UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	Docket Nos. 50-348-CivP
ALABAMA POWER COMPANY	)	50-364-CivP
	)	
(Joseph M. Farley Nuclear Plant,	)	
Units 1 and 2)	)	
	)	(ASLBP NO. 91-626-02-CivP)

REBUTTAL TESTIMONY OF RICHARD C. WILSON
ON BEHALF OF THE NRC STAFF CONCERNING CHICO A/RAYCHEM SEALS

Q1. State your full name and current position with the NRC.

A. Richard C. Wilson, Senior Reactor Engineer, Vendor Inspection Branch, Division of Reactor Inspection and Safeguards, Office of Nuclear Reactor Regulation.

Q2. Have you prepared a copy of your Professional Qualifications?

A. A copy of my Professional Qualifications has been admitted previously into evidence as Staff Exh. 1.

Q3. What is the purpose of your testimony?

A. The purpose of my testimony is to rebut portions of the Alabama Power Company Testimony regarding violations of the environmental qualification (EQ) requirements for the Chico A/Raychem Seals at the Farley nuclear plant which led to the civil penalty that is the subject of this hearing. The APCo testimony which

is the subject of this rebuttal testimony is contained in Direct Testimony of Jesse E. Love, James E. Sundergill and David H. Jones on Behalf of Alabama Power Company (ff. Tr. 978) (hereafter L/S/J), and Direct Testimony of Philip A. DiBenedetto on Behalf of Alabama Power Company (ff. Tr. 1227) (hereafter DiBenedetto).

Q4. Could you please summarize APCo's position regarding the Chico A/Raychem Seals as you understand it? (L/S/J Q&A 130, p. 146).

A. The licensee has advanced various arguments since the beginning of the November 1987 inspection. The NRC inspection report, pertinent portions of which are included in my Direct Testimony on pages 10 through 15, addresses information provided during the inspection. My Direct Testimony, particularly the response to Q16 on pages 26 to 31, addresses information submitted after the inspection.

Where the licensee presents only a vague rationale for qualification, and the NRC Staff is unable to envision any plausible rationale based on known tests and analyses, the NRC Staff has a very difficult time specifying what is wrong with the licensee's qualification arguments. The NRC Staff had that difficulty with qualification of the Farley Chico A/Raychem seals until APCo submitted direct testimony in January 1992.

The licensee's direct testimony finally presented a qualification rationale in the response to Q130 (L/S/J p. 146). This response states that (a) Raychem Report EDR 5033 demonstrated qualification of the boot materials, (b) the 1981 Farley submergence test demonstrated the seal's ability to exclude moisture; and (c) the 1981 Bechtel test demonstrated that the Chico backing resolved the moisture problem. I will address this argument in this rebuttal testimony as I am unaware of any other rationale that could demonstrate qualification, based on known test reports or analyses.

Q5. Were you aware of the argument for qualification presented by APCo through Mr. Love's testimony in his answer to Q130 (L/S/J p. 146) at the time of the NRC inspection in November 1987?

A. No. Two of the three test reports on which APCo now bases qualification of the seals were not introduced into this issue until APCo filed its direct testimony in January 1992. My written direct testimony, filed in December 1991, criticized the reports submitted by the licensee prior to 1992, including the 1981 Bechtel test (Staff Exhibit 33). The 1981 submergence test report (APCo Exh. 61) was unknown to me until the licensee submitted and referenced it in its January 1992 direct written testimony, except for a reference to it on pages 224-25 of Mr. Love's 1991 deposition which related only to outside-containment applications. Raychem Report EDR 5033 (also known as Wyle Report 58442-2) (APCo

Exh. 60) was also not referenced by the licensee until its 1992 testimony. I will address all of these reports in my rebuttal testimony.

Q6. Lets take things one step at a time. To begin with, what are the requirements applicable to the environmental qualification of Chico A/Raychem seals at Farley?

A. 10 C.F.R. § 50. 49 is the requirement for qualification and is what must be followed. The regulation specifies extensive criteria for qualification, essentially similar to Category I of NUREG-0588. Section (k) of that regulation does not require requalification for equipment that was previously required to be qualified to NUREG-0588 or to the DOR Guidelines. NUREG-0588 Category I is a higher level of criteria referencing IEEE Standard 323-1974, while Category II and the DOR Guidelines reference IEEE Standard 323-1971. Farley Unit 1 is subject to NRC IEB 79-01B, which requires meeting the DOR Guidelines. Farley Unit 2 is required to meet Category II of NUREG-0588. The DOR Guidelines are the less stringent of the two standards.

