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

DIRECT TESTIMONY OF ALABAMA POWER COMPANY

VOLUME II

Testimony of:

Jesse E. Love,
James E. Sundergill, and
David H. Jones

Alabama Power Company

the southern electric system

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DIRECT TESTIMONY OF JESSE E. LOVE,
JAMES E. SUNDERGILL and DAVID H. JONES
ON BEHALF OF ALABAMA POWER COMPANY

I. INTRODUCTION

A. Experience and Qualifications

Q1. Will you please state your name and title for the record?

A: (Love) Jesse E. Love. I am employed by Bechtel Corporation as a Project Engineer for the Farley Project.

(Sundergill) James E. Sundergill. I am employed by Bechtel Corporation as the Engineering Supervisor of the Electrical and Control Systems Group of the Farley Project.

(Jones) David H. Jones. As I stated in my earlier testimony in this proceeding, I am employed by Southern Nuclear Operating Company, Inc., as Manager of Engineering

Support, Farley Nuclear Plant. In my earlier testimony, I provided my background information. I refer you to that testimony.

Q2. Mr. Love and Mr. Sundergill, would you now provide your educational background and employment history?

A: (Love) As an undergraduate, I earned a Bachelor of Science degree in electrical engineering from Pennsylvania State University. I also have a Master of Science degree in nuclear engineering from Catholic University of America.

After graduating from Penn State in 1969, I immediately began working for Bechtel Corporation. I initially served as an engineer in Bechtel's Electrical Nuclear Control Grou assigned to the Baltimore Gas & Electric Company's Calvert Cliffs Nuclear Power Plant, Units 1 and 2. Ultimately, I became the Control Group leader and, in that capacity, was responsible for design and supervision of engineering associated with plant process instrumentation and computers, nuclear instrumentation, the radiation monitoring system, emergency diesel generators, reactor process control and protective systems, main and unit transformers, containment and electrical penetrations assemblies, plant synchronization and breaker controls, and the plant security system.

About four and one-half years later, I was transferred by Bechtel and became its Assistant Electrical Engineering Group Supervisor for the Grand Gulf Nuclear Station, Units 1 and 2. Eventually I became the Group Supervisor and was responsible for all engineering related to the electrical design of the plant. This included preparation of design schedules and budgets, system descriptions, and design calculations; development of electrical equipment specifications; evaluation of equipment proposals; preparation of electrical single lines and three line meter and relay diagrams; preparation of control schematics for the electrical and process control systems; and licensing activities.

My work at Grand Gulf ended in 1979 when I became the Electrical and Controls Systems Engineering Supervisor for Bechtel's Farley Nuclear Plant (Farley) project. In this position, I was responsible for the design and supervision of all electrical power, control and instrumentation engineering activities within Bechtel's scope of design. This included processing design changes and improvements requested by the licensee, Alabama Power Company (APCo), for the operating units, licensing activities for Units 1 and 2, and coordinating design activities with Southern Company Services.

In 1987, I became Bechtel's Assistant Project Engineer for Farley Project, and later, its Project Engineer, responsible for electrical and control systems, mechanical, civil, and plant facilities design for Farley Units 1 and 2. I still serve as the Project Engineer and, in that capacity, am responsible for managing design projects related to plant operability improvements, licensing commitments, and maintenance improvements.

(Sundergill) I have a Bachelor of Science degree in electrical engineering from the University of Maryland. In addition, I earned a Master of Science degree in Management Science from Frostburg State College. I am a registered Professional Engineer (Electrical) in Maryland, Pennsylvania, and Alabama as well as a registered Professional Engineer (Fire Protection) in California.

Immediately upon graduation from the University of Maryland in 1970, I began working for Bechtel Corporation. During my first assignment, I was responsible for the design of various electrical systems for the Calvert Cliffs Nuclear Power Plant and the SNUPPS project.

I was later assigned to be the Electrical Group Supervisor for Bechtel's Turkey Point Nuclear Power Plant project. Following that assignment, I served as Bechtel's Electrical

Systems Group Leader for the Grand Gulf Nuclear Power Station. My primary responsibilities in the latter position included reviewing electrical licensing responses, overseeing the electrical systems design, and acting as the project Equipment Qualification Coordinator for both seismic and environmental qualification. Near the end of the Grand Gulf assignment, I was also Bechtel's Electrical Group Supervisor for the Susquehanna Steam Electric Station.

In my next assignment at Bechtel, I became the Group Supervisor for TVA's Browns Ferry Nuclear Power Plant. In that position, I led a multi-discipline group responsible for the production of environmental qualification packages. Following the completion of that assignment, I was transferred to Bechtel's Farley Nuclear Plant Project. Initially, I served as the Equipment Qualification Group Supervisor. I am still assigned to the Farley Project at Bechtel, supervising the Electrical and Control Systems Group.

(Love, Sundergill) Resumes outlining our educational and employment histories, as well as our professional affiliations and activities, are included in APCo Exhibits 29 and 30.

Q3. Have you part 'pated in any post-graduate training programs or seminars re ted to environmental qualification of electrical equipment?

A: (Love) Yes. Since the early 1970's, I have participated in numerous in-house training programs at Bechtel pertaining to environmental qualification (EQ). These programs addressed the EQ requirements of IEEE-323 (1971 and 1974), the first industry standard addressing environmental qualification, as well as the daughter standards in IEEE-317, IEEE-334, IEEE-382, and IEEE-383. I served as the instructor in several of these seminars.

(Sundergill) Between 1980 and 1984, I attended three separate seminars on the subject of environmental qualification. The first was sponsored by IEEE/Drexel and was held on September 22 through 24, 1980. It addressed the overall subject of environmental qualification, from both a technical and regulatory viewpoint. We discussed the industry's EQ standards and the NRC's acceptance of them. In particular, the seminar addressed IEEE-323, including both the 1971 and 1974 versions; many of the daughter standards, such as IEEE-317; the issue of seismic qualification; Reg. Guide 1.89; and IE Bulletin 79-01B.

The second EQ seminar I attended was sponsored by the Electric Power Research Institute (EPRI). Held on March 8 through 10, 1983, it focused, almost entirely, on the interpretation of NUREG-0588.

The final seminar I attended was offered during December 1983. It was an EPRI-sponsored overview of 10 CFR 50.49 and the industry's interpretation of the regulation. It provided a forum for industry feedback on the experience gained during the ten months subsequent to the promulgation of 10 CFR 50.49.

Q4. How did you stay abreast of EQ developments after being assigned to Bechtel's Farley project?

A: (Love, Sundergill) The Bechtel licensing staff internally distributes notices of NRC developments, including those concerning EQ. For example, we were, and still are, routinely provided with information notices, bulletins, meeting minutes, and workshop materials relevant to our project assignments. Bechtel also tracks and distributes information concerning NRC enforcement actions. In addition, we were kept informed of the results of the NRC's first round of EQ inspections through Nuclear Group on Equipment Qualification (NUGEQ) documents.

B. Specific Roles of the Witnesses

Q5. In general, how have you been involved in the events leading up to this enforcement action?

A: (Love) My involvement with environmental qualification at Farley dates back to 1979 when Bechtel assigned me to be the Electrical and Control Systems Engineering Supervisor on the Farley project. I am familiar with APCo's response to IE 79-01B, NUREG-0588, Reg. Guide 1.97, the Franklin Research Center's Technical Evaluation Reports (TERs), and the NRC Staff's December 1984 Safety Evaluation Reports (SERs). In addition, I have been involved, in varying capacities, in the licensee's meetings with the Staff subsequent to the November 1987 inspection, the March 1988 Enforcement Conference, and the follow-up inspection in March 1988.

(Sundergill) In July 1987, I became fully involved with environmental qualification at Farley, working as part of APCo's EQ Task Team. The Task Team was charged with enhancing the Farley EQ files in anticipation of the NRC's "first round" EQ inspection later in the year. Prior to that time, in the fall of 1985, I briefly worked on some of Bechtel's continuing qualification efforts for the plant. I was present during the November 1987 inspection as well as the Enforcement Conference and follow-up inspection in March

1988. I alsc reviewed APCo's response to the Staff's August 1988 Notice of Violation.

(Jones) As I stated in my earlier testimony, in 1981 I was assigned to be the EQ Project Engineer for Farley Nuclear Plant. Again, I refer you to that testimony for more detail regarding my activities up to and including the time of the 1987 NRC EQ inspections at Farley.

Q6. What is the purpose of your current testimony?

