

Guide Specification for Grouted Post-Tensioning



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Guide Specification for Grouted Post-Tensioning

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The purpose of this document is to establish a unified, nationally recognized specification for grouted post-tensioning. It is intended to apply to buildings, bridges, storage structures, and other structures using grouted post-tensioning tendons, except as follows: stay cables and rock anchors that are already covered by other PTI documents.

The stated goals of this specification are:

- To set a minimum standard for all post-tensioning work;
- To define the testing requirements before a post-tensioning system can be used;
- To ensure the installed components meet the approved system description;
- To ensure the system is installed in a technically sound manner;
- To ensure the durability goals will be achieved;

- To give designers a choice of performance levels for a post-tensioning system based on the aggressiveness of the environment and protection provided by the structural element;
- To give suppliers an avenue for innovation beyond current best practice; and
- To provide minimum requirements for individual components used as part of the post-tensioning system.

This specification recognizes three tendon protection levels (PL):

- PL1A Protection Level 1A—Duct with filling material providing durable corrosion protection;
- PL1B Protection Level 1B—PL-1A plus engineered grout and permanent grout cap;
- PL2 Protection Level 2—PL-1B plus an envelope, enclosing the tensile element bundle over its full length, and providing a permanent leak-tight barrier; and
- PL3 Protection Level 3—PL-2 plus electrical isolation of tendon or encapsulation to be monitorable or inspectable at any time.

1.0 — INTRODUCTION

1.1 — General description

Furnish complete post-tensioning systems and all required accessories, including but not limited to anchorages, local zone reinforcement, ducts, pipes, strands, and bars from a single supplier, as required. Submit samples, drawings, calculations, procedures, reports, manuals, and certifications. Both temporary and permanent post-tensioning shall comply with this specification.

1.2 — Alternative post-tensioning scheme

Alternative post-tensioning schemes may be submitted for the Design Engineer's approval, provided they meet the following:

- The net compressive stress in the concrete after all losses is equal to or greater than that provided by the post-tensioning shown on the Contract Documents;
- The distribution of individual tendons at each cross section generally conforms to the distribution shown on the Contract Documents;
- No reduction in the protection level;
- Minimum concrete cover and concrete quality is not reduced;
- The ultimate strength of the structure with the proposed post-tensioning layout shall be equivalent to or greater than that provided by the original design;

- Stresses at all sections and at all stages of construction meet the design requirements of the Contract Documents;
- All post-tensioning provisions of the Contract Documents are satisfied;
- The Contractor redesigns and details the elements where the alternative post-tensioning scheme and/or layout are to be used;
- The Contractor submits complete installation drawings for post-tensioning layout and systems, reinforcing steel, concrete cover, and supporting design calculations, including short- and long-term prestress losses; and
- Alternative post-tensioning schemes shall be designed and sealed by a professional engineer licensed in the state where the work is to be performed.

1.3 — Referenced standards and specifications

ASTM International

ASTM A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

ASTM A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

ASTM A370, Standard Test Methods and Definitions for Mechanical Testing of Steel Products

ASTM A416/A416M, Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete

ASTM A500/A500M, Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes

ASTM A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

ASTM A722/A722M, Standard Specification for Uncoated High-Strength Steel Bars for Prestressing Concrete

ASTM C1583/C1583M, Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method)

ASTM D570, Standard Test Method for Water Absorption of Plastics

ASTM D638, Standard Test Method for Tensile Properties of Plastics

ASTM D1000, Standard Test Methods for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications

ASTM D2240, Standard Test Method for Rubber Property Durometer Hardness

ASTM D3035, Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter

ASTM D3350, Standard Specification for Polyethylene Plastics Pipe and Fittings Materials

ASTM D3895, Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry

ASTM D4101, Standard Specification for Polypropylene Injection and Extrusion Materials

ASTM D5309, Standard Specification for Cyclohexane 999

ASTM D5989, Standard Specification for Extruded and Monomer Cast Shapes Made from Nylon (PA)

ASTM E23, Standard Test Methods for Notched Bar Impact Testing of Metallic Materials

ASTM E28, Standard Test Methods for Softening Point of Resins Derived from Naval Stores by Ring-and-Ball Apparatus

ASTM F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs

ASTM F714, Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter

ASTM F2136, Standard Test Method for Notched, Constant Ligament-Stress (NCLS) Test to Determine Slow-Crack-Growth Resistance of HDPE Resins or HDPE Corrugated Pipe

Fédération Internationale du Béton (fib)

fib Bulletin 7, Technical Report, “Corrugated Plastic Duct for Internal Bonded Post-Tensioning”

