

# Special Specification 4035

## Mechanical Systems Rehabilitation



### 1. DESCRIPTION

- 1.1. Details and arrangements of Machinery systems are shown on the plans and must be in accordance with the requirements specified in Special Specification 4034, "Bridge Machinery."

The work will also include installing and aligning the drive motors and brakes, as well as control instrumentation that is to be supplied under Special Specification 6122, "Bridge Electrical System Replacement." The work under these items will be in accordance with the requirements specified in Special Specification 4034, "Bridge Machinery."

The Contractor will coordinate the installation of the Machinery with all other bridge machinery items, electrical work and structural work, as well as navigational and vehicular traffic closures and restrictions.

The Contractor will be responsible for maintaining the bridge (existing and rehabilitated) in a safe and serviceable operating condition for the duration of this project. This will include performing maintenance inspections to assure all components are functioning safely and reliably. The Contractor will also lubricate and adjust machinery as per the bridge maintenance lube charts, manual, existing procedures or individual component manufacturer requirements.

The work will include but not be limited to furnishing, repairing and/or replacing the following listed items.

- 1.2. **Counterweight Wire Rope Replacement.** This work will include removal of the existing wire ropes, take-ups and connections, cleaning contact surfaces, replacing corroded bolts, installing new take-ups and 6x19 filler wire construction wire ropes with IWRC. The new wire ropes will be extra improved plow steel. Work for installation of temporary components and equipment to support the counterweight in order to remove the wire ropes and provide support of the counterweight for the duration of the work to rehabilitate components and reinstall new wire ropes is covered under temporary support of the superstructure. When the ropes are removed the sheaves, shafts and bearings will be rehabilitated under Item B and new ring gears installed under Item C. As part of the installation, new take-up anti rotation devices will be installed to prevent the take-up/rope from rotating over time. After the ropes are installed, they will be tensioned to equalize the loads in the rope groups. It will also be required for the Contractor to re-check and re-tension the ropes after 6 mo. and at least a minimum of 30 operations following acceptance.
- 1.3. **Counterweight Sheave, Shaft and Bearing Rehabilitation.** The counterweight sheave rehabilitation includes removal of the counterweight sheaves from the towers for refurbishment at a shop. This work will include cleaning all components, reconditioning shaft journal and fillet surfaces, cleaning bearing lubrication passages and installing new bearing cap bolts. The potential contact points of the sheave web stiffeners with the bearing base are to be ground for clearance. Following this work all fillet and journal surfaces will be checked with magnetic particle testing.
- 1.4. **Operating Machinery Rehabilitation.** The operating machinery rehabilitation will include replacing the ring gears and pinions. New ring gears will be shop installed on the counterweight sheave. The pinion bearings, couplings, shafts and enclosed gear boxes will be rehabilitated. Reducer rehabilitation will include disassembly and inspection of internal components. Reducer bearings, seals and fasteners will be replaced. The machinery rehabilitation will include installing new motors, motor brakes and machinery brakes which will be furnished under the electrical item.

The Contractor will retain the professional services of a Texas State licensed Professional Engineer to prepare the calculations for maintaining the balance of the bridge. In addition, the Contractor will retain the professional services of a testing company to perform complete dynamic strain gage testing and reporting.

An inventory will be performed and maintained of the quantity and location of balance blocks in each counterweight pocket and elsewhere on the property.

The Contractor will keep track of the balance of each bridge at all times during the term of this Contract. The balance will be maintained within the final imbalance criteria anytime the bridge is operation. The lift span will be kept in a span heavy condition at all times.

Final strain gage balance test will be performed on the bridge at the completion of construction. Balance adjustments based on the final balance test as approved by the Engineer. Each lift span will be balanced such that a final span heavy imbalance of 1,000 lbs. -0/+500 lbs. per corner exists with the span in a seated position.

