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March 14, 2000

1CAN030004

U. S. Nuclear Regulatory Commission
Document Control Desk
Mail Station OP1-17
Washington, DC 20555

Subject: Arkansas Nuclear One - Unit 1
Docket No. 50-313
License No. DPR-51
ANO-1 Reactor Building IWL Inspection Report

Gentlemen:

As required by the Arkansas Nuclear One – Unit 1 (ANO-1) Technical Specifications (TS), the attached report concerning applicable inspection results of the ANO-1 Reactor Building is being submitted for your review. In accordance with ANO-1 TS 6.12.4 and the Bases to TS 3.6, any degradation exceeding the acceptance criteria of the containment structure detected during the tests required by the Containment Inspection Program must undergo an engineering evaluation and the findings of the evaluation shall be reported to the NRC. The report shall include the following:

- The cause of the condition that does not meet the acceptance standards,
- The applicability of the condition to any other unit at the same site,
- The acceptability of the concrete containment without repair of the item,
- Whether or not repair/replacement is required and, if required, the extent, method and completion date for the repair/replacement activity, and
- The extent, nature and frequency of additional examinations.

Similarily, this engineering evaluation is also required by ASME Code Section XI, Subsection IWL, Paragraph IWL-3310 on those examination results that do not meet the acceptance criteria of IWL-3100 and/or IWL-3200, as applicable. The deficiencies noted in the attached engineering evaluation were identified during the ANO-1 25-Year Reactor Building Concrete Surface and Post Tensioning System Examination that was completed on December 15, 1999. There were no findings that affected the ability of the ANO-1 reactor building to perform its design function. The attached engineering evaluation confirms that the ANO-1 reactor building remains operable as defined by TSs.

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The engineering evaluation is being furnished for reporting purposes under TS 6.12.4.1 and no action is being requested. Should further information be desired, please contact me.

Very truly yours,

Jimmy D. Vandergrift
Director, Nuclear Safety Assurance

JDV/dbb

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ATTACHMENT 1

TO

1CAN020005

25-YEAR REACTOR BUILDING

TENDON SURVEILLANCE

AND

CONCRETE SURFACE EXAMINATION

ENGINEERING EVALUATION

LICENSE NO. DPR-51

ENTERGY OPERATIONS, INC.

ARKANSAS NUCLEAR ONE, UNIT ONE

DOCKET NO. 50-313

FORM TITLE: ENGINEERING REQUEST	FORM NO. 1000.153A	REV. 004-03-0

ENGINEERING EVALUATION ON DEFICIENCIES DISCOVERED DURING ANO-1 25-YEAR REACTOR BUILDING TENDON SURVEILLANCE AND CONCRETE SURFACE EXAMINATION

Section I: Table of Contents

Section II: Description

The purpose of this response is to perform the engineering evaluation required by ASME Code Section XI, Subsection IWL, Paragraph IWL-3310 on the ANO-1 25-Year Reactor Building Concrete Surface and Post Tensioning System Examination on those Examination results that did not meet the acceptance standards of IWL-3210 and / or IWL-3221. This engineering evaluation is also being performed to meet the requirements of the ANO-1 Technical Specification 6.12.4.1.

The evaluation will answer the following questions noted in Tech Spec. 6.12.4.1 for each category of deficiency:

a. The cause of the condition that does not meet the acceptance standards;
b. The applicability of the condition to any other plants at the same site;
c. The acceptability of the concrete containment without repair of the item;
d. Whether or not repair / replacement activity is required and, if required, the extent, method and completion date for the repair / replacement activity; and
e. Extent, nature and frequency of additional examinations.

There are three (3) categories of deficiencies noted: (A) Degradation of the concrete surface; (B) Degradation of the Post-Tensioning System; and (C) Tendon Grease Leakage on the Surface of the Concrete Containment.

A summary description of the identified deficiencies is provided below. Each deficiency is individually addressed and all areas have been shown to be acceptable As-Is or with the identified actions. The detailed description is provided in Section IV of this evaluation.

A. Concrete Surface

1) Exposed reinforcing steel in a tendon low point drain blockout (CR # 1-99-0510).

2) A piece of wood in the exterior face of the Reactor Building at approximately azimuth 290, elevation 358' (CR # 1-99-0214).

B. Post-Tensioning System Components

1) Two cracks > .01 in. in width in the concrete extending outward a distance of 2 feet from the edge of the bearing plate (CR # 1-99-0582).

2) Broken tendon wires not previously documented (CR # 1-99-0317 and 1-99-0352).