A: (Love, Sundergill) The purpose of our testimony is to provide both factual and opinion evidence in support of the direct case which the Alabama Power Company is filing with the NRC in response to the Order Imposing a Civil Monetary Penalty, dated August 21, 1990. We address various issues cited in the Order as the bases for the imposition of a civil penalty. We will also address the Staff's direct testimony filed in this case.

(Jones) The testimony of this panel is intended to address in detail the technical issues still in dispute. The testimony is primarily that of the Bechtel witnesses. However, because of my longstanding involvement as the EQ Project Engineer for Farley and because of my oversight of

Bechtel's activities for APCo, I will occasionally offer additional insights and perspectives.

C. <u>Development of the EQ Program at Farley</u>

Q7. To what extent are you familiar with the EQ organization at the Farley Nuclear Plant?

A: (Love, Sundergill) We are both very familiar with the EQ activities undertaken at Farley. There is no "organization" at the plant dedicated solely to EQ. There are, however, specific individuals who are responsible for maintaining the EQ program and who act as a central point for on-site EQ coordination. The overall EQ program at Farley is comprised of both on- and off-site personnel. There is a central coordinator in the licensee's corporate office who monitors activities such as the production of EQ Packages by Bechtel.

Q8. How long has Bechtel been involved in the EQ program at Farley?

A: (Love, Sundergill) Since the early 1970s. Environmental qualification requirements can be traced back to General Design Criterion 4 (APCo Exhibit 31), which requires licensees to demonstrate that plant equipment can function in installed environments. Bechtel was involved in the design, as well as the construction, of Farley. As such, it assisted APCo in ensuring that the design and installation of the plant's electrical equipment was environmentally qualified. Consequently, the initial design of the plant and subsequent purchase of equipment were in accordance with EQ guidelines in effect at the time of those activities. As a result, EQ is not a new activity at Farley Nuclear Plant. Rather, it is an on-going program whose inception pre-dates promulgation of the current regulations.

Q9. What was the nature of th work performed by Bechtel at Farley prior to the issuance of IE Bulletin 79-01B? Was the environmental qualification of electrical equipment being considered?

A: (Love) Prior to the issuance of IE Bulletin 79-01B (APCo Exhibit 8), Bechtel was working with Southern Company Services, Inc. and beginning to identify and evaluate the electrical equipment that would ultimatelv be included in the EQ Master List for Farley. In this regard, APCo was addressing EQ in the design process and satisfying IEEE-323 prior to the issuance of IE Bulletin 79-01B. Basically, we were considering various formats for evaluation, looking at the type of qualification documentation that existed at that point in time in the plant's files, and determining what, if any, actions had to be taken in response to Circular 78-08. (APCo Exhibit 32).

Q10. Are you familiar with the work Bechtel performed at Farley in response to IE Bulletin 79-01B?

A: (Love) Yes. I have been involved with the Farley EQ program since 1979, when I became the Electrical and Control Systems Engineering Supervisor on Bechtel's Farley project. During that time period, Southern Company Services, Inc. and Bechtel were assisting APCo prepare its responses to IE 79-01B and NUREG-0588. This activity entailed the evaluation of electrical equipment, implementation of certain hardware modifications, such as the installation of NAMCO EA-180 limit switches, and development of an accompanying documentation system comprised of a Master List, checklists and SCEW sheets which will be discussed further, later in this testimony.

Q11. Please describe, in general, Bechtel's involvement in Farley's EQ program after APCo submitted its response to IE Bulletin 79-01B.

A: (Love) Bechtel assisted APCo in further evaluating the plant's electrical equipment, per the instruction of Regulatory Guide 1.97 (APCo Exhibit 32), and in determining the need for additional equipment modifications necessary to meet the NRC's EQ expectations. In order to qualify all Category I equipment, it was necessary to change-out some plant hardware. For example, APCo installed upgraded high radiation monitors in containment. When the Franklin Research Center Technical Evaluation Reports (TERs) were issued in January 1983 (APCo Exhibits 16 and 17), we reviewed the TERs and helped APCo address the deficiencies identified in them.

Q12. On December 13, 1984, the NRC Staff issued two SERs approving the Farley EQ program. What was your perception of this 1984 NRC approval?

A: (Love, Jones) The Staff's December 1984 SERs (APCo Exhibit 21) acknowledged the success of the licensee's EQ efforts. It concluded that APCo's EQ program was in compliance with the NRC's requirements at the time.

Q13. What, if any, EQ activities transpired at Farley between January 1985 and the 1987 inspections?

A: (Love, Jones) During this time period, APCo was implementing an Administrative Plan to ensure the maintenance of the plant's EQ program. It also implemented a program to ensure the replacement of EQ equipment with limited qualified lifetimes.

(Jones) In the summer of 1987, APCo also organized the EQ Task Team I mentioned earlier. In July 1987, Mr. Sundergill became Bechtel's representative on the Task Team, responsible for supervising an effort to review and assess the status of the EQ files at Farley.

(Sundergill) More specifically, with respect to the Task Team, APCo requested that we look at the auditability of the EQ packages that had been produced for Farley and determine if any enhancement to them was necessary. In response, we compared the existing EQ packages with the Master List and the standards set forth in IE Bulletin 79-01B, NUREG-0588, and 10 CFR 50.49. After completing this review, and prior to the September 1987 inspections by the NRC Staff, we concluded that, overall, the equipment was qualified. We did make recommendations, however, on how to enhance the level of explanation in the existing EQ packages in order to meet changing NRC demands pertaining to the required level of EQ documentation (as will be discussed further below). APCo ultimately accepted our recommendations and tasked Bechtel with implementing them. We subsequently reformatted the packages and included clarifying details so they would be easier to understand during the November 1987 NRC audit.

My group found no instances in which our ultimate qualification conclusion differed from what was in the files at the commencement of our efforts.

Q14. What role did the EQ Task Team play during and after the 1987 EQ inspections at Farley?

A: (Sundergill) Part of the Bechtel EQ Task Team (myself included) was present, on site, during the November 1987 inspection in order to assist APCo and answer any NRC Staff questions. The remaining members of the Bechtel portion of the EQ Task Team were in Bechtel's Gaithersburg, Maryland office to provide home office support.

After the November 1987 inspection, the Bechtel Team members revised EQ packages in order to meet commitments made to NRC Staff reviewers during the inspection, and included pertinent questions and responses from the inspection in the EQ packages.

II. <u>THE EVOLUTION OF EQ EXPECTATIONS</u>

A. <u>Overall Perspectives</u>

Q15. Based upon your experience in this field, and from an overall perspective, how would you characterize the development of EQ as a regulatory topic?

A. (Love, Sundergill) In a word, EQ has been "evolutionary." EQ has been evolutionary in two respects: regulatory and interpretational. Originally, there was some development of the standards and requirements to be met. IEEE-323 had been issued, and was implemented by industry. This was followed by IE Bulletin 79-01B (DOR Guidelines), NUREG-0588 (initially in a "for comment" version, which industry needed to address), and 10 CFR 50.49. In response to these latter NRC regulatory initiatives, industry conducted testing and was making hardware replacements to address the EQ requirements in the early 1980's. This was inherently a learning process. However, by November 30, 1985, the standards were clear and the design and testing had generally been accomplished. This is reflected, for example, in the Staff's SERs issued for both Farley units in 1984.

From the EQ deadline in 1985, and as particularly shown in the "first round" NRC inspections in 1987, the evolution in EQ was driven by changing NRC Staff expectations regarding documentation of qualification status. While in general the "requirements" may have been set for several years, the Staff's interpretation of those requirements continued to evolve. In the 1987 inspection at Farley, we simply saw the Staff expecting an entirely new level of EQ documentation than had been expected prior to the end of 1985. We also saw evolving expectations in other areas, such as the Staff's views regarding walkdowns and piece part qualification. These positions were indeed "evolutionary." And it is for this reason that compliance as of November 30, 1985, cannot fairly be based on 1987, or 1992 expectations regarding documentation.

Q16. So is it your testimony that the Farley EQ program was sufficient at the time of the inspection?

A: (Love, Sundergill) Yes. With a very few exceptions, the NRC's inspection findings at Farley were driven by documentation -- not by hardware or operability (i.e., capability of performing intended safety function) concerns. Very few hardware modifications were, in fact, necessary following the inspection.

