

Special Specification 4034

Bridge Machinery



1. DESCRIPTION

- 1.1. **Scope of Work.** This section will apply to all items listed in the Mechanical Systems Rehabilitation specification and gives the general requirements which apply to all bridge machinery and is given here to avoid repetition in each of the individual machinery sections. Also, this section applies to the installation of electric motors, brakes, instrument drives and limit switches to be mounted with the machinery but supplied under separate items.

Cleaning and painting will be included under each item. Lubrication as applicable will also be included under relative individual items.

When installing new and rehabilitated machinery components, new bolts and shims will be used. New shims will be full size.

Work detailed in the Mechanical Drawings, also known as the Plans, are to be coordinated with work detailed on the complete set of Contract Drawings, with particular attention to the structural and electrical interface points. It is the Contractor's responsibility to detail the erection, assembly and shop drawings, to insure proper clearances are maintained as shown, and to ensure there are no interference points throughout the entire range of motion of the bridge.

- 1.2. **Basis of Machinery Design.** The design of new and rehabilitated machinery conforms to the 2nd Edition 2007 AASHTO LRFD Movable Highway Bridge Design Specifications, and interim revisions unless otherwise noted.

- 1.3. **Submittals.** Manufacturer's data and/or shop drawing data will be submitted for all manufactured and purchased items of bridge machinery.

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

- 1.4. **Shop Drawings.** Shop drawings will conform to the Texas Department of Transportation (TxDOT) standards, as supplemented and amended elsewhere herein and to the special requirements specified hereinafter.

Shop drawings will show all parts completely detailed and dimensioned. The grade and amount of finish machining, with all tolerances and allowances, will be stated for each part for which a specific fit is required. Finished surfaces will be as defined by the ASME B46.1-1995, "Surface Texture"; and fits will be as defined by the ANSI B4.1, "Preferred Limits and Fits for Cylindrical Parts," unless otherwise stated herein or on the Plans. ANSI B4.1 will also apply to fits for non-cylindrical parts. The fits and finishes used will conform to the requirements for fits and finishes given on the Plans and as specified herein.

The general machine finish for parts unless otherwise noted is 125 micro-inches.

All proprietary items will be shown in outline on the drawings, which will also indicate the method and sequence to be employed in assembly of bridge machinery and installation of necessary utilities support and service facilities. Shop drawings will show all external dimensions and clearances necessary for installation and operation of each item of machinery in the bridge. For all bridge machinery shown on the Contract Plans

or listed herein, the Contractor will furnish complete assembly diagrams showing each part contained within the item and the manufacturer's part number assigned to each part. The diagram will be 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, the Contractor will deliver a drawing that details each modification; and the part will be assigned a unique part number to preclude the supply of replacement parts not modified in similar fashion. The assembly drawings of each item will, in addition to identifying and describing each internal part, 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

Certified prints of each manufactured assembly will be furnished. Certified prints are manufacturer's drawings of proprietary products on which the manufacturer or supplier states mounting dimensions, ratios, speeds, ratings, and any other details for use on this specific project. In addition to identifying and describing each part, they will show:

- dimensions of all principal parts comprising the assembly
- certified external dimensions affecting clearances required for installation
- capacity and normal operating ratings
- recommended lubrication, including location, lubrication fittings and provisions for adding, draining and checking the level of lubricants
- inspection openings, seals and vents
- details or description of all fasteners required to mount the assembly
- gross weight
- certified prints will be signed by an officer of the manufacturing company

Complete shop bills of materials will be made for all machinery parts. If the bills are not shown on the shop drawings, prints of the bills will be furnished for approval in the same manner as specified for the shop drawings.

The weight of each piece of machinery will be stated on the shop drawing upon which it is detailed or billed. The material and material specifications will be stated for each part. Where American Society for Testing and Materials Specifications or any other Standard Specifications are used, the designating numbers of such Specifications will be given. The following abbreviations will be used herein and on the Plans to designate Standard Specifications for materials and workmanship:

- American Society for Testing and Materials _____ ASTM
- American National Standards Institute _____ ANSI
- American Iron and Steel Institute _____ AISI
- American Gear Manufacturers Association _____ AGMA
- Society of Automotive Engineers _____ SAE
- National Electrical Manufacturers Association _____ NEMA
- American Association of State Highway and Transportation Officials _____ AASHTO
- National Lubricating Grease Institute _____ NLGI
- American Bearing Manufacturers Association _____ ABMA

Complete assembly and erection drawings will be furnished. These drawings will give 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 will not be allowed. Reproduction of the Contract Plans will not be used as foundation sheets for assembly or erection drawings.

Each shop drawing will be given a suitable title to describe the parts detailed thereon and will state by whom shop inspection will be made.

- 1.4.1. **Standard Compliance.** Where equipment or materials are specified to conform to requirements of the standards of an organization, such as American Society for Mechanical Engineers (ASME), Underwriters Laboratories (UL), American Gas Association (AGA), and American Refrigeration Institute (ARI), that use a label or listing as method of indicating compliance, proof of such conformance will be submitted and approved. The label or listing of the specified organization will be acceptable evidence. In lieu of the label or listing, the Contractor will submit a certificate from an independent testing organization adequately equipped and competent to perform such services and approved by the Engineer, stating 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.
- 1.4.2. **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.
- 1.4.3. **Factory Tests.** As used herein, factory tests refer to tests required to be performed on the actual materials or equipment proposed for use. Results of the tests will be submitted in accordance with the provisions of this Contract for laboratory test results.

The Contractor will submit the required shop drawings for machinery items to the Engineer for review within 120 days after the date of award of contract.

The Contractor will prepare a list of all machinery items that require lubrication and their recommended cycle for lubrication. The list will contain the types of lubricant used and the date it was lubricated by the Contractor and will be given to the Engineer prior to start up and testing of the machinery.

Lubrication charts will be prepared and submitted as working drawings.

If any departures from the Contract Documents are deemed necessary by the Contractor, details of such departures and the reasons therefore will be submitted to the Engineer in writing as soon as practicable for his approval. No departures from Contract Drawings will be made without the Engineer's approval.

If the Contractor has any objection to any feature of the machinery as designed or required by the Plans, the objection will be stated in writing to the Engineer at the time of submitting shop drawings or prior thereto; otherwise his objection will not be considered if offered later as an excuse for malfunctioning, defective or broken machinery.

The Contractor will submit to the Engineer for his approval all shop drawings. In case of correction or rejection, the Contractor will resubmit until drawings are approved. The Contractor will bear all costs for damages, which may result from the ordering of any materials prior to the approval of the shop drawings; and no work will be done until the shop drawings have been approved. After approval of the shop drawings, the Contractor will supply the Engineer with copies of the approved shop drawings. It is the Contractor's responsibility to manufacture and install suitable functioning machinery. Review and approval of shop drawings by the Engineer does not relieve the Contractor of this responsibility.

2. OPERATING AND MAINTENANCE MANUALS

- 2.1. **General Requirements for Manuals.** Manuals will contain 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 and each piece of equipment furnished by the Contractor. Any revisions required after the break-in period should be addressed by errata or addenda to the manuals.

All printed matter, data, drawings, diagrams, etc., will be accurate, distinct and clearly and easily legible. Illustrations will be clear; and printed matter, including dimensions and lettering on drawings, will be legible. If reduced drawings are incorporated to manuals, the original lines and letters will be darkened as necessary to retain their legibility after reduction. Larger drawings may be folded into manuals to page size.

All printed matter, data, drawings, diagrams, etc., will be produced by methods so as to result in permanence and durability, including paper that is water resistant; no materials will be used which will adversely affect this permanence and durability.

- 2.2. **Contents of Manuals.** The following identification will be inscribed on the cover: the words "Operating and Maintenance Manual," the name and location of the bridge, the contract number, the date and the names of the Consulting Engineer and Contractor

The manual will include the names, addresses, and telephone numbers of each subcontractor installing equipment and systems and of the local representatives for each item of equipment and each system.

