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OFFICE OF STANDARDS DEVELOPMENT
DRAFT REGULATORY GUIDE AND VALUE/IMPACT STATEMENT

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Division 1
Task SC 810-4

PROPOSED REVISION 3 TO REGULATORY GUIDE 1.35
INSERVICE INSPECTION OF UNGROUTED TENDONS[1] IN PRESTRESSED CONCRETE CONTAINMENTS

A. INTRODUCTION

General Design Criterion 53, "Provisions for Containment Testing and Inspection," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," requires in part that the reactor containment be designed to permit (1) periodic inspection of all important areas and (2) an appropriate surveillance program. This guide describes a basis acceptable to the NRC staff for developing an appropriate inservice inspection and surveillance program for ungrouted tendons in prestressed concrete containment structures of light-water-cooled reactors.

B. DISCUSSION

The recommendations of this guide are applicable to prestressed concrete containments having either a combination of hoop, vertical, and dome tendons or a combination of inverted U[2] and hoop tendons.

Inservice inspection should be performed on ungrouted wire and strand tendons of all sizes (up to an ultimate strength of approximately 1300 tons)

[1]For the purpose of this guide, a tendon is defined as a separate continuous multiwire or multistrand tensioned element anchored at both ends to an end anchorage assembly.

[2]A tendon, both ends of which are anchored at the bottom of the base of the cylindrical walls and which approximately follows the configuration of the containment in the vertical plane passing through the anchor points.

This regulatory guide and the associated value/impact statement are being issued in draft form to involve the public in the early stages of the development of a regulatory position in this area. They have not received complete staff review, have not been reviewed by the NRC Regulatory Requirements Review Committee, and do not represent an official NRC staff position.

Public comments are being solicited on both drafts, the guide (including its implementation schedule) and the value/impact statement. Comments on the value/impact statement should be accompanied by supporting data. Comments on both drafts should be sent to the Secretary of the Commission, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Docketing and Service Branch, by JUN 22 1979

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and all types (e.g., tendons with parallel wires, with one or several strands, and with different systems of anchors). Materials for all components should satisfy the requirements of applicable American Society for Testing and Materials (ASTM) material standards. The inservice inspection program should cover the anchor hardware and the corrosion-inhibiting filler (grease).

When an inservice inspection program is being developed, the total containment tendon population should be divided into homogeneous groups consisting of tendons having approximately the same probability of corrosion and similar functions in the overall structural capabilities and properties of the structure. Thus, for each structure, the inservice inspection program should consider separately the groups of vertical, inverted U, hoop, and dome tendons. This will permit a sampling base to be established for determining loss of prestress.

These groups may be further divided into subgroups if some tendons in a group are expected to be subject to greater prestress losses than the rest. In any case, it should be recognized that the inspection is oriented toward verifying the performance on an individual basis of a small-sized sample of randomly selected tendons.

At a site with mutiple containments, the alternative liftoff test provisions of regulatory position C.1.5 are acceptable for any qualifying pair of containments. For example, if there are three similar containments at a site, the alternative liftoff provisions can be applied to any two per C.1.5, but the third containment should be considered as an independent containment. However, it should be noted that a trend of abnormality in one containment in a pair would be presumed to indicate the likelihood of abnormality in the other containment. In this case, both containments shoul be subjected to investigation.

The inservice inspection programs outlined in this guide are applicable to all containments with ungrouted prestressing sytems regardless of plant geographical location.

The prestressing force in a tendon may be checked by liftoff or other equivalent tests. One of the main objectives of the test is to discover any brittle, damaged, or broken wires. Any eventual decrease in the prestressing force is due to the simultaneous interaction of several time-dependent factors such as:

1. Stress relaxation in the wire,
2. Temperature variation of the wire,
3. Shrinkage, creep, and temperature deformations in concrete,
4. Differential thermal expansion or contraction between the concrete and the tendon, and
5. Reduction in cross section of the wires, including possible fracture, due to corrosion.

The measured prestressing force does not separate the effects of these factors, and corrosion, the factor of greatest concern, cannot be isolated. Therefore, tolerance limits for the loss of prestressing force should be established and the inservice inspection program should be oriented toward verifying that any decrease in liftoff force of a randomly selected tendon stays within the limits established for that group or subgroup of tendons. Draft Regulatory Guide 1.35.1, "Determining Prestressing Forces for Inspection of Prestressed Concrete Containments," presents a method for establishing these limits.