Instead, the inspectors wanted more documentation to support qualification, such as more detailed "similarity analyses," documentation of analyses or engineering judgment for which documentation was previously not customary, or documentation to address new, unsubstantiated Staff concerns. What we were seeing evolve was the documentation standard. Documentation and qualification that would have -- and in many cases was -- viewed as sufficient in 1985, was no longer sufficient in the eyes of the inspectors in 1987.

APCo made enhancements to address these expectations following the inspections. The EQ files today are not at all what they were in 1985 or 1987. But the enhancements relate to documentation -- not to hardware.

Q17. Were you surprised by the NRC's 1987 EQ inspection focus?

A: (Love) Yes, but we had become aware in 1987 that NRC inspectors at other plants were looking for more detailed documentation, for example, than existed in the past. One of the purposes of the APCo EQ Task Team in the summer of 1987, on which Mr. Sundergill served, was to update the EQ files to the level we understood to be expected. However, enforcement in this context was not what we would have expected.

(Love, Sundergill) The NRC's Modified Enforcement Policy in Generic Letter 88-07 specifically excluded enforcement based on new industry knowledge and testing and based on new 1987 expectations by providing a "clearly should have known" threshold. (APCo Exhibit 2). That Modified Policy calls for an assessment of what the licensee "clearly should have known" as of November 30, 1985, as a prerequisite to a finding of a violation. Although it may be difficult to accurately recreate what was expected in 1985 -- muddied as it might now be by the wisdom of hindsight -- we believe it can be done; particularly regarding documentation and walkdowns. We think the violations found at Farley, because of the evolving nature of the field and of the NRC's expectations, did not and could not meet the "clearly should have known" threshold.

B. **Walkdowns**

Q18. In the Notice of Violation transmittal letter, and again in the Order imposing the civil penalty, the Staff charges that APCo failed to exercise "best efforts to complete environmental qualification of electrical equipment by the November 30, 1985 deadline." (APCo Exhibits 33 and 34). In particular, the Staff accuses APCo of conducting inadequate walkdowns of installed equipment. Were walkdowns conducted for EQ purposes at Farley prior to November 30, 1985?

A: (Love, Jones) Yes. Walkdowns were conducted prior to the deadline as part of the effort to respond to IE Bulletin 79-01B, NUREG-0588, and 10 CFR 50.49 when those standards were issued. Primarily, walkdowns were conducted as part of the development of the Master List of equipment to be addressed in the Farley EQ program. These walkdowns -- consistent with industry practice at the time -- were intended to verify equipment name plate data; that is, manufacturer and model number. In this way we knew that what was installed in the field was the same as the item listed on the Master List, and thus would be qualified. (The Master List indicates all EQ components and identifies them by plant system, plant equipment number, location in the plant, and manufacturer's model number).

Q19. When were these walkdowns conducted?

A: (Love, Jones) Originally, the walkdowns to support development of the Master List were conducted in 1979-80, as part of the IE Bulletin 79-01B and NUREG-0588 responses. APCo, Bechtel, and Southern Company Services, Inc. were involved in this process.

There were also additional walkdowns conducted by Bechtel and APCo personnel specifically directed at terminal blocks in the 1982-83 time frame. For terminal blocks, some questions had come up that made us want to verify what was installed in the plant. States, the terminal block manufacturer, at that time had introduced what they were calling a "nuclear grade" terminal block. Therefore, we wanted to verify which type of States terminal blocks we had installed from the standpoint of the barrier strips.

The terminal block walkdowns were therefore similar in intent to the Master List walkdowns -- to make sure we were gathering qualification documentation on the right equipment. We were walking down terminal blocks to identify whether each block was a States Type NT or a Type ZWM. (As will be discussed below, it was subsequently shown that the type was not significant in terms of qualification of the block. Qualification was maintained for both types.)

Also prior to the EQ deadline, there were some additional Limitorque motor operated valve (MOV) walkdowns. These were intended to verify serial numbers of the installed MOVs at Farley. Given the serial numbers, we requested that Limitorque identify the appropriate qualification test report.

Q20. Did these pre-1985 walkdowns address equipment installation concerns, such as equipment orientation or the presence of lubricants?

A: (Love) Not specifically. In that timeframe the scope of EQ was to document qualification of the equipment that was installed, by manufacturer and model number. In most cases, installation was not expected to affect qualification.

Generally, for type-tested equipment, the test reports are intended to demonstrate qualification in any orientation to envelope potential installed configurations. The equipment manufacturer installation drawings and manuals provided any specific installation details viewed as significant to maintaining qualification. If there were unique installation concerns/restrictions based upon parameters identified in a qualification test report, those would have been translated into installation engineering notes and details. From that point, installation was no longer viewed as being an EQ issue -- it was a maintenance or quality assurance issue. It was not routine practice prior to November 30, 1985, for licensees to conduct detailed walkdowns of equipment examining all aspects of the installed configuration.

I would also note that during the pre-deadline walkdowns, specific problems regarding improper installations should have been recognized, even though this was not the primary intent of the walkdown. But also note again that orientation, for example, was not generally considered to be a major qualification concern. Specific documentation addressing minor differences between installed versus tested configurations simply was not the norm.

Q21. Prior to November 30, 1985, did the NRC Staff issue any guidance to licensees on conducting walkdowns to support qualification?

A: (Love, Sundergill) No. There was no guidance by the NRC Staff prior to November 30, 1985. In Commission Memorandum and Order CLI-80-21, dated May 23, 1980, the Commission simply cautioned licensees to check their equipment to provide assurance that the installed equipment was the same model as the equipment that was tested or otherwise qualified. (APCo Exhibit 9). This is what Alabama Power Company did.

The DOR Guidelines issued as part of IE Bulletin 79-01B stated a concern regarding the configuration of installed equipment and stated that licensees should verify that installed equipment conformed to the tested configuration. (APCo Exhibit 8). However, it does not follow that this required walkdowns other than what industry -- including APCo -- was conducting prior to the deadline. As we mentioned, most tests are designed to encompass potential installed configurations. Reasonable engineers drew reasonable conclusions regarding the relevance of installation differences. Differences were generally not considered an EQ concern. A walkdown would not have been viewed as being necessary. Moreover, and this leads to the evolving documentation issue (discussed further below), documentation or similarity analyses justifying differences were not viewed as necessary as reasonable engineers would not have questioned the differences.

Q22. Before we turn to documentation in greater detail, let us ask a question related to another aspect of walkdowns. Prior to November 30, 1985, what was your perception of the practices and expectations regarding walkdowns of equipment internals?

A: (Love, Sundergill, Jones) Prior to November 30, 1985, it was not standard practice to disassemble equipment to verify qualification of subcomponent parts. There had been no regulation, standard, or guidance requiring walkdowns to this degree of detail.

The approach to internals at Farley - and we believe throughout the industry -- prior to the deadline was to qualify the major pieces of equipment, not the constituent components. Indeed, Reg. Guide 1.89, Rev. 1, § C.6.b., states that if "[t]he item to be replaced is a component that is part of an item of equipment qualified as an assembly; these may be replaced with identical components." (APCo Exhibit 35). This revision of the Reg. Guide was issued in June 1984 and served to assure the industry that the emphasis of the qualification programs should be directed at the overall equipment, not the components thereof. The walkdowns verified that the installed equipment was the same as had been type tested. When procuring the equipment, the manufacturer/vendor certified that the equipment was what it was purported to be. The manufacturer/vendor was responsible for what was inside. The vendor was (and is) required to have a quality assurance (QA) program, as is the licensee. The licensee's QA program is responsible for reviewing the vendors' quality assurance. Regardless of what we now may know about the adequacy of vendors' QA programs or certifications, prior to 1985 this was not an issue addressed by EQ. Nor was it an issue, we believe, that was intended to be addressed by 10 CFR 50.49.

In fact, quality assurance has been assumed to be a basis for EQ since the early industry standards. IEEE 323-1974 and subsequent requirements and guidance accept prototype testing for qualification purposes. To assure that what is installed meets the specifications of the tested prototype, licensees rely on manufacturer and licensee quality assurance programs. IEEE 323-1974 (APCo Exhibit 36, at p. 8) states:

> "It is the primary role of qualification to assure that for each type of Class IE equipment the design and the manufacturing processes are such that there is a high degree of confidence that future equipment of the same type will perform as required. The other steps in the quality assurance program require strict control to assure that subsequent equipment of the same type matches that which was qualified and is suitably applied, installed, maintained, and periodically tested. Margins used during type testing provide additional assurance that the equipment will perform as required."