The manual will have a table of contents and be assembled to conform to the table of contents with the tab sheets placed before instructions covering the subject. The instruction sheets will be legible and easily read, with large sheets of drawings folded in.

The manuals will include, but not be limited to, the following: a system layout showing all machinery components and equipment with data to explain detailed operation and control of each component; a control sequence describing operation; a detailed description of the function of each principal component of the system; the procedure for operating; installation instructions; maintenance and overhaul instructions; lubrication schedule including type, grade, temperature range, and frequency; safety precautions, diagrams, and illustrations; test procedures; performance data; and parts lists. The parts lists for equipment will indicate the sources of supply, recommended spare parts, and the service organization that is reasonably convenient to the bridge site.

The manuals may include manufacturer's standard publications provided that the literature covers information and data specific to the equipment actually furnished by the Contractor.

The manual will include information on trouble-shooting. A list of behavioral warning signs, possible problems and potential solutions will be developed and incorporated into the manual for each principal piece of equipment.

The manuals will include detailed steps for cursory and in-depth inspections that should be carried out annually and biennially, respectively.

The manuals will be complete in all respects for all equipment, controls, accessories and associated appurtenances provided.

- 2.3. **Materials for Manuals.** Operating and maintenance manuals will be bound in heavy-duty nickel plated three hole binders with three trigger positions: lock, unlock and open. Binder will have metal hinges. Locking mechanism will allow sheets to lie flat (i.e. channel lock). Covers will be stiff heavy-duty plastic or other approved material. Type binder will be either elliptical ring, round ring, screw post, or post with channel lock, as directed by the Engineer.

The material will be bound into each book between rigid covers. The instruction books will be approximately 9 in. by 12 in. to contain the drawings without excessive folding so that they may be easily opened. The books will be neatly entitled with a descriptive title, the name of the project, the location, year of installation, the name of the manufacturer, the engineering firm and the Contractor. Copies of drawings will be in black on white background and will be legible. The arrangements of the books, the method of binding, material to be included, and the text will all be submitted to and approved by the Engineer.

8 1/2 in. by 11 in. loose-leaf, on 60-pound, punched paper, acid free of a quality suitable for archival use with minimum diameter 5/16 in. holes, reinforced with plastic or cloth, standard three (3) hole spacing will be used.

Foldout diagrams and illustrations, will be 5/16 in. minimum diameter punched holes, reinforced with plastic or cloth, standard three (3) hole spacing.

- 2.4. **Sequence of Submittals for Manuals.** Two copies of sample formats and outlines of contents in draft form 90 days prior to the earliest of final inspection, acceptance tests, or return of span operation to the TxDOT showing proposed methods of binding, methods of printing and reproduction.

Two copies of complete manual in final form 30 days prior to final inspection, acceptance tests or return of span operation to the TxDOT.

Seven (7) copies of approved manual ten days after final inspection and acceptance tests. One of the seven copies will become the property of the Engineer, the remaining copies will become the property of the TxDOT.

- 2.5. **Posted Operating Instructions.** Operating instructions approved by the Engineer will be provided for the system and each principal piece of equipment for the use of operation and maintenance personnel. The operating instructions will include diagrams showing the complete layout of the entire system, and will be framed under glass or in approved laminated plastic and posted where directed by the Engineer; printed or engraved operating instructions for each principal piece of equipment including proper adjustment, operating, lubrication, safety precautions, procedure in the event of equipment failure, and any other necessary items of instruction as recommended by the manufacturer of the unit will be attached to or posted adjacent to the piece of equipment. Operating instructions exposed to the weather will be made of weather-resisting materials or will be suitably enclosed to be weather protected. Operating instructions will not fade when exposed to sunlight and will be secured to prevent easy removal or peeling.

3. QUALITY ASSURANCE

- 3.1. **Standard Products.** Materials and equipment will be essentially the standard catalogued products of manufacturers regularly engaged in production of such materials or equipment and will be manufacturer's latest standard design that complies with the specification requirements. Materials and equipment will essentially duplicate items that have been in satisfactory commercial or industrial use at least two years prior to bid opening. Where two units of the same class of equipment are required, these units will be products of a single manufacturer; however, the component parts of the system need not be the products of the same manufacturer. Each major component of equipment will have the manufacturer's name and address and the model and serial number on a nameplate, securely affixed in a conspicuous place. The name plate of the distributing agent will not be acceptable.
- 3.2. **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 will 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. The Contractor will provide as part of the work all special machining and installation required by the component manufacturer.
- 3.3. **Codes and Standards.** Work under bridge machinery pay items will 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 specification will be 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 Society of Mechanical Engineers _____ ASME
 - American Welding Society _____ AWS
 - National Lubricating Grease Institute _____ NLGI
 - Society of Automotive Engineers _____ SAE
 - Steel Structures Painting Council _____ SSPC

The work will meet the requirements of all other codes and standards as specified elsewhere in these specifications. 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.

- 3.4. **Qualifications, Personnel and Facilities.** For the fabrication, installation, aligning, cleaning, lubricating, testing and all other work required by bridge machinery pay items, the Contractor will 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. The Contractor will provide personnel and supervisory personnel with a minimum of two movable bridge projects as previous experience in the installation of bridge machinery. The installation of the machinery will be directly supervised by a representative of the machinery manufacturer and supplier having at least ten years of prior similar experience.

Mechanics, millwrights and service personnel will be properly equipped 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.

- 3.5. **Rules, Regulations and Ordinances.** Work will comply with all applicable Federal, State and Local rules, regulations, and ordinances.

In the event of a conflict between these specifications and the above mentioned codes, standards, rules, regulations, and ordinances, the most stringent requirement will apply.

- 3.6. **Measurements and Verification.** Dimensions indicated on the Plans are nominal and are intended for guidance only. All variations from the nominal dimensions on the Plans will be noted on the shop drawings.

- 3.7. **Substitutions.** The terms "approved equal," "of equal quality," and "or equal" which appear on the plans and in these specifications 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, the Engineer's approval of the equivalence of the substitute product will be obtained in writing. The acceptance of the substitute products 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 "Reject" substitute material. Upon return of a shop drawing showing rejection, the Contractor will resubmit the shop drawing showing the specified product. Rejection will not in any way result in any extra cost.

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

Where a manufacturer's name and catalog part number, in this specification or on the plans, specifies a particular product it 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, all necessary changes required by the substitution in related machinery, structural, architectural and electrical parts, will be made by the Contractor at no additional cost.

If any departures from the plans or these specifications are deemed necessary by the Contractor, details of such departures and the reasons therefore will be submitted as soon as practicable for approval. No such departures will be made without approval by the Engineer.

4. MATERIALS AND WORKMANSHIP

- 4.1. **Wire Ropes and Sockets.** New wire ropes and sockets will be fabricated, tested and installed in accordance with AASHTO specifications and ASTM A1032 except as otherwise noted on the plans or herein these specifications. The wire rope length shown on the plans is approximate. The Contractor will be responsible for verifying the existing wire rope length and coordinate with and determine the new wire rope length for installation to establish the original elevation of the counterweights. The Contractor will verify the existing dimensions and details of the wire rope take-ups, nuts, cap nuts and sockets and coordinate with new take-ups and sockets. All corners and edges will have suitable radii and all transitions of surfaces blending smooth.

Wire welds for wire ropes are to be no closer than 25 ft. in a single strand. Wire ropes will be pre-formed and pre-stretched. The rope manufacturer will measure the rope under load. The tolerance will be +/- 1/4 in. per 100 ft. of length. At the time of length measurement a white line will be added to aid in rope installation.