- 1.5. **Barrier Gate Machinery Rehabilitation.** The barrier gate machinery rehabilitation will include replacing the sprocket assemblies, bearings, couplings, shafts, reducers and limit switch drives. The new sprocket assemblies will include a new wire rope and idler sheave for redundancy. The machinery rehabilitation will include installing new motors with integral brake which will be furnished under the electrical item.
- 1.6. **Span Lock Machinery Rehabilitation.** The span machinery rehabilitation will include replacing the lock bar sockets and guides. The lock bars, cranks, connecting rods, bearings, couplings, shafts and enclosed reducer will be rehabilitated. Reducer rehabilitation will include disassembly and inspection of internal components. Reducer bearings, seals and fasteners will be replaced. The machinery rehabilitation will include installing new motors with integral brake which will be furnished under the electrical item. A new support will be provided for motor installation. The work will also require providing and installing machinery for electrical controls/limit switches.
- 1.7. **Live Load Bearing and Centering Device Rehabilitation.** The live load rehabilitation will include removal of existing live load bearings and machining the surfaces at a machine shop. The contractor will provide temporary supports for the sequencing work. The existing grout pads will be removed and mounting hardware rehabilitated or replaced as required. The rehabilitated assemblies will be reinstalled to establish the proper elevations of the seating surfaces and new grout pads installed.  
  
The centering device will include removal of existing lower assembly and machining the surfaces at a machine shop. The contractor will provide temporary devices if required to replace existing with new. The socket portion of the assembly will be replaced and reinstalled on the lift span. The existing grout pads will be removed and mounting hardware rehabilitated or replaced as required. The rehabilitated lower assemblies will be reinstalled to establish the proper elevations of the guiding surfaces and new grout pads installed.
- 1.8. **New Span Guides.** The existing roller guides on the lift span will be removed and new guides installed. New guide assemblies will be adjusted for acceptable guidance of the span.
- 1.9. **New Counterweight Guides.** The existing roller guides on the counterweight will be removed. New guide assemblies will be installed and adjusted for acceptable guidance of the counterweight. Grease piping,
- 1.10. supports and fittings will be provided for convenient application of roller lubricant.
- 1.11. **Air Buffer Removal.** Removal of the existing air buffers is included under a structural item.
- 1.12. **New Sheave Covers.** The existing sheave covers will be removed and new covers installed. This work is included under a structural item.

- 1.13. **New Wire Rope Inspection Platform.** A new access platform will be installed at the counterweight side, below each of the sheaves to allow inspection and maintenance of the wire ropes. This work is included under a structural item.
- 1.14. **New Wire Rope Roadway Protection.** New wire rope deflectors will be installed at the roadway level to aid in the protection of the ropes from being damaged from traffic impacts. This work is included under a structural item.

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## 2. MATERIALS

- 2.1. **General.** The materials used to fabricate the machinery components for these items will be as shown on the plans, noted in the specifications and in accordance with the requirements specified in Special Specification 4034, "Bridge Machinery."
- 2.2. **Lubrication.** Upon approval, the contractor will provide the following quantities of additional lubricants for the machinery, which will be stored at the site:
- |                                 |          |
|---------------------------------|----------|
| ■ Main Reducer Gear Oil         | 110 gal. |
| ■ Span Lock Reducer Gear Oil    | 110 gal. |
| ■ Barrier Gate Reducer Gear Oil | 110 gal. |
| ■ Open Gear Grease              | 50 lbs.  |
| ■ Bearing Grease                | 50 lbs.  |
| ■ Grid Coupling Lubricant       | 25 lbs.  |
| ■ Gear Coupling Lubricant       | 25 lbs.  |
| ■ Wire Rope Lubricant           | 200 lbs. |

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. New speed reducers for the barrier gate machinery will have mounting holes located such that final field drilling and reaming for permanent fasteners is feasible.

- 2.2.1. New Speed Reducers will be as manufactured by one of the following companies or approved equal:
- Earle Gear by Steward Machine Co., Inc., 3911 13<sup>th</sup> Avenue North, Birmingham, AL 35234, (205) 841-6461 (phone)
  - Horsburgh & Scott, 5114 Hamilton Avenue, Cleveland, OH 44114, (216) 431-3900 (phone)
  - Prager, Inc., P.O. Box 61670, New Orleans, LA 70161-1670, (504) 598-0322 (phone)
  - Rexnord, Industries, 4800 West Mitchell Street, Milwaukee, WI 53214-5408, (414) 643-2200 (phone)
  - Nuttall Gear, 2221 Niagara Falls Boulevard, Niagara Falls, NY 14304-5710, (716) 298-4100 (phone)
- 2.2.2. New wire ropes will be as manufactured by one of the following companies or approved equal:
- WireCo WorldGroup, 609 North 2nd Street, St. Joseph, MO 64501, (816) 236-5152 (phone)
  - Bridon America, 280 New Commerce Boulevard, Hanover, PA 18706, (570) 822-3349 (phone)
  - Wirerope Works, Inc., 100 Maynard Street, Williamsport PA 17701, (570) 326-5146 (phone)
- 2.3. **Spare Parts.** The spare parts provided for the machinery components for these items will be in accordance with the requirements specified in Special Specification 4034, "Bridge Machinery."
- Upon approval, the Contractor will provide the following spare parts, which will be stored at the site:
- two (2) Span Lock Front Guide Bushing Sets;
  - two (2) Span Lock Rear Guide Bushing Sets; and

