

# Specification for Unbonded Single-Strand Tendons and Commentary

Reported by ACI Committee 423

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*This specification provides specific performance criteria for materials for unbonded single strand tendons and detailed recommendations for fabrication and installation of unbonded single strand tendons. Specifications are presented for tendons in non-aggressive environments and for tendons in aggressive environments. The more restrictive material, fabrication, and construction requirements for tendons used in aggressive environments are essential to the long-term durability of tendons used in such circumstances.*

*Notes to Specifier: This specification is incorporated by reference in the project specifications using the wording in P4 of the preface and including the information from the mandatory, optional, and submittal checklists following the specification.*

*ACI Specification 423.6-01 and Commentary 423.6R-01 are presented in a side-by-side column format, with specification text placed in the left-hand column and the corresponding commentary text aligned in the right column. Commentary section numbers are preceded by the letter "R." The Commentary is not a part of this specification.*

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Reference to the Commentary shall not be made in contract documents. If items found in this document are desired by the Architect/Engineer to be a part of the contract documents, they shall be restated in mandatory language for incorporation by the Architect/Engineer.

**Keywords:** anchorage; construction joint; contractor; coupler; deicer; post-tensioning; prestress; prestressing steel; sheathing; specification; strand; unbonded tendon.

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### PREFACE TO ACI SPECIFICATION 423

**P1.** ACI Specification 423 is intended to be used by reference or incorporation in its entirety in the project specifications. Do not copy individual sections, articles, or paragraphs into the project specifications, because taking them out of context may change their meaning.

**P2.** If sections or parts of ACI Specification 423 are copied into project specifications or any other document, do not refer to them as an ACI Specification, because the specification has been altered.

**P3.** Each technical section of ACI Specification 423 is written in the three-part section format of the Construction Specifications Institute, as adapted for ACI requirements. The language is imperative and terse.

**P4.** A statement such as the following will serve to make ACI Specification 423 a part of the project specifications:

Work on (Project Title) shall conform to all requirements of ACI (Specification number with date suffix and title) published by the American Concrete Institute, Farmington Hills, Michigan, except as modified by these contract documents.

**P5. Units** — The values stated in inch-pound units are to be regarded as the standard. The values in SI units given in parentheses are for information only.

# PART 1 — GENERAL

## SPECIFICATION

### 1.1 — Scope

This specification provides specific performance criteria for materials for unbonded single strand tendons and detailed recommendations for fabrication and installation of unbonded single strand tendons. Specifications are presented for tendons in non-aggressive environments and for tendons in aggressive environments.

The more restrictive material, fabrication, and construction requirements for tendons used in aggressive environments are essential to the long-term durability of tendons used in such circumstances.

## COMMENTARY

### R1.1 — Scope

The intent of this document is to provide detailed specifications for all common structural uses of unbonded post-tensioning tendons. It is not intended to apply to tendons used in ground-supported post-tensioned slabs for light residential construction. There are certain special structures or applications that either because of their service requirements or structural behavior might impose additional requirements on the post-tensioning system that exceed the minimum requirements of this specification. In such cases, a special specification should be developed.

Structures exposed to aggressive environments include all structures subjected to direct or indirect applications of deicing chemicals, seawater, brackish water, or spray from these sources; structures in the immediate vicinity of sea-coasts exposed to salt-laden air; and structures where anchorage areas are in direct contact with soil. Stressing pockets that are not maintained in a normally dry condition after construction should also be considered exposed to an aggressive environment. Nearly all enclosed buildings (office buildings, apartment buildings, warehouses, manufacturing facilities) are considered to be non-aggressive environments. The engineer should decide if the structure, or a part of the structure, is exposed to an aggressive environment. Attention should be paid to such areas as the location of stressing-end and intermediate anchors, construction joints, locations of planters, balconies and swimming pools.

The durability of prestressed structures in aggressive environments requires the use of consistently higher quality concrete, and superior construction practices than required in non-aggressive environments.

This specification is not intended to apply to nonstructural applications, which might include topping slabs, waterproofing slabs on fill, and post-tensioning used only for control of cracking or deflection. For nonflexural or membrane type structures primarily under tensile forces, the provisions, where appropriate, are intended to apply.

This specification should be considered a minimum standard and, due to experience or project considerations, may be made more restrictive by the engineer.

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## COMMENTARY

### 1.2 — Definitions

**Aggressive environment** — An environment in which structures are exposed to direct or indirect applications of deicing chemicals, seawater, brackish water, or spray from these water sources; and salt-laden air as occurs in the vicinity of seacoasts. Aggressive environments also include structures where stressing pockets are wetted or are directly in contact with soils.

**Anchorage** — A mechanical device comprising all components required to anchor the prestressing steel and permanently transmit prestressing force to concrete.

**Concrete contractor** — Contracting entity responsible for placing, finishing, and curing the post-tensioned concrete.

**Coupler** — A device designed to connect ends of two strands together, thereby transferring the prestressing force from end to end of the tendon.

