit.

Check the clearance of finished body bolts with 0.011-inch wire. The hole is considered too large if the wire can be inserted in the hole together with the bolt.

Connect machinery components to structural elements or to other machinery components comprised of different thickness using high-strength bolts. Wherever possible, install the bolts such that the head is adjacent to the connected element with the least thickness.

Handheld reamers are not considered accurate enough; use a reaming jig to keep the bolt hole cylindrical. Use a jig made of structural steel, fixed to the drill, and secured to the work preventing the reamer shaft from deviating. Check holes with a bolt hole micrometer to assure uniform diameter.

Torque finished body high-strength bolts meeting the requirements of *ASTM A449* to 70 percent of the material proof strength, based on the nominal threaded shank size.

Torque high strength turned bolts meeting the requirements of *ASTM A449* to 50 percent of the material proof strength, based on the nominal threaded shank size.

For other classes of bolts, torque fasteners proportioned to their strength.

Show torque values on the erection drawings.

B. Coatings. Coat threads for turned bolts with anti-seize compound before assembly with nuts to prevent corrosion or galling, and to facilitate future removal, if necessary.

C. Edges and Corners. Round or chamfer all edges and corners of machinery parts, sheet metal work, bed plates, and fabricated supports that are exposed in the finished work. Remove all burrs or other surface defects that could be injurious to workers erecting or maintaining the bridge machinery.

D. Personnel and Facilities. Use competent millwrights that are skilled in the type of work involved to erect and adjust the machinery. Furnish all necessary measuring and leveling instruments, as required.

6. Painting. Clean and paint all unfinished surfaces of machinery, as specified in the standard specifications. Along with the shop drawings, submit an outline of painting materials and methods for review.

A. Shop Painting. During final preparation, blast clean all external surfaces of unfinished machinery prior to painting. Blast cleaning must comply with the requirements of *SSPC-SP6, Commercial Blast Cleaning*, with the following exceptions:

• Flexible couplings

• Reducers

• Sleeve bearings with bushings in place

• Electric motors

• Brakes

• Limit switches

• Other equipment with shaft seals

• The equipment excepted by the Engineer

Clean the excepted machinery or equipment with solvent and hand tools to meet the requirements of *SSPC-SP2, Hand Tool Cleaning* as depicted in *SSPC VIS 1*.

After proper surface preparation, apply one shop coat of primer by hand brushing to all unfinished machinery surfaces except for the interior of gear housings, flexible couplings, and pillow blocks. Ensure the modified aluminum epoxy mastic primer is compatible with the paints selected for subsequent coats. Protect the interiors of gear housings with special oil-resistant crankcase paint, or an approved equal.

For non-mating surfaces that receive a shop coat of primer but become inaccessible once the erection process begins, shop apply these surfaces with an intermediate coat to complement the below field painting requirements.

B. Field Painting. After erection is complete, thoroughly clean all exposed surfaces of the machinery (except machine finished surfaces in sliding contact), with an approved high-flash solvent and apply intermediate coat by hand brushing. Ensure the aliphatic acrylic polyurethane is compatible with the finish coat. Furnish an intermediate coat that is resistant to weathering (marine environment) and abrasion and free of lead.

After field testing is complete, but prior to final acceptance of machinery, re-clean all exposed surfaces of the machinery (except machine finished surfaces in sliding contact), with an approved high-flash solvent and apply a finish coat by hand brushing. Ensure the aliphatic acrylic polyurethane is compatible with previous coats. Furnish a finish coat to color code the machinery and distinguish the moving parts from the stationary parts. Use the following colors:

Federal Safety Orange (*AMS-STD-595 12300*). For all moving parts of the machinery such as shafting, couplings, and the sides of gears and brake wheels. (Exception: machine finished surfaces in sliding contact.)

Federal Safety Green (*AMS-STD-595 14260*). For all stationary parts of the machinery.

Use paint for the finish coat, which is compatible with the intermediate field coat; high-gloss, resistant to weathering and abrasion, and conforms to OSHA color requirements of the *ANSI Z53.1, Marking Physical Hazards Safety Color Code*. Submit the brand and colors to the Engineer for approval. Place cautionary signs in the bridge machinery and control house areas, which explain the color code. Furnish details of the signs; give text, dimensions, and materials on a shop drawing.