- one (1) complete set of bearings, seals and a moisture trap breather for each new and rehabilitated reducer.

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### 3. CONSTRUCTION

3.1. **Shop Inspection and Testing.** All operating machinery components will be assembled to assure proper fits and verify tolerances specified on the contract plans. Assemblies requiring disassembly will be match marked and documented so that the machinery can be reassembled at the bridge site.

3.2. **Machinery Removal, Rehabilitation and Installation.** The contractor will perform the work, remove, rehabilitate and install machinery and related components in accordance with the contract plans, as noted in the specifications and in accordance with the requirements specified in Special Specification 4034, "Bridge Machinery." The contractor will remove existing components shown on the contract plans which are designated to be replaced or rehabilitate. New or rehabilitated components removed, will be installed and aligned with new mounting bolts and shims.

3.2.1. **Counterweight Wire Rope Replacement.** The counterweight wire rope replacement will be as shown on the plans and noted in the specifications.

The counterweight wire rope replacement will include but not be limited to the following for each assembly (24 new wire rope assemblies required):

- Provide temporary support of the lift span and counterweight.
- Remove existing counterweight ropes.
- Furnish and install new counterweight ropes, take-ups and associated pins and hardware. Align counterweight ropes vertically straight based on striping painted on assemblies during manufacture. Install new counterweight rope anti-rotation devices.
- Load counterweight ropes and remove temporary supports of the lift span and counterweights.
- Adjust the rope tensions of each individual rope to within five percent of the rope group average tension. Rope tension will be tested using "strumming method" vibration testing. The testing for each rope group will be repeated until each individual rope meets this criterion. Wire rope adjustment will again take place after 6 mo.
- Lubricate counterweight ropes and maintain throughout the entire bridge rehabilitation project.

3.2.2. **Counterweight Sheave Shaft and Bearing Rehabilitation.** The counterweight sheave, shaft and bearing rehabilitation will be as shown on the plans and noted in the specifications.

The counterweight sheave, shaft and bearing rehabilitation will include but not be limited to the following for each assembly (Rehabilitation required for (4) assemblies):

- Measure and record the existing counterweight sheave bearing cap to shaft journal clearance.
- Identify potential contact points of the counterweight sheave web stiffeners with the bearing base and grind for clearance.
- Remove counterweight sheave bearing caps. Hoist counterweight sheaves from tower and transport to shop for rehabilitation.
- Clean bearing caps, shaft journals and grease lubrication passages.
- Rehabilitate shaft journal and fillet surfaces. Clean shaft journal surface and grease.
- Remove the existing counterweight ring gear 'R1' from the counterweight.
- Check all fillet, journal surfaces with magnetic particle testing. Visually check sheave web for cracks and check any suspect areas with magnetic particle testing.
- Confirm fit of new ring gear 'R1' on the counterweight sheave meets tolerance requirements and install with new 7/8 in. turned bolts. Fit of gear on sheave will be LC1.
- Return counterweight sheaves to tower and reinstall at bearings. The contractor will confirm that the shafts fully bear on the bottom width of the bearings. Reinstall bearing caps with new bolts and check

for clearance with shaft journals. Confirm that no direct bearing cap to shaft journal surface contact is present. Adjust bearing liners for bearing cap clearance with shaft journal as required. The contractor will also adjust the bearing laterally for 0.035 +/-0.010 in. gap at the sheave face. After an acceptable alignment is achieved new mounting bolt holes will be reamed and new turn bolts installed.

- Grease counterweight sheave bearing.

3.3. **Operating Machinery Rehabilitation.** New and rehabilitated machinery will be installed as shown on the plans and noted in the specification.