**Encapsulated tendon** — A tendon that is completely enclosed in a watertight covering from end to end, including a protective cap over the tendon tail at each end.

**Engineer** — Design professional responsible for the structural design of the post-tensioned concrete members on the project.

**Non-aggressive environment** — All environments not specifically defined herein as aggressive, including enclosed buildings.

**Prestressing steel** — High-strength steel used to prestress concrete, most commonly 7-wire strand. It is the element of a post-tensioning tendon that is elongated and anchored to provide the necessary design prestressing force.

**Post-tensioning coating** — Material used to protect against corrosion and reduce friction between prestressing steel and sheathing.

**Post-tensioning installer** — Contracting entity responsible for unloading the post-tensioning materials, storing and protecting them on the job site at all stages of handling, storage, placement, tendon installation, stressing, and tendon finishing in accordance with the contract documents and this specification.

**Post-tensioning supplier** — Contracting entity responsible for providing all components of the post-tensioning system including the tendons, anchorages, couplers, field placement drawings, and stressing equipment, and delivering them to the job site.

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**Sheathing** — A material forming an enclosure in which prestressing steel is encased to prevent bonding with surrounding concrete, to provide corrosion protection, and to contain post-tensioning coating.

**Tendon** — A complete assembly consisting of anchorages, prestressing steel, post-tensioning coating and sheathing. The tendon imparts prestressing forces to concrete.

**Unbonded tendon** — Tendon in which prestressing steel is prevented from bonding to concrete, and is free to move relative to concrete. Prestressing force is transferred to concrete by anchorages only.

### 1.3 — Referenced standards

#### ASTM

A370-97a Standard Test Methods and Definitions for Mechanical Testing of Steel Products

A 416/  
416M-99 Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete

B 117-97 Standard Practice for Operating Salt Spray (Fog) Apparatus

C 1077-00 Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation

D 92-98a Standard Test Method for Flash and Fire Points by Cleveland Open Cup

D 95-99 Standard Test Method for Water in Petroleum Products and Bituminous Materials by Distillation

D 512-89 Standard Test Methods for Chloride Ion in (1999) Water

D 566-97 Standard Test Method for Dropping Point of Lubricating Grease

D 610-95 Standard Test Method for Evaluating Degree of Rusting on Painted Steel Surfaces

D 638-00 Standard Test Method for Tensile Properties of Plastics

D 792-00 Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

## COMMENTARY

### R1.3 — Cited references

1. Mattock, A. H.; Yamazaki, J.; and Kattula, B. T., "Comparative Study of Prestressed Concrete Beams, with and without Bond," ACI JOURNAL, *Proceedings*, V. 68, No. 2, Feb., 1971, pp. 116-125.

2. Society of Automotive Engineers, "SAE-J449 Surface Texture Control (1963)," 400 Commonwealth Drive, Warrendale, PA.

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D 2265-00 Standard Test Method for Dropping Point of Lubricating Grease Over Wide Temperature Range

D 3867-99 Standard Test Methods for Nitrite-Nitrate in Water

D 4289-97 Standard Test Method for Elastomer Compatibility of Lubricating Greases and Fluids

E 328-86 Standard Test Methods for Stress Relaxation Tests for Materials and Structures

*American Public Health Association*  
APHA 4500-S<sup>2</sup>E

*Federal Test Method Standard*  
FTMS 791 B Method 321.2

*Post-Tensioning Institute*  
Field Procedures Manual for Unbonded Single Strand Tendons, October 2000.

These publications may be obtained from these organizations:

American Society for Testing and Materials (ASTM)  
100 Bar Harbour Drive  
West Conshohocken, PA 19428-2957  
610/832-9585 FAX 610/832-9555

American Public Health Association (APHA)  
1015 15th Street N.W., 3rd Floor  
Washington, D.C., 20005  
202/789-5600

Federal Test Method Standard (FTMS)  
U.S. Army General Materiel and Parts Center  
Petroleum Field Office (East)  
New Cumberland Army Depot  
New Cumberland, PA 17070 (NCAD)

Post Tensioning Institute  
1717 W. Northern Avenue, Suite 114  
Phoenix, AZ 85021-5470  
602/870-7540

**1.4 — System description**

Unbonded single-strand post-tensioning tendons are used as prestressed reinforcement in a wide variety of concrete building projects, and for the strengthening and retrofit of buildings built with all types of structural materials. The tendon consists of the prestressing steel and a post-tensioning coating encased in a sheath that prevents bond with the adjacent concrete and provides additional corrosion protection. Anchor-

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ages transfer the prestressing force to the concrete at the extreme ends of the tendon and at intermediate points as required. When stressing is required at either or both extreme ends of the tendon, the anchorage located at those points is called a stressing-end anchorage. When stressing is required at some point along the length of the tendon, between the ends, the anchorage at that point is called an intermediate anchorage. When stressing is not required at one extreme end of the tendon, the anchorage located at that point is called a fixed-end anchorage.