Material for all wire ropes will be tested to destruction according to ASTM A1023. Rope wires will be tested according to ASTM A1023. Sample rope assemblies will be made for testing. All wire rope for new and test assemblies will be made from the same run of rope and sockets from the same lot. Additional sockets from the same lot that are not used in the final assemblies will be provided for samples. All ropes will be pre-stretched. A minimum of five (5) test assemblies (~6 ft. long) will be made from the ends, middle and quarter points of the rope run for the project. All ropes will have similar properties and will be demonstrated by the tests. The modulus of the ropes will be measured and recorded for test assemblies and will not differ by more than 5%. All tests listed here will be in addition to testing required by ASTM A1023. If for any of the tests specified the material does not meet the requirements, all materials will be subject to rejection. Rope lengths for new assemblies will be measured under load.

All counterweight ropes will be pre-stretched a minimum of 3 cycles at the wire rope plant according to the following procedure.

- Tension the rope to forty (40) percent of the ultimate strength, holding that load for five (5) minutes.
- Reduce the load to five (5) percent of the rope's ultimate strength.
- Repeat this load/unload cycle two (2) more times.
- Release the load completely.

Wires and strands for wire rope will be lubricated with suitable rust-inhibiting lubricant during manufacturing operations. The lubricants used during manufacturing will be compatible with the wire rope field lubricant which will both be proposed by the wire rope manufacturer and submitted for approval.

- 4.2. **Castings and Forgings.** All castings will be free of cracks, cold shuts, shrink holes, blow holes, and porosity. Design mold and riser shape, size, locations, and quantity to limit solidification and cooling shrinkage. Identify surfaces that are to be machined to specified dimensions and allow for excess casting material to be removed, producing the required machined surface texture. At thick sections provide additional risers and/or add void areas to reduce hot spots. Use internal or external chills, riser heating or insulation to control the rate of cooling.

All castings will be cleaned free of loose scale and sand; all fins, seams, gates, risers, and other irregularities will be removed. All unfinished edges of castings will be neatly cast with rounded corners, and all inside angles will have ample fillets.

All castings that have solid sections 4 in. thick or greater and all fracture critical members will be ultrasonically tested in accordance with ASTM A609, Method A, Quality Level 3. Castings that do not pass this test may be rejected. Test results, whether positive or negative, will be submitted to the Engineer.

Carbon steel castings will be A27 grade 70-36 and alloy steel castings will be A148 grade 90-60 unless otherwise noted.

Carbon Steel and Alloy Steel Forgings will meet the requirements of AASHTO Specification M102 (ASTM A668) unless as otherwise approved by the Engineer.

All forgings will be 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, will have a cross-sectional area at least three times that required after finishing. No forging will be done at less than a red-heat.

Perform the following for each forging.

- Magnetic Particle exams in accordance with ASTM A275 and ASTM E709 performed by fabricator after finish machining.
- Ultrasonic exams in accordance with ASTM A388 performed by foundry.

Forgings acceptance based on non-destructive test free of indication of discontinuities or acceptance criteria of the forging material standard.

ASTM A668 forging class designations with an H suffix will be Brinell tested to meet the designated hardness. Forgings that are welded for fabrication of the completed machinery part will have carbon content limited in accordance with Supplementary Requirement S4.

No tack welding on forged materials permitted for lugs to aid with handling materials.

Submit certified material test reports for forgings. Submit factory test reports if required.

4.3.

Shafting and Pins. All shafts will conform to tolerances in ASTM A29 unless otherwise indicated. Turned, ground and polished shafting straightness tolerances will be 0.002 in. per ft. for shafts up to and including 1 1/2 in. diameter and 0.003 in. per ft. for shafts over 1 1/2 in. in diameter.

All shafts and pins will be accurately finished, round, smooth, and straight; and when turned to different diameters, they will have rounded fillets at the shoulders. Each shaft or pin having a uniform diameter of more than 8 in. and each shaft or pin having several diameters, of which the smallest is more than 8 in., will be bored lengthwise through the center to a diameter approximately one-fifth the smallest body diameter.

Each end of all shafts, when finished to the required lengths, will have a 60-degree lathe center, with clearance hole, at the exact center of the shaft. Shafts that have a hole bored lengthwise through their centers will have the ends prepared for the attachment of a centering device equivalent to the lathe center. All such devices will be furnished as part of the work.

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

All cold-finished shafting will be steel of the type and grade shown on the Plans and will be tested for its mechanical properties, and a test certificate will be furnished to the Engineer. Each cold-finished shaft will be free from camber and will run without vibration, noise, or chatter at all speeds up to and including the maximum rated speed.

All hubs mounted on the ends of cold-finished shafts will have the fit specified herein or on the Plans. To obtain the required fit between hub and shaft, the Contractor may furnish the cold-finished shaft 0.060 in. larger than the nominal diameter specified and will turn the ends to the required dimension for the hub. The selected tolerances will be shown on the shop drawings.

Turned, ground, and polished commercial shafting of the grade specified will be used where shown on the Plans.

After field installation of shafts supported in bearing the circular run-out tolerance will be measured and recorded. Run-out requirements:

- Shafts: 0.010 in. Full Indicator Movement (FIM)
- Pins: 0.003 in. FIM

The alignment of shaft assemblies will provide full bearing contact across bearing surfaces.

- 4.4. **Fasteners.** The following requirements for bolts, nuts, studs, caps screws, lock washers, and cotters will apply, except where otherwise called for herein or on the Plans.

All bolts for connecting machinery parts to each other or to supporting members will be as shown on the Plans or specified otherwise and conform to one of the following types:

- finished body, high-strength bolts
- turned bolts, cap screws, and studs
- high-strength turned bolts, cap screws, and studs

All high-strength bolts shown on the Plans will be finished body, high-strength bolts unless otherwise noted.

- 4.4.1. Finished body high-strength bolts will meet the requirements of ASTM A449 and the dimensional requirements for Hex Cap Screws. Holes for finished body high-strength bolts will be individually reamed for a clearance of not more than 0.010 in. larger than the actual diameter of the individual bolts for that hole. The clearance will be checked with 0.011 in. wire. The hole will be considered too large if the wire can be inserted in the hole together with the bolt. Wherever possible, high-strength bolts connecting machinery components to structural elements or to other machinery components comprised of different thickness will be installed such that the bolt head is adjacent to the connected element with the least thickness. Bolt bodies will have a straightness tolerance of 0.002 in. Polish or machine the bolt diameter to 64 micro-inch and to achieve an overall body diameter deviation within the given shaft tolerance of an LC3 fit for the entire lot of finished body bolts. The finished body diameter will be equal or greater than the thread major diameter after polishing or machining the bolt.

- 4.4.2. Turned bolts, cap screws, and studs will meet the requirements of ASTM A449. Turned bolts, cap screws and studs will have turned shanks; cut threads; and finished washer-faced, hexagonal heads and nuts. Heads and cut threads will meet the dimensional requirements of ANSI/ASME B18.2.1, Heavy Hex Screws. All finished shanks for turned bolts, cap screws, and studs will be 1/16 in. larger in diameter than the diameter of the thread, which will determine the head and nut dimensions. The shanks of all turned bolts, cap screws, and studs will have a Class LC1 fit in the finished holes in accordance with ANSI B4.1 and polished to 64 micro-inch. The material for the turned shank fasteners will meet the requirements of ASTM A325. Turned bolts, cap screws and studs will be fully detailed on shop drawings.

- 4.4.3. High-strength turned bolts, cap screws, and studs will meet the requirements of ASTM A449. All dimensional and clearance requirements will be as specified above for turned bolts, cap screws, and studs.

Bolts and studs will be secured with Hex Nuts meeting the requirements of ASTM A 563 and Property Class and Dimensional Style as recommended in Appendix X1. Turned bolts, cap screws and studs will be secured with Heavy Hex Nuts meeting the requirements of ASTM A 563 and Property Class as recommended in Appendix X1.