Reducer rehabilitation for the Operating Machinery will include disassembly, inspection of internal components, replacing bearings, seals and fasteners. Each reducer will be tested according to the shop inspection and testing requirements for speed reducers under the Special Specification 4034, "Bridge Machinery."

The new motor brakes will be set to a torque of 75 ft. lbs. and the machinery brakes will be set to 945 ft. lbs.

The existing racks and pinions are to be removed and replaced. Pinion bearings will be rehabilitated to accept the pinion shaft, shimmed and aligned.

The operating machinery rehabilitation will include but not be limited to the following for each of the two (2) assemblies.

- Disassemble and remove existing motors, motor couplings, motor brakes and reducer.
- Disassemble and remove floating shafts with couplings and machinery brakes.
- Remove pinion bearing caps and remove existing pinions with half couplings. Transport pinion shafts to shop for removal of coupling halves and installation on new pinion shafts.
- Remove pinion bearings for rehabilitation at shop.
- Remove ring gear from counterweight sheave.
- Clean all mounting surfaces for pinion bearings. Clean all existing fasteners that are to remain. The Contractor will take caution not to damage these surfaces when the bearings are disassembled.
- Inspect all mounting surfaces of the rack and pinion bearings. Remove any sharp edges or defects that are found.
- Install new ring gear on counterweight sheave.
- Install new machinery brake wheel and floating shaft half coupling half on new pinion shafts.
- Install rehabilitated pinion bearings. Install new pinion shaft in pinion bearings.
- Adjust pinion bearing liner shims for proper shaft journal running clearance (RC6).
- Adjust bearing mounting shims as necessary for proper rack and pinion open gear alignment.
- Install new machinery brakes furnished under electrical items.
- Reinstall rehabilitated reducer. Install new motor brakes furnished under electrical items.
- Install new floating shaft and confirm that alignment of new floating shaft couplings are within manufactures specifications. Adjust slip/torque couplings to equalize the loads in the pinion shafts for the span seated position as well as during operation. This requires reducing the torque setting, rotating the shafts relative to one another and then setting the torque to the maximum coupling rating for bridge operations.
- Install new motors furnished under electrical items with couplings and align.
- Install new lubrication fittings in couplings and lubricate couplings.
- Lubricate pinion bearings.
- Lubricate rack and pinion teeth.
- Paint all exterior, non-rubbing bearing surfaces.

3.3.1. **Pinion Bearing Rehabilitation Notes:** The bearing assemblies are to be shimmed at the base/structure as required to achieve proper bearing, rack and pinion open gear alignment as required under the Special Specification 4034, "Bridge Machinery."

Pinion bearings, reducers, couplings and any associated shims that are to be removed for rehabilitation should be tagged prior to removal for reinstallation in the same location.

Removals, rehabilitation of existing components and the installation of new components may require the temporary removal, temporary support and reinstallation.

### 3.3.2. Machinery torque and balance testing, balance procedures and balance adjustments

The contractor will weigh the counterweights with calibrated jacks when the wire ropes are removed.

Strain gage testing will be used to test the balance of the lift span and confirm load sharing torques of the pinions.

A minimum of three (3) milestones will be tested and documented with a report. The three milestones are:

- Initial balance condition;
- After construction condition; and
- Final Balance condition.

In addition to the balance testing, the contractor will provide a step by step procedure of weight changes from milestone 1 to 2 and milestone 2 to 3.

The after construction condition will be taken as after major weight changes have been made and right after putting the bridge back into operation.

Motor power readings will also be monitored throughout the project by the Contractor as a secondary means to confirm balance.

Measurements of the after construction condition and final balance condition and pinion torque load sharing will be repeated until the balance and load sharing of the pinions meets the criteria as specified in this procedure.

The contractor will provide all counterweight block material and labor to make balance changes and measurements.

### 3.4. **Barrier Gate Machinery Rehabilitation.** The new and rehabilitated barrier gate machinery will be installed as shown on the plans and noted in the specifications.