In the EQ rule, 10 CFR 50.49, the NRC endorsed IEEE 323-1974. The rule and accompanying materials did not address walkdowns or component disassembly.

It was the vendors' responsibility to supply equipment in accordance with whatever requirements were specified. The vendors performed prototype testing and provided certification that the equipment supplied was qualified by virtue of this testing. There was no implicit or explicit requirement for a utility, under the auspices of its EQ program, to verify that all equipment was as stated by the vendors. The EQ program imposed the requirements that all equipment be the same and the vendors certified that it was the same. No walkdo by the utility would have been deemed necessary.

Q23. Under this regulatory regime, can you give me an example of where more detailed inspections of equipment internals might be appropriate?

A: (Love, Sundergill, Jones) NRC regulations in Part 21 call for vendors to notify the NRC (and ultimately licensees) of problems in a specific item or internal part of their equipment. A 10 CFR Part 21 notice, or an NRC Bulletin, may have required a walkdown and inspection of the internals for that equipment. In such a case, the walkdown would have been performed. Absent such a specific concern, it was not industry practice to look at each component at the detailed level now suggested by the Staff.

Q24. In your opinion, then, based upon all of the above, do you believe APCo exercised "best efforts" with respect to equipment walkdowns prior to November 30, 1985?

A: (Love, Sundergill) Yes. In proper historical perspective, APCo conducted walkdowns and defined its EQ program commensurate with contemporaneous industry practices and NRC expectations.

Q25. In your opinion, can APCo fairly be said to have "clearly known or should have known" that more detailed walkdowns would be required by the NRC?

A: (Love, Sundergill) When viewed in proper historical perspective, the answer is a strong "no." Detailed walkdowns of installed equipment configurations, beyond walkdowns to verify name plate data, were simply not the norm. Similarly, APCo had no basis to know that, by 1987, NRC Staff inspectors would be deciding that disassembly of components to verify qualification of internal parts would be necessary to meet 10 CFR 50.49.

C. <u>Documentation</u>

Q26. Let's turn to EQ documentation. How would you characterize this topic?

A: (Love, Sundergill) Documentation is really the focal point for our overall characterization of EQ as "evolutionary." The 1987 NRC EQ inspection at Farley, and apparently elsewhere, simply imposed a quantum leap in the volume and type of EQ documentation expected to be in the licensees' EQ files. APCo has done much work to address these expectations. However, if assessed relative to a November

1985 standard, APCo's previous files would not have been defective to the degree the NRC now alleges.

Q27. What standards do you perceive as applying to documentation?

A: (Love, Sundergill) 10 CFR 50.49 requires that equipment within the scope of the rule be qualified -- that is, capable of performing the intended safety function under postulated accident environmental conditions. Moreover, qualification by testing or analysis is to be documented in an "auditable form."

We are aware of no discussion at the time the rule was issued that purported to define "auditable form" or otherwise address what EQ documentation would be necessary. However, because 10 CFR 50.49 did not require licensees to requalify equipment previously qualified to DOR Guidelines or NUREG-0588, it seems logical to conclude that 10 CFR 50.49 was not intended to create any new documentation requirements for plants such as Farley. (Note that Farley Unit 1, under 10 CFR 50.49, must meet DOR Guidelines and Farley Unit 2 must meet NUREG-0588, Category II. Both the DOR Guidelines and NUREG-0588, Category II, generally follow the standards of IEEE 323-1971.)

Q28. What were the documentation standards under these earlier standards endorsed in 10 CFR 50.49?

A: (Love, Sundergill) IEEE 323-1971 refers to "documentation to permit an independent evaluation of the equipment qualification." (APCo Exhibit 37, at p. 5, ¶ 4.4). The more recent -- although, at Farley, technically inapplicable -- IEEE 323-1974, flushes this out a little. It defines "auditable data" as "technical information which is documented and organized in a readily understandable and traceable manner that permits independent auditing of the inferences or conclusions based on the information." (APCo Exhibit 36, at p. 7). In discussing qualification by analyses (which is not type testing), the 1974 standard also discusses documentation of the analysis to a degree "so persons reasonably skilled in this type of analyses can follow both the reasoning and the computations." (APCo Exhibit 36, at p. 10). However, the latter standard was in the context of qualification by analysis, and did not necessarily apply to overall EQ conclusions based on type testing or even partial testing, although it readily can be inferred that the test for a "reasonably skilled" person would be applicable to the entire body of the document.

In any event, you can see that these are all very subjective standards. It is the interpretation and application of these standards that evolved considerably. As far as can be ascertained, many of the NRC inspectors on the Farley inspection team in 1987 had received their initial or supplemental training in EQ immediately prior to the Farley audit. This training reflected 1987, not 1985, philosophies. Consequently, much of what was required of APCo in the Notice of Violation was based on the evolving interpretation of the EQ standards and not on the interpretation which was generally conveyed in the 1985 time frame. Therefore, the questions being asked, the level of detail being required, and the degree of documentation being requested was in excess of the standards being applied two years earlier.

At bottom, to view APCo's documentation properly, two considerations seem particularly relevant. First, the degree of documentation is directly related to the degree of sophistication (or "skill") of the auditor. Second, to some extent, documentation had been discussed with the NRC and had been addressed by the Staff's contractor prior to the deadline. We believe that a general consensus existed at that time (i.e., as of November 30, 1985). By 1987, however, this consensus had disappeared. When these factors are considered, we believe APCo's documentation was sufficient as of the deadline, based on a November 30, 1985, perspective.

Q29. Let's turn to your first consideration; auditor's "skill." How do you view that as fitting into the picture at Farley?

A: (Love, Sundergill) This is crucial when you consider the nature of many of the specific deficiencies identified in 1987 by the Staff inspectors. Often these deficiencies were for lack of documentation of reasonable engineering judgments. In most cases, to a reasonable engineer versed in environmental qualification, documentation of these judgments and the bases therefore would not have been necessary. The judgment would have been readily understood.

Under the 1987 inspection approach, however, the Staff inspector could simply ask a question, due to a lack of understanding, and thereby create a violation. If a question could not be answered from the file on its face, no matter how obvious the answer was, the Staff considered it to be a documentation deficiency. It was then, and is now, an unreasonable standard for EQ files, practically unachievable, and unprecedented for both EQ files and areas outside of EQ.

A similar interpretational evolution occurred for "similarity analyses." Section 50.49 and all of the predecessor EQ standards allowed for qualification by testing, analyses, or some combination of the two.

Predecessor standards applicable to Farley also allowed for separate effects testing. While the term "similarity analysis" is not specifically used and is never defined in NRC regulations, guidance, or industry standards, it has been accepted that qualification by "similarity" to a tested sample can be acceptable. For example, if the tested sample differs in some respect from the component to be qualified, the licensee can show qualification by a similarity analysis that shows why the differences would not impact qualification. Neither the regulations, the industry standards, nor the regulatory guidance ever attempted to define how detailed the documentation of such an analysis must be, or even which differences between tested and installed samples must be analyzed in a documented fashion. In the pre-deadline approach to EQ documentation, reasonable engineering judgment was assumed in the documentation. In fact, similarity analyses for type testing were often based on reasonable judgments. Discrepancies that had been analyzed and had been concluded to be immaterial were not necessarily addressed by a documented "similarity analysis."

Here again, in the 1987 inspections, the NRC Staff inspectors held out a new standard of perfection for EQ documentation. At this time, practically all discrepancies between tested and installed configurations were to be addressed in the EQ files. Documentation was required --

seemingly regardless of any possible impact of the issue on the ultimate capability of the equipment to perform its intended function under appropriate accident conditions. The point here to keep in mind is that the person performing the analysis, and others more versed in qualification issues, would often not have needed such detailed documentation to understand (i.e., "audit") the bases for the conclusions documented in the files.

Q30. Before turning to the second factor noted above, it may be helpful if you provide a brief description of what was documented in the Farley EQ files prior to the deadline.

A: (Sundergill) In essence, APCo had four sets of documents: the EQ Master List, the System Component Evaluation Worksheets (SCEW sheets), the equipment "checklists," and files of test reports. Additionally, there were backup letters from vendors and from Bechtel addressing various aspects of the program.

The Master List was developed to identify all components within the scope of the EQ program. The components are listed by vendor and manufacturer's model number, with references to installed applications by system, plant equipment number, and plant location.