Detensioning of any wedge-anchored tendon could be accomplished on a random basis as needed if each tendon were provided with a shim (or shims) under its anchor head. This would ensure that the previously gripped portions of the prestressing elements (wires or strands) do not form a part of the retensioned tendon. Such a provision would be needed only for one-time detensioning and retensioning.

Many hoop tendons are anchored on buttresses partially located inside the auxiliary building adjacent to the containment. Since these anchors are not easily accessible, especially during operation of the facility, they present a special problem for liftoff tests. In the original layout of tendons, this problem should be specifically considered. Any architectural treatment or environmental protection of the anchors should be removable without damage to the anchor.

Regulatory position C.2.4 recommends the selection of tendons in a random but representative manner to include the tendons from typical areas, areas of structural discontinuities, and areas around hot penetrations.

It is recommended that the exterior surfaces of the containment structure be visually examined prior to the start of liftoff testing. The visual examination should be general, and its intent should be to detect areas of widespread cracking, spalling, or grease leakage. If areas with such obvious deterioration are detected, they should be examined in detail to evaluate the potential effects of such deterioration on the integrity of the structure. The selection of tendons for the measurement of prestressing force could be influenced by the need to evaluate such areas in more detail.

The procedure for liftoff testing of randomly selected tendons requires the removal of the grease cap and the grease to facilitate visual examination of anchorage hardware and the jacking operation. The method used for removing grease in order to permit visual examination of the stressing washers, shims, wedges, and bearing plates should neither increase the effects of corrosion nor damage the steel (for instance, scratch it). The volume of the filler grease removed should be recorded, and a grease sample should be analyzed for the amount of contaminants and water content and for establishing its suitability as a corrosion-inhibiting medium. The volume of the filler grease injected after the completion of the liftoff testing should also be recorded. If the volume of the newly injected filler grease is excessive compared to the removed grease, it could be indicative of leakage in the tendon-duct system. If the required additional amount is small (say, up to 5% of the net duct volume), it may not be a cause of concern, since temperature effects during and after installation could have formed voids in the filler grease that were filled up during re-injection.

The removal of wire or strand for the purpose of inspection and testing should be performed carefully to avoid damage to the prestressing element during removal and handling.

In addition to the obvious defects such as missing buttonheads, cracked wedges or anchor heads, grease discoloration, or signs of incipient corrosion that an inspector should look for, any other defects pertinent to the prestressing system or the environment should be identified. For the purpose of acceptance of these defects (without further evaluation and corrective action), all these defects should have preestablished tolerance limits within which the system performance has been demonstrated to be acceptable.

Regulatory position C.7 of this Proposed Revision 3 clarifies and expands regulatory position C.7 of Revision 2 of this guide; it is currently being used by the NRC staff in evaluating the results of prestress monitoring tests of ungrouted tendons.

C. REGULATORY POSITION

1. GENERAL

1.1. The inservice inspection program described in this guide is applicable to the following types of prestressed concrete containment structures:

1.1.1. Prestressed concrete containments having a shallow-dome roof on cylindrical walls with the cylinder prestressed in hoop and vertical directions and the dome prestressed by three families of tendons at 60°.

1.1.2. Prestressed concrete containments having a hemispherical-dome roof on cylindrical walls with two families of inverted U tendons placed at 90° to each other and hoop tendons located in the cylinder and dome.

1.2. For containments that differ from these two types, the program described should serve as the basis for the development of a comparable inservice inspection program.

1.3. The inservice inspection should be performed 1, 3, and 5 years after the initial structural integrity test (ISIT) and every 5 years thereafter.

1.4. Containments should be designed and constructed so that the prestressing anchor hardware is accessible for inservice inspection.

1.5. All containment structures with ungrouted tendons should be inspected in accordance with this guide. However, the liftoff force comparison may be performed as shown in Figure 1 if any two containments at the same site are shown to satisfy the following conditions:

a. The containments are identical in all aspects such as size, tendon system, design, materials of construction, and method of construction.

b. If their ISITs are performed within two years of each other.

c. If there is no unique situation that may subject either containment to a different potential for structural or tendon deterioration.

The visual inspection, however, of both containments should be performed according to regulatory position C.3 and at frequencies described in regulatory position C.1.3.

