SP-150217
(New)

SPECIAL PROVISIONS
FOR
POST-TENSIONING TENDONS

Scott County
IM-NHS-074-1(198)5--03-82

Effective Date
April 25, 2017

THE STANDARD SPECIFICATIONS, SERIES 2015, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE SPECIAL PROVISIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

150217.01 DESCRIPTION.

A. Furnish and install all post-tensioning system components as shown in the contract documents, and any other pertinent items necessary for the particular post-tensioning system used, including but not limited to ducts, anchorage assemblies, supplementary steel reinforcing bars and grout, to construct the post-tensioned, cross beams. Post-tensioning shall comply with the requirements of this section. Furnish all components of a post-tensioning system from a single supplier. Prestressing steel and local zone reinforcing can be obtained from any supplier.

B. Install tendons through ducts in the concrete. Stress to a predetermined load and anchor directly against the hardened concrete. Grout ducts to fill all voids and install protection at the end anchorages.

C. Furnish and install all hardware used for pressure grouting ducts and all associated operations.

D. Prepare and submit shop and working drawings and manuals to address all requirements stated in the plans and stated herein. A Professional Engineer licensed in the state of Iowa shall produce, sign, and seal all shop drawings.

150217.02 QUALIFICATIONS AND INSPECTION.

A. The post-tensioning supplier shall furnish a qualified technician (minimum of 3 years experience on previous projects involving post-tensioning of a similar type and magnitude) to the job site as an advisor in the appropriate use of the post-tensioning system. Perform all post-tensioning and grouting field operations under the direct supervision (crew foreman) of the qualified technician.

B. Conduct all stressing and grouting operations in the presence of the Engineer.

150217.03 TERMINOLOGY.

Anchorage Assembly: An assembly of various hardware components which secures high strength strands at their ends after they have been stressed and transfers a compressive force into the concrete.

Anchor Plate: That part of the anchorage that bears directly on the concrete and through which the post-tensioning force is transmitted.

Anticipated Set: Anticipated set is that set which was assumed to occur in the design calculation of the post-tensioning forces at the time of load transfer.

Duct: Material forming a conduit to accommodate post tensioning tendon installation and provide an annular space for the grout which protects the prestressing steel.

Fluidity: A measure of time, expressed in seconds necessary for a stated quantity of grout to pass through the orifice of a flow cone.

Grout: A mixture of cementitious materials and water, with or without mineral additives or admixtures, proportioned to produce a pumpable consistency without segregation of the constituents, when injected into the duct to fill the space throughout the prestressing steel, anchorages and ducts.

Grout cap: A device that contains the grout and forms a protective cover sealing the post-tensioning steel at the anchorage.

Inlet: Tubing or duct used for injection of the grout into the duct.

Outlet: Tubing or duct to allow the escape of air, water, grout and bleed water from the duct.

Post-tensioning: A method of prestressing where tensioning of the tendons occurs after the concrete has reached a specified strength.

Post-Tensioning Scheme or Layout: The pattern, size and locations of high strength post-tensioning tendons provided by the designer in the contract documents.

Post-Tensioning System: A proprietary system where the necessary hardware (anchorages, wedges, strands, couplers, etc.) is supplied by a particular manufacturer or manufacturers of post-tensioning components.

Prestressing steel: The steel element of a post-tensioning tendon, which is elongated and anchored to provide the necessary permanent prestressing force.

Pressure Rating: The estimated maximum pressure that water in a duct, or in a duct component, can exert continuously with a high degree of certainty that failure of the duct, or duct component, will not occur (commonly referred to as working pressure).

Set (also Anchor Set): Anchor Set is the total movement of a point on the strand just behind the anchor wedges during load transfer from the jack to the permanent anchorages. Set movement is the sum of slippage of the wedges with respect to the anchorage head and the elastic deformation of the anchor components.

Strand: An assembly of several high strength steel wires wound together. Strands usually have six outer wires helically wound around a single straight wire of a similar diameter.

Tendon: A single, or group of, prestressing steel elements and their anchorage assemblies imparting prestress forces to a structural member or the ground. Also included are ducts, grouting attachments, grout and corrosion protection filler materials or coatings.

Tendon Type: The relative location of the tendon to the concrete shape, internal or external.
Thixotropic: The property of a material that enables it to stiffen in a short time while at rest, but to acquire a lower viscosity when mechanically agitated. Grouts having thixotropic properties can be highly resistant to bleed. Admixtures that may produce thixotropic properties include anti-bleed admixtures and silica fume.

Wedge Plate: The hardware that holds the wedges of a multi-strand tendon and transfers the tendon force to the anchorage assembly. (This is commonly referred to as the anchor head.)

Wedge: A conically shaped device that anchors the strand in the wedge plate.

150217.04 MATERIALS.

A. Prestressing Steel Strands.
Unless otherwise noted on the plans, provide uncoated, low relaxation, 7-wire strand meeting the requirements of AASHTO M203 (ASTM A416), Grade 270. Fabricate the tendons with sufficient length beyond the anchor bearing plates to allow for stressing and anchorage device installation.

B. Post-Tensioning System.

1. Use an approved post-tensioning system, of proper size and type, to construct tendons as shown on the contract documents. Do not substitute components of the approved post-tensioning system. Use only post-tensioning systems that utilize tendons fully encapsulated in anchorages and ducts and fully filled with approved grout.

2. Systems which transfer prestress force by bonding the prestressing steel strand directly to concrete are prohibited. Strand or tendon couplers are not permitted.

C. Ducts.

1. General.
Unless specifically noted on the plans, or otherwise approved by the Engineer, use ducts for post-tensioning meeting the requirements of this Special Provision. Use all duct material complying with AASHTO and the Post Tensioning Institute (PTI) for bonded tendons. Use corrugated plastic duct in all post-tensioning systems used for all internal tendons. Do not use ducts from recycled materials.

2. Size of Ducts.
a. Provide duct for multi-strand tendons with a minimum cross-sectional area of 2 1/2 times the cross-sectional area of the prestressing steel.
b. Furnish duct with a minimum thickness as defined in the following table:

Duct Shape	Duct Diameter	Duct Thickness
Flat	Any size	0.08 inch
Round	0.9 inch	0.08 inch
Round	2.375 inches	0.08 inch
Round	3.0 inches	0.10 inch
Round	3.35 inches	0.10 inch
Round	4.0 inches	0.12 inch
Round	4.5 inches	0.14 inch
Round	5.125 inches	0.16 inch
Round	5.71 inches	0.16 inch

3. Corrugated Plastic Duct.
a. All duct material shall be sufficiently rigid to withstand loads imposed during placing of concrete and internal pressure during grouting while maintaining its shape, remaining in proper alignment and remaining watertight. Use seamless fabrication methods to manufacture ducts.

b. Plastic material used shall not react with concrete or enhance corrosion of the high strength strands and shall be free of water soluble chloride.

c. Use corrugated duct manufactured from non-colored, unfilled polypropylene meeting the requirements of ASTM D 4101 “Standard Specification for Polypropylene Plastic Injection and Extrusion Materials” with a cell classification range of PP0340B44541 to PP0340B67884. The duct shall be white in color containing antioxidant(s) with a minimum Oxidative Induction Time (OIT) according to ASTM D 895 of 20 minutes and containing a non-yellowing light stabilizer. Perform tests on samples from the finished product.