SCEW sheets summarize and provide a ready source of the qualification conclusions for particular categories of equipment in the format suggested in the DOR Guidelines. There is one SCEW sheet for each type of equipment. Plant location is important because it defines the relevant environment for which plant equipment must be qualified. Each SCEW sheet lists, for the item of equipment, the required and qualified levels of the various parameters of concern. These include temperature, radiation, chemical spray, humidity, pressure and aging, as applicable. The SCEW sheet also references the relevant test reports which were included in the Farley EQ files prior to the 1987 work of the EQ Task Team. The SCEW sheets were consistent with the example provided in IE Bulletin 79-01B.

EQ Review Evaluation Checklists are included with the SCEW sheets, and again address equipment by manufacturer and model number. The format of the checklists was originally based on DOR Guidelines. Each checklist sets out a series of relevant qualification questions to be answered. The APCo checklists called for a series of "yes/no" answers, with a section for "remarks." The engineer completing the checklist would thus document his basis for concluding that the equipment was qualified by answering the relevant questions pertinent to the parameter of concern. Any necessary explanations would have been appropriate for the "remarks" section. The format for these checklists was consistent with those in use by NRC inspectors at that time. I will observe here that this was by no means a detailed documentation of every step of the qualification thought process. But prior to the deadline, when the focus on documentation was much less severe, this was considered to be a very adequate record of qualification. Moreover, as this enforcement action subsequently proved, you can never document the entire EQ thought process. It is always possible later to ask more questions that would not be addressed in the document (even regarding matters that do not impact qualifiability).

The last link in the paperwork chain was the test reports themselves. These reports, usually prepared by the manufacturers or contractors, documented prototype testing. One report could document testing of equipment for one set of parameters and another report could address other parameters and considerations. Thus, for many equipment items, qualification (as documented on the checklist) would be based on reference to more than one test report. (Test reports are presently bound in the EQ packages along with the SCEW sheets, EQ Review Evaluation Checklists and other supporting documents to further facilitate their review.)

Q31. Did this documentation address installation or configuration issues?

A: (Love, Sundergill) Let us be clear that all of the original EQ documentation assumed: a) that the equipment would be installed per vendor installation documents and procedures; and b) vendor installation procedures were consistent with vendor EQ testing.

As noted above, most testing was designed to utilize a conservative configuration to envelope potential installations. Under the EQ program, any specific installation limitations were addressed in engineering notes and details or other installation procedures. There was no attempt made to address specifically in the EQ documentation every particular installation difference. Consistent with the philosophy at the time -- and we still believe this is a good philosophy -- once the EQ program established qualification and set any relevant installation requirements, insuring proper installation was not an EQ program issue. This was a matter for quality assurance and maintenance. We don't believe that it was the intent of 10 CFR 50.49 to create new requirements in those areas or, more aptly, to require more qualification documentation of installation specifics.

In fact, as specified in IEEE 323-1974 (APCo Exhibit 36, at p. 8), maintenance and installation are separate activities from those described as "qualification."

> "The manufacturers and users of Class IE equipment are required to provide assurance that such equipment will meet or exceed its performance requirements throughout its installed life. This is accomplished through a disciplined program of quality assurance that includes but is not limited to design, qualification, production quality control, installation, maintenance, and periodic testing. This document will treat only the qualification portion of the program."

Since the NRC Staff has endorsed the precepts of IEEE 323-1974 without any exceptions to the above-quoted section, it is only reasonable to conclude that in doing so they also considered installation and maintenance to be separate from the EQ program.

Q32. You mentioned above that the second important consideration in looking at APCo's documentation was the evolution of the Staff's expectations, relative to previous industry/NRC interactions (or "consensus"). Could you elaborate?

A: (Love, Sundergill) Yes. You have to start with the original context, long before EQ became an NRC documentation matter.

First, there was General Design Criterion (GDC) 4. (APCo Exhibit 31). This GDC specifically requires that equipment be capable of performing its intended function under anticipated environmental (and other) conditions. Nuclear plant design engineering had always been done to meet this functional performance goal. GDC 4 did not require any specific EQ documentation beyond normal Appendix B design-related QA documentation. IEEE 323-1971 and IEEE 323-1974 were the first industry standards to require some form of summary documentation of the qualification considerations.

When the NRC issued the DOR Guidelines, documentation specifics were not addressed in detail. It's probably fair to say that at that point, documentation was still a secondary consideration to actual hardware operability, as it should be today. However, DOR Guidelines did specifically suggest the format for the SCEW sheets used by APCo and other licensees as EQ documentation. This gives some idea of the level of documentation detail that was being developed. The checklists as adopted at Farley evolved subsequent to DOR Guidelines in the industry -- and certainly with interaction with the NRC Staff -- as an additional means to document the bases for the conclusions on the SCEW sheets. Thus, we believe that some consensus existed that the SCEW sheets and checklists, or at least the level of detail suggested by these documents, was satisfactory documentation of the EQ conclusions.

In this regard, it is also important to realize that prior to the EQ deadline, APCo formally submitted its Master List, SCEW sheets, and test reports to the NRC. These were reviewed by the Staff's contractor, Franklin Research Center (Franklin). Regardless of what the NRC Staff may now say about the scope of Franklin's review, the fact remains that prior to the EQ deadline APCo received no negative feedback regarding the scope, type, or format of the EQ documentation. Not only does this reflect then-prevailing notions of documentation, it gave APCo a sound basis to assume that its basic documentation approach was satisfactory.

(Sundergill) At this point, it is worthwhile to note again the evolutionary nature of the volume of required EQ documentation. In the time frame from 1970 to about 1978, licensees were adhering to the guidelines set forth in GDC 4. Equipment specifications for safety related electrical equipment routinely required a determination of qualified life and a demonstrable capability to withstand the extreme parameters of an accident environment. An engineer, at that time, who was responsible for the equipment would review the qualification documentation, make the determination of acceptability, if justified, and document it by simply signing or initialing a document eview stamp.

With the issuance of the DOR Guidelines, NUREG-0588, 10 CFR 50.49, et al., a checklist documenting the review effort was deemed to be necessary. As previously noted, these checklists, typically, consisted of a series of questions followed by a "yes" or a "no" response. The checklists were signed by the reviewer and often by an additional person indicating approval.

Now, in essence, the requirement is to explain in great detail the basis for the "yes" and "no" answers in the checklists. Thus, the requirement has evolved from documentation of an overall conclusion, to documentation of the methodology employed to arrive at that conclusion, to the present level of documentation of the conclusion in each step of the supporting methodology. In virtually all cases, the qualification document and final conclusion have remained unchanged -- thus indicating the soundness of the original engineering judgment. The only change has been to the amount of written justification required to support the underlying engineering judgment.

Q33. Has APCo made documentation enhancements since the 1987 inspections?

A: (Sundergill) Yes. As I mentioned, my Bechtel EQ Group participated in both the APCo EQ Task Team (in 1987) and a subsequent EQ Task Force (in 1988) at Farley. The latter effort was initiated after the 1987 inspection to address the Staff's findings regarding the program. Both of these efforts were specifically chartered by APCo to respond aggressively to the Staff's new documentation expectations. In this respect, I believe APCo was extremely responsive to the Staff.

Although much of the equipment identified in the Notice of Violation was changed-out or modified (in many cases, unnecessarily), the focus of APCo's subsequent efforts was largely one of improving documentation. For example, we expanded the equipment checklists to provide more thorough documentation of the bases for acceptability of qualification. We added new curves to illustrate visually how the relevant parameter profiles were met. I believe NRC Staff's own subsequent reviews have found the program to be quite effective.

D. <u>Other Evolving Topics</u>

Q34. Were there any other aspects of EQ that were "evolving" subsequent to the EQ deadline and prior to the 1987 Farley inspections?

A: (Love, Sundergill) Yes. One example is terminal blocks, which we will discuss further below. This was a topic where Sandia National Laboratories (Sandia) had conducted some tests and was developing data. Sandia became involved in the inspection process after the deadline and it was only natural that they brought to the inspection the most recent, post-deadline perspectives. However, their 1987 views do not properly refle what APCo "knew or clearly should have known" as of the November 30, 1985 deadline.

Another example is grease, which Mr. Sundergill will also discuss further below. This was a specific example of an installation, or configuration, discrepancy that, prior to the deadline, was never viewed as an EQ matter (i.e., one that needed to be addressed in EQ documentation). Instead, this was a maintenance issue. By the time of the inspection, the Staff was deciding -- apparently regardless of any impact on operability of EQ equipment -- that differences between installed lubricants and lubricants used in test samples must be analyzed and documented in EQ files. We perceived this to be an evolutionary interpretation of 10 CFR 50.49 and an unreasonable position.

