

**Technical Consulting Service for
Development of Specification and Procedure on
Unbonded Single-Strand Tendons**

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CHAPTER I GENERAL INFORMATION

1. BACKGROUND

The containment of APR1400 nuclear power plant is a prestressed concrete structure and is prestressed by a post-tensioning system. The containment post-tensioning system used for APR1400 NPP consists of high strength multi-strand tendons and end anchorage hardware including basic bearing plates. The duct through which the tendon passes is filled with a corrosion prevention coating material to protect bare strands.

The provision for unbonded single-strand tendons was incorporated in the 2015 edition of the ASME Code (Section III, Division 2). The 2015 edition of the ASME Code also significantly revised the requirements related to the prestressing system including cement grout and system performance.

KEPCO Engineering & Construction Company, Inc. (KEPCO E&C) is developing the new containment post-tensioning system using unbonded single-strand tendons with individually greased and sheathed strands contained in the duct, cement grouted before tendons stressing. The special bearing plates that have special shape and multiple bearing surfaces will be considered for the new tendon system. For the development of the new post-tensioning system, KEPCO E&C, Korea Hydro & Nuclear Power Company, Ltd. (KHNP) and Freyssinet Korea have performed various tests using actual size mock-up.

This new system which allows each strand to slide freely offers many advantages such as excellent protection against corrosion and very low friction coefficient.

The use of the unbonded single-strand tendons has the following benefit:

- 1) reduce the quantities of horizontal and vertical tendons
- 2) increase the effective area of a tendon
- 3) reduce the construction period
- 4) improve the components of anchoring hardware
- 5) enhance the effectiveness of tendon stressing
- 6) improve the convenience of in-service inspection for the post-tensioning system.

KEPCO E&C does not have any design experience on the application of unbonded single-strand tendons grouted in a duct, and it is required to have a technical support from a company who has sufficiently experienced on the post-tensioning system for nuclear power plant.

2. OBJECTIVE

The purpose of this consulting service is to develop the following documents by creating new documents or modifying existing KEPCO E&C documents for the new post-tensioning system using unbonded single-strand tendons.

- 1) Purchase Order (PO) Specification
- 2) Construction Package (CP) Specification (Post-Tensioning System Only)
- 3) In-Service Inspection (ISI) Specification and Procedure.

CHAPTER II TECHNICAL INFORMATION

1. SCOPE OF SERVICES

This consulting service is divided into 3 main tasks to develop specifications and procedure for procurement, construction and in-service inspection of unbonded single-strand tendons. The Contractor shall provide the following engineering services based on the 2015 edition of the ASME Code.

1.1 Task 1 (PO Specification for Containment Post-Tensioning System)

The PO Specification for the containment post-tensioning system covers design, material, furnishing, fabrication, installation, stressing, inspection, test, shipping, handling and storage. KEPCO E&C's existing PO Specification (9-107-C209) is based on the typical unbonded multi-strand tendon system using bare strands, steel duct, end anchorage hardware and corrosion inhibiting grease.

The scope of this task is to modify the technical requirements portion of the existing PO Specification to be applicable for new tendon system using unbonded single-strand tendons. This task shall include, but not be limited to, the following activities:

- 1) Review of existing KEPCO E&C's PO Specification
- 2) Review of technical requirements of ASME Code (Section III, Division 2)
- 3) Review of related codes and standards
- 4) Preparation of PO Specification for unbonded single-strand tendons

The modified PO Specification should be able to use any tendon system (for example, VSL, Freyssinet, etc.) using unbonded single-strand tendons. As a minimum, the following items shall be included in the PO Specification. If attachments and appendices are required, they shall be included in the PO Specification.

- 1) Scope
- 2) Abbreviations and Definitions
- 3) Quality Standards
- 4) Submittals
- 5) Design Conditions
- 6) Material and Fabrication
- 7) Surface Preparation
- 8) Installation

- 9) Post-Tensioning Operation
- 10) Installation Equipment
- 11) Shipping, Handling and Storage
- 12) Inspection and Testing

1.2 Task 2 (CP Specification for Containment Post-Tensioning System)

The CP Specification for the containment post-tensioning system describes the requirements and activities performed by Constructor to construct the prestressing system. KEPCO E&C's existing CP Specification (9-192-C294) is also based on the typical unbonded multi-strand tendon system using bare strands, steel duct, end anchorage hardware and corrosion inhibiting grease.

The scope of this task is to modify the technical requirements portion of the existing CP Specification to be applicable for new tendon system using unbonded single-strand tendons. This task shall include, but not be limited to, the following activities:

- 1) Review of existing KEPCO E&C's CP Specification
- 2) Review of technical requirements of ASME Code (Section III, Division 2)
- 3) Review of related codes and standards
- 4) Preparation of CP Specification for unbonded single-strand tendons

The modified CP Specification should be able to use any tendon system using unbonded single-strand tendons. As a minimum, the following items shall be included in the Construction Specification. If attachments and appendices are required, they shall be included in the CP Specification.

- 1) Codes and Standards
- 2) Quality Requirements
- 3) Materials Furnished by Owner
- 4) Materials Furnished by Contractor
- 5) Contractor Furnished Material Specification
- 6) Service Conditions / Design Requirements
- 7) Fabrication
- 8) Receiving, Handling and Storage
- 9) Field Operations
- 10) Inspection and Testing
- 11) Submittals / Quality Verification Reports and Records
- 12) Measurement for Payment

1.3 Task 3 (In-Service Inspection Specification and Procedure for Containment Post-Tensioning System)

The ISI specification and procedure provide technical information and procedure required to perform the in-service inspection. KEPCO E&C's existing ISI Specification (9-316-C463-001) and Procedure (9-316-C463-002) are also based on the typical unbonded multi-strand tendon system using bare strands, steel duct, end anchorage hardware and corrosion inhibiting grease.