Q7. Please explain the requirements of the DOR Guidelines (APCo Exh. 8) as they relate to qualification of the Chico A/Raychem Seals.

A. The DOR Guidelines are the lowest level of qualification criteria. They were written to permit qualification of existing equipment in operating plants for which qualification testing had preceded establishment of specific qualification criteria.

The DOR Guidelines allow limited separate effects testing because existing (pre-1980) test reports often had limitations such as failure to irradiate the LOCA steam test specimens, and could not substantiate qualification to higher level criteria. (Separate effects testing involves simulating a LOCA by multiple tests, each of which includes only some of the LOCA harsh environment parameters.) Radiation and chemical spray normally may be addressed separately, by test or analysis, and thermal aging of test specimens is normally not required.

The DOR Guidelines do not endorse qualification by analysis or evaluation with respect to temperature, pressure, and steam. Section 5.1 states that

> "type testing is the preferred method of qualification for electrical equipment located inside containment required to mitigate the consequences of design basis events.... As a minimum, the qualification for severe temperature, pressure, and steam service conditions for Class IE equipment should be based on type testing."

Again, section 5.3 states that "an item of Class IE equipment may be shown to be qualified ... even though it was only type tested for high temperature, pressure and steam."

The DOR Guidelines have limited, but very clear, criteria for supplementing partial-effects tests with analysis. Section 5.1 states:

> Qualification for other service conditions [other than the combined LOCA temperature, pressure, steam test] such as radiation and chemical spray may be by analysis (evaluation) supported by test data (see Section 5.3 below). Exceptions to these general guidelines must be justified on a case by case basis."

Section 8.0 states:

> "Complete and auditable records must be available for qualification by any of the methods described in Section 5.0 above to be considered valid. These records should describe the qualification method in sufficient detail to verify that all of the guidelines have been satisfied.

The DOR Guidelines do not endorse the concept of "qualified materials" as advanced by the licensee. Section 5.2.2 states:

> The test specimen should be the same model as the equipment being qualified. The type test should only be considered valid for equipment identical in design and material construction to the test specimen. Any deviations should be evaluated as part of the qualification documentation.

None of the environmental qualification criteria make any provision for generic qualification of any materials.

The DOR Guidelines have additional restrictions for installation interfaces such as seals. Section 5.2.6 states that,

> ...seals used during the type test shall be representative of the actual installation for the test to be considered conclusive. The equipment qualification program shall include an as-built inspection in the field to verify that equipment was installed as it was tested.... Particular emphasis should be placed on common problems such as penetrations in equipment housings for electrical connections being left unsealed.

Section 5.3.2 states:

> The effects of chemical sprays on the pressure integrity of any gaskets or seals present should be considered in the analysis.

The DOR Guidelines do not allow qualification credit for failed tests. Section 5.2.5 states:

> If a component fails at any time during the test ... the test should be considered inconclusive with regard to demonstrating the ability of the component to function....

In other words, test failures are not a basis for qualification. This requirement prohibits the sort of argument that says, there were test failures, but we know what caused them and fixed it, so there is no need to retest. The reasons are that a) another failure mode may have been masked by the observed failure and b) another failure mode might have occurred if the test had run to completion.

Q8. To which standard has APCo attempted to demonstrate qualification of the Chico A/Raychem Seals?

A. During the NRC inspection on November 18, 1987, I asked the qualification level of the seals and the licensee responded NUREG-0588 Category II only. APCo testimony filed in January 1992, however, addresses the DOR Guidelines.

Q9. Mr. Love asserts that the concerns regarding the Chico A/Raychem Seals in the inspection report from the November 1987 inspection (Staff Exh. 12) have no technical basis. What is your response? (L/S/J Q&A 139, p. 156).