The new speed reducers for the Barrier Gate Machinery will be tested as required under Special Specification 4034, "Bridge Machinery." Additionally, each reducer will be load tested by operating at 150% rated full load motor torque and at 100% rated RPM for 1/2 hr. in each direction (1 hr. total continuous operation). The Contractor will supply testing equipment, which will include separate test motors (main leaf motors to be permanently installed with the Operating Machinery will not be used for testing). The tests will be performed in the presence of the Engineer. The test will be run with the reducers filled to the maximum oil level mark, with new oil of the viscosity the manufacturer recommends on his lubrication chart for normal operation. The load test on each of the reducers will be performed in addition to the testing required under the general machinery requirements.

Perform barrier gate drive replacement at two locations as shown on the contract plans, this will include but not be limited to the following:

- Remove existing barrier gate drive machinery.
- Furnish, install and align new sprocket and sheave assembly including new bearings, chains, wire ropes and connections.
- Furnish, install and align new reducer and floating shafts with couplings.
- Furnish, install and align new motor supplied under electrical items with new motor grid coupling.
- Install and align new limit switch furnished under electrical items with drive.

- Lubricate and maintain barrier gate machinery throughout the entire bridge rehabilitation project.

- 3.5. **Span Lock Machinery Rehabilitation.** Span lock new and rehabilitated machinery will be installed as shown on the plans and noted in the specifications.

Perform span lock replacement/rehabilitation at two locations as shown on the contract plans and included but not limited to the following list.

- Remove existing span locks with drive machinery.
- Rehabilitate crank bearings, connecting rods, cranks and lock bars.
- Rehabilitate floating shaft with couplings and reducer.
- Furnish, install and align new span lock bar socket, lock bar front guide and rear guide with rehabilitated lock bar assembly.
- Reinstall and align rehabilitated span lock drive system including reducer and floating shaft.
- Install and align new span lock motor furnished under electrical items with new grid coupling and support.
- Install and adjust new span lock limit switch furnished under electrical items.
- Lubricate and maintain span lock machinery throughout the entire bridge rehabilitation project.
- The bearing assemblies are to be shimmed at the base/structure as required to achieve proper bearing, and floating shaft alignment.
- Crank bearings, connecting rods, cranks, lock bars, pinion bearings, reducers, floating shaft couplings, and any associated shims that are to be removed for rehabilitation will be tagged prior to removal for reinstallation in the same location.

- 3.6. **Live Load Bearing and Centering Device Rehabilitation.** The live load bearings and centering device rehabilitation will be as shown on the plans and noted in the specifications.

The live load bearings and centering device rehabilitation will include but not be limited to the following list for each assembly (Rehabilitation required for 6 assemblies).

- Remove existing live load bearings with grout pads.
- Rehabilitate live load bearings by machining mating surfaces at shop.
- Reinstall rehabilitated live load bearings on new grout pads at the proper elevation and full bearing of the seating surfaces.
- Remove existing centering device lower assembly with grout pad. Rehabilitate mounting hardware or replace as required.
- Rehabilitate centering device lower assembly by machining mating surfaces at a machine shop.
- Furnish, install and align the socket portion of centering device assembly.
- Reinstall rehabilitated lower assemblies to the proper elevations and planer alignment of the guiding surfaces on new grout pads.

- 3.7. **New Span Guides.** Perform span guide replacement at four (4) locations as shown on the contract plans and noted in the specifications including but not limited to the following list.

- Remove existing span guides.
- Furnish, install and align new span guides. Guides will be set for proper gaps and full bearing with rail when in contact.
- Lubricate and maintain span guides throughout the entire bridge rehabilitation project.

- 3.8. **New Counterweight Guides.** Perform counterweight guide replacement at four locations as shown on the contract plans and noted in the specifications including but not limited to the following list.

- Remove existing counterweight rollers from existing guides.

- Furnish, install and align new counterweight guides. Adjust existing sliding guides as necessary for proper gaps and rehabilitate mounting bolts. The new roller guides will be set for proper gaps and full bearing with rail when in contact.
- Lubricate and maintain counterweight guides throughout the entire bridge rehabilitation project.

3.9. **Air Buffer Removal.** The air buffers will be removed as shown in the contract plans. The Contractor will provide or remove counterweight block to compensate for changes in lift span weight in accordance with the requirements specified in Section 3.3., "Operating Machinery Rehabilitation."

This work is covered under a structural item.

3.10. **New Sheave Covers.** This work is covered under a structural item.

3.11. **New Wire Rope Inspection Platform.** This work is covered under a structural item.