A. In-Service Inspection (ISI) Specification

The scope of this task is to modify the technical requirements portion of the existing ISI Specification to be applicable for new tendon system using unbonded single-strand tendons. This task shall include, but not be limited to, the following activities:

- 1) Review of existing KEPCO E&C's ISI Specification
- 2) Review of technical requirements of ASME Code (Section XI, Division 1, Subsection IWL)
- 3) Review of Regulatory Guides 1.90 and 1.107
- 4) Review of related codes and standards
- 5) Preparation of ISI Specification for unbonded single-strand tendons

The modified ISI Specification should be able to use any tendon system using unbonded single-strand tendons. As a minimum, the following items shall be included in the ISI Specification. If attachments and appendices are required, they shall be included in the ISI Specification.

- 1) Scope
- 2) References
- 3) Materials and Equipment
- 4) Description of Post-Tensioning System
- 5) Working (Inspection) Requirements and Design Requirements
- 6) Field Work (Inspection)
- 7) Inspection and Testing
- 8) Acceptance Criteria
- 9) Submittals
- 10) Repair and Replacement

B. In-Service Inspection (ISI) Procedure

The scope of this task is to modify the technical requirements portion of the existing ISI Procedure to be applicable for new tendon system using unbonded single-strand tendons. All of procedures, guidelines and manuals for the use of surveillance equipment shall be reviewed. All of inspection methods and activities shall be also reviewed.

The modified ISI Procedure should be able to use any tendon system using unbonded single-strand tendons. As a minimum, the following items shall be included in the ISI Procedure. If attachments and appendices are required, they shall be included in the ISI Procedure.

- 1) Objective
- 2) Responsibility
- 3) References
- 4) Handling of Materials and Equipment
- 5) Procedures
 - Construction Lifts (Work Platforms)
 - Jack Calibration
 - Removal and Inspection of Grease Cap
 - Installation of Hydraulic Jacks
 - Measurement of Tendon Forces
 - Release of Tendon Forces
 - Removal of Strand
 - Retensioning of Tendon
 - Refilling of Grease
 - Storage of Construction Lifts (Work Platforms)

1.4 Kick-off & Technical Review Meetings

A. Kick-off Meeting

KEPCO E&C and Contractor will have a kick-off meeting. KEPCO E&C staffs will visit Contractor's office for the meeting. Activities that will be discussed during the meeting are as follows:

- 1) Both KEPCO E&C and Contractor will discuss on how to perform the consulting services.
- 2) KEPCO E&C staffs will explain the contents of existing KEPCO E&C's reference documents.
- 3) Contractor will also explain the technical consultant performance plan and exact schedule based on actual working time.

B. Technical Review Meetings

KEPCO E&C and Contractor will have a technical review meeting. KEPCO E&C staffs will visit Contractor's office for checking the process and reviewing the technical contents before submitting final deliverables.

2. METHODS OF PERFORMANCE

The Contractor shall start this consulting service in accordance with the schedule shown in Section 4, immediately after the contract. This schedule can be adjusted by mutual consent after discussion between the Contractor and KEPCO E&C at the kick-off meeting.

The Contractor shall review the existing KEPCO E&C's documents based on the typical unbonded multi-strand tendon system and modify them to be applicable to the 2015 edition of the ASME Code. The Contractor may use other related codes and standards such as Regulatory Guides 1.90 and 1.107, ACI 423.7, PTI, ETC-C, ETAG, etc.

The Contractor shall modify them to be applicable to any tendon system (for example, VSL system, Freyssinet system, etc.) using unbonded single-strand tendon. The Contractor may use specifications and procedures obtained from other utilities to develop the in-service inspection procedure and specification.

For this consulting service, the Contractor shall make the best use of the results for the mock-up tests already performed in Korea.

KEPCO E&C will provide the following information to Contractor, either in English or Korean. These documents are based on the typical unbonded tendon system using grease as the corrosion prevention coating material.

- 1) Existing KEPCO E&C PO Specification (English)
- 2) Existing KEPCO E&C Construction Specification (English)
- 3) Existing KEPCO E&C ISI Specification (Korean)
- 4) Existing KEPCO E&C ISI Procedure (Korean)

3. DELIVERABLES

The deliverables for this scope of service are:

- 1) PO Specification for Containment Post-Tensioning System (Task 1)
- 2) CP Specification for Containment Post-Tensioning System (Task 2)
- 3) ISI Specification for Containment Post-Tensioning System (Task 3A)
- 4) ISI Procedure for Containment Post-Tensioning System (Task 3B)
- 5) Presentation material and meeting minutes of the kick-off meeting
- 6) Presentation material and meeting minutes of the technical review meeting
- 7) All backup documents developed as part of this scope of service

The native files shall be submitted with the final deliverables.

4. SCHEDULE

Duration of the work activities is 12 weeks after the contract is issued. Details of the schedule and milestones are set in the following bar chart. Detailed time schedule can be adjusted during the kick-off meeting through discussion between the Contractor and KEPCO E&C taking into account the date of contract awards and work schedule.