4. Duct Connections and Fittings.

a. Make all splices, joints, joints between stages, couplings and connections to anchorages with devices or methods (i.e. mechanical couplers, plastic sleeves in conjunction with shrink sleeve) producing a smooth interior alignment with no lips or kinks. Design all connections and fittings to be airtight. Duct tape is not permitted to join or repair duct connections.

b. Duct system, including duct coupling at construction joints, shall effectively prevent entrance of cement paste, or water, into the system and shall effectively contain pressurized grout during grouting of the tendon.

5. Shipping and Storage of Ducts.

Furnish duct with end caps to seal the duct interior from contamination. Ship ducts in bundles which are capped and covered during shipping and storage. Protect ducts against ultraviolet degradation, crushing, excessive bending, dirt contamination and corrosive elements during transportation, storage, and handling. Do not remove end caps supplied with the duct until the duct is incorporated into the bridge component. Store duct in a location that is dry and protected from the sun. Storage must be on a raised platform and completely covered to prevent contamination. If necessary, wash ducts before use to remove any contamination.

6. Coupling of Ducts Between Construction Joints.

a. Furnish and install heat shrink sleeves having unidirectional circumferential recovery manufactured specifically for the size of the duct being coupled consisting of an irradiated and cross linked high density polyethylene backing for external applications and linear density polyethylene for internal applications. Furnish adhesive having the same bond value to steel and polyolefin plastic materials. Ensure the heat shrink sleeves have an adhesive layer that will withstand 150 °F operating temperature and meet the requirements of the table below:

		Minimum Requirements	
Property	**Test Method**	**Internal Application**	**External Application**
Minimum Fully Recovered Thickness		92 mils	111 mils
Peel Strength	ASTM D 1000	29 pli	46 pli
Softening Point	ASTM E 28	162ºF	216ºF
Lap Shear	DIN 30 672M	87 psi	58 psi
Tensile Strength	ASTM D 638	2900 psi	3480 psi
Hardness	ASTM D 2240	46 Shore D	52 Shore D
Water Absorption	ASTM D 570	Less than 0.05%	Less than 0.05%
Color		Yellow	Black

b. Install heat shrink sleeves using procedures and methods in accordance with manufacturer’s recommendations.

c. The Contractor may submit, for approval by the Engineer, alternate methods for coupling of ducts between construction joints.

D. Inlets, Outlets, Valves and Plugs.

1. Use inlets for injecting grout into the duct. Use outlets to allow the escape of air, water, bleed water and grout. Provide permanent grout inlets, outlets, and threaded plugs made of ASTM A240 Type 316 stainless steel, nylon or polyolefin materials. For products made from nylon, the cell class of the nylon according to ASTM D5989 shall be S-PA0141 (weather resistant), S-PA0231 or S-PA0401 (ultimate strength not less than 10,000 psi with UV stabilizer added). Products made from polyolefin shall contain antioxidant(s) with a minimum Oxidation Induction Time (OIT) according to ASTM D3895 of not less than 20 minutes. Perform OIT test on samples taken from the finished product. Test the remolded finished polyolefin material for stress crack resistance using ASTM F2136 at an applied stress of 348 psi resulting in a minimum failure time of 3 hours. Neither metallic nor plastic components, if selected and approved, shall react with the concrete or enhance corrosion of the post-tensioning steel. Use plastic components free of water soluble chlorides.

2. All inlets and outlets will be equipped with pressure rated mechanical shut-off valves or plugs. Inlets, outlets, valves and plugs will be rated for a minimum pressure rating of 150 psi. Use inlets and outlets with a minimum inside diameter of 3/4 inch.

E. Grout.

1. Description.
Grouts shall be prepackaged in moisture proof containers. Grout bags shall indicate date of manufacture, LOT number and mixing instructions. Any change of materials or material sources requires retesting and certification of the conformance of the grout with this Special Provision. A copy of the Quality Control Data Sheet for each lot number and shipment sent to the job site shall be provided to the Contractor by the grout supplier and furnished to the Engineer. Materials with a total time from manufacture to usage in excess of 6 months shall be tested and certified by the supplier that the product meets the QC Control Specifications before use or the material shall be removed and replaced.

2. Product Approval.
Post-tensioning grout components sources will need written approval for use and shall be materials which conform to this Special Provision and the requirements prescribed in Section 2407 of the Standard Specifications, for the particular kind and type of material specified. Manufacturers of post-tensioning grout seeking evaluation of their product shall submit an application in accordance with Materials I.M. 409 and include certified test reports from an audited and independent Cement Concrete Research Laboratory (CCRL) which shows the material meets all the requirements specified herein. Compliance with the requirements stated in the Accelerated Corrosion Test Method (ACTM) may be by written manufacturer’s certification.

3. Mixing.
The material shall be mixed in accordance with the manufacturer's recommendations.

4. Grout Properties.

a. Gas Generation.
The grout shall not contain aluminum or components, which produce hydrogen, carbon dioxide or oxygen gas.

b. Laboratory Test.
The grout shall meet or exceed the specified physical properties stated herein as determined by the following standard and modified ASTM test methods. Conduct all grout

tests with grout mixed to produce the minimum time of efflux. Establish the water content to produce the minimum and maximum time of efflux.

Property	Test Value	Test Method
Total Chloride Ions	Max. 0.08% by weight of cementitious material	ASTM C1152
Fine Aggregate (if utilized)	99% passing the No. 50 Sieve	ASTM C136*
Hardened Height Change @ 24 hours and 28 days.	0.0% to + 0.2%	ASTM C1090**
Expansion	≤2.0%for up to 3 hours	ASTM C940
Wet Density – Laboratory	Report max. and min obtained test value, lb/ft^3	ASTM C185
Wet Density – Field	Report max. and min obtained test value, lb/ft^3	ASTM C138
Compressive Strength 28 day (Average of three cubes)	≥7000 psi	ASTM C942
Initial Set of Grout	Min. 3 hours Max 12 hours	ASTM C953
Time of Efflux*** (a) immediately after mixing	Min. 20 sec. Max. 30 sec. or Min. 9 sec. Max. 20 sec.	ASTM C939 ASTM C939****
Time of Efflux*** (b) 30 minutes after mixing with remixing for 30 seconds	Max. 30 sec. or Max. 30 sec.	ASTM C939 ASTM C939****
Bleeding @ 3 Hours	Max 0.0%	ASTM C940*****
Permeability @ 28 days	Max. 2500 coulombs at 30 V for 6 hours	ASTM C1202