3.12. **New Wire Rope Roadway Protection.** This work is covered under a structural item.

#### 4. SUBMITTALS

4.1. The contractor will submit the following items as part of the submittals.

- Qualifications of the Texas State licensed Professional Engineers to be utilized in this Section.
- Qualifications of the testing company to be utilized in this Section.
- Calculations for the span balance.

4.1.1. The calculations will account for all existing components to be removed and new components to be installed including allowances for bolts, rivets, welds, paint and normal overruns on plate thicknesses. The calculations will account for the longitudinal and transverse location of loads to ensure an even distribution of loads between the four corners of each bridge.

4.1.2. The calculations will be formatted such that each removal and installation is in sequential order according to the Contractor's planned schedule.

4.1.3. The balance calculations summary will be prepared using an Excel spreadsheet.

4.1.4. The balance calculations for the lift span will be approved by the Engineer before construction operations affecting span balance can begin. The balance calculations will be updated on a daily basis as components are removed and added to the lift span. The updated calculations will be submitted to the Engineer prior to each span opening and at any other time as directed by the Engineer.

4.1.5. Reports giving the results of the strain gage balancing as well as the inventory of balance blocks in each counterweight pocket at each stage will be submitted to the Engineer.

4.2. Execution - Maintenance of Balance and Pinion Loading Requirements

The Contractor will perform a survey of the number of balance blocks, location, type and weight of the blocks in the counterweight and those which are stored and available as spares before proceeding with preparing a scheme for maintaining the balance. All balancing and checking of the lift span and counterweights will be performed by approved personnel. All balancing of the lift span will be approved by the Engineer.

During construction, the Contractor will remove, replace or install the balance blocks in the pockets as necessary so that the lift span is always maintained in the specified balance condition when the bridge is operational.

The specified balance condition of each lift span is 1,000 to 1,500 lbs. span heavy at each corner, 2,000 to 3,000 lbs. span heavy at each end, and 4,000 to 6,000 lbs. total span heavy. Pinion loading is to be within 10% between transverse sides.

#### 4.2.1. **Strain Gage Balance and Shaft Torque Testing.**

The Contractor will balance the lift span so as to provide the required reactions at the four bearings of the lift span.

The imbalance of the lift span will be measured using the dynamic strain gauging technique. The Contractor will provide all labor, materials and equipment necessary to determine the lift span's imbalance by dynamic strain gauging.

The Contractor will employ the services of an established testing company experienced in performing dynamic strain gauge testing of movable bridges. Such experience will be demonstrated by identifying a minimum of six (6) movable bridges including at least two (2) tower drive vertical lift bridges for which the testing company has provided complete dynamic strain gauge testing and reporting. The testing agency selected by the Contractor for this work will be submitted for approval by the Engineer.

The testing company will furnish and install the required strain gauges, all cabling and transmission equipment, data acquisition equipment and strip chart recorders and produce fully documented reports detailing the results of the testing.

4.2.2. The approved testing company will submit the following items to the Engineer for approval.

- Description of experimental procedure including type and method of installation of strain gauge rosettes, method of transmission of low level signals, data acquisition equipment and/or strip chart recorders.
- Layout plan of span drive equipment showing proposed location of strain gauges, amplifiers, cable or radio links, data acquisition equipment and all associated cabling.
- Details of method of transmission of signals from shafting to data acquisition units.
- Elementary wiring diagrams of interconnection of strain gauges, amplifiers, data acquisition equipment and/or strip chart recorders.
- Description of electrical and mechanical factors including sample calculations for obtaining shaft torque from measured strains, span imbalance and curve fitting and basis for friction correction.

4.2.3. The Contractors work will include the following items.

4.2.3.1. Affix two foil resistance strain gauge rosettes to each of the main pinion shafts. The areas of the shafts where the gauges are to be mounted will be sufficiently cleaned to remove all contaminants. On each main pinion shaft will be mounted two rosettes at 180 degrees from each other. The two gauges will be connected such that any direct shear forces in the shafts are neglected and true torsional shear is measured.

4.2.3.2. The gauge leads on each shaft will be connected to a four arm amplifier which will be securely mounted to the shafts. Transmission of signals from the shafts to the data acquisition equipment will be either through cable links wound on spring operated cable reels with sufficient capacity and torque or through wireless transmitters.