3) Absolute difference in the amount of sheathing filler (grease) removed and the amount of sheathing filler replaced being greater than 10% of the net tendon duct volume. (CR # 1-2000-0003).

C. Tendon Grease Leakage on the Surface of the Concrete Containment

1) Tendon grease leaks in multiple locations (CR # 1-99-0415, 1-99-0547, 1-99-0568, 1-99-0596, 1-2000-0020)

Section III: Reference Documents

1) CR # 1-99-0214, 1-99-0317, 1-99-0352, 1-99-0415, 1-99-0510, 1-99-0547, 1-99-0582, 1-99-0596, 1-2000-0003, 1-2000-0020, 2-99-0684, 2-2000-0024 and 2-2000-0027.
2) Procedure 5220.011
3) 10CFR50.55a
4) ANO-1 Technical Specification 6.12.1.4
5) ASME Code, Section XI, Subsection IWL, 1992 Edition, 1992 Addenda
6) Calculations 87-E-0052-01 (ANO-1 Grease Volumes); 87-E-0052-03 (ANO-2 Grease Volumes)
7) Calculation 87-E-0052-02 (Responses to NRC Questions on ANO-1 15-Year Tendon Surveillance)
8) NUREG/CR-6598, "An Investigation of Tendon Sheathing Filler Migration into Concrete", ORNL, March 1998

Section IV: Evaluation

A. Concrete Surface Examination

1) Exposed Reinforcing Steel

a. The cause of the condition that does not meet the acceptance standards

The condition that does not meet acceptance standards is an exposed reinforcement bar found during the Unit 1 Reactor Building 25-Year Tendon Surveillance and Concrete Surface inspection. The rebar is an outside horizontal #11 bar that is exposed for approximately 4" at a low point drain for tendon 32H18. The rebar is located below the personnel airlock at elevation 387'-6". The personnel airlock is located in the Upper North Electrical Penetration Room inside the Auxiliary Building and is not exposed to the elements. Only about the top 1/3 of the rebar is exposed and does not show evidence of extensive rusting.

The apparent cause of the condition is inattention to detail when forming the blockout pockets for the tendon low point drains or high point vents in these locations during original construction.

b. The applicability of the condition to any other plants at the same site

Similar conditions have been discovered in three (3) tendon high point vents on ANO-2 (CR# 2-99-0684) and at the top of Tendon Buttress # 3 on ANO-2 (CR # 2-2000-0024).

c. The acceptability of the concrete containment without repair of the item

The personnel airlock is located in the Upper North Electrical Penetration Room in side the Auxilliary Building and is not exposed to the elements. The horizontal reinforcing bar that is exposed is part of the outside layer of continuous vertical and horizontal reinforcing around the exterior of the Reactor Building. Due to the discontinuity in the containment wall caused by the personnel airlock penetration there is additional reinforcing steel added to the area in the form of 4 #11 hoops placed just inside of the exterior reinforcing steel (see Drawings C-130 and C-131) (see Attachment 3).

The personnel airlock penetration was evaluated for containment uprate for Unit 2. Unit 1 and Unit 2 have the same reinforcing in this area. Calc. 97-E-0009-22 evaluated this penetration for 59 psig, which is also the design pressure for Unit 1. The calculation is very conservative since it does not consider the compressive force from the tendons but instead evaluates the capacity of the penetration based solely on the hoop reinforcing bars added around the penetration. It was determined that the outside reinforcing required was 4.37 in^2 while 5.72 in^2 is provided. The area of steel in a #11 is 1.56 in^2. There is 1.35 in^2 of excess steel in the hoop rebar. The exposed rebar function is in slight compression during normal operations due to the compression of the wall by the tendons, but is in tension during LOCA accident conditions. There is not enough rebar exposed to have buckling problems (only 4") and the rebar will function normally in tension conditions. There is also only slight corrosion (mill scale) on the rebar and therefore the rebar can be fully developed while performing its function in this area.

In summary, the exposed reinforcement bar as found above can adequately perform its function in it present condition and there is excess capacity available in the area if it had not been able to function. The exposed bar can be code qualified in its current condition without rework.

d. Whether or not repair / replacement activity is required and, if required, the extent, method and completion date for the repair / replacement activity

No repair / replacement activity is required on this condition. A Maintenance Action Item (MAI) (# 16679) has been written to wire brush the mil scale, prep and coat the exposed reinforcing steel with epoxy coating to protect the rebar from further corrosion. This work is not considered to be a "code" repair because the rebar is still able to perform its design function without being coated and coating, by itself, is considered to be cosmetic by inspection.

e. Extent, nature and frequency of additional examinations

No additional examinations are planned because the exposed rebar is acceptable as-is and because it has been coated for corrosion protection.