- * Use ASTM C 117 procedure modified to use a No. 50 sieve. Determine the percent passing the No. 50 sieve after washing the sieve.
- ** Modify ASTM C1090 to include verification at both 24 hours and 28 days.
- *** Adjustments to flow rates will be achieved by strict compliance with the manufacturer’s recommendations. The time of efflux is the time to fill a one liter container placed directly under the flow cone.
- **** Modify the ASTM C 939 test by filling the cone to the top instead of to the standard level.
- ***** Modify ASTM C 940 to conform with the wick induced bleed test as follows:
  - (a) Use a wick made of a 20 inch length of ASTM A416 seven wire 0.5 inch diameter strand. Wrap the strand with 2 inch wide duct or electrical tape at each end prior to cutting to avoid splaying of the wires when it is cut. Degrease (with acetone or hexane solvent) and wire brush to remove any surface rust on the strand before temperature conditioning.
  - (b) Condition the dry ingredients, mixing water, prestressing strand and test apparatus overnight at 65°F to 75°F.
  - (c) Mix the conditioned dry ingredients with the conditioned mixing water and place 800 ml of the resulting grout into the 1000 ml graduated cylinder. Measure and record the level of the top of the grout.
  - (d) Completely insert the strand into the graduated cylinder. Center and fasten the strand so it remains essentially parallel to the vertical axis of the cylinder. Measure and record the level of the top of the grout.
  - (e) Store the mixed grout at the temperature range listed above in (b).
  - (f) Measure the level of the bleed water every 15 minutes for the first hour and hourly for two successive readings thereafter.
  - (g) Calculate the bleed water, if any, at the end of the 3 hour test period and the resulting expansion per the procedures outlined in ASTM C940, with the quantity of bleed water expressed as a percent of the initial grout volume. Note if the bleed water remains above or below the top of the original grout height. Note if any bleed water is absorbed into the specimen during the test.

5. Accelerated Corrosion Test Method.

a. Perform the ACTM as outlined in Appendix B of the “Specification for Grouting of Post-Tensioned Structures” published by the Post-Tensioning Institute. Report the time to corrosion for both the grout being tested and the control sample using a 0.45 water-cement ratio neat grout.

b. A grout that shows a longer average time to corrosion in the ACTM than the control sample, and the time to corrosion exceeds 1000 hours, is considered satisfactory.

F. Post- Tensioning Anchorage.

1. All prestressing steel shall be secured at the ends by means of permanent type anchoring devices. Dead end anchorages shall not be used. Two-part wedges will not be approved for anchoring prestressing strands. The manufacturer of the post-tensioning system shall supply the special reinforcement, such as spirals or grids, for the tendons. Such reinforcement is required in the concrete end zones of anchors. The design of the end anchorages and the end-zone reinforcing is the sole responsibility of the post-tensioning system manufacturer.

2. Ensure that the anchorages develop at least 95% of the actual ultimate tensile strength of the prestressing steel, when tested in an unbonded state, without exceeding the anticipated set.

3. Design anchorages so that the average concrete bearing stress is in compliance with the AASHTO LRFD Bridge Design Specifications. Test anchorages with the typical local zone reinforcement shown in the system drawings. Provide written certification that anchorages meet or exceed the testing requirements in the AASHTO LRFD Bridge Construction Specifications.

4. The anchorages shall be cast with grout outlets suitable for inspection from either the top or front of the anchorage. The grout outlet will serve a dual function of grout outlet and post-grouting inspection access. The geometry of the grout outlets must facilitate being drilled using a 3/8 inch diameter straight bit to facilitate endoscope inspection directly behind the anchor plate.

5. Galvanize the embedded body of the anchorage in accordance with ASTM 123. Other components of the anchorage including wedges, wedge plate and local zone reinforcement are not required to be galvanized. The local zone reinforcement shall be epoxy coated. Construct the bearing surface and wedge plate from ferrous metal. Equip all anchorages with a permanent grout cap that is vented and bolted to the anchorage.

6. Anchorages may be fabricated to facilitate both inspection locations or may be two separate anchorages of the same type each providing singular inspection entry locations.

7. Testing of post-tensioning anchorage devices shall be performed using samples of the type of prestressing steel to be used on the project. The test specimen shall be assembled in an unbonded state, and, in testing, the anticipated set shall not be exceeded.

8. Trumpets associated with anchorages will be made of either ferrous metal or polypropylene plastic material conforming to the requirements stated in Article 150217.04, C, 3. The thickness of the trumpet at the transition location (choke point) will not be less than the thickness of the duct. Alternately, trumpet materials shall be a polyethylene or polyolefin containing antioxidant(s) with a minimum Oxidation Induction Time (OIT) according to ASTM D 3895 of not less than 20 minutes. Test the remolded finished polyolefin material for stress crack resistance using ASTM F 2136 at an applied stress of 348 psi resulting in a minimum failure time of 3 hours.

G. End Anchorage Permanent Grout Cap.

Use permanent grout caps made from fiber reinforced polymer or ASTM A240 Type 316L stainless steel. The resins used in the fiber reinforced polymer shall be nylon, Acrylonitrite Butadiene Styrene (ABS) or polyester. For products made from nylon, the cell class of the nylon according to ASTM D5989 shall be S-PA0141 (weather resistant), S-PA0231 or S-PA0401 (ultimate strength not less than 10,000 psi with UV stabilizer added). Seal the cap with O-ring seals or precision fitted flat gaskets placed against the bearing plate. Place a grout vent on the top of the cap. Grout caps must be rated for a minimum pressure rating of 150 psi. Use ASTM A240 Type 316L stainless steel bolts to attach the cap to the anchorage. When stainless steel grout caps are supplied, provide certified test reports documenting the chemical analysis of the steel.

H. Testing Requirements.

1. General.

- **a.** Testing shall conform to the applicable ASTM Specifications for the post-tensioning material used.
- **b.** Furnish all material samples for testing at no cost to the Contracting Authority.
- **c.** Consider the job site, or site, referred to herein as the location where the post-tensioning steel is to be installed.

2. Pre-Stressing Steel.

- **a.** Furnish samples for testing as described below for each manufacturer of prestressing steel to be used on the project.
- **b.** With each sample of prestressing strand furnished for testing submit a certification stating the manufacturer's minimum guaranteed ultimate tensile strength of the sample furnished.
- **c.** The Engineer will obtain three randomly selected samples, 5 feet long, per manufacturer, per size of strand, per shipment, with a minimum of one sample of every ten reels delivered, at the plant or jobsite, from the prestressing steel used for post-tensioning operations:
- **d.** One of each of the samples furnished to represent a lot will be tested. The remaining sample(s), properly identified and tagged, will be stored by the Engineer for future testing in the event of loss or failure of the component represented to meet minimum strength requirements. For acceptance of the lot represented, test results must show that 100% of the guaranteed ultimate tensile strength has been met.

3. Lots and Identification.

A lot is that parcel of components as described herein. All strands from each manufacturer reel to be shipped to the site shall be assigned an individual lot number and shall be tagged in such a manner that each such lot can be accurately identified at the job site. Submit records to the Engineer identifying assigned lot numbers with the heat, coil or reel of material represented. All unidentified pre-stressing steel, anchorage assemblies or bar couplers received at the site will be rejected. Also, loss of positive identification of these items at any time will be cause for rejection.