4.2.3.3. Output loads from each channel of the amplifiers in each tower will be connected to either a computer-based data logger provided with a 2-channel strain gauge module streaming the amplified data to disk at a minimum 1 KHz sample rate, or a 5-channel minimum strip chart recorder with at least ten inch wide chart paper. Provide an event marker which will be connected to sensors on the pinion shaft such that increments of pinion shaft revolutions are recorded. Each increment will be interpreted as span height utilizing the gear ratios of the machinery. The chart speed will be step-wise adjustable and will at least include a setting of at least 10 in. per minute. Use a recorder that is capable of recording data from at least four channels if it is equipped with a dedicated event marker or five channels if a channel is used to record events.

- 4.2.3.4. The strains in all four main pinion shafts per lift span in each tower versus span height will be recorded simultaneously during a full opening and closing cycle to a suitable scale. The readings for all main pinions will be at the same strain scale and chart speed and will be recorded during the same span opening if a strip chart recorder is used.
- At each milestone, in order to make a determination of a state of imbalance or pinion load sharing measurement, a minimum of three bridge operations (opening and closing cycles) will be performed which demonstrate repeatable data. The Contractor will perform more runs and record data as necessary in order to obtain three repeatable sets of data. Testing for each milestone will be done on a day where the wind is less than 5 mph and the lift span and counterweights are visually dry.
- 4.2.3.5. The strains induced in the main pinion shafts in each tower will be numerically converted to torque for at least 50 points at equal intervals along the strain plots for both opening and closing. This data will be processed to give a curve of torque for the full travel of the lift span versus span height in feet, which has been corrected for friction.
- 4.2.3.6. The Contractor will submit ten copies of a full report documenting the results of the strain gauge tests. The reports will contain the following:
- Description of experimental procedure and equipment used.
  - Span drive diagram showing location at which strain gauges and event markers were attached and all applicable gear ratios.
  - Photocopies of original strip charts for both span opening and span closing for all pinion shafts.
  - Description of relationships and sample calculations for obtaining pinion shaft torque from strains, span imbalance moment from pinion shaft torque and curve fitting and basis for friction correction.
  - Fitted curves of torque versus span height during opening and closing for each main pinion shaft.
  - Curve of shaft torque versus span height corrected for friction.
  - Discussion of probable error.
- 4.2.3.7. The reports will be bound in between heavy plastic covers. The report will include introductory section incorporating the name of the bridge, the shafts tested, the date of the test, weather conditions during testing and any other information requested by the Engineer.
- 4.2.3.8. The Contractor will provide at minimum 160 new concrete balance blocks at approximately 120 lbs. each. The size and material will match the existing counterweight block. Unused blocks are to be stocked as directed by the Engineer.
- 4.2.3.9. All material and labor will be provided as part of this item. This will include all labor and equipment to add or remove counterweight blocks from the two lift span counterweights.

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## 5. TESTING

When the mechanical components and electrical equipment are ready for final testing, the Contractor will submit to the Engineer a testing procedure and schedule in accordance with the requirements specified in Special Specification 4034, "Bridge Machinery," Section 5.11., Field Testing.

Each test run will verify that the Operating Machinery, Counterweight Sheaves and Ropes, Span Lock Machinery, Barrier Gate Machinery, Counterweight Guides, Span Guides and overall lift span operation is in proper working order and fully meets the requirements of the Contract Plans and Specifications. If any tests show that the machinery components are defective or inadequate, or function improperly, the Contractor will make all corrections, adjustments, or replacements required before final acceptance at no additional cost.

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## 6. MEASUREMENT

Payment of Mechanical Systems Rehabilitation Machinery Items will be made on a lump sum basis.

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**7. PAYMENT**

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Mechanical Systems Rehabilitation." This price is full compensation for furnishing all material, labor and equipment necessary for the manufacturing, erecting, rehabilitating, testing, adjusting, lubricating, painting and all incidental work for a complete installation.

The Contractor will submit to the Engineer a detailed breakdown of costs under these items. The Engineer will evaluate this breakdown, and will have the authority to revise the breakdown as, in his judgment, may be required to make the various components of work conform to their true values.

The Contractor will agree that the detailed breakdown will not become effective until it has been approved by the Engineer.

The approved detailed breakdown will be used as a basis of payment for the progress payments.