2) Piece of Wood Exposed on Exterior Surface

a. The cause of the condition that does not meet the acceptance standards

The condition that does not meet acceptance standards was believed to be a 2 x 4 piece of form lumber at azimuth 291 deg, 37 minutes, elevation 360' that was not removed when the original construction opening was closed. This wood was removed by MAI 12911 and determined to be a wooden wedge to provide adequate clearance between the outer layer of rebar and the inner face of the steel formwork.

b. The applicability of the condition to any other plants at the same site

This condition could exist, even though no similar conditions have been discovered during the general visual examination of the concrete surface of ANO-2.

c. The acceptability of the concrete containment without repair of the item

The Operability Assessment associated with CR # 1-99-0214 determined that the containment was in a code-qualified condition with the wood in place in its current condition for the following reasons:

- This specific location is above the shear steel of the containment shell in a region of lower stresses. The void this type of item would create would cause only a small decrease in the overall section modulus; thus, its impact upon the localized concrete stress will be insignificant. The discontinuity created by the board should not create a stress riser in the concrete due to its small size.

- The board is on the outer face of the containment in the tensile region of the beam section during a design bases accident. The stresses in this region are carried by the tendons and the steel rebar. The wood will not affect the structural capacity of these items.

- The above arguments are proven by the fact that the reactor building has previously been subjected to a Structural Integrity Test (SIT), where the containment is pressurized to 115% of design pressure, and Integrated Leak Rate Tests (ILRT), where the containment is pressurized to 100% of the design pressure. The SIT was performed prior to the Unit going commercial and the ILRTs were performed on 3 year intervals through 1992 and have been performed on 10 year intervals since. All total, 6 ILRT and 1 SIT tests have been performed. Inspection of the concrete surface around the board did not reveal any cracking or other signs of distress. Since the form wood was cast into the concrete at original construction this discontinuity has been proven several times by testing to a pressure greater than that which would be experienced by a design accident. Since no cracking was encountered during previous tests; no deterioration is expected during future events to the same or less loading.

- The board, as stated previously, is oriented parallel to the surface of the concrete and does not perpendicularly penetrate the containment shell for any appreciable distance. The seasoned wood will have a density in the 30-45 pcf range so it will provide some shielding. A worse case orientation of this wood to the perpendicular distance of the containment would decrease the 150 pcf concrete thickness from 45 inches to 41.5 inches for a vertical height of 1-3/4 inches. This constitutes an 8% reduction in shielding for a distance less than 0.1% of the height of the containment. A thickness reduction of this magnitude will not affect the overall dose rate analyses for a post LOCA condition; and because of the board orientation, there should not be any appreciable localized change in dose rate due to streaming. The 10CFR100 analyses should remain unaffected.

Issue Resolution:

Even though the wood was determined to have no detrimental effect, it was removed since industry experience at Virginia Power's North Anna 1 noted corrosion due to a peace of form wood left in the concrete that had wicked moisture. ANO Engineering instructions to remove the wood and "repair" the concrete were provided to the plant in ER 980080E104 and MAI 12911.

When the wood was removed, it was discovered to be a triangular wooden wedge 5" long x 2" wide by 2 1/2" deep that was probably used to separate the form and the outer layer of rebar so that adequate concrete cover could be provided.

d. Whether or not repair / replacement activity is required and, if required, the extent, method and completion date for the repair / replacement activity

The defect was corrected under MAI 12911. The wood was removed, the concrete roughened and prepared and the void was grouted flush to the surface to prevent water intrusion and potential long-term degradation. The repair of this defect is considered to be a "cosmetic repair" and not a structural repair of the containment building structure. It has been classified “cosmetic” because the outer layer of reinforcing steel has not been exposed and there is no other damaged material in the vicinity. Since it is cosmetic in nature, the implementation of the requirements of ASME Section XI, Subsection IWL-4000 are not required in the judgement of the Responsible Engineer.

e. Extent, nature and frequency of additional examinations

No additional examinations are planned because this area was "repaired" as a "cosmetic repair" and all the other concrete surfaces have been examined with no similar situations being found.