4. Approval of Materials.

The approval of any material by the Engineer shall not preclude subsequent rejection if the material is damaged in transit or later damaged or found to be defective.

5. In Place Friction Test.

- **a.** Test in place a minimum of one tendon in tendon group performing the same function. The selected tendon will represent the size and length of the group of tendons being tested.
- **b.** The test procedure consists of stressing the tendon at an anchor assembly with a load cell or a second certified jack at the dead end. Stress the test specimen to 80% of ultimate tendon strength in eight equal increments. For each increment, record the gauge pressure, elongations and load cell force. Take into account any wedge seating in both the live end (i.e., back of jack) and the dead end (i.e., back of load cell) and any friction within the anchorages, wedge plates and jack as a result of slight deviations of the strands through these assemblies. For long tendons requiring multiple jack pulls with intermediate temporary anchoring, keep an accurate account of the elongation at the jacking end allowing for intermediate wedge seating and slip of the jack's wedges.

- **c.** If the elongation's fall outside the +/- 5% range compared to the anticipated elongations, investigate the reason and make detailed calculations confirming the final tendon forces are in agreement with the requirements of the approved contract documents.
- **d.** In reconciling theoretical and actual elongations, do not vary the value of the expected friction and wobble coefficients by more than +/- 10%. Significant shortfall in elongations is indicative of poor duct alignments and/or obstructions. Correct or compensate for such elongations in a manner proposed by the Contractor and reviewed, and approved, by the Engineer at no additional cost to the Contracting Authority.
- **e.** The Engineer will require one successful friction test for a westbound cross beam and one successful test for an eastbound cross beam.
- **f.** If there are irreconcilable differences between forces and elongations, or other difficulties during the course of routine stressing operations, the Engineer may require additional in place friction tests.
- **g.** The apparatus and methods used to perform the test must be submitted to the Engineer for approval. Tests must be conducted in the Engineer's presence.

150217.05 CONSTRUCTION.

A. Protection of Prestressing Steel and Hardware.

1. All prestressing steel shall be protected against physical damage or rust at all times (from time of manufacturer to grouting or encasing in concrete). Prestressing steel that has sustained physical damage at any time shall be rejected. Prestressing hardware shall be protected from rust and corrosion at all times (from time of manufacturer until completion of the project).

2. Prestressing steel shall be packaged in containers or shipping forms for protection of the steel against physical damage and corrosion during shipping and storage. A corrosion inhibitor, which prevents rust or other results of corrosion, shall be placed in the package or form, or shall be incorporated in a corrosion inhibitor carrier type packaging material. A corrosion inhibitor shall not be applied directly to the steel. The corrosion inhibitor shall have no deleterious effect on the steel or concrete or bond strength of steel to concrete. Inhibitor carrier type packaging material shall conform to the provisions of Federal Specification MIL-P-3420. Packaging or forms damaged from any cause shall be immediately replaced or restored to original condition.

3. The shipping package or form shall be clearly marked with the heat number and with a statement that the package contains high-strength prestressing steel and care is to be used in handling. The type and amount of corrosion inhibitor used, the date when placed, safety orders and instructions for use shall also be marked on the package or form.

4. Prestressing steel shall be stored and handled in a manner which will protect it from physical damage or contamination at all times from manufacture until grouted in place. Prestressing steel shall not be dragged on abrasive surfaces during fabrication and installation. Damaged, abraded, or contaminated prestressing steel shall be rejected.

5. The prestressing steel shall be stored in a manner which will at all times prevent the packaging material from becoming saturated with water and allow a free flow of air around the packages. If the useful life of the corrosion inhibitor in the package expires, it shall immediately be rejuvenated or replaced.

6. At the time the prestressing steel is installed in the work, it shall be free from rust, loose mill scale, dirt, paint, oil, grease or other deleterious material. Removal of tightly adhering mill scale will not be required. Prestressing steel which has experienced rusting to the extent that all evidence of it cannot be removed by wiping with a clean rag shall be subject to rejection.

7. The Contractor shall install, stress, and grout the tendons in less than a seven consecutive calendar day time period. If the time period between installation and stressing of the prestressing steel and grouting of the tendon will exceed seven consecutive calendar days, the prestressing steel shall be completely removed from the duct and inspected for corrosion by the Engineer. If corrosion other than light surface rust (which can be completely removed by rubbing) is found, the existing pulled strand will be replaced with new strand.

8. Within 4 hours after stressing, install grout caps and seal all other tendon openings. If acceptance of the tendon is delayed, seal all tendon openings and temporally weatherproof the open ends of the anchorage. If tendon contamination occurs, remove and replace the tendon.

9. Flushing of grout is not permitted and vacuum grouting is required to repair all voids and blockages.

B. Shop Drawings and Calculations.

1. General.
The Contractor shall submit detailed shop drawings, calculations, and manuals for all work related to post-tensioning. The shop drawings must be sealed by a Professional Engineer licensed in the state of Iowa. The shop drawings must be approved by the engineer before beginning fabrication.

2. Submittal.
The shop drawing submittal shall include, but not necessarily be limited to, the following:

a. A post-tensioning system that meets the requirements of the contract documents;
b. The sequence of the post-tensioning operation;
c. Appropriate details of changes from the dimensions shown on the plans where variations are made to details shown on the plans, including any special reinforcing required but not shown on the plans, with clear and concise cross reference to the appropriate plans to which the variations apply;
d. Details of, and supporting calculations for, any modifications to reinforcement at anchorages, made necessary for accommodating the elected post-tensioning system hardware;
e. A procedure for casting and geometry control of the post-tension tendons in accordance with the information provided in the contract documents;
f. Distance from the bottom of the slab to the bottom of the duct;
g. Duct support detail and spacing and the sequence of operations for securing the tendons;
h. The location of grout ports and grout vents;
i. A table detailing the post-tensioning jacking sequence, jacking forces, and elongation of each tendon, including stressing end seating losses at each stage of erection for all post-tensioning;
j. Elongation calculations and tolerances;
k. Properties of each of the components of the post-tensioning.
l. Equipment to be used in the post-tensioning operation.
m. Details covering the assembly of the post-tensioning tendons.
n. Designation of the specific post-tensioning steel, anchorage devices, duct material, duct size, grout injection and outlet vents, connection details such as duct coupler, anchorage to duct and grout ports, and vents to ducts, and accessory items to be used;
o. Details of special reinforcement at anchorage ”local-zones”;
p. Permanent grout cap details, concrete recess, pour backs and temporary protection;
q. Parameters to be used to calculate the typical tendon force, such as expected friction coefficients, anchor set, and post-tensioning steel relaxation curves.
r. The sequence of the stressing of the post-tensioning strands. The sequence shall be such that the stresses are uniform across the cross section throughout the post-tensioning operation.
s. All material specifications (e.g. strands, ducts and grout) and equipment data;

- **t.** Grouting operation and equipment data including the materials and proportions for grout, and details of equipment and methods for mixing and placing grout;
- **u.** Calculations to substantiate the post-tensioning system and procedures to be used. These calculations shall show a typical tendon force after applying the expected friction coefficient and anticipated losses for the stressing system to be used, including seating losses
- **v.** If duct sizes different from the sizes shown in the contract documents are approved, modify the spacer frame details shown in the contract documents; and
- **w.** Safety procedures;

3. Submittal Procedures.
All submittals by the Contractor shall be submitted sufficiently in advance of the start of construction to allow a 30 calendar day review period. All submittals not approved and requiring resubmittal shall be subject to the above review time period, with the review time beginning anew for each such submittal. The Contractor shall coordinate all submittals between his various subordinates (contractors, suppliers, and engineers) to allow for a reasonable distribution of the review effort required by the Engineer at any given time. Final approval shall be received before any fabrication begins. Manufacturer's literature shall be supplied where applicable. All shop drawings are to accurately detail the actual methods, materials, equipment, etc., that the Contractor will be using in the field on the project. Deviation is not permitted unless approved by the Engineer.