Unless otherwise specified on the Plans, socket-head cap screws will meet the mechanical requirements of ASTM A 574 and the dimensional requirements of ANSI/ASME B18.3, Socket Head Cap Screws. Socket button and flat countersunk head cap screws will meet the requirements of ASTM F 835 with dimensions conforming to the latest requirements of ANSI/ASME B18.3 Hexagonal Socket Button Head Cap Screws and ANSI/ASME B18.3, Hexagonal Socket Flat Countersunk Head Cap Screws. Screws will be furnished with a self-locking nylon pellet embedded in the threaded section.

Socket-set screws will meet the requirements of ASTM F 912 and the dimensional requirements of ANSI/ASME B18.3, Socket Set Screws. Set screws will be of the headless, safety type; will have threads of the coarse series; and will have cup points. Set screws will neither be used to transmit torque nor as the fastening or stop for any equipment that contributes to the stability or operation of the bridge.

All bolt holes through unfinished surfaces will be spot-faced for the head and nut, square with the axis of the bolt.

Unless otherwise called for, all bolts holes in machinery parts for connecting these parts to the supporting steel work will be subdrilled at least 0.030 in. smaller in diameter than the bolt diameter and will be reamed assembled for the proper fit at assembly or at erection with the steel work after parts are correctly assembled and aligned.

Positive locks of an approved type will be furnished for all nuts. If double nuts are used, they will be of standard thickness. Double nuts will be used for all connections requiring occasional opening or adjustment. If lock washers are used for securing screws or nuts, they will be made of tempered steel and conform to the dimensional requirements of ANSI/ASME B18.21.1. Lock Washers. The material will meet the SAE tests for temper and toughness.

High-strength bolts and nuts, when properly torqued, are self locking and need no additional locking devices.

High-strength bolts will be furnished with a hardened steel washer at each end. Washers will meet the requirements of ASTM F 436.

When these fasteners connect a machinery component/support directly to the concrete, there must be a filler material in the annular area between the bolt and the bolt link in the machinery component. The filler material may be a non-shrink grout, babbitt metal or zinc.

Bolt holes through unfinished surfaces will be spot faced for the head and nut, square with the axis of the hole.

All cotters will conform to ANSI/ASME B18.8.1 – ‘Clevis Pins and Cotter Pins’, standard dimensions and will be made of half-round stainless steel wire, ASTM A276, Type 316.

Eye bolts for lifting are to be provided as required and manufactured according to ASTM A489. Eye bolts are to be Type 2 – shoulder pattern, Style B, and dimensioned in accordance with ANSI/ASME B18.15. Eye bolts are specified by the bolt shank diameter.

Miscellaneous Fasteners and Hardware: provide miscellaneous fasteners and hardware, including cotter pins and lock wire of corrosion resistant stainless steel, with material composition of AISI type 304 or 316.

All fasteners will be manufactured in the United States with the property class and source identification appearing on the top of head.

Anchor bolt holes will be filled with a non-shrink grout.

- 4.5. **Keys and Keyways.** Keys and keyways will conform to the dimensions and tolerances for square and rectangular keys and keyways of the ANSI B17.1. All keys will be effectively held in place, preferably by setting them into closed-end keyways milled into the shaft, or a threaded set screw through the hub against the top of the key. The ends of all such keys will be rounded to a half circle equal to the width of the key. Keyways will not extend into any bearing or shaft shoulder fillet. If two keys are used in a hub, they will be located 120 degrees apart and in line with wheel arms where practicable. The fit between key and keyways will be as shown on the Plans.

Unless otherwise specified herein or in the Plans, keys will be machined from alloy-steel forgings, ASTM A 668 Class K.

- 4.6. **Bearings and Bushings.** All split bearings will have one half fitted to the other half as shown on the Plans. The surface between the cap and base will be accurately machined. All caps will be securely bolted to the bases with turned bolts and double nuts. All caps and bases will be provided with double-flanged bronze bushings securely held against changing position under load by hexagonal head, steel cap screws, unless

otherwise shown on the Plans. All bushings will fit the inside bore and end faces of the base and cap, with an ANSI Class LC1 clearance and location fit, and will fit the shaft journals, with an ANSI Class RC6 running fit. All caps will be provided with a tapped hole for lifting eyebolt, which will be furnished for the purpose.

Bushings for split bearings will be finished-bored with the caps in place and with 1/4 in. thick rolled bronze or brass liners. At least 1/8 in of the liner thickness will be of laminated construction capable of adjustment in increments of 0.003". The edges of the liners toward the shaft journal will be cut to fit the shaft shoulder fillets where they occur and will be cut square and flush with the bushing flange if there is no change in shaft diameter. Except for a short distance from each end, the inside edges of the liners will be cut back to form a grease groove along the shaft. All bolt holes will be drilled through the liners.

For split bearings, each half bushing will have spiral grease grooves connecting with the ends of the liner grooves and intersecting at the center of each half bushing, unless otherwise shown on the Plans. All grease grooves will be precision machine-cut and smooth. The corners of all grooves will be rounded to a radius of not more than half the width of the groove

All Anti-friction bearings will be sized for a L-10 life of 40,000 hours as defined by ABMA for the ratings shown on the Plans.

Pillow block bearings will be, adapter mounted, self-aligning expansion and non-expansion types as called for on the drawings. Housings will be cast steel and capable of withstanding the design radial load in any direction, including uplift. Bases will be cast without mounting holes. Mounting holes will be drilled from the solid at assembly with the supporting steel work. Seals will retain the lubricant and exclude water and debris. Cap bolts on pillow blocks will be high-strength steel. The cap and cap bolts will be capable of resisting the rated bearing load as an uplift force.

The alignment of live load bearings, span lock guides and span lock receivers will provide full bearing contact across the bearing contact surfaces.

4.7. **Shaft Journals.** All journal bearing areas on shafts and pins will be accurately turned, ground and polished with no trace of tool marks or scratches on the journal surface or adjoining shoulder fillets. Burnishing of the shaft journal areas and adjoining shoulder fillets will be acceptable in lieu of grinding and polishing, provided the burnishing is done with a Stellite roller or equal which has been finished to a mirror surface. Journal diameters will be finished to the limits of an ANSI Class RC6 running fit. The alignment of shaft assemblies will provide full bearing contact across the shaft journal surfaces.

4.8. **Open Gearing.** Spur gears will have a 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.

The teeth of all gears will be cut from solid rims or blanks. The sides and peripheries of all gears and pinions will be finished, and the pitch circle will be scribed on both sides not less than 0.020 inches deep with a V-pointed tool. The working surfaces of all gear teeth will be true to the proper outline, accurately spaced on the true pitch circle, exceptionally smooth, and free from planing or milling-cutter ridges. Cutter burrs will be removed from all edges of the teeth, and the top edges of all teeth will be rounded to a 1/32 inch radius.

Except as otherwise provided herein or on the Plans, all gears will be cut and mounted to meet the requirements for accuracy of AGMA Standard 390.03a, AGMA Gear Classification Manual. The AGMA quality number will be stated on the applicable shop drawings. Open gearing will conform to AGMA quality class Q8 or higher, including the tolerance on runout, pitch and profile.

4.9. **Enclosed Speed Reducers.** Speed reducers will be standard models from one manufacturer, with sizes, ratios and construction details as shown on the Plans.

Speed reducers will be designed to meet all requirements of ANSI/AGMA Standard 6010, manufactured in accordance with the requirements of AGMA and given nameplates with the following information:

- size
- ratio
- service power rating
- high speed shaft RPM
- service factor
- lubrication specification

Gear teeth will be through hardened and conform to AGMA quality class Q10 or higher. Casehardened gears will not be used to drive bridge machinery.

Gears will have spur, helical, herringbone or bevel teeth, bearings will be antifriction type, and housings will be steel castings or welded steel plate, which will be stress relieved.

The inside of the housings will be sandblast cleaned prior to assembly and be protected from rusting. Exact ratios will be furnished where specified.

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

Lubrication of the gears and bearings will be automatic 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, which require lubrication, are partially submerged in an oil bath.