B. Post Tensioning System Examination

1) Concrete Cracks > .01 in.

a. The cause of the condition that does not meet the acceptance standards

There are two cracks. The first is a diagonal crack approximately 13" long, having a maximum crack width of 0.03", and radiating upward at a 45^0 angle from the edge of the base plate. The second crack is approximately 5" long, having a maximum crack width of 0.01", and radiating downward at a 45^0 angle from the edge of the base plate. These cracks were found in the concrete on ANO Unit 1 Reactor Building at the shop end of horizontal tendon 31H8 on buttress #3. The 13" long crack extends around the chamfered corner of the buttress onto the face of the buttress. The 5" long crack is located only on the concrete adjacent to the tendon base plate since it is not long enough to reach the chamfered edge of the buttress. The tendon base plate is 3" thick, 24" wide, and extends on each side of 31H8 for at least one tendon. The cracks exceed the acceptance criteria in IWL-3221.3 (d). These cracks were documented as part of CR# 1-99-0582.

Based upon location and characteristics the crack origin appears to be Poisson effect/creep induced cracking. Poisson effect cracking is caused by the physical "shrinking" of the building as the tendons are tensioned (i.e. as the building shrinks in height, the sides would be slightly bulged) and the redistribution of mass causes a stress riser near the anchor attachments. This almost immeasurable movement/stress concentration can generate a crack almost immediately after the initial tendon tensioning. Once the initial stress is relieved by the crack generation, there is no additional crack propagation. This phenomenon is confirmed by the observation that the crack appears inactive.

b. The applicability of the condition to any other plants at the same site

Cracking above the threshold criteria of .01" within two feet of the tendon anchorage has not been observed on ANO-2 to date. Although the event that initiated the crack is present in both units, the inspection process is adequate to detect the condition if it is encountered.

c. The acceptability of the concrete containment without repair of the item

During design and construction of ANO Unit 1, Bechtel performed extensive testing of the tendon anchorage and tendon designs used at the Bechtel containments being designed and built at the time. The testing is documented in BC-Topical-7, "Full Scale Buttress Test for Prestressed Nuclear Containment Structures." This Topical documents the performance of the tendons and the concrete under the specified testing conditions. Cracking similar to the two cracks described above was noted in the test specimen. The cracking did not affect the tendon capacities during the tests even when the tendons were taken to destruction.

Tendon 31H8 was inspected during the 25th year surveillance and was found to have good lift-off force, no corrosion, and good grease condition without any water being found. The lift-off force was found to be 7.145 kip/wire as compared with an expected force of 6.66 kip/wire; so there has been no appreciable creep as a result of this defect.

The following justifies that the crack is acceptable as-is:

- The cracks found in the Unit 1 Reactor Building at 31H8 were the only ones found during the surveillance and are similar to those found during the full scale test documented in Bechtel's BC-Topical-7, which was used to prove the acceptability of the reactor building during the original design phase. Based upon this comparison, there is no indication of any problem that would prevent the tendon performing its design function.

- The location of the cracks is in a very highly conventionally reinforced section of the structure. This extra rebar provides additional margin to accommodate this relatively small crack (0.03" width).

- Based upon location and characteristics the origin of the cracks appear to be Poisson effect/creep induced cracking. Poisson effect cracking is caused by the physical "shrinking" of the building as the tendons are tensioned (i.e. as the building shrinks in height, the sides would be slightly bulged) and the redistribution of mass causes a stress riser near the anchor attachments. This almost immeasurable movement/stress concentration can generate a crack almost immediately after the initial tendon tensioning. Once the initial stress is relieved by the crack generation, there is no additional crack propagation. This phenomenon is confirmed by the observation that the crack appears inactive.

- Tendon 31H8 examinations noted that no tendon anchorage corrosion was encountered, the grease condition was acceptable, and the lift-off forces were well above the minimum established values.

- The location of the cracks is on the edge of the buttress and the cracks are oriented in a vertical position. There is no potential of water ponding in this area. Additionally, the cracks are poisson induced which creates a compression type of a crack which is not conducive to water penetration.

In summary, based upon the location, orientation, and inactivity of the crack, the reactor building is considered acceptable in its current condition.

d. Whether or not repair / replacement activity is required and, if required, the extent, method and completion date for the repair / replacement activity

No repair / replacement activity is required at this time.

e. Extent, nature and frequency of additional examinations

Detailed visual examinations will be conducted of this area during the upcoming ILRT on ANO-1 during the 1R16 refueling outage and during subsequent examinations.