A. I will focus my answer on the importance that sections 5.2.2 and 5.2.6 of the DOR Guidelines (APCo Exh. 8) place on the similarity between installed

equipment and test specimens. Item (1) in the inspection report (quoted on page 14 of my Direct Testimony) stated that the installation instructions do not control the minimum quantity of Chico mixture. APCO has never disputed that. However, Mr. Love testified that the Chico cement would be visible. (Tr. 998 and 991). Even if the view through the limit switch permitted that, APCO provided no instructions directing the installer to perform a visual inspection or to take any action based on observations.

Item (2) in the inspection report stated that the procedures provided during the inspection did not cover details known to be important in Raychem-designed applications of its seals. The response to rebuttal Q11 below shows that APCO still has not adequately addressed the differences pertaining to installing Raychem materials over a steel pipe nipple.

Item (3) in the inspection report stated that Bechtel's test plan references different drawings and revisions than were provided to me as plant installation drawings, and that the installation drawings showed that pertinent information had been changed by drawing revision. APCO has never addressed these concerns.

Item (4) in the inspection report documented differences in various APCO descriptions of the compression adapter applied over the Raychem sleeve. Contrary to the DOR Guidelines, none of these characterizations provide a model number or other descriptive information. APCO has never addressed this concern. When questioned by the Licensing Board, Mr. Love testified that the

primary purpose of the coupling was to reconnect the conduit to the limit switch assembly. He stated that the connecting force would be exerted against the Raychem sleeve. (Tr. 989). Thus, the torque available from several feet of cable conduit is applied to the conduit's end support through the Raychem sleeve, with potential for damaging the Raychem material.

Q10. Does APCo's qualification argument meet even the less stringent requirements of the DOR Guidelines?

A. APCo's qualification argument for the Chico A/Raychem seals does not satisfy any applicable regulatory requirements for environmental qualification including the DOR Guidelines. The NRC Staff's position is not based on technicalities with respect to when an argument was made or whether documentation is sufficient. The NRC Staff's position is based on the simple fact that, more than six years after the EQ deadline and more than four years after the Farley inspection, there is no credible basis for qualification to even the most lenient EQ criteria for the argument stated in the response by Mr. Love to Q130 (L/S/J p. 146), that (a) Raychem Report EDR 5033 demonstrated qualification of the boot materials; (b) the 1981 Farley submergence test demonstrated the seal's ability to exclude moisture; and (c) the 1981 Bechtel test demonstrated that the Chico backing resolved the moisture problem.

Q11. Let us take these reports one at a time. Why is APCo mistaken in its reliance on Raychem Report EDR 5033?

A. Raychem Report EDR 5033 is also known as Wyle Report 58442-2 and is dated April 3, 1981 (APCO Exh. 60). This report covers qualification testing of cables with Raychem's basic cable breakout boots, where each boot provided an environmental seal between the jacket of a cable and the insulators of the cable's individual conductors. Each breakout had a Raychem keeper sleeve. Testing was conducted in accordance with IEEE Standard 323-1974. Each test specimen was subjected to thermal aging, radiation exposure, and a simulated LOCA test that combined temperature-pressure-steam-chemical spray.

The NRC Staff contends that even the lenient DOR Guidelines require documented evaluation beyond what the licensee has provided. The Farley Chico A/Raychem seal uses the Raychem material in a very different application than in the Wyle tests for Raychem. For Farley, the boot is installed over a metal pipe nipple, clamped against the nipple under a metal conduit fitting, and lacks the (non-metallic) plastic and elastomeric backing provided in a cable application. With the exception of Sandia tests (NUREG/CR-2812 and NUREG/CR-3361) that included no Raychem material or electrical application, and other test reports marred by failures, the licensee has provided no basis except qualitative rhetoric for applying the cable test reports to the Farley seal.

The NRC Staff has long accepted reports such as Wyle Report No. 58442-2 as the basis for plant-specific qualification of Raychem products on many types of cables. We have not reviewed this particular report with respect to Farley plant conditions (and we note that the licensee should document the evaluation as part of his files), but the NRC Staff recognizes that Raychem breakout boots on cables have been qualified for many plants with harsh environments comparable to Farley.