2. SAMPLE SELECTION

2.1. For the inspections at 1, 3, and 5 years, four percent of the population of each group (vertical, hoop, dome, and inverted U) of tendons should be selected with a minimum of four tendons from each group. The sample size from any group need not exceed ten.

2.2. If the inspections performed at 1, 3, and 5 years indicate no abnormal degradation of the post-tensioning system, two percent of the population of each group (vertical, hoop, dome, and inverted U) of tendons may be selected for the subsequent inspection with a minimum of three tendons for each group. The sample size from any group need not exceed five.

2.3. The fraction obtained as a percentage of a tendon population should be rounded off to the nearest integer.

2.4. The tendons for inspection should be randomly but representatively selected from each group during each inspection. However, to develop a history and to correlate the observed data, one tendon from each group may be kept unchanged after the initial selection.

3. VISUAL INSPECTION

3.1. The exterior surface of the containment should be visually examined with a view to detecting areas of widespread cracking, spalling, and grease leakage.

3.2 Tendon anchorage assembly hardware (such as bearing plates, stressing washers, shims, wedges, and buttonheads) of all tendons selected as described in regulatory position C.2 should be visually examined. For those containments for which only visual inspections need be performed, tendons selected as described in regulatory position C.2 should be visually examined to the extent practical without dismantling load-bearing components of the anchorage.

The surrounding concrete should also be checked visually for indications of abnormal material behavior.

4. PRESTRESS MONITORING TESTS

Tendons selected as described in regulatory position C.2 should be subjected to liftoff or other equivalent tests to monitor their prestress. Additionally, the tests should include the following:

4.1. One tendon, randomly selected from each group of tendons during each inspection, should be subjected to essentially complete detensioning in order to identify broken or damaged wires or strands.

4.2. The simultaneous measurement of elongation and jacking force during retensioning should be made at a minimum of three approximately equally spaced levels of force between the seating force and zero.

5. TENDON MATERIAL TESTS AND INSPECTIONS

5.1. A previously stressed tendon wire or strand from one tendon of each group should be removed for testing and examination over the entire length to determine if evidence of corrosion or other deleterious effects is present. At each successive inspection, the samples should be selected from different tendons. The tendon selected for the purpose may be the same as that selected for the purpose of detensioning.

5.2. Tensile tests should be made on at least three samples cut from each removed wire or strand (one at each end and one at mid-length; the samples should be the maximum length practical for testing; the gage length for the measurement of elongation should be in accordance with the relevant ASTM specification). If frequent stress cycling is suspected, tests simulating this condition should be conducted. Similarly, where the inservice inspection program indicates the possibility of a potentially corrosive atmosphere, accelerated corrosion tests should be made.

6. INSPECTION OF FILLER GREASE

The method used for checking the presence of sheathing filler grease should account for (1) the minimum grease coverage needed for different parts of the anchorage system including, for example, buttonheads; (2) the influence of temperature variations, especially the lowest temperature likely to occur between two successive inspections; (3) the procedure used to uncover possible voids in the grease in the trumpet; and (4) requirements imposed by grease specifications, qualification tests, and acceptability tolerances.

7. EVALUATION OF INSPECTION RESULTS

7.1. The prestressing force measured for each tendon in the tests described in regulatory position C.4 should be within the limits predicted for the time of the test. Regulatory Guide 1.35.1 provides further information on the determination of these limits.

7.1.1. If the prestressing force of a selected tendon in a group lies above the prescribed lower limit, the liftoff test is considered to be a positive indication of the sample tendon's acceptability.

7.1.2. If the prestressing force of a selected tendon in a group lies between the prescribed lower limit and 90% of the prescribed lower limit, two tendons, one on each side of this tendon should be checked for their prestressing forces. If the prestressing forces of these two tendons are within the prescribed limits for the tendons, all three tendons should be restored to the required level of integrity. The single deficiency may be considered as unique and acceptable.

7.1.3. In regulatory position 7.1.2, if the prestressing force of any of the adjacent tendons falls below the prescribed lower limits for the tendons, the condition should be considered as reportable.

7.1.4. If the prestressing force of the selected tendon lies below 90% of the prescribed lower limit, the defective tendon should be completely detensioned and a determination should be made as to the cause of such occurrence. Such an occurrence should be considered as a reportable condition.