German Institute for Standardization

DIN 30 672M

Post-Tensioning Institute

PTI M50.1-98, Acceptance Standards for Post-Tensioning Systems

PTI M55.1-12, Specification for Grouting of Post-Tensioned Structures

U.S. Department of Defense

Federal Specification MIL-P-3420, Performance Specification: Wrapping Materials, Volatile Corrosion Inhibitor Treated

2.0 — DEFINITIONS AND ABBREVIATIONS

2.1 — Definitions

Admixture, water-reducing – An admixture that either increases the slump of freshly mixed grout without increasing the water content or that maintains the slump with a reduced amount of water due to factors other than air entrainment.

Anchorage assembly – Mechanical device comprising all components required to anchor the prestressing steel and permanently transfer the post-tensioning force from the prestressing steel to the concrete.



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Anchor nut – The threaded device that screws onto a threaded bar and transfers the force from the bar to the bearing plate.

Anchor set – The expected movement of the wedge into the wedge plate or nut into the bearing plate during the transfer of the prestressing force to the anchorage assembly.

Bar – Bars used in post-tensioning tendons conform to ASTM A722, Standard Specification for Uncoated High-Strength Steel Bars for Prestressing Concrete. Bars have a minimum ultimate tensile strength of 150,000 psi (1035 MPa). A Type 1 bar has a plain surface and a Type 2 bar has surface deformations.

Bearing plate – Any hardware that transfers the tendon force into the structure.

Bearing plate, basic – Flat plate bearing directly against concrete meeting the analytical design requirements of PTI (refer to “Acceptance Standards for Post-Tensioning Systems,” Section 3.1).

Bearing plate, special – Any hardware that transfers tendon anchor forces into the concrete and does not meet the analytical design requirements of PTI (refer to “Acceptance Standards for Post-Tensioning Systems,” Section 3.1).

Bleed – The autogenous flow of mixing water within, or its emergence from, newly placed grout; caused by the settlement of the solid materials within the mass and filtering action of strands and bars.

Confinement reinforcement – Nonprestressed reinforcement in the local zone, usually in the form of spirals, which provide concrete confinement and are considered part of the bearing plate.

Contractor – The person, firm, or organization who has entered into a contractual agreement with the Owner to construct the project and who has the prime responsibility for the overall construction of the project in accordance with contract documents.

Coupler – A device transferring the prestressing force from one partial-length tendon to another.

Duct – Enclosure forming a conduit to accommodate prestressing steel installation and provide an annular space for grout that protects the prestressing steel.

Duct coupler – A device that connects individual lengths of duct forming a continuous enclosure around the prestressing steel.

Electrically isolated tendon (EIT) – Tendon demonstrating sufficient electrical resistance between the tensile elements and the structure.

Engineer (Licensed Design Professional, Engineer of Record, Design Engineer) – The person, firm, or organization engaged by the Owner to prepare the Contract Documents for the construction of the project.

Friction – The force resisting the relative lateral (tangential) movement of material elements that are in contact.

Grout – A mixture of cementitious materials and water—with or without mineral additives, admixtures, or fine aggregate—proportioned to produce a pump-

able consistency without segregation of the constituents; injected into the duct to fill the space around the tendon strand or bar. Refer to PTI’s “Specification for Grouting of Post-Tensioned Structures,” Table 3.1, for classes of grout.

Grout, basic – Cementitious material consisting of cement and water that is proportioned and mixed on site. Class A (refer to PTI’s “Specification for Grouting of Post-Tensioned Structures”).

Grout, engineered – Grout designed and tested for specific performance characteristics (refer to PTI’s “Specification for Grouting of Post-Tensioned Structures”). Class B (designed by the manufacturer and mixed on site), Class C (designed by the manufacturer, prepackaged, and mixed on site solely with water), or Class D (special) determined by design engineer.

Grout cap, temporary – A device that contains the grout by covering the post-tensioning steel at the wedge plate.

Grout cap, permanent – A device covering the post-tensioning steel and wedge plate at the anchorage that contains the grout and forms a protective cover, sealing the post-tensioning steel and wedge plate at the anchorage.

f_{pu} – The nominal ultimate tensile unit stress sometimes referred to as GUTS. When stated as force, F_{pu} , the nominal ultimate tensile unit stress is multiplied by the nominal cross-sectional area of strand or bar.

Hydrogen embrittlement – Brittle cracking process caused by the conjoint action of tensile stress and hydrogen ions (atomic hydrogen).