When the configuration of gears and bearings prevent bath lubrication, a splash lubrication system should be used. Splash lubrication systems will continuously lubricate all gears and bearings properly. Oil feed troughs may be used to supply oil to bearings and gears, which are above the bath. Splash lubrication systems will be designed 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, a redundant lubrication system will be provided. The redundant system will operate at all times when the primary system is functioning.

Inspection ports on reducers will provide for inspection of all gears, bearings and other internal devices. The ports will be located above the oil level, if practicable, so that oil draining is not required for inspection. The port will be sized such that minor repairs could be made to reducers without requiring housing disassembly. Ports will be properly sealed with seals that do not require replacement when ports are opened.

Reducers will be furnished with moisture trap breathers, oil fills, break proof glass oil level indicators, drains and inspection ports.

Moisture-trap breathers will be located above maximum oil levels in all positions of the reducer during operation, and its piping will enter the unit at the highest point possible. Breathers will not be mounted in bearing caps.

Oil level indicators will be mounted in locations that can be easily viewed by maintenance crews. On reducers in which the oil level varies by more than 1/2 in. per 50°F temperature change, the sight glass will be graduated. The indicator will be vented back to the case. Sight glasses will be of rugged construction and protected against breakage.

Oil drains will be located at the lowest point possible. The drain will have a hand operated lever which can be locked in the closed position.

Oil sampling cocks will be located in accessible positions on the reducers. There will be two sampling cocks, one located at the lowest level of oil and one just below the upper oil level.

Speed reducers will have provisions for oil expansion due to churning and temperature change.

Grease lubricated reducer bearings will be furnished with grease fittings readily accessible after installation of reducer. Internal seals between the bearing housing and the gear oil will prevent interaction between them.

On shaft extensions, bearing shaft ring seals will be mechanical type oil seals which compensate for wear. Dual lip spring loaded seals are preferred.

Shaft extensions for the various reducers will be of the arrangement, lengths, and diameters shown on the Plans. Couplings will be shrink fitted on the shafts in the shop.

The manufacturer will submit for approval a certified print of each speed reducer showing as a minimum the following information.

- All external mounting dimensions including shaft sizes, bores, and keyways where required.
- Internal Plans showing each reducer component with part numbers.
- The ratings that will appear on the nameplate.
- Location of all lubricant connections.
- Lubrication recommendations.

The manufacturer will submit for approval by the Engineer computerized calculations showing conformity to the requirements of the AGMA Standard Practice specified. The reducer design calculations must be made available to the Department prior to construction of the unit.

On open-ended lower bearings of vertical shafts, extra precaution must be taken to prevent oil leakage. A dry-well arrangement in which the bearing is isolated from the oil bath is preferred. Grease lubrication of the lower bearing is required in these applications.

Pinions will be proportioned so that the root diameter of the pinion is not smaller in diameter than the diameter of the journals for the pinion shaft.

Base plates for the reducers will be large enough to give unobstructed access for drilling and reaming the mounting holes from above the unit.

Speed reducers driving bridge machinery and electrical controls will be as shown on Plans or approved equal.

4.10. **Hubs and Bores.** The hubs of all gears, wheels, and couplings will be finished on both faces and polished where the hub face performs the function of a collar to prevent shaft movement. The hubs will be bored concentric with the rims of gears and wheels or with the outside of couplings. All hubs will have an ANSI Class FN2 medium shrink fit on the shafts, unless otherwise specified. The minimum thickness at any place on the hub, especially at keyways, should not be less than 0.4 of the gross section diameter of the bore.

4.11. **Shims.** Where shown on the plans, all machinery shims required for leveling and alignment of equipment will be stainless steel, neatly trimmed to the dimensions of the assembled parts and drilled for all bolts that pass through the shims. Shims will be Stainless Steel ASTM A240 Type 316 and furnished with bolt hole diameters that are 1/4 in. greater than the bolt diameter used at final assembly. Holes in shims will be drilled and reamed to the same tolerance as the connected parts at final assembly. Shims greater than 1/2 inch will include one solid plate of thickness equal to 1/2 inch less than total shim thickness.

Shims will be shown and fully dimensioned as details on the working drawings. Shims with open side or U-shaped holes for bolts will not be permitted. No shims will have less than two holes for bolts. Bolt holes will not be punched at machine shop to prevent distortion of the shims.

In general, sufficient thickness' will be furnished to secure 1/64 in. variations of the shim allowance plus one shim equal to the full allowance. The ½ in. nominal shim pack will consist of the following thickness variations: one ½ in., one ¼ in., one 1/8 in., one 1/16 in., one 1/32 in., and two 1/64 in. Thinner thickness shims will be provided if needed.

4.12. **Steel Plate and Structural Shapes.** Steel for plate and structural shapes will meet the requirement of ASTM A709 grade 50, unless otherwise noted.

4.13. **Welding.** Welding required for machinery will be done in accordance with the requirements for welding structural steel. Stress relieving will be required only when specified. All welds used to fabricate machinery will be completely tested by ultrasonic inspection (ASTM E164-74) per AWS D1.5 for compression welds unless otherwise noted. All machining will be performed after welding and stress relieving.

Steel plates and shapes not connected by bolting will be joined by welding. Welds not shown will be continuous 5/16 in. groove weld for flat mating surfaces or continuous 5/16" fillet welds for perpendicular surfaces.

Welding joint sizes and details will be shown on working drawings. Where multi-pass welds are required, welding procedures will be submitted with shop drawings.

Distortion during fabrication will be kept to a minimum by the use of welding fixtures and proper welding procedures. Base metals that are forged or heat treated to increase hardness will be preheated to prevent cracking prior to any welding. All machining will be performed after welding and stress relieving.

4.14. **Machinery Guards.** Machinery guards will be provided for all moving parts readily accessible to personnel including but not restricted to the following:

- couplings
- open gears
- unused shaft extensions
- shafts
- brakes
- instrument drives and limit switches

Machinery guards will be constructed to comply with the applicable requirements of ANSI B15.1, Safety Standard for Mechanical Power Transmission Apparatus.

Unless otherwise indicated or specified, all machinery guards will be constructed of stainless steel having minimum thickness of No. 12 Gauge and will have provision for removal without requiring disassembly of any machinery component.

Machinery guards will be provided with removable hinged or bolted covers for access to lubrication fittings enclosed by the guard. Phenolic nameplates will be provided on these covers with lubrication instructions.

The Contractor will provide rigid supports for all machinery guards. The supports will be sufficient to not allow excessive deflection or contact with moving parts when subjected to a force of 500 lbs. The details will be submitted on shop drawings for approval.

The inside and outside of machinery guards will be painted Safety Orange to alert workers to the hazardous condition when removed.

4.15. **Flexible Couplings.** Couplings will be of the type as shown on the Plans and will include grid type, gear type, and others as needed.

Couplings will, in general, be finish-bored and have keyways cut by the Coupling Manufacturer to dimensions and tolerances established on the shop drawings and then shipped to the manufacturers of the various components for shop installation on the shafts.

Grid-type, self-aligning, fully flexible, torsionally flexible couplings will be used to connect electric motors to machinery components. The grid-type couplings will have steel hubs, alloy steel grids, and steel or aluminum covers. Bolts in the covers will be shrouded.

Gear-type, self-aligning, full-flexible couplings or semi-flexible couplings with floating shafts will be used to connect all machinery components, except where other types of couplings are called for on the Plans. All couplings will have shrouded bolts. The gear-type couplings will be made of forged steel, have curved face teeth, and will provide for at least a plus and minus $\frac{3}{4}$ degree misalignment per gear mesh.

Special couplings will be as shown on the Plans.

Couplings will be standard products of an established Manufacturer.

All coupling hubs with interference fits will be provided with tapped holes for a means of removal from the shafts.