III. V-TYPE ELECTRICAL TAPE TERMINATIONS

Q35. We will now turn to the specific violations -- originally cited in the August 15, 1988, Notice of Violation -- that remain in issue. The first concerns tape splices or terminations (Violation I.A.1). Are you familiar with this issue?

A: (Love, Sundergill) Yes.

Q36. What is an electrical splice? How does it differ from an electrical termination?

A: (Love) Just to be clear, the "components" at issue at Farley were V-type electrical terminations rather than splices. A splice is an electrical connection between two cable ends in the middle of a cable run. A termination is the electrical connection between the cable at the end of its run and the instrument or equipment lead. Obviously, the connection -- whether at the end of the cable or in the middle -- must be able to function in an appropriate environment.

This distinction is only significant, as Mr. Shipman has explained, because, as a conservative measure, Farley procedures did not permit splices in cables, at least absent some specific engineering evaluation and approval. A log of those splices would be maintained. Therefore, prior to November 30, 1985, there would have been very few cable "splices" in the plant -- and APCo had not reason to look for "splices."

Splices and terminations were not listed on the EQ Master List and were not something APCo viewed as a potential problem. APCo had electrical "terminations" at Farley that were addressed by the EQ program, which insured that the Electrical Notes and Details required the proper use of qualified materials and configurations for cable terminations in harsh environment areas of the plant.

Q37. Explain then the V-type "splice" issue cited in the EQ NOV.

A: (Love, Jones) In essence, in July 1987, APCo became aware that the licensee at Calvert Cliffs had experienced problems with potentially unqualified V-type splices. APCo proceeded to walk down cable terminations at Farley (where the field cables were terminated to the equipment leads) and identified V-type configurations. As I stated, this issue at Farley really concerns electrical terminations. When APCo identified these terminations, it quickly concluded that they were qualifiable. That is, documentation specifically addressing these previously unknown configurations was not in the EQ files; but APCo's engineering judgment was that the terminations would be operable in appropriate accident environments.

Q38. Let's take this more slowly. What exactly is a V-type configuration?

A: (Love, Sundergill) To join together two or more insulated sections of cable, a portion of the insulation on each section must be removed so that the bare conductors can be mechanically connected and in electrical contact. Then, some form of insulation must be installed in order to restore the required electrical properties of the insulation. A common method of restoring the insulation to the joint is by wrapping the bare portion of the conductors and mechanical joint with insulating tape.

A V-type termination is one in which the two leads are placed side-by-side, oriented from the same direction. A mechanical connection maintaining electrical continuity is then made and the termination is wrapped with insulating tape. See Diagram 1. This is in contrast to an "in-line" configuration in which the leads are placed together, oriented from opposite directions, and then wrapped with insulating tape.

DIAGRAM

1

Based on our reconstructions during the investigation of this issue, it appears that the V-type configuration was generally utilized by electricians during plant construction inside certain equipment enclosures or terminal boxes. The V-type configuration was more space-efficient than an in-line configuration, and thus was more easily installed.

Q39. Is it fair to say that the V-type configuration was not what APCo expected?

A: (Love, Jones) That is true. APCo had addressed qualification of electrical terminations prior to the EQ deadline by providing termination details for an Okonite tape or Raychem in-line configuration in the Electrical Notes and Details. For tape configurations, the qualified in-line splice or termination was made with Okonite T-95/No. 35 tape. Qualification for the Okonite tape was documented by Okonite Test Report NQRN-3, Revision 1 (June 30, 1982), present in APCo's EQ files. (APCo Exhibit 25). The test report, incidentally, established qualification of the Okonite tape as an insulation/sealing material for 5000 volt in-line terminations. This sufficiently enveloped qualification for lower voltage applications.

In any event, the APCo EQ program, based on Test Report NQRN-3, specifically referenced the Electrical Notes and

Details for preparation of these splice/termination connections. Consistent with the approach discussed above regarding installation of EQ equipment, the EQ program thus established a qualified termination and provided the engineering Electrical Notes and Details for craft to make appropriate terminations. The generic design details (Detail Nos. A-172389-172398) specifically addressed in-line terminations and a bolted termination configuration. (APCo Exhibit 38). The instructions specified the method of installation of the Okonite tape insulating system, setting forth specific directions as to details such as preparation of the connection, and the overlap, tightness and number of wraps of the tape. This was intended to provide assurance that any installed terminations or splices would be encompassed by the qualification test report.

Based on this approach, APCo had no basis to expect -- prior to its own identification of the issue in July 1987 -- that installed terminations would be anything other than in-line terminations. In this sense, the V-type terminations were a surprise.

Q40. You stated above that the V-type terminations found in July 1987 were "qualifiable." What do you mean by "qualifiable"?

A: (Love, Sundergill, Jones) This equipment was <u>at least</u> qualifiable. And note that we are using NRC's current-day terminology. Equipment is "qualifiable" where there is reasonable assurance that it will perform its intended safety function, under the relevant accident environmental conditions. However, full qualification documentation -- such as documentation of testing and/or analysis -- may not yet be available or present in the EQ files. Where equipment is "qualifiable," there is an EQ documentation issue, but obviously no safety issue.

Q41. What was your basis in this case -- prior to any testing or analysis -- to conclude that the V-type terminations were capable of performing their intended safety function.

A: (Love, Sundergill, Jones) First, we already knew based on Okonite Test Report NQRN-3 that the tape materials used in these terminations (Okonite T-95 and No. 35) was qualified for the various applicable environmental parameters (e.g., radiation, temperature, pressure, chemical spray).

Second, in July 1987, upon discovery of the termination configurations, APCo immediately obtained Wyle Test Report 17859-02, dated March 11, 1987. (APCo Exhibit 27). That report provided qualification data on certain V-type splice configurations, utilizing Okonite tape, at a Commonwealth

Edison Company (CECo) facility. Although these tests did not exactly encompass the Farley configurations, and there were failures in that testing, the data reasonably indicated that the Farley splices could be qualified since the failures did not reflect Farley installed configurations.

The NRC Staff, in its Order, noted that Farley had no documentation in July 1987 analyzing the test failures and demonstrating similarity to the Farley splices. The Staff raises similar concerns in page 6 of its testimony on this issue. However, keep in mind here that we are only asserting that Wyle Test Report 17859-02 was a basis for "qualifiability;" we are not suggesting that, at the time, it was sufficient in itself to "qualify" (i.e., fully document qualification for) the terminations. The Test Report was certainly a valid basis at the time for a justification for continued operation, pending further efforts.

Q42. Were the failures in the Wyle testing for CECo (Wyle Test Report 17859-02) based on a moisture intrusion failure mode?

A: (Love, Sundergill) Yes they were. But due to the conservatisms of that test, we believe that the anomalies were inapplicable to Farley. In those tests there were instances in which fuses blew, apparently due to moisture intrusion into the splices. However, in the test in which the anomalies occurred, the entire V-type configuration had been submerged. Such a submergence test was not a valid application for Farley. Along with other activities undertaken after this issue had been identified, APCo specifically reviewed the relevant junction boxes at Farley to assure that sufficient drainage existed to prevent submergence of the terminations. We found that sufficient drainage was provided by the conduit system and/or weep holes, such that condensate would not accumulate.

The Staff, on page 6 of its testimony on this issue, implies that submergence was not the only mode which could lead to failures. The Staff states that contact with the ground plane -- such as the bottom of housings, condulets, or junction boxes -- would make grounding a concern. However, this was not the reason for the failures in the CECo test. The tape on these terminations provided sufficient insulation to prevent gounding due to contact with the ground plane. The CECo failures occurred due to proximity with the ground plane in conjunction with a leakage path to ground created by immersion or submergence. As stated, we had determined that drainage at Farley was sufficient to preclude submergence.

Also, it is worth noting that in Wyle's testing for CECo the splices were mounted in such a way that there was direct spray into the conduit or junction box. At Farley there were no splices directly exposed to containment spray.

Q43. Did engineering judgment also support your initial assessment that the V-type terminations would be fully operable under accident environmental conditions?

A: (Love, Sundergill) Yes. Three considerations were germane to this engineering judgment.