7.2. During detensioning and retensioning of tendons (regulatory position 4.2), if the elongation corresponding to a specific load differs by more than 5% from that recorded during installation of tendons, an investigation should be made to ensure that such difference is not related to wire failures or slip of wires in anchorages.

7.3. Failure in the tensile test at a strength or elongation value less than the minimum requirements of the tendon material should be considered as reportable.

7.4. Such conditions as the presence of significant voids within the grease filler material, the presence of free water, or chemical or physical properties outside the tolerance in the specifications should be considered reportable. Other conditions found by tests or visual examinations that indicate possible effects on the integrity of two or more tendons should also be considered as reportable conditions.

8. REPORTING TO THE COMMISSION

The reportable conditions of regulatory position C.7.1.3, C.7.1.4, C.7.3 or C.7.4 could indicate a possible abnormal degradation of the containment structure (a boundary designed to contain radioactive materials). Any such condition should be reported to the Commission in accordance with the recommended reporting program of Regulatory Guide 1.16, "Reporting of Operating Information - Appendix A Technical Specifications."

D. IMPLEMENTATION

This proposed guide has been released to encourage public participation in its development. Except in those cases in which an applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method to be described in the active guide reflecting public comments will be used in the evaluation of all (1) construction permit applications, (2) standard reference system preliminary design applications (PDA) or Type-2 final design applications (FDA-2), and (3) licenses to manufacture that are docketed after the implementation date to be specified in the active guide, except those portions of a construction permit application that:

a. Reference an approved standard reference system preliminary or final design (PDA or FDA) or an application for approval of such design.

b. Reference an approved standard duplicate plant preliminary or final design (PDDA or FDDA).

c. Reference parts of a base plant design qualified and approved for replication.

d. Reference a plant design approved or under review for approval for manufacture under a Manufacturing License.

This implementation date (to be specified in the active guide) will in no case be earlier than December 1, 1979.