2) Broken Tendon Wires

a. The cause of the condition that does not meet the acceptance standards

This condition occurred in two (2) wires in tendon 21H8 as noted in CR's # 1-99-0317 and 1-99-0352. Four test wire samples were cut from these two wires and metallurgical evaluations were performed on the test samples. The metallurgical evaluations concluded the primary mechanism of test wire failure during the tests was ductile tensile overload. Test Wire # 1's most probable cause of failure was overtensioning during original installation. Test Wire # 2's most probable cause of failure was that it was partially saw cut during original installation. Test Wire # 3's most probable cause of failure was overtensioning during original installation. Test Wire # 4's most probable cause of failure was a manufacturing defect (piping porosity in the original ingot).

b. The applicability of the condition to any other plants at the same site

The broken wires were discovered with a visual inspection and no wires were broken when the lift off tests (physical inspection of the tendons) were performed. The visual inspection consisted of the required surveillance tendons, in addition to a 100% sampling of the top vertical tendons with no unacceptable conditions being encountered. A visual inspection was performed on the tendon system for Unit 2 to the same procedure as used for Unit 1 and 100% of the top vertical grease cans were also replaced, the same as Unit 1. There were no undocumented broken wires found in Unit 2 even with the larger than required sample size. The tendons are considered acceptable based upon Unit 2's inspection.

c. The acceptability of the concrete containment without repair of the item

The concrete containment is acceptable without repair or replacement of tendon 21H08 for the following reasons.

- In the course of the ANO-1 25-Year Tendon Surveillance inspection we visually examined: (A) 100% of the 102 top vertical tendon anchorages concurrent with the replacement of the top vertical tendon grease cans, (B) the bottom end of 9 vertical tendons, (C) both ends of nine (9) other tendons (5 dome and 4 hoop), and (D) a review of the previous inspection results . This amounts to a visual examination of approximately 20% of the total accessible tendon anchorages with no additional broken wires.

- The original design bases for the ANO-1 Reactor Building is documented in calculation 11406-014 in which it states that the required area per tendon is 5.4764 sq. in/lf. verses an actual area of 5.6951 sq in/lf. provided. Each tendon consists of 186 tendon wires. Therefore, a total of 7 wires (186 - (5.4764/5.6951 x 186) = 7) may be missing from each tendon. The original acceptance criteria limited the tendon to 3 broken wires or less, so this would allow up to four more wires to be broken in each tendon without extensive review of historical documentation on the tendon of question. Based upon the above criteria a tendon will remain in a code qualified condition providing that seven (7) or less broken wires are encountered in any one tendon. Additional broken wires may be accepted if historic reviews, additional tests, and/or additional inspections are performed and these will be evaluated on a case by case bases.

- A tension test was performed at both ends of the tendon and the tendon was found to have a "lift off" well above the minimum required force. Based upon these tests, the tendon has full capacity and there is no measurable loss. The tendon is in its code qualified condition based upon these tests.

- A visual inspection was made at each tendon end and no corrosion was found. No additional wires failed during the lift off testing.

d. Whether or not repair / replacement activity is required and, if required, the extent, method and completion date for the repair / replacement activity

Repair / replacement is not required since tendon 21H08 is code qualified in its present condition.

e. Extent, nature and frequency of additional examinations

No additional examinations are planned at this time.

3) Grease Void > 10% Net Duct Volume

The tendons where the absolute difference between the amount of sheathing filler removed and the amount replaced exceeded 10% of the net tendon duct volume were tendons V40 (13.3%) and V70 (13.4%). A similar situation where the absolute difference between the amount of sheathing filler (grease) removed and the amount replaced exceeded 5 percent of the net tendon duct volume occurred during the ANO-1 15-Year tendon surveillance. At that time, this variance occurred in 2 vertical tendons (V70 – 9.3 % & V71 – 7.2%) and 3 dome tendons (1D330 – 22.8%, 2D208 – 8.6% and 3D120 – 45.4%). At that time, a 5% variance was used as the "trigger criteria" based upon Regulatory Guide 1.35, Proposed Revision 3 criteria. It should be noted that ANO is not committed to this revision of the Regulatory Guide but rather used this portion as guidance.

a. The cause of the condition that does not meet the acceptance standards

In response to a NRC question on a similar occurrence during the ANO-1 15-Year Tendon Surveillance, calculation 87-E-0052-01 was prepared. The portions of that evaluation that are germane to this occurrence are noted below.

The voids in the tendon sheathing may be attributed to a number of factors:

- Visconorust 2090P-4 has a coefficient of expansion of about 1 % per every 20 deg. F. Initial filling temperatures of the filler material range from 160 to 220 deg. F. Cold weather conditions can cool the filler material to 40 deg. F. giving a contraction of 6% to 9% of the net duct volume.

