

Comparative Analysis of In-service Inspection Procedures for Post-tensioning Systems in Nuclear Reactor Containment Building

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***Keywords:** Nuclear Reactor Containment Building, In-service Inspection, HDPE Coated and Greased Tendon System, Unbonded Post-tensioning System

1. Introduction

The unbonded post-tensioning system has been adopted for reactor containment buildings in most domestic nuclear power plants. However, the unbonded post-tensioning system is very difficult to handle and manage the grease filled into the duct during in-service inspections. Recently, several experimental studies have been performed to apply HDPE (High Density Polyethylene) coated and greased tendon system with three anti-corrosion concepts (greased steel strand + HDPE sheath + cement grout filling in duct) as an alternative to the existing unbonded post-tensioning system for nuclear reactor containment building. In this paper, the in-service inspection procedures for the post-tensioning systems were analyzed, and when applying the HDPE coated and greased tendon system as a replacement for the unbonded post-tensioning system, the items necessary to be revised for the inspection procedures and relevant technical standards were analyzed.

2. Analysis of In-service Inspection Procedures for Post-tensioning Systems

The in-service inspection of the post-tensioning system in nuclear reactor containment building is conducted in accordance with technical standards such as KEPIC MIL [1] and ASME Sec. XI, Div. 1, Sub. IWL [2]. Plant-specific in-service inspection procedures are established based on these standards, and the inspections are performed in accordance with the established procedures. The unbonded post-tensioning systems have been adopted for most domestic nuclear reactor containment buildings, and corresponding in-service inspection procedures have been developed. To replace the existing unbonded post-tensioning system with HDPE coated and greased tendon system, revisions to the in-service inspection procedures and relevant technical standards are required.

Fig. 1 compares the in-service inspection procedures for the unbonded post-tensioning system and the HDPE coated and greased tendon system. For the HDPE coated and greased tendon system, each strand can be individually detensioned without detensioning tendon for extraction of a single strand, and the cement grout is filled instead of grease in duct. Accordingly, to adopt the HDPE coated and greased tendon system, revisions

of the in-service inspection procedures are necessary as shown in Fig. 1.

[Unbonded Post-tensioning System]	[HDPE Coated and Greased Tendon System]
① Operation and Maintenance of Work Platform	① Operation and Maintenance of Work Platform
② Jack Calibration	② Jack Calibration
③ Visual Examination of Concrete Surface	③ Visual Examination of Concrete Surface
④ Removal and Inspection of Anchorage End Cap	④ Removal and Inspection of Anchorage End Cap
⑤ Jack Installation	⑤ Jack Installation
⑥ Measurement of Tendon Force	⑥ Measurement of Tendon Force
⑦ Tendon Detensioning	⑦ Individual Strand Detensioning
⑧ Strand Removal	⑧ Strand Removal and Replacement
⑨ Tendon Retensioning	⑨ Individual Strand Retensioning
⑩ Grease Replacement(Duct and Anchorage End Cap)	⑩ Grease Replacement(Anchorage End Cap)
⑪ Storage of Work Platform	⑪ Storage of Work Platform

Fig. 1. Comparison of in-service inspection procedures for post-tensioning systems

3. Analysis of Technical Standards

To reflect the characteristics of the HDPE coated and greased tendon system, the in-service inspection procedures for the unbonded post-tensioning system should be revised as follows:

- Tendon detensioning ⇒ Individual strand detensioning
- Strand removal ⇒ Strand removal and replacement
- Tendon retensioning ⇒ Individual strand retensioning
- Grease replacement (duct and anchorage end cap) ⇒ Grease replacement (anchorage end cap)

The corresponding chapters in KEPIC MIL are MIL 2523.1 (Tendon detensioning and sample removal), MIL 2523.2 (Sample examination), MIL 3221.1 (Tendon force and elongation), and MIL 2526 (Removal and replacement of corrosion protection medium), respectively. The exception rules on the inspection requirements are proposed as follows:

- [MIL 2523.1] (Proposed) For tendon systems where detensioning and removal of individual strand is possible, a single strand shall be removed after complete detensioning for a single strand of one sample tendon from each tendon group.
- [MIL 3221.1] (Proposed) For tendon systems where individual strand retensioning is performed, random strands (e.g. approximately 20% of total strands) shall be selected and the force of the strands shall be measured (e.g. the differences between the strand forces shall be less than 10%).

- [MIL 2526] (Proposed) For unbonded tendon systems where grout is filled into duct, the differences between amount removed and amount replaced from each tendon anchorage end cap shall be documented.

4. Conclusions

In this paper, the in-service inspection procedures for the post-tensioning systems were analyzed, and when applying the HDPE coated and greased tendon system as a replacement for the unbonded post-tensioning system, the items necessary to be revised for the inspection procedures and relevant technical standards were analyzed. Based on these analyses, the following conclusions have been obtained:

- The in-service inspection procedures for the unbonded post-tensioning system should be revised for tendon detensioning, strand removal, tendon retensioning, and grease replacement (duct and anchorage end cap) to apply HDPE coated and greased tendon system.

- The corresponding chapters in KEPIC MIL were MIL 2523.1 (Tendon detensioning and sample removal), MIL 2523.2 (Sample examination), MIL 3221.1 (Tendon force and elongation), and MIL 2526 (Removal and replacement of corrosion protection medium), respectively. The exception rules on the inspection requirements were proposed for applying HDPE coated and greased tendon system.

REFERENCES

- [1] KEPIC, Class CC Concrete Components, KEPIC MIL, 2022.
- [2] ASME, Requirements for Class CC Concrete Components of Light-Water-Cooled Plants, ASME Sec. XI, Div. 1, Sub. IWL, 2023.