h. When all the components are in proper working order and adjustment, the pressure readings taken at each test station shall be recorded, and provided to the Company.

i. After completion of final tests hydraulic fluid shall be removed, properly discarded, replaced with new fluid, and air bled from the entire hydraulic system. New fluid shall be added using portable filtration units in conformance with Article 6.5.37.6.1g.

In lieu of fluid replacement, the Contractor may take fluid samples from each reservoir for analysis by the fluid supplier. The fluid shall be changed if sample contamination levels are greater than the following, as defined by specification ISO 4406:1999, Hydraulic Fluid Power - Fluids - Method of Coding the Level of Contamination by Solid Particles:

Servo valve applications.....ISO 15/13/11

Span drive applications.....ISO 16/14/12

Auxiliary drive applications.....ISO 17/15/13

New fluid, where required, shall be added using portable filtration units in conformance with Article 6.5.37.6.1g.

j. After completion of final hydraulic testing, and either fluid replacement or the continued use of fluid which has passed contamination level testing, filter elements shall be replaced and strainers and magnets cleaned.

SECTION 6.6 WIRE ROPES AND SOCKETS

6.6.1 MANUFACTURER (1984) R(2010)

Wire rope shall be made by a manufacturer whose facilities and experience are approved by the Engineer.

6.6.2 DIAMETER OF ROPE (2010)[1]

a. The nominal diameter of counterweight ropes shall not be less than 1 inch. For counterweight ropes with a nominal diameter larger than 2-3/8 inch, a wire rope manufacturer shall be consulted during the design phase of the project, before the construction contract is awarded. Operating ropes shall not be less than 3/4 inch in diameter.

b. The actual diameter of a wire rope (the diameter of the circumscribed circle) shall be measured when the rope is unstressed.

6.6.3 CONSTRUCTION (2010)[2]

a. Wire rope shall be improved plow steel (IPS) grade or extra improved plow steel (EIP) grade. All ropes shall be of preformed construction. The wire rope may be manufactured from uncoated (bright), drawn-galvanized, or drawn-zinc aluminum mischmetal alloy (Zn5Al-MM) wire. On any structure, the use of different types of wire rope construction shall not be permitted for the same type of component. The type of wire rope construction shall be stated on the shop drawings.

---

[1] See Part 9 Commentary
[2] See Part 9 Commentary

b. Counterweight ropes of 2-3/8 inch diameter or less shall conform to ASTM A1023 and shall be of either Class 6x19 or Class 6x36 construction. They may be made of only circular wires with either fiber or independent wire rope cores (IWRC), as listed in Tables 12, 13, 14, and 15 of ASTM A1023. Fiber cores shall be of natural or synthetic fibers as defined in Article 5.2.1 of ASTM A1023, except that jute shall not be used. The ropes may be of compacted strand construction (CS) as listed in Tables 28 and 29 of ASTM A1023.

Counterweight ropes greater than 2-3/8 inch diameter shall be Class 6x61 per Federal Specification RR-W-410F with either fiber core or IWRC as listed in Tables XVII through XIX. Wire strand core shall not be permitted. They shall be of Construction 4, 5, or 6. Fiber cores shall be of natural or synthetic fibers as defined in Article 3.2.1 of Federal Specification RR-W-410F except that jute shall not be used.

c. Ropes shall be laid in accordance with the best practice. Every effort shall be made to obtain ropes of uniform physical properties. The ropes shall be fabricated in the greatest lengths practicable, and all similar ropes for any one bridge shall be cut from ropes manufactured with one setting of one stranding machine and one setting of one closing machine.

6.6.4 LAY (2010)

a. All wire ropes, unless otherwise specified, shall be right regular lay. Where required by the design, counterweight wire ropes may be right or left lay, with all other construction, and lay length, identical. The maximum length of lay shall be as follows:

(1) Operating ropes – 6.75 times nominal rope diameter.

(2) Counterweight ropes – 7.25 times nominal rope diameter.

b. The lay of the wires in the strands shall be such as to make the wires approximately parallel to the axis of the rope where they would come in contact with a circular cylinder circumscribed on the rope.

6.6.5 LUBRICATION DURING FABRICATION (1983) R(2010)

Manila and sisal fiber cores shall be thoroughly impregnated by the cordage manufacturer with a suitable lubricating compound free from acid. All portions of wire rope core, wires and strands shall be lubricated during manufacture with a lubricant containing a rust inhibitor approved by the Engineer.