There is no test of the Farley Chico A/Raychem seal design in the LOCA temperature, pressure, and steam environment. Wyle report 58442-2 is the only steam or chemical spray test used for in-containment qualification of the Chico A/Raychem seals at Farley. (I note that failures invalidate every known LOCA test involving Raychem boots on metal pipe nipples; cf. DOR Guidelines section 5.2.5.) DOR Guidelines section 5.1 specifies a combined temperature-pressure-steam test for LOCA conditions. Section 5.2.2 specifies that the plant equipment must be identical to the test specimen in design and material construction; evaluation of any deviations should be documented.

Mr. Love's description of APCo Exh. 103, (Tr. 987) describes how the Raychem breakout boot is shrunk over the steel pipe nipple with a hot air gun. Mr. Love testified that Raychem provided instructions for installing the breakout boot on the steel pipe nipple. (Tr. 1091).

I am unaware of any successful LOCA test of a Raychem boot over a steel pipe nipple. Further, Raychem did not market such a configuration for in-containment use. Thus, when Farley installed the breakout boot kits in 1980-81 there was no basis for an environmentally qualified installation instruction for such a design, as Mr. Love's testimony suggests.

The tautness and thickness of the Raychem boot across the open end of the steel pipe nipple are direct functions of heating during installation. APCo has testified that LOCA test failures of this design were caused by "the material weakness of the boot in the center of the boot legs." (L/S/J p. 144). While I contend that APCo does not necessarily know the exact failure mode, the test failures certainly occurred in the Raychem material stretched across the open end of the steel pipe nipple, which includes the base of the legs. Where in that region the failures initiated is not clear.

APCo has never provided the installation instructions for the Raychem boots over steel pipe nipples at Farley. But it is clear that, unless the instructions specified heat-shrinkage control more precisely than is necessary for a qualified cable installation, Raychem material thinning and weakening could result. Further, Wyle LOCA tests for Raychem (Staff Exh. 35) and APCo's pressure-temperature test in 1981 (Staff Exh. 33) both produced catastrophic failures, again suggesting that 1980-81 instructions for installing Raychem boots over steel pipe

nipples were not based on successful harsh-environment tests and would not produce a qualified seal.

Mr. Love testified further that no special preparation of the steel pipe nipple was necessary before installing the Raychem materials on it. (Tr. 1006, 1076, and 1084). Fittings such as pipe nipples often are coated with chemical residue from manufacturing operations that could interfere with bonding of the Raychem adhesive to the steel. In addition to the absence of a cleaning procedure, the Farley plant drawings provided to the NRC Staff do not specify the use of degreased pipe nipples. Pipe fittings often have burrs or sharp edges that could cut the Raychem material, but the Farley procedures do not specify any smoothing. The drawings provided during the NRC inspection merely specify a '1" nipple,' and the 1981 Farley test procedure specifies a '1" pipe nipple (4" long).' The effects of possible chemical contamination of the steel pipe nipple on the Raychem adhesive bonding or of sharp steel edges on the Raychem material should also be addressed in any analysis of specimen differences between cable and steel pipe nipple configurations.

The NRC Staff did not place APCo in the predicament of having to analyze large deviations between plant and test specimens and conditions. By its selection of the test specimens and conditions, APCo determined the scope of analysis required. The DOR Guidelines were applicable to Farley Unit 1, and NUREG-0588 to Unit 2, before APCo made the decision not to LOCA-test the

seal design. Even the 1979-80 testing reported in Wyle report 58442-2 was performed to the high level qualification procedures of IEEE Standard 323-1974 (referenced by NUREG-0588 Category I). The licensee's direct testimony states that no testing of the Farley metal pipe nipple seal was planned (except a submergence test unrelated to in-containment service) because its qualification was considered assured. (L/S/J pp. 144-146). Fortunately, Raychem then had Wyle LOCA-test a metal-nipple configuration, which failed catastrophically. Even then, the licensee did not perform a LOCA test. Instead, APCo assumed a failure mode, added Chico cement as a fix, and performed the simple 1981 Bechtel temperature and pressure test to demonstrate that the Chico backing resolved the moisture problem.

Q12. Before we get to that test, can you explain why is APCo mistaken in its reliance on the 1981 Farley submergence test to demonstrate the seal's ability to exclude moisture?