Take special care to avoid painting machinery surfaces, which are in normal rubbing contact. Mask, for protection from paint, all nameplates, legend plates, and escutcheons mounted on machinery. Ensure lubrication fittings are kept clog-free.

7. Contractor’s Inspection. After erection is complete, make a thorough inspection to ensure that all gears are clean and free of obstruction, that all parts are properly aligned and adjusted as closely as practicable without actual operation; that all bolts are properly tightened; and that the span is properly balanced.

Inspect tightened fasteners in accordance with the standard specifications. Verify that field painting has been performed as specified herein. Perform touch-up painting to correct all painting defects found during this inspection.

Verify that all enclosed gear housings are filled to the proper level, and all rotating and sliding parts are supplied with lubricants as recommended by the manufacturers of the units. Typical products for the various locations are as follows:

• Sleeve Bearings and Pillow Blocks: National Lubricating Grease Institute (NGLI) #2 EP Grease

• Open Gears: Open Gear Lubricant (Mobiltac 375 Non-Chlorinated (NC))

Specific Gravity @ 72 °F - 0.96

Saybolt Universal Seconds (SUS) @ 100 °F - 25,000

SUS @ 210 °F - 5,000

• Enclosed Gear Reducers: Refer to *AGMA Standard 9005.D94* “Lubrication of Industrial Enclosed Gear Drives”

• Gear Couplings: NLGI #0 EP Grease

• Grid Couplings: NLGI #2 EP Grease

Prior to machinery testing, the Engineer will accompany the Contractor during his final inspection. On the basis of the results of this inspection, the Engineer determines whether the bridge is ready for field testing.

8. Field Testing. When the mechanical components, hydraulic components, and electrical equipment are ready for final testing, inform the Engineer not less than 15 calendar days prior to the scheduling of tests. During all tests, keep available a complete crew of mechanics in order to provide operation of the span and to make all adjustments and corrections, which are required to complete the tests.

Prepare a field-testing procedure and submit to the Engineer for review and approval. Coordinate the testing procedure with tests required for the electrical equipment and include measurements of power and current drawn as a function of position by the motors when operating under load as required hereinafter.

The testing procedure must include but not be limited to the verification of proper installation, alignment, fastening, operation, and/or final adjustment of the following:

• Operating Machinery

• Tail Lock Machinery

• Machinery Instrument Drives and Limit Switches

• Track and Tread

• Jaw and Diaphragm

When the machinery is ready for field testing, drive the machinery assemblies under normal and auxiliary operations. During normal operation, use the main electric power to cycle the tail locks and operating machinery in the proper sequence to raise/lower the bascule span 10 times. During auxiliary operation, use hand cranks to cycle the tail locks and the auxiliary motor to cycle the operating machinery in the proper sequence to raise and lower the bascule span five times.

During the tests, inspect each machinery assembly in its entirety to determine whether everything is in proper working order and fully meets the requirements of this special provision, the plans, and manufacturers’ recommended tolerances. Perform all test runs in the presence of the machinery manufacturer’s representative, the electrical control equipment manufacturer’s representative, and the Engineer. The temperature rise of all electrical components must not exceed design ratings. If any test shows that the components are defective, inadequate, or functioning improperly, make all corrections and adjustments, or provide the replacements required before final acceptance, at Contractor’s expense.

9. Training. Furnish five, 8-hour days of instruction to the Department’s Operation and Maintenance personnel. The instruction must include but not be limited to the following with respect to all bridge machinery components:

• Function, Purpose

• Normal Operation

• Auxiliary Operation

• Manual Operation

• Maintenance

• Adjustment

• Troubleshooting

• Repair and Replacement

During the training period, use the completed operating and maintenance manuals, in final form, for the purpose of familiarizing the Department personnel with its contents and usefulness. Furnish an opportunity for Department personnel to offer final review comments on the content of the manuals both during and after the training period.

**d. Measurement and Payment.** The requirements described in this special provision will not be paid for as a separate unit of work. All work described above will be included and paid for under various other pay items. See Special Provision for Operating Machinery and Special Provision for Tail Lock Machinery.