6.6.6 SPLICES (1983) R(2010)

No splicing of the ropes or individual strands will be permitted. Wire splices shall be securely and properly made by electric welding, and no two joints in any one strand shall be closer than 25 feet apart, except for filler wires.

6.6.7 WIRE – PHYSICAL PROPERTIES (2010)[1]

The wire from which wire ropes are made shall be tested in the presence of an inspector designated by the Engineer. Excepting that filler wires may be made to the manufacturer's standards, the physical properties of the bright (uncoated) individual wires before manufacture into rope shall be as follows:

a. The tensile strength of the wires shall meet the requirements of Table 1 - Wire Tensile Strength Grades or Levels for Wire Rope Grades, of ASTM A1023. Wire tensile strength is related to wire level in Articles 8.1.3 and Table 3 of ASTM A1007.

[1] See Part 9 Commentary

b. The wire ductility shall be evaluated per Article 3.13.1 of ASTM A1023, which refers to Article 9.2 and Table 3 of ASTM A1007.

c. All of the tests specified above shall be made upon fair samples which may be taken from either end of any coil of wire, and such samples shall be taken from not less than 10 percent of the number of coils.

d. Wire rope for operating ropes obtained from stock may be accepted upon certification by the manufacturer that all provisions of the specifications are met; tensile strength and torsion tests may be waived, where test data are not available, but the tension test on the rope as specified in Article 6.6.8 is required.

6.6.8 ULTIMATE STRENGTH (2010)[1]

In order to demonstrate the strength of the rope and its socket, test pieces with a length between the sockets of not less than 25 rope diameters, and preferably not less than 50 rope diameters, shall be cut, and shall have sockets, selected at random from the job lot, attached to their ends. The sockets used for these tests shall not be used in the structure. The number of test pieces shall be not less than two from each manufactured length of rope, but not more than 10 percent of the total number of finished assemblies of rope to be fabricated. The test pieces shall be taken from both ends of the manufactured lengths of rope. A suitable mark shall be placed around the rope near the base of the socket, so that any relative movement of the latter can be readily detected. These test pieces are to be tested to destruction per ASTM A931 Test Methods for Tension Testing of Wire Rope and Strand, in the presence of an inspector designated by the Engineer. Wire ropes 2-3/8 inch diameter or less shall develop the minimum breaking force given in ASTM A1023 for the particular size, construction, grade and coating (if any). Wire ropes larger than 2-3/8 inch diameter shall develop the minimum breaking force given in Federal specification RR-W-410F for the particular size, grade and coating (if any).

6.6.9 REJECTION (1985) R(2010)

Where the physical properties of the rope or of its individual wires do not meet those specified, the manufacturer shall replace the entire manufactured length with a new length, the physical properties of which conform to those specified.

6.6.10 PRESTRETCHING (1985) R(2010)

Each counterweight rope shall be prestretched using the following procedure:

a. Tension the rope to 40% of its ultimate strength as given in Article 6.6.8 and hold that load for 5 minutes.

b. Reduce the load to 5% of the ultimate strength.

c. Repeat this load-unload cycle two more times.

d. Release the load.

6.6.11 SOCKETS (1985) R(2010)

a. Sockets for wire ropes shall conform to the requirements of Federal Specification RR-S-550, latest revision, except that sockets for 2-1/2-inch diameter ropes may be cast steel conforming to ASTM A148, Grade 80-50. Sockets shall be attached to the ropes by using zinc of a quality not less than that defined in the current Specifications for Slab Zinc (Spelter), ASTM B6 High Grade. Maximum socket slip or seating of the zinc cone, with the rope, when tensioned to 80% of its specified ultimate strength under the test specified in Article 6.6.8, shall be 1/6 the nominal diameter of the rope. If a greater slip should occur, the socketing method shall be changed until satisfactory results are obtained.

[1] See Part 9 Commentary

b. Variations or substitute designs of sockets will be considered acceptable if they meet or exceed the functional requirements for strength, materials, and other applicable provisions of the Federal Specification.

c. Sockets shall be stronger than their ropes. If a socket should break during the test specified in Article 6.6.8, two other job sockets shall be selected at random and attached to another piece of rope, and the test repeated, and this process shall be continued until the Inspector is satisfied of socket reliability, whereupon the lot shall be accepted. However, if 10% or more of the tested sockets fail at a load less than the specified minimum ultimate strength of the rope, the entire lot of sockets shall be rejected, and new ones shall be furnished which meet specification requirements.

d. Pin and socket fits different from those specified by the Federal Specification may be specified by the Engineer.

e. Sockets shall be shop painted as specified for structural steel.