C. Fabrication.

1. General.
Accurately and securely fasten all post-tensioning anchorages, ducts, inlet and outlet pipes, miscellaneous hardware, reinforcing bars, and other embedments at the locations shown on the plans or on the approved shop or working drawings or as otherwise approved by the Engineer. Construct tendons using the minimum number of duct splices possible.

2. Ducts.
- **a.** Accurately align ducts and position at the locations shown on the plans or according to the approved Shop or Working Drawings or as otherwise approved by the Engineer. Securely fasten all internal ducts in position at regular intervals not exceeding 24 inches to prevent movement, displacement or damage from concrete placement and consolidation operations. Show the method and spacing of duct supports on appropriate shop drawings.
- **b.** Ensure that all alignments, including curves and straight portions, are smooth and continuous with no lips, kinks or dents.
- **c.** Carefully check and repair all ducts as necessary before placing any concrete.
- **d.** After installing the ducts and until grouting is complete, ensure that all ends of ducts, connections to anchorages, splices, inlets and outlets are sealed at all times. Provide an absolute seal of anchorage and duct termination locations by using plumber's plugs or equal. Grout inlets and outlets shall be installed with plugs or valves in the closed position. Leave low point outlets open. The use of duct tape is not permitted.

3. Splices and Joints.
All splices, joints, couplings, connections (inlet and outlet) and valves shall be part of the approved post-tensioning system. Approved shrink-sleeve material may be used to repair duct. The use of any tape to repair or seal duct is not permitted.

4. Location of Grout Inlets and Outlets.
- **a.** Place grout inlets and outlets at locations as shown on the plans and shop drawings. Equip all grout inlets and outlets with positive shut-off devices. At a minimum, grout inlets and outlets shall be placed in the following positions:
  - **1)** Top of the tendon anchorage;
  - **2)** Top of the grout cap;

3) At the high points of the duct when the vertical distance between the highest and lowest point is more than 20 inches;
4) At a location 3 feet past high points of the duct on the downstream side opposite the direction of grouting;
5) At all low points;
6) At major changes in the cross section of the duct;
7) At other locations required by the Engineer.

b. Extend grout tubes a sufficient distance out of the concrete member to allow for proper closing of the valves.

5. Tolerances.

a. Ensure that tendons are not out of position by more than +/- 1/4 inch in any direction.
b. Ensure entrance and exit angles of tendon paths at anchorages and/or at faces of concrete are within +/- 3 degrees of desired angle measured in any direction and any deviations in the alignment are accomplished with smooth transitions without any kinks.
c. Angle changes at duct joints must not be greater than +/- 3 degrees in any direction and must be accomplished with smooth transitions without any kinks.
d. Locate anchorages within +/- 1/4 inch of desired position laterally and +/- 1 inch along the tendon except that minimum cover requirements must be maintained.
e. Position anchorage confinement reinforcement in the form of spirals, multiple U shaped bars or links, to be properly centered around the duct and to start within 1/2 inch of the back of the main anchor plate.
f. If conflicts exist between the reinforcement and post-tensioning duct, the position of the post-tensioning duct shall prevail and the reinforcement shall be adjusted locally with the Engineer's approval.

6. Internal Duct Pressure Test.

Pressure test each different type and size of duct assembly at the site of casting before its first time use on the project. Pressure test all assemblies constructed on the project. Test the assemblies in their final position just prior to concrete placement by sealing them at their anchorage or construction joint termini and then by applying compressed air to determine if the assembly connections are pressure tight. In the presence of the Engineer, pressurize the duct to 1.5 psi and lock-off the outside air source. Then record the pressure loss for a duration of one minute. If the pressure loss exceeds 0.15 psi, find and repair the leaks in the duct assembly using repair methods approved by the Engineer and retest.

D. Placing Concrete.

1. Precautions.

Exercise great care when placing and consolidating concrete so as not to displace or damage any of the post-tensioning ducts, anchorage assemblies, splices and connections, reinforcement or other embedment.

2. Proving of Post-Tensioning Ducts.

Upon completion of concrete placement, prove that the post-tensioning ducts are free and clear of any obstructions, or damage, and are able to accept the intended post-tensioning tendons by passing a torpedo through the ducts. Use a torpedo having the same cross-sectional shape as the duct and that is a 1/4 inch smaller all around than the clear, nominal inside dimensions of the duct. Make no deductions to the torpedo section dimensions for tolerances allowed in the manufacture or fixing of the ducts. For curved ducts, determine the length so that when both ends touch the outermost wall of the duct, the torpedo is 1/4 inch clear of the innermost wall. If the torpedo will not travel completely through the duct, the Engineer will reject the member, unless a workable repair can be made to clear the duct. The torpedo must pass through the duct easily, by hand, without resorting to excessive effort or mechanical assistance.

3. Problems and Remedies.
The Engineer will reject ducts or any part of the work found to be deficient. Perform no remedial or repair work without the Engineer's approval.

E. Installing Tendons.

1. Push or pull post-tensioning strands through the ducts to make up a tendon using methods which will not snag on any lips or joints in the ducts. Strands which are pushed should be rounded off at the end of the strand or fitted with a smooth protective cap. During the installation of the post-tensioning strand into the duct, the strand shall not be intentionally rotated by any mechanical device.

2. Alternatively, strands may be assembled to form the tendon and pulled through the duct using a special steel wire sock ("Chinese finger") or other device attached to the end. The ends of the strands may not be welded together for this purpose. The end of the preassembled tendon shall be rounded for smooth passage through the duct. Cut strands using an abrasive saw or equal. Flame cutting is not allowed.

3. Do not install permanent tendons before the completion of testing as required by these specifications or plans. As a sole exception, the tendon to be tested in the "In Place Friction Test" may be installed for the test.

F. Post-Tensioning Operations.

1. General.
Do not apply post-tensioning forces until the concrete has attained the specified compressive strength as determined by cylinder tests. Conduct all stressing operations in the presence of the Engineer.