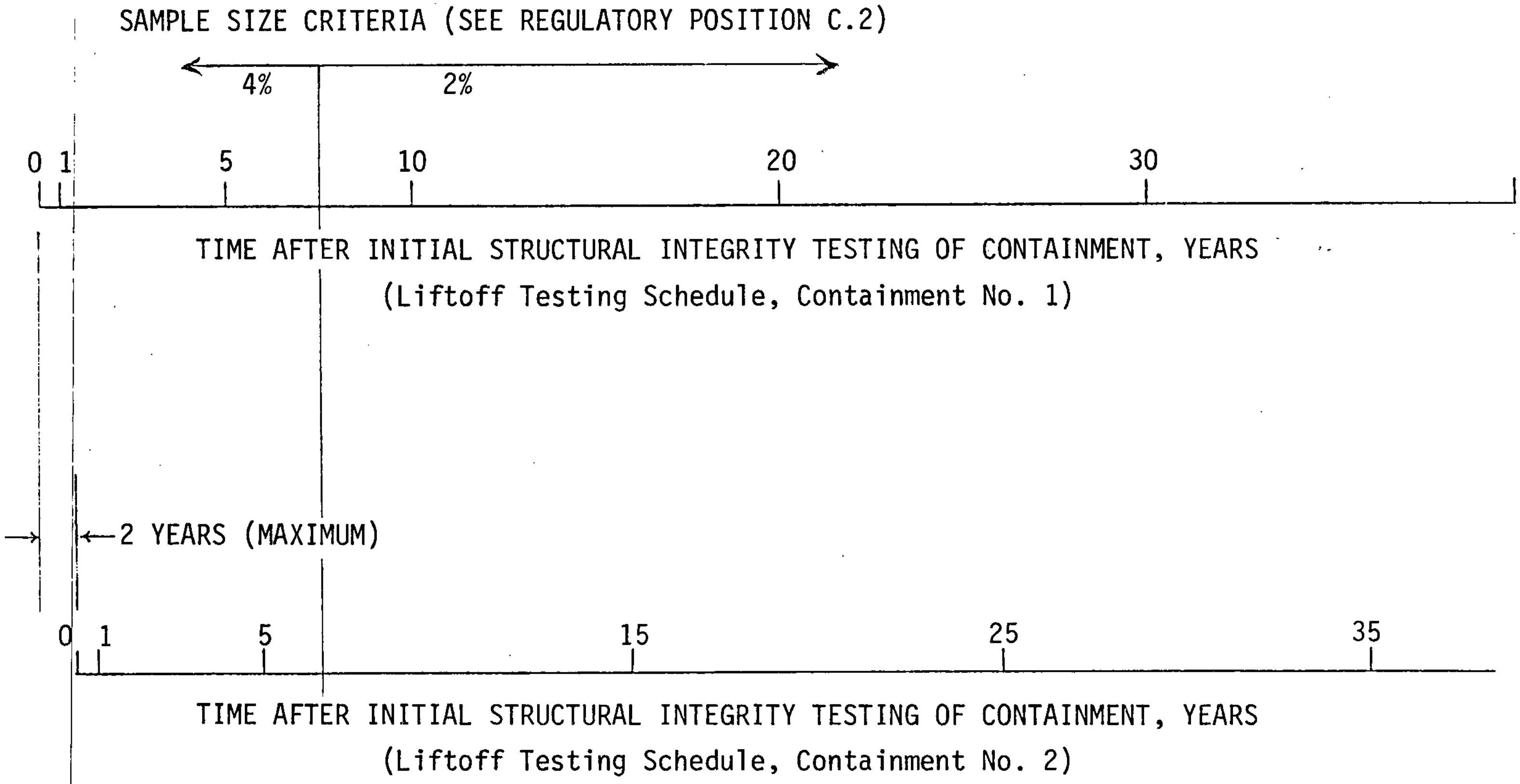

Figure 1. Schedule of Liftoff Testing for Two Containments at a Site

VALUE/IMPACT STATEMENT

1. THE PROPOSED ACTION

1.1 Description

This guide provides guidance for performing inspections of ungrouted tendons in prestressed concrete containment structures. The experience thus far in using this guide has been satisfactory; however, there are various gray areas that need clarification, expansion, or additional guidance. The proposed action of revising this guide will serve this purpose.

1.2 Need for the Proposed Action

After the publication of Revision 2 of the guide, the NRC staff identified certain provisions of the guide that required reexamination. However, the need for revising the guide became apparent when the Division of Operating Reactors (DOR) started implementing the Standard Technical Specification Requirements based on this guide.

It was expected that the Working Group on Concrete Pressure Components of Section XI would incorporate the guide provisions with the necessary changes in developing its standard. However, the progress of the working group is slow, and a schedule for publishing the needed standard is undetermined at this time.

1.3 Value/Impact of the Proposed Action

Attachment 1 provides the value/impact assessment for each major proposed change in the regulatory position.

1.3.1 NRC

It is expected that the proposed action accompanied by a supplementary guide (a new proposed Regulatory Guide 1.35.1) on methods of determining the prestressing forces will adequately clarify the NRC staff position on the subject. These two actions in combination will provide a consistent basis for implementing the Standard Technical Specification requirement of DOR.

1.3.2 Industry

The industry will get a clarification of certain issues not fully addressed in Revision 2 of the guide.

The proposed action will also relax some of the expensive provisions of the present guide that have been proved to be of marginal utility. Some of the provisions will be tightened up to ensure adequate safety.

1.3.3 Public

The proposed action will not increase the occupational exposure.

1.4 Decision on the Proposed Action

The guide has to be revised.

2. TECHNICAL APPROACH

2.1 Technical Alternatives

A sampling program different from that proposed in the guide for liftoff testing of tendons has been proposed by Sargent & Lundy. That program has been exhaustively discussed during the meetings of the working group on concrete pressure components of ASME Section XI.

No decision has been made by the working group or higher committees as to the adoption of the alternative sampling program.

2.2 Discussion and Comparison of Technical Alternatives

The basic difference between the NRC plan (which has been used since 1971) and the one proposed by Sargent & Lundy lies in the method of interpreting the results of liftoff measurements. Theoretically, the proposed plan is a valid alternative. However, more work is needed in framing the plan to ensure the intended results.

2.3 Decision on Technical Approach

For the purpose of the proposed action (Revision 3 of the guide), the NRC staff intends to use basically the same plan as used in the previous versions of the guide.

3. PROCEDURAL APPROACH

At this time no viable procedural approach other than revising the guide is contemplated. When the content of the guide is satisfactorily included in ASME Section XI, it will be endorsed by addition to the existing regulation or by an endorsing guide.