6.6.12 FACILITIES FOR TESTING (1985) R(2010)

The manufacturer shall provide proper test facilities, and shall make, at his own expense, the required tests. Tests shall be made in the presence of an inspector representing the Engineer.

6.6.13 ROPE LENGTH (1985) R(2010)

a. The Contractor shall verify the exact lengths to which the counterweight ropes shall be fabricated.

b. The fabricated length, after prestretching, of each counterweight rope bearing-to-bearing of sockets shall be determined, and stamped on a metal tag securely attached to the rope. While being measured, each rope shall be twisted to the correct lay, supported throughout its length at points not more than 25 feet apart, and tensioned 12% of its ultimate strength. Variation from the required length shall be not more than 1/4 inch in 100 feet. For ropes having bearing sockets, this permissible length variation shall be corrected in the shop by permanently fastening, by a method approved by the Engineer, the appropriate thickness of steel shims to the bearing face of one socket. No shim shall be less than 3/8 inch thick.

c. Each rope shall have a stripe painted along its entire length at the time of length measurement, to facilitate its correct alignment upon installation in the bridge.

d. Ropes shall be suitably marked or tagged for identification prior to shipment.

6.6.14 OPERATING ROPES (1985) R(2010)

Ends of non-socketed operating ropes shall be seized and shall have the end wires composing the ropes welded together. Seizing shall be removed prior to rope installation. Lengths of operating ropes shall be verified by the Contractor.

6.6.15 SHIPPING (1985) R(2010)

Ropes shall be shipped on reels, the drum diameter of which is not less than 25 times the rope diameter, unless coil shipment is specified in the order.

SECTION 6.7 POWER EQUIPMENT

6.7.1 POWER OPERATION (1984) R(2002)

If the bridge is to be operated by mechanical power, the type of power will be specified by the Company. The internal combustion engine, electric motor, or other type of power specified shall be of ample capacity to move the bridge at the required speed. Where the design is made by the Contractor, the type of prime mover and the name of the manufacturer shall be given in the proposal.

6.7.2 MANPOWER OPERATION (1984) R(2002)

a. Where the bridge or parts thereof are to be hand-operated, the required number of men and the time of operation shall be calculated on the following basis:

   (1) One man can exert continuously on a capstan lever a force of 40 lb while walking at a speed of 160 feet per min.

   (2) One man can exert continuously on a crank a force of 30 lb at a radius of 15 inches with rotation at 15 rpm.

b. For calculating the strength of the machinery parts, the design load per man applied to a lever shall be taken as 150 lb, and to a crank as 50 lb. Under these loads, the allowable stresses may be increased 50%.

6.7.3 MACHINES (1984) R(2003)

Machines of the usual manufactured types, such as internal combustion engines, electric motors, pumps, and air compressors, shall be factory-tested for the specified requirements to the satisfaction of the Engineer, and shall be guaranteed by the Contractor to fulfill operating requirements for one year.

6.7.4 INTERNAL COMBUSTION (1997) R(2002)

6.7.4.1 Engine Torque for Span Operation

a. The ratio of rated engine torque to the maximum bridge starting torque shall not be less than the found in Table 15-6-6.

Table 15-6-6. Torque Ratio

No. of Cylinders	Minimum Ratio
Less than 4	1.50
4 or more	1.33

b. The rated engine torque, as referred to above, shall be measured at the flywheel at the operating speed with all metal housings, radiator, fan, and all other power consuming accessories in place, and shall be taken as not more than 85% of the rated torque of the stripped engine.

6.7.4.2 Engines

a. These requirements apply to separately mounted engines and to engines forming part of an engine-generator set (see Article 6.7.5.12 for generators). Internal combustion engines shall be of the truck or marine type and of the most substantial kind. The engines shall operate at a speed of not more than 2200 rpm but preferably not more than 2000 rpm unless a higher speed is recommended by the manufacturer, and shall be equipped with a governor to limit the maximum speed to the designated value. Unless otherwise specified, the engine shall have not less than 4 cylinders.