2. Stressing tendons.
Tension all strands with hydraulic jacks so that the post-tensioning force is not less than that required by the contract documents and the approved shop drawings. Do not utilize monostrand jacks to stress tendons.

a. Maximum Stress at Jacking.
The maximum temporary stress (jacking stress) in the post-tensioning strands shall not exceed 80% of its specified minimum ultimate tensile strength. Do not overstress tendons to achieve the expected elongation.

b. Initial and Permanent Stresses.

1) The post-tensioning strands shall be anchored at initial stresses that will result in the long term retention of permanent stresses or forces of no less than those shown on the contract documents, and on the approved shop drawings. The initial stress at the anchorages after anchor set shall not exceed 70% of the specified ultimate tensile strength of the post-tensioning strands.

2) Permanent stress and permanent force are the stress and force remaining in the post-tensioning strands after all losses, including long term creep and shrinkage of concrete, elastic shortening of concrete, relaxation of steel, losses in the post-tensioning strands from the sequence of stressing, friction and unintentional wobble of the strands, anchor set, friction in the anchorages and all other losses peculiar to the post-tensioning system.

3) Tendons shall be tensioned by jacking at each end of the tendon. The required force may be applied at one end and subsequently at the other end or simultaneously at both ends.

3. Stressing Equipment.
Only use equipment furnished by the manufacturer of the post-tensioning system (strands, hardware, anchorages, etc.).

a. Stressing Jacks and Gauges.
Each jack shall be equipped with a pressure gauge for determining the jacking pressure. The pressure gauge shall have an accurately reading dial at least 6 inch in diameter.

b. Calibration of Jacks and Gauges.

1) Within 30 days of use, each jack and its gauge shall be calibrated as a unit with the cylinder extension in the approximate position it will be in at the final jacking force. Calibration shall be done when the jack is connected to the equipment (pumps and gauges) in the identical configuration as will be used on the job site, e.g. with the same length hydraulic lines. Initial calibration of the jacks and gauges shall be performed by an independent laboratory using a proven load cell. For each jack and gauge unit used on the project, furnish certified calibration charts from the independent laboratory prior to stressing the first tendon. The jack and its gauge shall be used together in the field.

2) Certified calibration shall be made at the start of the work, or as requested by the Engineer. Calibrations subsequent to the initial calibration with a load cell may be accomplished by the use of a master gauge. Supply the master gauge to the Engineer in a protective waterproof container capable of protecting the calibration of the master gauge during shipment to a laboratory. Provide a quick-attach coupler next to the permanent gauge in the hydraulic lines to enable quick and easy installation of the master gauge to verify the permanent gauge readings. The master gauge will be calibrated by, and remain in the possession of, the Engineer for the duration of the project.

3) Any jack repair, such as replacing seals or changing the length of the hydraulic lines, is cause for recalibration using a load cell.

4) No extra compensation will be allowed for the initial or subsequent calibrations or for the use and required calibrations of the master gauge.

4. Elongations and Agreement with Forces.

a. Ensure that the forces being applied to the tendon and the elongation of the post-tensioning tendon can be measured at all times.

b. All tendons shall be tensioned to a preliminary force as necessary to eliminate any take-up in the tensioning system before elongation readings are started. This preliminary force shall be between 5% and 25% of the final jacking force. The initial force shall be measured by a dynamometer, or by another approved method, so that its amount can be used as a check against elongation as computed and as measured. Each strand shall be marked prior to final stressing to permit measurement of elongation and to ensure that all anchor wedges set properly.

c. Elongations shall be measured to the nearest 1/16 inch.

d. For the required strand force, the observed elongation shall agree within 7% of the theoretical elongation or the entire operation shall be checked and the source of error determined and remedied to the satisfaction of the Engineer before proceeding further. Do not overstress the tendon to achieve the theoretical elongation.

5. Friction.

a. The plans were prepared based on assumed friction coefficient, wobble and anchor set as shown on the plans. The post-tensioning forces shown are for jacking forces. Submit calculations and show a typical strand force diagram, after friction and anchor set losses, on the shop drawings, based upon the expected actual coefficients and values for the post-tensioning system to be used. Show these coefficients and values on the shop drawings.

b. If, in the opinion of the Engineer, the actual friction significantly varies from the expected friction, revise post-tensioning operations so the final tendon force is in agreement with the plans.

6. Wire Failures in Post-Tensioning Tendons.

a. Multi-strand post-tensioning tendons, having wires which fail, by breaking or slippage during stressing, may be accepted provided the following conditions are met:

1) The completed structure must have a final post-tensioning force of at least 98% of the design total post-tensioning force.
2) Any single tendon must have no more than a 5% reduction in cross-sectional area of post-tensioning steel due to wire failure.

b. Either of the above conditions may be waived with approval of the Engineer, when conditions permit the Contractor to propose acceptable alternative means of restoring the post-tensioning force lost due to wire failure.

7. Cutting of Post-Tensioning Strands.
Cut post-tensioning strands by an abrasive saw within 3/4 inch to 1 1/2 inch away from the plan location. Flame cutting of post-tensioning strands shall not be used.

8. Record of Stressing Operations.

a. Keep a record of the following post-tensioning operations for each tendon installed:

1) Project name, Financial Project ID;
2) Contractor and/or subcontractor;
3) Tendon location, size and type;
4) Date tendon was first installed in ducts;
5) Reel number for strands and heat number for bars;
6) Tendon cross-sectional area;
7) Modulus of elasticity;
8) Date Stressed;
9) Jack and Gauge numbers per end of tendon;
10) Required jacking force;
11) Gauge pressures;
12) Elongations (theoretical and actual);
13) Anchor sets (anticipated and actual);
14) Stressing sequence (i.e. tendons to be stressed before and after;
15) Stressing mode (one end/ two ends/ simultaneous);
16) Witnesses to stressing operation (Contractor and inspector);
17) Date grouted

b. Record any other relevant information. Provide the Engineer with a complete copy of all stressing and grouting operations.

9. Duct Pressure Field Test.
After stressing and before grouting, install all grout caps, inlets and outlets and test the tendon with compressed air to determine if duct connections require repair. In the presence of the Engineer, pressurize the tendon to 50 psi and lock-off the outside air source. Record the pressure loss for one minute. A pressure loss of 15 psi is acceptable. If the pressure loss exceeds the allowable, repair leaking connections using methods approved by the Engineer and retest.

10. Tendon Protection.
Within 4 hours after stressing, install grout caps and seal all other tendon openings. If acceptance of the tendon is delayed, seal all tendon openings and temporally weatherproof the open ends of the anchorage. If tendon contamination occurs, remove and replace the tendon.

G. Grouting Operations.

1. General.

a. When stressing has been completed, and the stressed tendons have been accepted by the Engineer, grout the annular space between the strands and the duct.

b. All grouting operations shall be carried out under the direct supervision of a grouting supervisor. The grouting supervisor shall be an ASBI certified grout technician with at least 3 years of experience on previous projects involving grouting of a similar type and magnitude. The grouting supervisor must have experience on at least four previous, and satisfactorily completed, projects. This person shall be named and shall furnish proof of experience. All grouting operations shall by performed by personnel who have received instructional training and are under the immediate control of a grouting supervisor. Approval of the grouting operation plan by the Engineer is required before any grouting of the permanent structure takes place.