4. STATUTORY CONSIDERATION

4.1 NRC Authority

The guide was originated to develop an inservice inspection program for ungrouted tendons in prestressed concrete containment structures. The implementation of this inspection program will partly satisfy the requirements of General Design Criterion 53, "Provision for Containment Testing and Inspection," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities."

4.2 Need for NEPA Assessment

The proposed action does not fall into a category requiring a NEPA assessment as defined by 10 CFR 51.5(a).

5. RELATIONSHIP TO OTHER EXISTING OR PROPOSED REGULATIONS OR POLICIES

The proposed action is directed toward ensuring the continued integrity of prestressing tendons of prestressed concrete containment structures with ungrouted tendons. Thus, this action forms a part of the total inspection program for containment system components.

6. SUMMARY AND CONCLUSION

The guide has to be revised to clarify the intent of some provisions that are causing implementation problems and to reflect the results of experience in using the guide recommendations.

ATTACHMENT 1

Value and Impact of the Major Changes in the Proposed Revision 3 to Regulatory Guide 1.35

1. REGULATORY POSITION C.1.5

The recommendation for monitoring the prestressing force of two similar containments at a site is revised so that, instead of waiving the prestress monitoring for the second containment, each of the two containments will be subjected to prestress monitoring on an alternating basis. Also, more specific guidelines are provided to identify the similarity of two containments at a site.

The need for this revision was dictated by the experience thus far, which showed that such degradations as wire breakage, wire corrosion, low liftoff forces, and discoloration of grease are random processes. They do not depend on the sequence of construction, nor do they follow any particular pattern. The NRC staff felt that all containments with ungrouted tendons should be inspected. When there are two similar containments at a site, the prestressing force can be monitored by performing the liftoff testing during alternate inspections.

Value. The recommendation will enhance the effectiveness of the inspection program.

Impact. The tendon anchorages of all tendons in any containment should be accessible for prestress monitoring. However, those applicants who have planned to fully inspect the first containment (as provided by Revision 2 of the guide) may not have provisions to mobilize equipment necessary to lift the tendons in the second containment. In the case of future containments, provisions could be made for mobilizing such equipment. The added cost of the proposed revision would amount to approximately $33,000 in eighty years of the combined life of the two containments. This proposed position would be used in the evaluation of new applications only.

2. REGULATORY POSITIONS C.2.1 and C.2.2

The method of selecting the number of tendons for inspection is changed from the arbitrary numbers of 21, 10, 9, etc, to a percentage of the tendon population in each group with limitations on the minimum and maximum number of tendons to be inspected.

Value. The revised method (originally proposed by Bechtel Corporation in a meeting of the working group on inservice inspection of concrete pressure components) makes it possible to extend the applicability of the guide to containments of various sizes having different tendon sizes and tendon configurations.

Impact. For older containments with 500-ton-capacity tendons, this change entails a slight increase in the number of tendons to be inspected. For newer containments with approximately 1000-ton-capacity tendons (having fewer tendons), the proposed revision should result in a slight reduction in the number of tendons to be inspected. These proposed positions would be used in the evaluation of new applications only.

3. REGULATORY POSITION C.4.1

The proposed revision recommends the detensioning of only one tendon in a group instead of detensioning all the tendons selected for inspection.

Value. If the tendon prestressing forces are precisely monitored, the NRC staff believes that this relaxation will not reduce the effectiveness of the inspection program. The potential degradation of the system due to the dismantling of the components (for the purpose of inspection) is reduced to a minimum.

Impact. It has been indicated by industry sources that the usefulness of this provision in identifying defective tendons is quite marginal and the cost is high. A reduction in the cost of inspection up to 40% of the cost of liftoff testing (by the implementation of the proposed provision) is expected.

4. REGULATORY POSITION C.7.1

The evaluation criteria are described in detail. It is an expansion and clarification of Regulatory Position C.7.1 in Revision 2 of the guide. Proposed Regulatory Guide 1.35.1 provides guidance for establishing the tolerance band for prestressing force.

Value. The revised provision will help clarify the acceptance criteria. It is not a change from the previous position.

Impact. The impact of this change would vary from none to some additional engineering work, depending on how the intended acceptance criteria were interpreted.

It should be noted that the proposed Revision 3 of the guide would result in a certain amount of tightening and a certain amount of relaxation of the current position in Revision 2, and the NRC staff intends to use the revised regulatory position in its entirety only.

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