- 4.16. **Paint.** Machinery Paint will be a (3) coat system (epoxy primer, urethane intermediate and urethane finish coat) suitable for machinery and a marine environment. The paint system will be manufactured by one of the companies listed in Table 1, or approved equal:

Table1
Approved Paint Systems

Manufacturer	Epoxy Primer	Finish Coat
Carboline Company	Carbomastic 15	Carbothane No. 134 HG
Amerno Coatings	Amerlock 400	Americoat 450H
Keeler & Long Inc.	1800 Kolrmastic II	Acrythane Y-series

The intermediate coat will be compatible with the primer and finish coat.

- 4.17. **Grout.** Grout will be factory mixed, nonmetallic, non-shrink grout, ready for use. Grout formulation will be provided for shrinkage correction by producing a controlled expansion to compensate for vertical and horizontal shrinkage in cementitious mixtures. Grout will provide a solid load-bearing surface that insures the structural integrity of any installation and will have the following characteristics:
- compressive strength will be 6000 psi minimum (28 days) tested per ASTM C109.
 - volume change, percent will be +0.02, -0.0 tested per ASTM C157
 - noncorrosive and nonreactive in contact with aluminum or magnesium

The Contractor will provide all temporary structural steel supports as part of the work to allow the required curing time of the grout pads without load.

The grout will be equal to Sika 212 or approved equal.

- 4.18. **Lubrication.**

- 4.18.1. **Lubrication Fittings.** All bearings and surfaces requiring lubrication, other than gear teeth, will be fitted for a pressure system of lubrication using NPS $\frac{1}{4}$ giant button head fittings, unless otherwise indicated on the Plans. The fittings for greasing bushed bearings will be tapped into the housing or connected thereto by seamless stainless steel pipe, which will be tapped into the housings so that grease will be discharged directly through the housing, shims, bushing, and into the grease grooves for distribution. New span guide rollers will have lube ports on the end of the threaded portion of the mounting stud. All grease fittings will be conveniently located for greasing, and if necessary, they will be connected to the points requiring lubrication from convenient lubrication stations by NPS $\frac{1}{4}$ extra strong stainless steel pipe with stainless steel

accessories. All pipe extensions will be kept as short as practical, will be securely supported at fittings and intermediate points and located so that it will be protected from injury. Supports for grease piping will be included as part of this work. All lubricating equipment will be installed in perfect condition.

Not more than two sizes of fittings will be used. The large size will be used wherever possible, and the smaller size will be used for motor bearings and other small devices. Pressure fittings will be rated at a minimum of 10,000 psi. Fittings will contain a steel check valve that will receive grease and close against back pressure.

Immediately after the completion of fabrication, all fitting locations will be plugged until components are installed and regular lubrication is started. The plugs will then be replaced with the proper grease fittings. During installation, the Contractor will 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.

4.18.2.

Lubrication Charts. The Contractor will furnish five (5) 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, and will show the kind of lubricant to be used at each point and the frequency of lubrication. The charts will be framed under glass in neat wooden frames and will be placed as directed by the Engineer.

A Phenolic nameplate matching the number designation shown on the lubrication chart will be mounted at each lubrication point. Characters on the plates will be a minimum of 1 inch high. Plates will be fastened with stainless steel screws.

Maintenance and lubrication literature for each machinery component will be kept in the Control House in a heavy bound binder.

The lubricant for each type of machinery component will be kept separately in clearly marked containers. All measures will be taken to prevent lubricant contamination.

During installation, the Contractor will lubricate all rotating and sliding parts of the machinery and fill all gear reducers and pillow block housings and flexible couplings with lubricants indicated on the approved charts.

4.19.

Tools and Equipment. The following tools and lubrication equipment will be provided:

- One
 - 4ft x 3ft x 8ft heavy duty steel tool storage cabinet with four shelves, hinged doors and a heavy duty padlock. All steel will be a minimum of ¼ inch thick.
- 1 set
 - Box and open-end combination wrenches made of high-grade, drop-forged steel, with chrome plated over nickel finish, to fit bolt heads, nuts, and cap screws from 1/4 to 1 ½ inch, inclusive.
 - Single-end, angle wrenches of high-grade, drop-forged steel to fit all bolt heads and nuts larger than 1 ¼ inch size actually used on the job.
 - Socket wrenches to supplement the wrenches in Items 1 and 2 and for dismantling flexible couplings.
 - Alloy-steel wrenches for all socket-head screws.
- 1 each
 - 12 inch adjustable wrench.
 - 8 inch and 10 inch screw drivers with solid, hardened steel; square shanks; and insulated composition handles.
 - 2 pound ball peen hammer.
 - Loader pump for 25 pound capacity pail for each type gun furnished.
 - Grease transfer pump complete with hose and fittings for 120 pound drum.
 - Of any other special size wrench and special tools or special lubrication equipment necessary to service machinery components actually installed in the bridge which are not otherwise specified.

- 2 each
 - Hand lubrication guns, screw type, 12 ounce capacity, for each size lube fitting used.
- Four
 - One-Ton hoists with a minimum standard lift of 15 feet equal to Coffing Model CG-1 as manufactured by Duff-Norton, Charlotte, NC.

4.20. **Spare Parts.** The Contractor will provide a complete list of each and every shaft and coupling seal used at the job, including current part number and manufacturing 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 the following spare parts will be provided:

- one (1) grid of each grid-type coupling
- one (1) complete set of gaskets for every flexible coupling
- five (5) fittings of each different type and size used

5. GENERAL CONSTRUCTION DETAILS

5.1. **Shop Fabrication.** The Contractor will give no less than ten (10) working days notice to the Engineer of the beginning of work at foundries, forge, and machine shops so that inspection may be provided. No materials will be cast, forged, or machined before the Engineer has been notified where the orders have been placed.

The Contractor will furnish all facilities for the inspection of material and workmanship in the foundries, forge, and machine shops and the Inspector designated by the Engineer will be allowed free access to necessary parts of the premises. 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 these specifications.

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.

The Contractor will furnish the Engineer with a copy of all orders covering work performed by subcontractors or suppliers.

Unless otherwise provided, the Contractor will furnish without additional charge 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. A copy of all test reports and chemical analyses will be furnished to the Engineer.

The acceptance of any material or finished parts by the Engineer will not be a bar to their subsequent rejection if found defective. Rejected material and workmanship will be replaced or made acceptable by the Contractor at no additional cost.

5.2. **Shop Inspection and Testing.** Machinery components will be shop assembled to verify their correct fit prior to shipment. Measurements required for each assembly are shown on the Plans and/or described in the individual pay items.

The speed reducer manufacturer will shop test each reducer by running it at no load and at the normal operating speed for at least 2 hours in each direction (4 hours total continuous operation). This test will be performed in the presence of a representative of the Engineer. The tests will be run with the reducers filled to

the maximum oil fill level, 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 half-hour intervals thereafter, the following measurements will be made and recorded and records will be submitted 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 1 meter distant from center of unit

The temperature of the oil will not rise more than 30°F from ambient during this test and no shaft will experience a temperature rise of more than 50°F from the ambient. The noise level of the reducer will not exceed 90db with the microphone held 1 meter from the reducer housing.

During testing each speed reducer will be checked for unusual noise (thumping or any nonuniformity), excessive bearing clearance, and any other unusual operating characteristics. The units will operate smoothly, without signs of lubrication leakage, and without excessive vibration or temperature rise. All malfunctions will be recorded and corrected, and the units retested if necessary before release from the manufacturer's shop. After the unit has passed the test, a Certificate of Compliance will be submitted by the Contractor to the Engineer.

The proper operation of the lubricating system will be demonstrated during the shop test. In addition to the test specified above, the proper distribution of load on the gear teeth will be demonstrated by the application of tooth contact tape applied to each gear and these tapes will be preserved in the records to be submitted with the Certificate of Compliance.

Additional testing of speed reducers may be specified under individual pay item sections.

- 5.3. **Defective Materials and Workmanship.** All machinery rejected during inspection and testing that is not made acceptable will be removed from the work site and replaced without additional cost.