2. Grouting Operations Plan.

a. The Contractor shall submit a grouting operation plan for approval at least 45 days in advance of any scheduled grouting operations. Written approval of the grouting operation plan by the Engineer is required before any grouting of the permanent structure takes place.

b. At a minimum, provide the following items in the grouting operation plan:

1) Names, training, and experience records for the grouting crew and the Supervisor in conformance with this Special Provision;
2) Type, quantity, and brand of materials used in grouting including all certifications required;
3) Type of equipment furnished, including capacity in relation to demand and working condition, as well as back-up equipment and spare parts;
4) General grouting procedure;
5) Duct pressure test and repair procedure;
6) Method to be used to control the rate of flow within the ducts;
7) Theoretical grout volume calculations per tendon;
8) Mixing and pumping procedures;
9) Direction of grouting.
10) Sequence of use of the inlets and outlet pipes;
11) Procedures for handling blockages;
12) Procedures for post grouting repair, including repair of any grout voids detected
13) Method(s) for sealing and protecting ducts at all connections, vents, splices, etc.
14) Types and locations of inlet and outlet pipes;
15) Duct cleaning methods prior to grouting;
16) Method(s) to inspect behind anchorages;
17) Samples of Contractor QC forms that are to be signed daily by the grouting Supervisor;

c. Before grouting operations begin a joint meeting of the Contractor, grouting crew, grout manufacturer's field representative and the Engineer will be conducted to discuss the grouting operation plan, required testing, corrective procedures and any other issues requested by the Engineer.

d. The time between the first installation of the prestressing steel in the duct and the completion of the stressing and grouting operations will not exceed 7 calendar days.

e. Any light surface corrosion that can be removed by wiping with a clean rag formed during this period of time will not be a cause for rejection of the prestressing steel.

3. Grout Inlet and Outlets.

Ensure the connections from the grout pump hose to inlets are free of dirt and are air- tight. Inspect valves to be sure that they can be opened and closed properly.

4. Supplies.

Before grouting operations start, provide an adequate supply of water and compressed air for clearing and testing the ducts, mixing and pumping the grout. Where water is not supplied through the public water supply system, a water storage tank of sufficient capacity must be provided.

5. Equipment.

a. General.

1) Provide grouting equipment consisting of measuring devices for water, a highspeed shear colloidal mixer, a storage hopper (holding reservoir) and a pump with all the necessary connecting hoses, valves, and pressure gauge. Provide pumping equipment with sufficient capacity to ensure that the post-tensioning ducts to be grouted can be filled and vented without interruption at the required rate of injection in not more than 30 minutes.

2) Provide an air compressor and hoses with sufficient output to perform the required functions.

3) Provide vacuum grouting equipment (volumetric measuring type) and experienced operators within 48 hours notice.

b. Mixer, Storage Hopper.

1) Provide a high speed shear colloidal mixer capable of continuous mechanical mixing producing a homogeneous and stable grout free of lumps and undispersed cement. The colloidal grout machinery will have a charging tank for blending and a holding tank. The blending tank must be equipped with a high shear colloidal mixer. The holding tank must be kept agitated and at least partially full at all times during the pumping operation to prevent air from being drawn into the post-tensioning duct.

2) Add water during the initial mixing by use of a flow meter or calibrated water reservoir with a measuring accuracy equal to 1 percent of the total water volume.

c. Grout Pumping Equipment.

1) Provide pumping equipment capable of continuous operation which will include a system for circulating the grout when actual grouting is not in progress.

2) The equipment will be capable of maintaining pressure on completely grouted ducts and will be fitted with a valve that can be closed off without loss of pressure in the duct.

3) Grout pumps will be positive displacement type, will provide a continuous flow of grout and will be able to maintain a discharge pressure of at least 145 psi.

4) Pumps will be constructed to have seals adequate to prevent oil, air or other foreign substances entering the grout and to prevent loss of grout or water. The capacity will be such that an optimal rate of grouting can be achieved.

5) A pressure gauge having a full scale reading of no more than 300 psi will be placed at the duct inlet. If long hoses (in excess of 100 feet) are used, place two gauges, one at the pump and one at the inlet.

6) The diameter and rated pressure capacity of the grout hoses must be compatible with the pump output.

d. Vacuum Grouting Equipment.

1) Volumeter for the measurement of void volume.

2) Vacuum pump with a minimum capacity of 10 cubic feet per minute and equipped with flow-meter capable of measuring amount of grout being injected.

3) Manual colloidal mixers and/or dissolvers (manual high speed shear mixers), for voids less than 5.28 gallons in volume.

4) Standard colloidal mixers, for voids 5.28 gallons and greater in volume.

e. Stand-by Equipment.

1) During grouting operations, provide a stand-by colloidal grout mixer and pump.

2) Under normal conditions, the grout equipment must be capable of continuously grouting the longest tendon on the project in not more than 20 minutes.

6. Grouting.

a. General.

1) Perform test to confirm the accuracy of the volume-measuring component of the vacuum grouting equipment each day when in use before performing any grouting operations. Use either water or grout for testing using standard testing devices with volumes of 0.5 gallons and 6.5 gallons and an accuracy of equal to or less than 4 ounces. Perform one test with each device. The results must verify the accuracy of the void volume-measuring component of the vacuum grouting equipment within 1% of the test device volume and must verify the accuracy of the grout volume component of the vacuum grouting equipment within 5% of the test device volume. Ensure the Engineer is present when any tests are performed.

2) Grout tendons in accordance with the procedures set forth in the approved grouting operation plan. Grout all empty ducts.

b. Temperature Considerations.
Maximum grout temperature must not exceed 90°F at the grout inlet. Use chilled water and/or pre-cooling of the bagged material to maintain mixed grout temperature below the maximum allowed temperature. Grouting operations are prohibited when the ambient temperature is below 40°F or is 40°F and falling. Postpone grouting operations if freezing temperatures are forecasted within the next 2 days and it is expected the concrete temperature surrounding the duct will fall below 40°F.

c. Mixing and Pumping.
Mix the grout with a metered amount of water. The materials will be mixed to produce a homogeneous grout. Continuously agitate the grout until grouting is complete.

d. Grout Production Test.

1) During grouting operations the fluidity of the grout must be strictly maintained within the limits established by the grout manufacturer. A target fluidity rate will be established by the manufacturer's representative, based on ambient weather conditions. Determine grout fluidity by use of either test method found elsewhere in this Special Provision. Perform fluidity test for each tendon to be grouted and maintain the correct water to cementitious material ratio. Do not use grout which tests outside the allowable flow rates.

2) Prior to grouting empty ducts, condition the grout materials as required to limit the grout temperature at the inlet end of the grout hose to 90°F. Prior to performing repair grouting operations with vacuum grouting, condition the grout materials to limit the grout temperature at the inlet end of the grout hose to 85°F. Check the temperature of the grout at the inlet end of the grout hose hourly.