Owner – The person, firm, or organization that initiated the design and construction of the project, provides or arranges for funding, is responsible for partial and final payments, and who will take possession and ownership of the project upon completion.

Post-tensioning – A method of prestressing in which prestressing steel is tensioned after the concrete has reached a specified strength.

Post-tensioning scheme or layout – The pattern, size, and locations of post-tensioning tendons in a structure.

Post-tensioning system (PTS) – A particular size tendon, including prestressing steel, anchorages, local zone reinforcement, duct, trumpets, couplers, grout caps, inlets, outlets, all supplied by a single supplier.

Pourback – Blockouts created for tendon anchorage and/or vent access that are to be filled with concrete, nonshrink grout, or epoxy at a later date.

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 maximum allowable working pressure (MAWP).

Prestressing steel – High-strength steel strand or bar.

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

Profile – Vertical deviation (path) a tendon follows from end to end.

Quality assurance (QA) – Actions taken by the Owner or his/her representative to provide assurance to the Owner that the work meets the project requirements and all applicable standards of good practice.

Quality control (QC) – Actions taken by the Contractor to ensure that the work meets the project requirements and all applicable standards of good practice.

Set time – The lapsed time from the addition of mixing water to a cementitious mixture until the mixture reaches a specified degree of rigidity as measured by a specific procedure.

Setting – The process—due to the chemical reactions—occurring after the addition of mixing water, which results in a gradual development of rigidity of a cementitious mixture.

Sheathing – General term for the duct material surrounding the prestressing element to provide corrosion protection or conduit for installation.

Strand, seven-wire – Strand conforming to ASTM A416 and consisting of seven wires having a center wire enclosed tightly by six helically placed outer wires with a uniform pitch of not less than 12 and not more than 16 times the nominal diameter of the strand.

Stress corrosion cracking – Brittle cracking process caused by the conjoint action of tensile stress and a corrodent.

Stressing jack – Hydraulic jack designed for the explicit purpose of stressing one or more strands or bar to the desired load; sometimes also referred to as a ram.

Subcontractor – A person, firm, or organization engaged by the Contractor to provide select construction activities, materials, or other specialized construction or engineering services.

Tendon – A single or group of prestressing elements and their anchorage assemblies, which impart the prestress force to a structural member. Also included are ducts, grouting attachments, grout, and corrosion protective materials or coatings.

Tendon size – The number of individual strands of a certain strand diameter or the diameter of a bar.

Tendon type – Description of tendon relative to location in the concrete element and/or functional use (that is, internal, external, cantilever, transverse, longitudinal, continuity, stem wall, top slab, and so on).

Trumpet – Transition piece between bearing plate and duct, which collects the strands into a tight bundle that fits inside the duct.

Volume change – The change in volume produced by continued hydration of cement, excluding effects of the applied load and change in thermal or moisture content.

Wedge – A conically shaped device typically containing two or three pieces, which anchors the strand in the wedge plate.

Wedge plate (anchor head) – The hardware that holds the wedges of a multi-strand tendon and transfers the force from the strands to the bearing plate.

Wobble – Friction caused by unintended duct deviations between profile control points.

Zone, anchorage – The portion of the member through which the concentrated prestressing force is transferred to the concrete and distributed more uniformly across the section. Its extent is equal to the largest dimension of the cross section. For anchorage devices located away from the end of the member, the anchorage zone includes the disturbed regions ahead of and behind the anchorage.

Zone, general – The region in which the concentrated prestressing force spreads out to a more linear stress distribution over the cross section of the structural member (Saint Venant Region). It includes the local zone. The general zone extends from the anchorage along the axis of the member for a distance equal to the overall depth of the member. The height of the general zone is equal to the overall depth of the member. The Design Engineer is responsible for the general zone design.

Zone, local – The local anchorage zone is the volume of concrete surrounding and immediately behind the anchorage device, where concrete compressive stresses exceed acceptable values for unconfined concrete (concrete without confinement reinforcement). The local zone is defined as a rectangular prism of concrete surrounding the bearing plate and any integral confinement reinforcement. The local zone design is the responsibility of the post-tensioning system (PTS) supplier. The transverse dimensions of the prism are equal to those of the bearing plate, including any integral confining reinforcement, plus the supplier's specified minimum edge covers. The length of the local zone extends over the confinement reinforcement. For anchorage devices with multiple bearing surfaces, the local zone extends over the distance from the loaded concrete surface to the bottom of each bearing surface of the anchorage device, plus the maximum dimension of that bearing surface.