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

All defects found during the guarantee period resulting from faulty material, components, workmanship, or installation will be corrected by the Contractor without cost. In the event that the Contractor does not make the corrections in a timely manner, the Department reserves the right to make necessary corrections with its own forces and charge the resulting costs to the Contractor.

- 5.4. **Delivery and Storage**

- 5.4.1. **Protection for Shipment.** Machinery parts will be cleaned of dirt, chips, grit, and all other injurious materials prior to shipping and will be given a coat of corrosion-inhibiting preservative.

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

Any interface between stainless steel or aluminum and Structural Steel will receive an Engineer approval coat of zinc-chromate primer prior to assembly.

Machinery parts will be completely protected from weather, dirt, and all other injurious conditions during manufacture, shipment, and storage.

Shaft journals that are shipped disassembled from their bearings will be protected 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. Every precaution will be taken to ensure that the bearing surfaces are not damaged and that all parts arrive at their destination in satisfactory condition.

Assembled units will be mounted on skids or otherwise crated for protection during handling and shipment.

- 5.4.2. **Packaging and Delivery of Spare Parts.** Spare parts will be protected for shipment and prolonged storage by coating, wrapping, and boxing.

All spare parts will be durably tagged or marked with a clear identification showing the designation used on the approved shop drawing.

Boxes for spare parts will be clearly marked on the outside to show their contents. Spare parts will be delivered to a location designated by the Department.

- 5.4.3. **Guarantee and Warranties.** Manufacturer's warranties or guarantees on equipment, materials or products purchased for use on the Contract which are consistent with those provided as customary trade practice, will be obtained by the Contractor and, upon acceptance of the Contract, the Contractor will assign to the Department, all manufacturer's warranties or guarantees on all such equipment, material or products furnished for or installed as part of the Work.

The Contractor will warrant the satisfactory in-service operation of the mechanical equipment, material, products, and related components. This warranty will extend for a period of one year following the date of final acceptance of the Project. Final acceptance will be considered when there is no item left for the Contractor to complete as determined by the Resident Engineer for the DOT. This must include acceptance of all work, inspection, all documentation, all testing, completion of maintenance manuals, completion of training, delivery of all spare parts and completion of all punch list items.

- 5.5. **Field Work – General.** For each stage of construction, the Contractor will submit calculations, drawings and procedures detailing their intended scheme for removing, rehabilitating and installing all machinery. Machinery removals, rehabilitation and installation will be done in a coordinated manner to ensure all the machinery components fit the adjacent material furnished under other items. All temporary equipment, supports, rigging and work platforms will be provided and considered part of the work. This will include the temporary disassembly of existing platforms, supports and mechanical & electrical components and their reassembly to facilitate the installation of all machinery. All calculations and temporary supports will be designed and prepared by a Texas State Professional Engineer.

All reassembly of any item that needed to be temporarily disassembled during/for the course of the work for this project will be included as part of the work. Reassembly of items is to be of a condition equal to or better than that prior to disassembly.

- 5.6. **Existing Machinery Removal.** Where permanent machinery removal is required, unless indicated to be delivered to TxDOT, all items will be removed of and disposed of in accordance with all environmental regulations and local and state law. These items will include but not be limited to lead paint, components containing lead paint, lubricants, brake thruster fluid or any other environmentally sensitive material. Items which are required to be removed and not installed in the final machinery system but are identified to remain the property of TxDOT, will be removed and delivered to the maintenance facility. All removals will be done by methods which result in no damage to any structural, mechanical or electrical component which is to remain the property of TxDOT. Any damage that does occur to such components will be replaced or repaired to the satisfaction of the Engineer by the Contractor at no additional cost to TxDOT.

- 5.7. **Existing Machinery Rehabilitation.** All existing machinery which is to remain will be rehabilitated as shown on the Plans and specified in the specific sections of the specification and noted herein. All components will be thoroughly cleaned and exterior non-rubbing surfaces painted with a three coat paint system. All visible surfaces will be inspected prior to painting for any defects. Defects will be reported to the Engineer. All sharp edges or defects will be rounded and bended in smooth. See painting section of the specifications for further

details. All existing lubricant will be removed or purged. All existing lubrication fittings, piping and connections will be replaced with new in-kind components. New lubricant will be applied to prevent corrosion or prior to operation. When assembling shaft journals into plain bronze bearings both surfaces will be coated with the approved lubricant. If the machinery component requires removal or needs to be disassembled or realigned, new shim packs and fasteners will be provided to properly assemble and align the machinery. Note, for existing fasteners called out to be replaced on the plans, only nominal dimensions are given. Existing fasteners (where only nuts are called out to be replaced) and tapped holes for fasteners will be cleaned and repaired using a thread die or tap. For tapped holes all remaining portions of the fastener will be removed. It is the Contractors responsibility to verify all dimensions, tolerance and details prior to ordering/machining new fasteners. New fasteners will be provided with new washers, nuts and cotter pins (as applicable). New bolt lengths will suit required final alignment.

The reducer rehabilitation will include complete disassembly of the gearbox, cleaning of all components, surfaces and inspection of all parts. The gearbox will be reassembled with new bearings, seals, gaskets, bolts, breathers, sight glasses, drains and filled with new lubricant. New components will match or be equivalent to the existing. After reassembly the reducer will be spin tested in each direction at full speed for one hour by a motor provided by the contractor and not part of any final assembly on the bridge. During the test the reducer will be observed for any unusual vibration, noise or temperature rise. The results of the inspection and testing will be provided to the engineer.

The coupling rehabilitation will include the complete disassembly of the coupling, cleaning of all components, surfaces and inspection of all parts. The coupling alignment will be recorded and submitted to the engineer as well as any unusual observations found during the coupling inspection. The coupling alignment will be reassembled with new seals, bolts and lubricant. New components will match or be equivalent to the existing.

Counterweight sheave shaft and journal rehabilitation will include cleaning and inspection of all surfaces. All lubrication ports and passages are to be completely cleaned. Defects will be reported to the engineer. All localized defects on the journals and fillets will be carefully removed with suitable hand or guided machine tools, blended smooth and polished to the satisfaction of the engineer. All shaft journal and fillet surfaces will be rehabilitated to a polished condition. After surfaces on the sheave trunnion shaft have been rehabilitated, all journal surfaces and fillet surfaces regardless of their condition will be wet magnetic particle tested in accordance with ASTM E709 and a written report will be submitted to the engineer.

5.8. **Field Assembly and Alignment**

- 5.8.1. **General.** New fasteners, bolts, nuts, washers and shims will be provided for all new and existing machinery components during assembly. All manufactured machinery components will be installed as per manufactures recommendations and as specified herein.

The Contractor will furnish all lubricants and labor to lubricate and maintain all machinery during the Construction Project. Lubricants will be equal to those currently in use at the bridge and as recommended by the specific machinery component manufacturer. All lubricants are subject to the approval of the TxDOT and the Engineer.

- 5.8.2. **Alignment and Bolting.** The order of assembly and alignment of bridge machinery will start at the final driven components and work back to the prime mover. The Contractor will limit the finality of some staged machinery installations so that proper alignment of mating components is met prior to final reaming and fastening

All open gearing will be aligned such that backlash is within tolerance and at least the center 50% of the effective face width of each pair of meshing teeth is in contact. The cross mesh will not exceed 0.010 per 6" face width. All open gear measurements will be submitted to the Engineer for review and approval. The measurements will include backlash, cross-mesh alignment, tooth valley gap and face contact. The type of bluing or lubricant used for face contact measurements will be submitted to the Engineer for approval prior to any measurements. The measurements will be performed at a minimum of eight (8) equally spaced span positions ranging from fully open to fully closed.

All parts of the machinery will be match marked for proper assembly and correct orientation. Before final drilling or reaming, all parts will be adjusted to exact alignment by means of shims. If required, tapered shims will be provided at no additional cost. Installation, alignment and shimming of the electric motors, and devices such as limit switches and encoders, will be included with the machinery for such erection. After final alignment and bolting, all parts will operate smoothly.