A. The 1981 Farley submergence test report 2BE-1049-3 (APCO Exh. 61) reports testing of a Namco limit switch with an attached cable entrance seal. The seal is somewhat like those used in the Farley plant, with several differences: the test specimen and plant equipment have different Raychem kit numbers; the test specimen has no conduit clamp bearing down on the Raychem sleeve; and the test specimen contains no Chico cement. The test specimen was submerged in 10 feet

of 210°F water for 24 hours. The limit switch was periodically actuated, and continuity and insulation resistance measurements were made for the limit switch contact circuits.

This test falls far short of the temperature-pressure-steam test required by section 5.1 of the DOR Guidelines, and no analysis of test condition differences has been provided by the licensee. Analysis of design differences has not been documented as required by section 5.2.2. The test does not demonstrate the moisture resistance of the seal for in-containment use for numerous reasons, but primarily because the test specimen simply never saw the LOCA harsh environment conditions of high temperature, high pressure, and chemical spray. The test is subject to the same types of deficiencies cited in the response to my Direct Testimony Question 8: no steam; no chemical spray; temperatures and pressures well below LOCA conditions; differences between installed and tested equipment; and APCO's failure to analyze all of these differences (APCO merely claims credit for favorable features and ignores differences). This evaluation, and that of Wyle report 58442-2 above, can be added to those presented in the response to Question 8 of my Direct Testimony to provide a summary evaluation of all of the seal tests reports advanced by APCo through January 1992.

Q13. Why is APCo mistaken in its reliance on the 1981 Bechtel test (Staff Exh. 33) to demonstrate that the Chico backing resolved the moisture problem?

A. Specifically in terms of DOR Guidelines requirements, Section 5.1 specifies a combined temperature-pressure-steam test for LOCA conditions. Section 5.2.2 specifies that the plant equipment must be identical to the test specimen in design and material construction; evaluation of any deviations should be documented.

The 1981 Bechtel test did not include steam or any other moisture; it did not simulate the initial temperature rise of the specimen that would be produced in a LOCA; there was no adequate method of assessing seal performance; and, as specified in the NRC inspection report (Staff Exh. 12 and page 14 of my Direct Testimony), the test specimen was built according to different instructions than the plant equipment. The licensee has not provided analyses of any of these deviations which the NRC identified in the inspection report.

In a LOCA, saturated steam will impinge on the room-temperature seal. The steam will condense on the surface of the seal, transferring heat because of both temperature differential and latent heat of vaporization. The condensed steam in turn will enhance heat transfer from additional steam to the seal, resulting in rapid heating and intimate contact with moisture containing chemical spray. Most LOCA tests simulate this effect; the 1981 Bechtel test did not. In the Bechtel test, the seal could be heated only by dry stagnant air or by conduction from a test chamber with undocun.ented dimensions and materials, and with undefined electrical heaters as a heat source. As the room-temperature

thermal mass of the seal and chamber cover absorbed heat, they would tend to reduce the chamber ambient temperature.

Because of the large differences between test and accident conditions, thermal lag calculations comparing the Bechtel test with LOCA conditions are appropriate. The calculations would be very difficult, however, because they would have to take into account the behavior of the Raychem material stretched across the open end of the steel pipe nipple.

Q14. The licensee has testified at length regarding the design evolution of the Chico and Raychem seal design, and has extensively argued about postulated failure modes for untested situations. Why is this not sufficient for qualification?

A. Documentation of qualification is not a design review process, in which the design is critiqued and a judgment concerning acceptability is reached. APCo unsuccessfully tried that approach with the seal assembly designed with Raychem without Chico cement that subsequently failed when tested under LOCA conditions. Environmental qualification relies on proving by test, supplemented by analysis, that safety-related components in fact can perform their harsh-environment safety functions according to published regulatory requirements.

This proceeding does not address whether the seal design makes sense, or was developed in a logical manner, or has a reasonable chance of performing its

harsh-environment safety function. It addresses whether the licensee has satisfied the published qualification requirements for the seal. Whether or not a violation occurred should be based on whether the licensee satisfied the environmental qualification requirements, not on design reviews or exercises in speculating on what might happen if the accident situation occurs.

Q15. APCo's witnesses have criticized the NRC Staff's review of the Chico A/Raychem seals as incomplete and biased, indicating a sense of unfairness on the part of the NRC Staff toward APCo regarding inspection of the Chico A/Raychem Seal environmental qualification. (L/S/J Q&A 139, p. 156; L/S/J Q&A 151, pp. 176-77; DiBenedetto Q&A 115, pp. 94-97). How do you respond to this?