(Love) First, a review of the terminations as made by the electricians provided considerable confidence as to the operability or qualifiability of the terminations. The asserted potential qualification problem with the V-type configuration is a pathway for moisture intrusion into the crotch of the terminations that would result in an electrical loss of function. The wrap was made around the two leads only, with no wrap through the crotch. However, a look at the splices is enough to reveal that the pathway for moisture intrusion is tortuous and that an electrical loss of function is unlikely.

The V-type terminations were made with several layers of insulating tape and with considerable overlap of the tape material. Moreover, the cable legs were not actually pulled apart into a "V" as the nomenclature might suggest. Instead, the cables were wrapped tightly together, with the tape extending well down the cable from the exposed electrical termination. Okonite tape is a self-fusing material, which also tends to close any gap at the crotch. Thus, the moisture pathway for electrical conductivity is really not as obvious as was asserted by the NRC inspectors.

Second, the V-type configuration is a standard configuration for making splices and terminations in the electrical trade. At Farley, the terminations were made by the craft in order to fit the configurations inside enclosures or terminal boxes. My engineering judgment was that the terminations, made in accordance with skill-of-the-craft, would be fully capable of preventing moisture intrusion of sufficient magnitude to cause a functional failure. Remember, skilled electricians are well-versed in making splices or terminations that are resistant to moisture. And, keep in mind, the potential for moisture intrusion was the only issue before us. We knew, and had ample qualification documentation, that the Okonite tape itself was fully qualified for the accident environment.

(Love, Sundergill) Third, you must also consider the significance of the purported failure mode to the capability of equipment to fulfill its intended function. Here, the failure mode was moisture intrusion. However, even if one assumes that moisture somehow follows the tortuous path inside the termination and reaches the electrical connector, there in all likelihood would be no impact. Moisture in a single connection would not create an electrical short. In order for a short to occur, the water must create a pathway for electrical current flow to another splice (overcoming the same torturous pathway) or to a ground. Our judgment was that this would be unlikely.

Based on all of these considerations, it was our judgment that the as-found connections were fully capable of performing their function under appropriate environmental conditions. The analysis as just explained was ample to "qualify" the splices before the November 1987 first round EQ inspection. Instead, APCo chose to replace the terminations. Testing was subsequently and successfully completed by Wyle for APCo prior to the November inspection.

Q44. On page 5 of its testimony on this issue, the Staff discusses the inspection on the V-type termination issue. The Staff states that the team disagreed with Mr. Love's "opinion that the splices would be qualified by just doing volts per mil analysis, without taking into account the performance of the tape during accident conditions at elevated temperatures, pressures, radiation levels and with the effects of aging." Mr. Love, did the team understand what you were saying?

A: (Love) Apparently not. During my discussions with Mr. Merriweather and Mr. Paulk, I spent a considerable amount of time addressing the applicability of Okonite Test Report NQRN-3 (APCo Exhibit 25) for qualifying tape insulation systems. The test report addressed a power cable in-line splice at 5000 volts AC and demonstrated qualification of T-95 and No. 35 tape for radiation, steam pressure, temperature, and chemical sprays. The point I was trying to make was that, given that the report qualified the tape materials to environmental parameters at a voltage of 5000 volts, it could be applied for in-line power cable splice configurations at lesser voltages based on a volts per mil analysis. The performance of the tape during accident conditions was thus demonstrated.

Mr. Merriweather and Mr. Paulk, on page 5 of their testimony, go on to state that they believe that, "splice configuration was important in establishing qualification of the splices." I don't disagree. The volts per mil analysis was never intended to address the V-configuration aspect of the termination. We went on in our analysis to address configuration, and concluded that configuration ultimately did not impact qualification based on all of the reasons discussed earlier.

Q45. Now let's turn to the subsequent qualification testing by Wyle for APCo. Please describe that testing.

A: (Love, Sundergill, Jones) Essentially, since APCo had chosen to replace all of the V-type terminations to be responsive to the NRC inspectors, APCo was in a unique position to actually test types representative of the as-found installed configurations to verify their operability. APCo removed the terminations and asked Wyle to test samples representative of these actual terminations. The results were completed and documented in October 1987 in Wyle Test Report 17947-01. (APCo Exhibit 39). The testing was completed prior to the November 1987 EQ inspection. The terminations were fully qualified for Farley conditions by that date.

Q46. How did these EQ tests bound the installed configurations?

A: (Love, Sundergill, Jones) Prior to testing, APCo found 82 V-type terminations at the Farley units. Bechtel analyzed these terminations and categorized them into fourteen types for testing, specifically selected to conservatively bound the installed configurations. To be conservative, a less or equal number of tape wraps was used.

In the Order, the Staff charges that APCo's testing did not bound the installed configurations, because the splices were not installed in accordance with any specific design drawings. Thus, the Staff charges, the tested samples could only approximate the installed samples. This argument, however, seems to run counter to the very concept of qualification as outlined in DOR Guidelines, NUREG-0588, and 10 CFR 50.49. Those requirements do not specify qualification by testing the actual installed equipment. Moreover, they do not even require type testing in all cases.

APCo specifically based its tested samples on installed terminations cut out of the plant and destructively examined. Moreover, APCo sent one of the original electricians who had installed the splices at Farley to Wyle to actually make the tested splices, based on his skill-of-the-craft. Because APCo attempted to duplicate actual field installation practices for the testing, the Wyle tests were much more representative than a typical prototype test. We have a high degree of confidence that the tested splices bounded the installed splices. Any differences that might have existed would be -- based upon reasonable engineering judgment -- not material.

Q47. How was the testing conducted?

A: (Love, Sundergill, Jones) The testing was highly conservative. The samples were aged for the equivalent of 15 years and exposed to 2.2E7 rads (the requirement at Farley is 1.87E7 rads). The samples were arranged in the test chamber in conservative configurations or orientations for the accident portion of the test. (APCo Exhibit 39). For example, the opposing legs of instrument splices were routed in opposite directions to provide the maximum opportunity to open a path for moisture. This was not the case in the plant. Also, unlike the terminations at the plant, the tested splices were installed in condulets without covers and with conduit openings exposed, so that the splices were in the direct path of the spray. Power cable splices were installed in an open tray rather than a junction box or a conduit to maximize the potential for moisture intrusion. The test samples were also installed in such a manner that the taped insulation was in forced contact with a grounded surface during all phases of the test. This was certainly not the case in the plant.

Q48. What were the results of the tests?

A: (Love, Sundergill, Jones) As documented in the test report, the splices were qualified for use at Farley Nuclear Plant.

Q49. In this testimony on this issue, on page 14. Mr. Merriweather states that this test did not qualify the splices for use in instrumentation circuits. Is this true?

A: (Love, Sundergill, Jones) No. The test qualified the V-type terminations for use in instrument circuits. The test specifically monitored leakage current with no detectable leakage.

Q50. In the Staff's direct testimony on this issue, Mr. Paulk remarks that Wyle Test Report 17947-01 was "never formally presented to NRC for review . . .," adding that the "Staff cannot accept or evaluate a report that was not presented to it." Staff testimony at pages 11, 15. Mr. Merriweather similarly notes that even though he was informed of the existence of the final report, he was never "asked" to review the report. Staff testimony at 14. How do you respond?

A. (Sundergill, Jones) In offering the above-quoted justification for not reviewing Wyle Test Report 17947-01, the Staff ignores the procedure which was utilized at their request during the November 1987 inspection: APCo informed the inspectors of the contents of the Farley EQ file and the inspectors identified the packages they wished to review. We do not believe that the inspectors felt reluctant to perform a review due to the lack of an invitation from APCo. The inspectors were informed that the Farley EQ file included the Wyle report together with the associated EQ package at the time of the inspection and they simply chose not to review it. Then, they went on to allege a violation while now acknowledging that they did not review all pertinent data.

Q51. Ultimately, Mr. Merriweather concludes that a review of the Wyle test report "was not part of the November inspection." Staff testimony at page 15. As he further explains in the next sentence, the Staff "considered the issue resolved as far as corrective action and all that remained was for NRC to assess what if any enforcement was appropriate." Do you agree with this philosophy?

A: (Sundergill, Jones) No. We fail to see how the Staff could determine the appropriate enforcement action if they did not know the results of the test If, as we contend, the test proved that the splices as they existed prior to their discovery were capable of performing their safety related function under accident conditions, then the issue was one of documentation. The appropriate enforcement action would have been the assessment of when the discovery was made and what APCo should have known, in addition to an assessment of whether new documentation made available to the inspectors rendered documentation deficiencies to be "insignificant" within the meaning of Modified Policy, Section III. However, if it was found that the report demonstrated that the splices could not survive the design basis accident (DBA) conditions (it did not), then there would have been an actual equipment discrepancy. We would think that enforcement would be more severe in the latter case. Consequently, from our perspective, it is of extreme importance for the Staff to review the report prior to assessing the appropriate enforcement action. The Staff's failure to do so was bizarre at best.