The span will not be operated by the bridge machinery until all components are installed, in final alignment and bolted as approved by the Engineer.

Bolt holes in structural steel for connecting machinery will, in general, be drilled from the solid after final alignment of the machinery. Sufficient erection holes, subdrilled $\frac{1}{4}$ inch undersize for undersized temporary bolts, may be used for erection and alignment of the machinery. When the machinery is aligned in its final position, full-size holes for the remaining bolts will be drilled or subdrilled and reamed, the full size bolts installed, and temporary bolts removed. The undersized holes used for temporary bolts will then be reamed full size and full-size bolts installed.

Bolt holes in structural steel, shims and machinery components will be drilled and reamed assembled to assure accurate alignment of the hole and accurate clearance over the entire length of the fastener's body within the specified limit. Hand held reamers are not considered accurate enough and the Contractor will assume that a reaming jig will be used to keep the bolt hole cylindrical. This jig will be of structural steel, fixed to the drill and secured to the work preventing the reamer shaft from deviating. Holes will be checked with a bolt hole micrometer to assure uniform diameter.

Finished body high-strength bolts meeting the requirements of ASTM A449, will be torqued to the same tension required for ASTM A325.

Torques for other classes of bolts will be proportioned to their strength and will be indicated on the erection drawings

- 5.8.3. **Coatings.** All threads for finished body bolts and turned fasteners will be coated with anti-seize compound before assembly with nuts to prevent corrosion or galling and to facilitate future removal if necessary. All newly machined mounting surfaces will be protected with a rust-inhibiting coating
- 5.8.4. **Edges and Corners.** All edges and corners of machinery parts, sheet metal work, bed plates, and fabricated supports that are exposed in the finished work will be rounded or chamfered. All burrs or other surface defects that could be injurious to workers erecting or maintaining the bridge machinery will be removed.
- 5.8.5. **Personnel and Facilities.** The machinery will be erected and adjusted by competent millwrights skilled in the type of work involved. They will be provided with all necessary measuring and leveling instruments as may be required.
- 5.9. **Painting.**
- 5.9.1. **General.** Cleaning and painting of all unfinished surfaces of machinery will comply with requirements of the TxDOT Standard Specifications. The Contractor will submit for review with the working Plans an outline of painting materials and methods.
- 5.9.2. **Shop Painting.** All unfinished machinery external surfaces will be cleaned with final surface preparation, prior to painting, done by blast cleaning to meet 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

The excepted machinery or equipment will be cleaned 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, all unfinished machinery surfaces except for the interior of gear housings, flexible couplings and pillow blocks will be given one shop coat of primer by hand brushing. The primer will be compatible with the paints selected for subsequent coats. Interiors of gear housings will be protected with special oil-resistant crankcase paint or approved equal.

5.9.3.

Field Painting. After erection is complete, all machinery surfaces remaining exposed, except machine finished surfaces in sliding contact, will be thoroughly cleaned with an approved high-flash solvent and given a prime coat and an intermediate field coat of machinery enamel (minimum 2 mils dry each coat) as specified under TxDOT Standard Specification, Section 740 – Painting Procedures. The machinery enamel will be applied by hand brushing, resistant to weathering (marine environment) and abrasion and free of lead.

After field testing is complete but prior to final acceptance of machinery, all machinery surfaces remaining exposed, except machine finished surfaces in sliding contact, will be re-cleaned with an approved high-flash solvent and given a finish field coat of machinery enamel as specified in the aforementioned Standard Specification. The machinery enamel will be applied by hand brushing, which will color code the machinery to distinguish between fixed and moving parts. The following colors will be used:

- FEDERAL SAFETY ORANGE: Except for machine finished surfaces in sliding contact, for all moving parts of the machinery such as shafting, couplings, and the side of gears and brake wheels.
- FEDERAL SAFETY GREEN: For all stationary parts of the machinery.

Paint for the finish field coat, which will be compatible with the intermediate field coat, will be high-gloss machinery enamel resistant to weathering and abrasion, conforming to OSHA color requirements of the Safety Color Code for Marking Physical Hazards, ANSI Z53.1. The brand and colors will be submitted to the Engineer for approval. The Contractor will place cautionary signs in the Operating Machinery Room and Control House which will explain the color code. Details of the signs giving text, dimensions and materials will be placed on a shop drawing.

The Contractor will take special care to avoid painting of machinery surfaces which are in normal rubbing contact. All nameplates, legend plates, and escutcheons mounted on machinery will be masked for protection from paint. Lubrication fittings will be kept clog-free.

5.10.

Contractor's Inspection. After erection is completed, the Contractor will make a thorough inspection to insure 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.

Inspection of tightened fasteners will be in accordance with the TxDOT specifications. The Contractor's inspection will verify that field painting has been performed as specified herein. Touch-up painting will be performed to correct all painting defects found during this inspection.

The Contractor's inspection will 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. The following provides a list of typical products for the various locations.

5.10.1.

Sleeve Bearings and Pillow Blocks:

- NGLI #2 EP Grease

5.10.2.

Open Gears:

- Open Gear Lubricant (Moblitac 375 NC)
- Specific Gravity, 22°C (72°F) 0.96
- cSt @ 40°C 5,000
- (SUS @ 100°F 25,000)
- cSt @ 100°C 1,100
- (SUS @ 210°F 5,000)

- 5.10.3. Enclosed Gear Reducers:
- Refer to AGMA Standard 9005.D94
 - "Lubrication of Industrial Enclosed Gear Drives"

- 5.10.4. Gear Couplings:
- NGLI #0 EP Grease

- 5.10.5. Grid Couplings:
- NGLI #2 EP Grease

The Contractor will be accompanied by the Engineer during his final inspection before machinery testing. On the basis of the results of this inspection, the Engineer will determine whether the bridge is ready for field testing.

- 5.11. **Field Testing.** When the mechanical components and electrical equipment are ready for final testing, the Contractor will inform the Engineer not less than fifteen (15) calendar days prior to the scheduling of tests. The Engineer will provide a list of Department personnel to be informed of the tests by the Contractor. During all tests the Contractor will keep available a complete crew of machinists/mechanics in order to provide operation of the span and to make all adjustments and corrections, which will be required to complete the tests.

The Contractor will prepare a field testing procedure, which will be approved by the Engineer. The testing procedure will be coordinated with tests required for the electrical equipment and will include measurements of power and current drawn by the motors when operating under load as required hereinafter.

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

- operating machinery
- span lock machinery
- barrier gate machinery
- sheave trunnions and bearings
- wire rope tensions
- live load bearings and centering devices
- operating machinery instrument drives and limit switches
- span lock machinery instrument drives and limit switches
- barrier Gate machinery instrument drive and limit switches

When the machinery is ready for field testing, the machinery assemblies will be driven under normal and auxiliary operations. During normal operation, the main electrical system will be used to cycle the span lock and operating machinery in the proper sequence to raise/lower the bascule span ten (10) times. During auxiliary operation, the backup generator will be used to cycle the span lock and operating machinery in the proper sequence to raise/lower the bascule span five (5) times. During manual operation, hand cranks will be used to cycle the span lock machinery five (5) times.

During the test runs, each machinery assembly will be inspected in its entirety to determine whether everything is in proper working order and fully meets the requirements of these specifications, plans and

manufacturer's recommended tolerances. All test runs will be performed in the presence of machinery manufacturer's representative, electrical control equipment's manufacturer and the Engineer. The temperature rise of all electrical components will not exceed design ratings. If any tests show that any components are defective or inadequate, or function improperly, the Contractor will make all corrections, adjustments, or replacement required before the final acceptance at no additional cost.

5.12. **Training.** The Contractor will provide five (5) 8-hour days of instruction to Department Maintenance personnel. The instruction will include but not be limited to the following with respect to all bridge machinery components:

- function, purpose
- normal operation
- auxiliary operation
- maintenance
- adjustment
- trouble shooting
- repair and replacement