A. APCo was not treated unfairly in the NRC Staff's review of environmental qualification of the Chico A/Raychem Seal or any other item of equipment during the November 1987 inspection. I exerted extra effort to review the seal design at Farley. As the inspection report (Staff Exh. 12) and my Direct Testimony document, the qualification documentation for the Chico A/Raychem Seals at Farley was incomplete and unorganized during the inspection. Because of the lack of an auditable qualification file two years after the November 30, 1985 deadline, I conducted the inspection primarily by oral questions and answers, and discussions with licensee representatives, supplemented by review of all documents APCo was able to produce and even a drawing I made during the

inspection on a whiteboard. I, in fact, used a similar approach during the Farley inspection for ASCO solenoid valves and instrument accuracy issues, as described on pages 35-37 and 42-44 of the inspection report (Staff Exh. 12). I considered all the information APCo could produce regardless of whether it was in the qualification file. In the case of the other two issues, after extensive review, no violation was recommended. However, in the case of the Chico A/Raychem Seals, APCo's information, as I have testified, was clearly inadequate.

The testimony in this hearing shows that I found an incomplete EQ file for the Chico A/Raychem Seals and that I attempted to obtain whatever information APCo could provide to support qualification of the seals. Notwithstanding my consideration of all the arguments advanced by APCo, both during and subsequent to the inspection, APCo has not demonstrated qualification of the Chico A/Raychem seals as they were installed at Farley.

HEARING TESTIMONY REBUTTAL

Q16. Mr. Love supported the argument that Chico cement need not be compressed during installation by testifying that the Crouse-Hinds explosion-proof fitting tested in the Southwest Research Institute (SwRI) test was not intended to compress the Chico cement. (Tr. 1087-88). What does the SwRI test report in the EQ file for Chico A/Raychem seals indicate?

A. The July 13, 1979 letter report (Attachment 3 to Staff Exh. 40) states in item 5 of Attachment No. 1 (Bates No. 005580 of Staff Exh. 40):

> The [Chico] compound was then poured through the large opening in the fitting making sure no air pockets developed during the pour. Both plugs were then screwed in flush with the body of the fitting forcing the excess sealing compound to exert pressure on the fiber dams at each end of the fitting.

In contrast to the concern about air pockets cited in this quotation, Mr. Love testified that the length of tygon tubing used for inserting Chico cement from the veterinary syringe, through the side of the limit switch, into Farley plant seals was not specified. (Tr. 1096). This testimony is consistent with installation instructions provided to the NRC Staff. However, the unspecified tubing length and the failure to specify the position of the bottom of the tubing during cement insertion constitute additional examples of assembly operations that were not procedurally controlled.

Mr. Love testified that he was unaware of problems with the release of water from Chico cement at elevated temperatures in explosion-proof fittings. (Tr. 1096). With respect to the SwRI testing, I note that the fittings involved "pass-through" cables with intact jackets presumed impervious to moisture, and that no moisture measurements were made.

Q17. Could the fact that the Chico cement is not compressed in the Farley Chico A/Raychem seal impact its performance under LOCA conditions?

A. Absent a test of the seal under LOCA conditions, I do not know. APCo has not established that the Chico cement bonds to the steel pipe nipple for Farley LOCA conditions, particularly if not compressed. The upper end of the Chico mass in the seal is not restrained. If the Chico mass moves, it will not perform its design function of backing the Raychem material stretched across the open end of the steel pipe nipple. Since APCo has not performed a temperature-pressure-steam test of the seal, one may readily speculate that the approximations of the simplified test that was performed do not challenge the seal as would a LOCA, particularly at the beginning of the accident where the test simulation is least accurate.

Q18. Messrs. Love and Sundergill refer to analysis that was performed to show why temperature-pressure-steam testing of the Farley seal design was not performed, and why LOCA testing of Raychem's cable breakout boot applied to the Farley seal design using a steel pipe nipple. (Tr. 1079-83). Is documentation of these analyses required?

A. Sections 5.1, 5.2.2, and 8.0 of the DOR Guidelines require documentation of such analysis. No documentation has been provided by APCo.

Q19. Does this complete your testimony regarding this matter?

A. Yes.