- Calculated voids between the wires of the tendon bundle are approximately 7% or greater of the net tendon duct volume. During the initial filling operation, the tendon bundle may have been cold (ambient temperature of 45 to 65 deg. F.) and as the filler material was pumped into the sheathing void, it solidified on the surface of the cold tendon bundle, leaving small voids between the wires. As the filler material gradually heated the tendon bundle, it is likely that the voids between the wires allowed migration of the filler material into the tendon bundle. Because this process is slow and gradual, it is reasonable to expect that it took place substantially after the filling operation was completed and possibly during the summer or at operational temperatures. In addition, this type of migration could also occur where the tendons are in contact with the sheathing.

- Characteristics of the initial filling method may induce air entrapment into the filler material. Pumping operations can introduce air into the filler material which may add up to as much as 2% of the net duct volume.

b. The applicability of the condition to any other plants at the same site

No similar conditions have been encountered at ANO-2. However, the installation of the post tensioning system at ANO-2 is similar to that used on ANO-1.

c. The acceptability of the concrete containment without repair of the item

The design basis for the ANO-1 Reactor Building includes the post tensioning system tendons being installed in sheathing embedded in the building's concrete wall and dome. The sheathing is filled with sheathing filler (grease) for long term corrosion protection of the tendon itself. A film of grease adheres to the tendon wires, providing the required corrosion protection. The regulatory concern with tendon grease voids exceeding > 10% net duct volume is that it can indicate either grease leaks or improper filling. When the grease is installed, it is pumped into the duct at a temperature around 190 deg F to ensure adequate coverage of the tendon wires. On vertical tendons, it is pumped in from the bottom of the vertical tendon to preclude the formation of air pockets. The temperature of the grease will be much less during normal plant operation; and as the grease cools, it will contract and form voids. However, experiments performed under extreme temperature ranges have indicated that the voids form in the body of the grease, not against the duct or the tendons. Therefore, even for large temperature changes, the tendons remain sufficiently protected as long as the duct was originally filled with grease.

In response to a NRC question on this occurrence, calculation 87-E-0052-01 was prepared. The portions of that evaluation that are germane to this occurrence are noted below.

> "The main function of the sheathing filler material is to prevent corrosion of both the tendon wires and the anchorage components. The material used, Visconorust 2090-P4, accomplishes this by a characteristic which gives the filler material an affinity to adhere to steel surfaces and its ability to emulsify any moisture in the system, thus nullifying its rusting ability.
>
> **Summary**
> Even under optimum filling conditions, voids ranging from 2% to 19% could be encountered after the initial filling operation. Therefore any void below 19% may be considered as an apparent void and may be related to the reasons indicated above. A true void is that which is in excess of 19%. Based on physical tests on the tendon wires and chemical test of the filler material, there seems to be little correlation between the 2% to 19% void and the structural integrity of the tendon and anchorage system.
>
> In the process of tendon fabrication, all wires are protected from corrosion with Visconorust 1601 Amber material which adheres to the surface of the wires. Unless physically removed, this material provides lasting protection against corrosion."

Since none of the tendon surveillance results indicated any evidence of wire or anchorage component corrosion, it can be concluded that the system is adequately protected.

d. Whether or not repair / replacement activity is required and, if required, the extent, method and completion date for the repair / replacement activity

   No repair / replacement activity is planned because no degradation has been noted to the post tensioning system components as a result of the 13.4 % difference in amount of filler removed and the amount replaced.

e. Extent, nature and frequency of additional examinations

   No additional examinations beyond those normally conducted at the five-year intervals are planned at this time.

C) Tendon Grease Leaks on Concrete Surface

a. The cause of the condition that does not meet the acceptance standards

Minor tendon sheathing filler (tendon grease) leaks exist on the outside of the containment wall on both units in several locations as shown in Table 1 of the Attachment. The cause of these is believed to be one of two potential sources: (1) Loose caps at tendon low point drains or high point vents or (2) Taped joints in the sheathing. The location of several leaks coincide with the location of horizontal tendon low point drains. These drains are plugged with screw on caps which may not have been screwed on tight initially. The other leaks are located along the tendon sheathing and are probably coming from the taped joints in the sheathing. The tendon sheathing is installed in the concrete forms prior to concreting. The requirement of the sheathing is to form the void inside the concrete wall for later installation of the tendons. The sheathing has no requirement for resisting any internal pressure. The joints between two pieces of sheathing or between the sheathing and the trumpet are secured by fitting with a coupler or over each other. To prevent leakage of the concrete paste into the sheathing, the joints are taped with a duct tape. During construction and over time, the duct tape no longer provides a seal and grease leaks from the sheathing and eventually to the concrete surface.