3) At the beginning of each day's grouting operation, obtain a representative sample of grout from the first production batch of grout and perform a wick induced bleed test in accordance with requirements elsewhere in this Special Provision using this sample. Begin grouting operations after the sample is obtained. If zero bleed is not achieved in the wick induced bleed test at any time during the required test time period, complete the grouting of any partially grouted tendons and do not begin grouting of any new or additional tendons until the grouting operations have been adjusted and further testing shows the grout meets the specified requirements.

e. Grout Operations.

1) Open all grout outlets before starting the grouting operation. Grout tendons in accordance with the Grouting Operations Plan.

2) Unless approved otherwise by the Engineer, pump grout at a rate of 16 feet to 50 feet of duct per minute. Conduct normal grouting operations at a pressure range of 10 psi to 50 psi measured at the grout inlet. Do not exceed the maximum pumping pressure of 145 psi at the grout inlet for round ducts and 75 psi for flat ducts in deck slabs.

3) Use grout pumping methods which will ensure complete filling of the ducts and complete encasement of the steel. Grout must flow from the first and subsequent outlets until any residual water or entrapped air has been removed prior to closing the outlet.

4) Pump grout through the duct and continuously discharge it at the anchorage and grout cap outlets until all free water and air are discharged and the consistency of the grout is equivalent to that of the grout being pumped into the inlet. Close the anchorage outlet and discharge a minimum of 2 gallons of grout from the grout cap into a clean receptacle. Close the grout cap outlet.

5) For each tendon, immediately after uncontaminated uniform discharge begins, perform a fluidity test using the flow cone on the grout discharged from the anchorage outlet. The measured grout efflux time will not be less than the efflux time measured at the pump or minimum acceptable efflux time as established in Article 150217.04, E. Alternately, check the grout fluidity using the Wet Density method contained in Article 150217.04, E. The density at the final outlet must not be less than the grout density at the inlet. If the grout fluidity is not acceptable, discharge additional grout from the anchorage outlet and test the grout fluidity. Continue this cycle until an acceptable grout fluidity is achieved. Discard grout used for testing fluidity. After all outlets have been bled and sealed, elevate the grout pressure to ±75 psi seal the inlet valve and wait two minutes to determine if any leaks exist. If leaks are present, fix the leaks using methods approved by the Engineer. Repeat the above stated process until no leaks are present. If no leaks are present, bleed the pressure to 5 psi and wait a minimum of 10 minutes for any entrapped air to flow to the high points. After the minimum ten minutes period has expired, increase the pressure as needed and discharge grout at each high point outlet to eliminate any entrapped air or water. Complete the process by locking a pressure of 30 psi into the tendon.

6) If the actual grouting pressure exceeds the maximum allowed, the inlet will be closed and the grout will be pumped at the next outlet, which has just been, or is ready to be closed as long as a one-way flow is maintained. Grout will not be pumped into a succeeding outlet from which grout has not yet flowed. If this procedure is used, the outlet/inlet, which is to be used for pumping will be fitted with a positive shut-off and pressure gage.

7) When complete grouting of the tendon cannot be achieved by the steps stated herein, stop the grouting operation. After waiting 48 hours, fill the tendon with grout in accordance with the procedure outlined elsewhere in this Special Provision.

7. Construction Traffic and Operations Causing Vibrations.

During grouting and for a period of 4 hours upon completion of grouting, eliminate vibrations from all sources such as moving vehicles, jackhammers, compressors, generators, pile driving operations, soil compaction, etc., that are operating within 300 feet down-station and 300 feet up-station of the ends of the span in which grouting is taking place.

8. Post-Grouting Operations and Inspection.

Do not remove or open inlets and outlets until the grout has cured for 24 to 48 hours. Remove all outlets located at anchorages and high points along the tendon to facilitate inspection and perform inspections within one hour after the removal of the inlet/outlet. Drill and inspect all high points along the tendon as well as the inlets or outlets located at the anchorages. Depending on the geometry of the grout inlets, drilling may be required to penetrate to the inner surface of the trumpet or duct. Use drilling equipment that will automatically shut-off when steel is encountered. Unless grout caps are determined to have voids by sounding, do not drill into the cap. Perform inspections in the presence of the Engineer using endoscopes or probes. If voids are detected in tendon ducts or anchorages during inspection, fill voids using the volumetric measuring vacuum grouting process within 48 hours. If no voids are detected in tendon ducts or anchorages, seal and repair all anchorage and inlet/outlet voids that are produced by drilling for inspection purposes as specified elsewhere in this Special Provision within 4 hours of completion of the inspections. Remove the inlet/outlet to a minimum depth of 2 inches. Use an injection tube to extend to the bottom of the drilled holes for backfilling with epoxy.

9. Grouting Report.

a. Provide a grouting report signed by the Contractor and/or the subcontractor within 72 hours of each grouting operation for review by the Engineer.

b. Report the theoretical quantity of grout anticipated as compared to the actual quantity of grout used to fill the duct. Notify the Engineer immediately of shortages or overages.

c. Information to be noted in the records must include but not necessarily be limited to the following: identification of the tendon; date grouted; number of days from tendon installation to grouting; type of grout; injection end and applied grouting pressure, ratio of actual to theoretical grout quantity; summary of any problems encountered and corrective action taken.

H. Repair of Grout Inlets and Outlets

Place threaded plastic caps in all inlet/outlet locations. Repair inlets/outlets using an epoxy grout. Prepare the surface to receive the epoxy material in strict compliance with the manufacturer’s recommendations.

I. Protection of End Anchorages

Wait at least 72 hours after completion of the grouting operation, then, in the presence of the Engineer, probe, through vents or other devices, behind the anchorages and grouted pockets, for the presence of voids. Do not fill any voids, or begin activities to protect the end anchorage, prior to inspection by the Engineer. Upon inspection by the Engineer, fill any voids detected using methods approved by the Engineer. Within 54 hours of the inspection, clean the exposed areas of the end anchorages and other metal accessories, of rust, misplaced mortar, grout and other such materials. Immediately following the cleaning operation, apply a coat of zinc rich epoxy paint, with a minimum thickness of 4 mils, to the exposed areas of the anchorage assemblies and apply a bonding agent to the surrounding concrete surfaces as shown in the contract documents.

150217.06 METHOD OF MEASUREMENT.

Post-tensioning of the tendons will be measured by the linear foot.

150217.07 BASIS OF PAYMENT.

A. Payment for post-tensioning of the tendons will be at the contract unit price for Post-tensioning Tendons per linear foot.

B. Such prices and payments will be full compensation for successful furnishing of materials, placement, stressing and grouting of all post-tensioned tendons and similar miscellaneous details. These prices and payments will also include material testing, special erection equipment, post-tensioning, tools, labor and incidental items necessary for completing the work in accordance with the plans, specifications and approved shop drawings. No additional payment will be made for extra concrete necessitated by approved modifications to the structure needed to accommodate the Contractor’s construction methods. No additional payment will be made for extra reinforcement necessitated by approved modifications to the structure for the purposes of the Contractor’s construction methods. No additional payment will be made for extra post-tensioning necessitated by approved modifications to the structure for the purposes of the Contractor’s construction methods.