2.2 – Abbreviations

ASQ – American Society of Quality

AMRL – AASHTO Materials Reference Laboratory

ASBI – American Segmental Bridge Institute

A2LA – American Association for Laboratory Accreditation

GAI – Geosynthetic Accreditation Institute

3.0 — POST-TENSIONING SYSTEM (PTS) TENDON PROTECTION LEVELS (PL)

Furnish and install PTS meeting the following minimum requirements for the tendon PL as identified in the Contract Documents:

3.1 — Protection Level 1A (PL1A)

Duct with filling material providing durable corrosion protection.

Performance requirements:

- Bare strand or bar per Sections 4.2.1 and 4.2.2, respectively;
- Duct sufficiently strong and durable for fabrication, transportation, installation, concrete placement, and tendon stressing, sufficiently leak-tight for concrete placing and grout injection. Duct shall meet the requirements of Section 4.3.5 and may be one of the following:
 - Galvanized duct per Section 4.3.5.1;
 - Plastic duct per Section 4.3.5.2;
 - Plastic pipe per Section 4.3.5.3;
 - Duct connections per Section 4.3.6;
- Filling material to be chemically stable, nonreactive with prestressing steel and tendon duct, and may be one of the following:
 - Basic grout Class A per PTI's "Specification for Grouting of Post-Tensioned Structures";
 - Engineered grout Class B, C, or D per PTI's "Specification for Grouting of Post-Tensioned Structures"; and
- Grout filling procedure to leave no voids in duct.

3.2 — Protection Level 1B (PL-1B)

PL-1A plus engineered grout and permanent grout cap.
Performance requirements:

- Bare strand or bar per Sections 4.2.1 and 4.2.2, respectively;
- Permanent grout caps meeting the requirements of Section 4.3.3;
- Duct sufficiently strong and durable for fabrication, transportation, installation, concrete placement, and tendon stressing, sufficiently leak-tight for concrete placing and grout injection. Duct shall meet the requirements of Section 4.3.5 and may be one of the following:
 - Galvanized duct per Section 4.3.5.1;
 - Plastic duct per Section 4.3.5.2;
 - Plastic pipe per Section 4.3.5.3;
 - Duct connections per Section 4.3.6;
- Filling material to be chemically stable, nonreactive with prestressing steel and tendon duct, and be engineered grout Class B, C, or D per PTI's "Specification for Grouting of Post-Tensioned Structures"; and
- Grout filling procedure to leave no voids in duct.

3.3 — Protection Level 2 (PL-2)

PL-1B plus an envelope, enclosing the tensile element bundle over its full length, and providing a permanent leak-tight barrier.

Performance requirements:

- PTS shall meet the system pressure tests contained in Section 4.4.5;

- Bare strand or bar per Sections 4.2.1 and 4.2.2, respectively;
- Galvanize or epoxy coat the embedded part of the anchorage;
- Permanent grout caps meeting the requirements of Section 4.3.3;
- Envelope to be watertight and impermeable to water vapor over entire length. Envelope material to be chemically stable, without embrittlement or softening during anticipated exposure temperature range and service life, no free chloride ions extractable from material. Duct shall meet the requirements of Section 4.3.5 and may be one of the following:
 - Plastic duct per Section 4.3.5.2;
 - Plastic pipe per Section 4.3.5.3;
 - Duct connections per Section 4.3.6;
- Precast segmental duct couplers for precast segmental construction per Section 4.3.8.
- Filling material to be chemically stable, nonreactive with prestressing steel and tendon duct, and shall conform to:
 - Engineered grout Class C or D per PTI's "Specification for Grouting of Post-Tensioned Structures"; and
 - Thixotropic in nature.
- Grout filling procedure to leave no voids in duct.

3.4 — Protection Level 3 (PL-3)

PL-2 plus electrical isolation of tendon or encapsulation to be monitorable or inspectable at any time.

Performance requirements:

- PTS shall provide complete electric isolation of entire tendon and meet the system pressure tests contained in Section 4.4.5;
- PTS shall have the ability to be monitorable or inspectable at any time;
- Bare strand or bar per Sections 4.2.1 and 4.2.2, respectively;
- Electrically isolate the tensile elements;
- Permanent grout caps meeting the requirements of Section 4.3.3;
- Envelope to be watertight and impermeable to water vapor over entire length. Envelope material to be chemically stable, without embrittlement or softening during anticipated exposure temperature range and service life, no free chloride ions extractable from material. Duct shall meet the requirements of Section 4.3.5 and may be one of the following:
 - Plastic duct per Section 4.3.5.2;
 - Plastic pipe per Section 4.3.5.3;
 - Duct connections per Section 4.3.6;