b. The applicability of the condition to any other plants at the same site

This condition is evident on both units in several locations. These locations and the amount of total historic grease leakage is provided in Table 1 of the attachment.

c. The acceptability of the concrete containment without repair of the item

There should be no concern regarding the effect of sheathing filler on the concrete integrity or shear capacity. This conclusion is supported by the findings of a study performed by the Oak Ridge National Labs in 1998 entitled "An Investigation of Tendon Sheathing Migration into Concrete". This study was intended to provide an indication of whether leakage of the tendon sheathing filler into the concrete of a prestressed concrete containment (PCC) affects the concrete properties (tensile and compressive) to an extent that the containment structural capacity could be affected.

This study concluded that the sheathing filler has significantly advantageous characteristics as compared to organic-based lubricants which can cause damage to concrete, especially when elevated temperatures were present. It noted that the study done on tendon grease leakage at San Onofre Nuclear Generating Station indicated that the presence of sheathing filler in the radial concrete cracks did not compromise the structural integrity of the containment and the sheathing filler was non-reactive with the concrete. In addition, the Oak Ridge study noted the following:

- Examination of the concrete core samples removed from the Trojan containment indicated that the appearance of tendon sheathing filler on the concrete surface was due to leakage of the filler from the sheathing and its subsequent migration to the surface through cracks.

- Migration of the tendon sheathing filler was confined to the crack and there was no perceptible movement into the concrete.

- There were no visible indications of chemical interactions between the sheathing filler and the concrete (i.e. absence of concrete spalling and pattern cracking).

- There should be no migration of tendon sheathing filler along the interface between the concrete and mild steel reinforcement unless the interface region has been degraded due to the presence of a crack or corrosion products.

- Results of compression strength tests performed on several uncracked concrete cores obtained from areas of the Trojan containment near observable tendon sheathing filler leakage indicated the concrete quality was consistent in the containment. Additionally, the concrete compressive strength had increased over 40% in the 25-year life of the structure relative to the average compressive strength at 28-days age, so the long term strength characteristics were unaffected.

d. Whether or not repair / replacement activity is required and, if required, the extent, method and completion date for the repair / replacement activity

No repair / replacement activity with regard to repairing these tendon grease leaks is planned at this time for the following reasons:

- Most of these drain plug leaks have existed at least since 1984. Several of them coincide with the location of horizontal tendon low point drains. These drains are plugged with screw on caps which may not have been screwed on tight initially. The drains are recessed in the wall and are presently covered with a cementitious grout. It is difficult to locate the exact location of these drains in many instances. Any attempt to uncover them by chipping of the grout could result in greater damage.

- The other leaks are located along the tendon sheathing and are probably coming from the taped joints in the sheathing. It is especially difficult to locate the exact location of these leaks in most instances. The horizontal tendon and vertical tendon sheathing is located behind the outside layer of reinforcing steel. The horizontal tendon sheathing has a typical concrete cover of 8.5 inches with the vertical tendon being located inside of the horizontal tendon.

- The leaks encountered at ANO are relatively small as shown in Table 1 and the potential for an undetected loss of grease significant enough to leave the tendon unprotected at these leak rates is negligible.

e. Extent, nature and frequency of additional examinations

The inspection programs established for the containment is adequate to detect and measure the leakage to assure that sufficient volume remains to perform this function.

Section V: Conclusion

A) Concrete Surface Examination

1) Exposed Reinforcing Steel

The exposed reinforcement bar as found above can adequately perform its function in it present condition. If the bar had been corroded to the point it was non-functional, the containment would not have been adversely effected because of the excess capacity available at this location.

2) Wood Embedded in Exterior Surface

The piece of wood embedded in the ANO-1 Reactor Building wall had no effect on Reactor Building Structural Integrity. When the wood was removed and a "cosmetic" repair performed, the concrete surface was restored to its originally planned configuration.

B) Post Tensioning System Examination

1) Concrete Cracks > .01 in.