Tendons are typically fabricated in a manufacturing facility or plant. Fabrication consists of applying post-tensioning coating and sheathing to the prestressing steel, cutting the tendon to a specified length and marking it for a specific location in the structure, attaching the fixed-end anchorages, positioning intermediate anchors, if required, coiling and securing the tendons into bundles which are loaded onto trucks for delivery to the job site along with the stressing-end anchorages, wedges, stressing equipment, and all required accessories.

At the construction site, the tendons are installed into the forms (in new construction) or externally attached to an existing structure (in retrofits). The tendon profile and number of tendons (or effective prestress force) is specified by the engineer. Stressing of the tendons is done with hydraulic equipment (jacks and pumps). In new construction, stressing is done after the concrete is placed and reaches a minimum compressive strength, determined by the engineer. In retrofits tendon stressing is done as soon as practical after installation of tendons and required hardware. After stressing, the protruding ends of the tendons are cut off, and any pockets required to recess the stressing end anchorages inside the concrete surfaces are filled with grout and finished.

### 1.5 — Submittals

#### 1.5.1 — Prestressing steel

Certified mill test reports shall be furnished for each coil or pack of strand, containing the following test information:

- Heat number and identification;
- Tensile strength;
- Yield stress at 1% extension under load;
- Elongation at failure;

## COMMENTARY

### R1.5 — Submittals

#### R1.5.1 — Prestressing steel

It is recommended that designers verify the material properties of the strand on their project to avoid the possibility of inadvertent substitution of strand with material having lower physical properties, which might reduce the structural capacity of some members.

Although ASTM A 416/A 416M does not specify a standard chemical analysis for the heat of steel, such analysis is available.

Tensile strength is defined as the tensile stress at ultimate.

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- Modulus of elasticity;
- Diameter and net area of strand; and
- Type of material (normal = relaxation or low = relaxation).

### 1.5.2 — Anchorages and couplers

Static and fatigue test reports of representative assemblies shall be furnished for each different assembly to be used on the project.

### 1.5.3 — Sheathing

A sheathing material report shall be furnished containing type, thickness, and density of material; and supporting test data demonstrating compliance with all requirements of [Section 2.3](#).

### 1.5.4 — Post-tensioning coating

Test results on post-tensioning coating, tested in accordance with [Table 1](#), shall be furnished.

### 1.5.5 — Fabrication plant

A copy of the tendon fabrication plant certification shall be furnished.

### 1.5.6 — Stressing jack calibration

Calibration certificates for every jack and gage shall be furnished ([Section 3.4.2](#)).

### 1.5.7 — Stressing records

Stressing records shall be filled out during the stressing operation, with the following data recorded:

- Name of the project;
- Floor number and concrete placement area number;
- Tendon identification mark;
- Required elongation;
- Stressing jack calibration certificate ([Section 1.5.6](#) and [3.4.2](#));
- Gage pressure to achieve required stressing force per supplied calibration chart;
- Actual elongation achieved;
- Actual gage pressure;
- Date of stressing operation;
- Name and signature of stressing operator or inspector;
- Serial or identification number of jacking equipment;
- Date of approved installation drawings used for installation and stressing; and

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- Weather conditions including temperature and rainfall.

Completed stressing records shall be submitted to the engineer for acceptance.

### 1.6 — Fabrication

#### 1.6.1 — General

Unbonded single-strand tendons shall be fabricated in a plant certified by an externally audited quality assurance program, which shall ensure that the unbonded tendons and components comply with the requirements of this specification. The post-tensioning supplier shall be responsible for the fabrication and packaging of unbonded tendons. Individual tendons shall be secured in bundles using a tying product that does not damage the sheath. The tendon sheath shall be protected from damage by banding materials. Padding material shall be used between any metal banding and the tendon.

#### 1.6.2 — Handling, storage, and shipping

The post-tensioning supplier shall be responsible for the handling, storage, and shipping of unbonded tendons, including:

##### 1.6.2.1 — Handling

- 1) Tendons shall not be damaged during handling, loading, or moving at supplier's yard;
- 2) Smooth forklift booms or padded forks shall be used to handle tendons;
- 3) Slings used to lift tendons shall be non-metallic (metal chokers or chains shall not be used); and
- 4) All tendons shall be protected during bundling, handling, loading, and securing to transportation. Tendons shall be protected from rain, snow, deicing salts, and other corrosive elements during transportation.

##### 1.6.2.2 — Storage before shipping

- 1) All tendons shall be protected from exposure to rain and snow;
- 2) Fabricated tendons shall be stored on a paved surface with proper drainage away from tendons; and
- 3) All tendons stored for 1 month or longer shall be protected from the damaging effects of direct sunlight.

## COMMENTARY

### 1.6 — Fabrication

#### R1.6.1 — General

The requirements of this section apply to tendons intended for use in both aggressive and non-aggressive environments. Plants certified by the Post-Tensioning Institute (PTI) have been shown to meet the fabrication requirements of this specification.

#### R1.6.2.2 — Storage before shipping

Protection is required to prevent water from penetrating tendons.

Means of protection from direct sunlight may be an additive to the sheathing material and/or by external protection.