The crack origin appears to be Poisson effect/creep induced cracking. Poisson effect cracking is caused by the physical "shrinking" of the building as the tendons are tensioned and the redistribution of mass causes a stress riser near the anchor attachments. Once the initial stress is relieved by the crack generation there is no additional crack propagation. This phenomenon is confirmed by the observation that the crack appears inactive. The same type of cracking in BC-Topical 7 had no effect on the capacity of the tendons even when the tendons were taken to destruction. The cracks are acceptable as-is and will be monitored.

2) Broken Tendon Wires

The causes of wire failure are either due to manufacturing defect (piping porosity) or installation induced defects (partial saw-cut of the wire, overtensioning of the wire during original installation). Research into original records indicates that nineteen tendons were fabricated from material with the same heat as the failed wires, but only two tendons were fabricated from material from the same coils of wire as tendon 21H08. One of these tendons has been previously inspected and no abnormalities were discovered. Tendon 21H08 was also tested by performing liftoff tests which confirmed that the tendons force level was higher than the expected prestress force at this time in the plant life.

This is considered mute because analysis shows that the tendon would still be code qualified with up to seven (7) wires missing.

3) Grease Void > 10% Net Duct Volume

There is no concern regarding the effect of the grease void in tendons V40 and V70 exceeding 10% of the net duct volume because the grease void was less than 19% of the net duct volume and, in the process of tendon fabrication, all wires are protected from corrosion with Visconorust 1601 Amber material which adheres to the surface of the wires. Unless physically removed, this material provides lasting protection against corrosion. Since none of the tendon surveillance results indicated any evidence of wire or anchorage component corrosion, it can be concluded that the system is adequately protected.

C) Tendon Grease Leaks on Concrete Surface

There is no concern regarding the effect of sheathing filler on the concrete integrity or shear capacity. There were no visible indications of chemical interactions between the sheathing filler and the concrete. There is no evidence of migration of tendon sheathing filler along the interface between the concrete and mild steel reinforcement unless the interface region has been degraded due to the presence of a crack or corrosion products. The grease leaks are considered benign defects at their current leakage rate as determined in the Oak Ridge National Laboratory report of 1998.

Section VI: Attachments

1) Table 1: ANO-1 Grease Leakage From Reactor Building Tendons
2) 10CFR50.59 evaluation
3) Photographs of deficiencies
4) Dwg. C-130 and C-131
5) Hurst Metallurgical Research Laboratory, Inc. Report # 31644, " Failure Analysis of Four Tendon Wires from ANO-1 Tendon # 21H8", January 26, 2000

Attachments

FORM TITLE: ENGINEERING REQUEST	FORM NO. 1000.153A	REV. 004-03-0

Table 1
Grease Leaks From Post Tensioned Tendons in ANO-1 Reactor Building

Unit	Leak Location #	Tendon #	Previous ER / CR #	Amount of leakage (gal)	10 % Void Allowable (gal)
1	Room 144 El. 425, Az 121	31H18	CR 1-99-0547	Not measurable	20.9
	El 365, Az 77	32H9	ER 980481R101, Item 4, # 1	.6 gram	21.0
	El 373'-10, Az 77	32H12	ER 980481R101, Item 4, # 2	.6 gram	20.9
	El 369'-8, Az 76	31H10	ER 980481R101, Item 4, # 3	~ 1/4 pint	20.9
	El 366, Az 89	31H9	ER 980481R101 Item 4, # 4	1.7 gram	21.0
	El 375, Az 75.5	32H12	ER 980481R101 Item 4, # 5	.1 gal	20.9
	Room 77 El. 367, Az 146	32H10	ER 980481R101 Item 5	< 1/16 pint	20.9
	Room 112 El. 379'-10, Az 33	32H14	ER 980481R101 Item 6	9.2 gram	20.9
	Room 112 El. 380'-9, Az 33	31H14	ER 980481R101 Item 6	< 1/2 pint	20.9
	Room 170 El 423'-6, Az 143	31H28	ER 980481R101 Item 7	< 1 pint	20.8
	El 434, Az 50	32H32	ER 980481R101 Item 8	< 1 pint	20.8
	El 436, Az 48	21H32	ER 980481R101 Item 8	< 1 Pint	20.8
	~ El 438, Az 48	32H33	ER 980481R101 Item 8	1 pint	20.9
	El. 436 ~ Az 44	21H32	CR 1-99-0547 Leak # 6	< 1 pint	20.8
	Room 170 El 423, Az 75	32H27	CR 1-2000-0020 Leak 1	< 1/2 pint	20.9
	Room 170 El 420, Az 77	31H27	CR 1-2000-0020 Leak 2	< 1/2 pint	20.9