Q52. To the best of your knowledge, has the NRC ever reviewed Wyle Test Report 17947-01, as it pertains to the Farley docket?

A: (Love, Sundergill, Jones) No.

(Love, Sundergill) The only technical review of the report of which we are aware was a document from Gary M. Holahan, Office of Nuclear Reactor Regulation, to Samuel J. Collins and Leonard J. Callan, NRC Region IV, "Qualification of Tape Splices for Use in Instrument Circuits Subject to Harsh Environments, Waterford Steam Electric Station, Unit 3 (TAC No. M75342)," dated May 16, 1990. (APCo Exhibit 40). This report was turned over to APCo during discovery in this proceeding. The Staff there assesses the Wyle test as applied to the conditions at the Waterford Station. It does not, by its terms, address the Farley conditions. In any event, as it relates to Farley, it is deeply flawed.

Q53. Please explain.

A: (Sundergill) The assessment (APCo Exhibit 40) seems to have two problems with Wyle Test Report 17947-01. First, it argues that only six specimens were wired for instrument (low power) circuits, and of these only two were energized continuously. The other four, the assessment states, were de-energized prior to the introduction of chemical spray. The assessment goes on: "Therefore, of the six specimens . . ., insulation resistance measurements were not recorded during LOCA simulation and only two were energized continuously. Once again, the functional performance of the specimens during LOCA simulation with chemical spray was not determined during the tests." (APCo Exhibit 40, at p. 2).

These assertions are not valid. The tested samples were both energized and de-energized during the test to simulate actual Farley usage. Further, two instrument circuit splices were energized continuously, and leakage current was monitored for these samples for the entire duration of spray. (See APCo Exhibit 39, at pp. VI-7, VI-81 and VI-82). No leakage current was detected. Id. at VI-7. Leakage current measurement is an acceptable method of determining insulation resistance. Zero leakage current indicated no degradation of insulation resistance.

The second concern relates to the use of Arrhenius techniques. Arrhenius calculation techniques are used to extend testing by analysis to encompass the longer time periods required under actual accident conditions. In the Wyle tests, accident testing was conducted for 45 hours and extended by Arrhenius techniques to encompass the Farley accident duration of 33 days. The Arrhenius techniques were used for the portion of the test subsequent to the transient (167 minutes into the test after the test temperature had stabilized at 245° F). The Staff seems to argue that the only portion of the test curve that may be extended by Arrhenius techniques is the stabilized portion of the curve after the transient. We agree. This was the portion of the test curve that was utilized by Bechtel to extend the 45 hour test to encompass the Farley-specific accident duration of 33 days.

Therefore, the Staff's assessment gives no technical basis to undermine the conclusion that the V-type terminations were fully qualified for Farley based on testing even before the end of the November 1987 EQ inspection. Furthermore, the Staff's only assessment of the issue was addressed specifically to the use of the test report for Waterford. As stated before, we know of no instance where the Staff has ever stated that the report is not completely applicable to support qualification of V-type terminations at Farley.

Q54. In their direct testimony on this issue, Mr. Paulk and Mr. Walker also allude to "deficiencies" in the Wyle report. First, on page 15 of his testimony, Mr. Paulk implies that the test was concluded prematurely. Subsequently, on page 17 of the Staff's testimony, Mr. Walker states that "[t]he test conducted at Wyle was terminated prior to its completion . . . ." Are these alleged deficiencies valid?

A: (Sundergill) No. As I explained, the Staff accepts Arrhenius techniques in its May 16, 1990, Waterford document as a means of extending accident testing. (APCo Exhibit 40). Wyle's calculation determining the test time and temperature equivalent to the specified Farley DBA profile is included in the Wyle report. Bechtel's review of the Wyle report concluded that the Wyle calculation was proper and was numerically correct. The test was run to its completion, demonstrating that the V-type tape terminations could have performed their safety related functions during the entire postulated DBA period at Farley Nuclear Plant. Thus, the Staff's concerns pertaining to the duration of the test are unfounded and at odds with their own accepted techniques.

Q55. Next, on page 14 of the Staff's testimony Mr. Merriweather states that Wyle Test Report 17947-01 "would not qualify the application of V-type splices in instrumentation circuits." An additional Staff criticism of the Wyle test report is found on page 15 of the Staff's direct testimony where Mr. Paulk states that "NRR reviewed this [Wyle] report in 1990 and concluded that it was not sufficient to support qualification of the splices APCo stated represented those at Farley." Mr. Walker, on page 17, also charges that the report was "without sufficient information to demonstrate qualification for the Farley application." Do these allegations have any merit?

A: (Sundergill) None whatsoever. In my prior testimony, I have already addressed the concerns pertaining to instrument circuits, leakage currents, and test durations as they apply to Farley. With respect to the charges that NRR's review of the Wyle test report showed the report to be deficient for Farley, the Staff testimony mischaracterizes the NRR review. The Staff document dated May 16, 1990, (APCo Exhibit 40) pertains to Waterford Nuclear Plant -- not to Farley. The conclusions in that report pertinent to the enveloping of DBA conditions are directed to conditions at Waterford, which are in excess of those at Farley. The Wyle test report was tailored specifically for conditions at Farley and, as such, did not envelope the Waterford conditions. While this may be detrimental to Waterford, it in no way adversely reflects on the applicability of the test for Farley. The NRC inspectors, who by their own admission have not reviewed the Wyle test report against Farley conditions, are taking an NRR conclusion (that they were not even involved in), intended to apply to one plant, and are then applying it to the Farley plant. This seems to me to be an extreme example of taking information out of context. By virtue of my familiarity with the Wyle test report and with the postulated conditions at Farley and Waterford, and my review of the NRR document, I must conclude that the allegations made by the Staff in their testimony have no merit.

Q56. Do you have any other concerns with the Staff assessment of this issue as set forth on page 16 of their direct testimony?

A. (Sundergill) Yes. On page 16 of his direct testimony, Mr. Paulk states that in conversations between Okonite and Entergy Operations, Okonite stated that "the T-95 tape (insulation tape) was not a self-vulcanizing tape and was highly viscous at room temperature because it lacked peroxides." Mr. Paulk further states that testing by Entergy at the Arkansas Nuclear One site "showed that as temperature rose, the T-95 tape expanded and began to run as it became less viscous and more fluid, similar to the way glass responds."

Taking these comments one at a time, I note that Mr. Paulk's first comment is based on second-hand information: he does not state that he personally had this discussion with Okonite. Nevertheless, I have heard similar allegations over the past few years so we contacted Okonite to determine if the statement was true. We were informed by Mr. Jim Rogers of Okonite that the standard T-95 tape is self-fusing tape, which is the way it was designed, and has been demonstrated to be effective for many years of installation. There is a new type of T-95 tape which Okonite provides which is "self-vulcanizing." It is for installations where a rapid fusing of the tape is desired but it in no way detracts from the standard product.

The second of Mr. Paulk's statements is more puzzling and more difficult to address because Mr. Paulk does not reveal the details of the testing. He does not state over what period of time the test was run, at what temperatures the degradation began to occur, or even which product was tested. The statement is particularly suspicious in that it contradicts the testing conducted by Wyle for the V-type splices at Farley, as well as the testing by Okonite for the in-line configuration (NQRN-3). If Mr. Paulk's statement is true it should have been the subject of an NRC notice since it also implicates in-line splices.

Q57. Assuming that the installed terminations were fully operable, the NRC still appears to have the concern that APCo did not know about the V-type configurations until July 1987. Can you address this?

A: (Love, Sundergill, Jones) First, as we have addressed already, it was not surprising that APCo did not locate the termination issue earlier. APCo had addressed terminations as an EQ matter well before the EQ deadline: a qualified in-line splice/termination had been specified in installation notes and details. From an EQ perspective, documentation existed and the installation instructions were adequate. Maintenance and/or QA would address any installation deviations. APCo had no basis to believe there was an EQ concern. When a tape splice issue was identified by another licensee as a potential issue in July 1987, APCo immediately went to look for a similar condition at its units.

Note that in their testimony on page 9, quoting from the prior inspection report, the Staff states a "root cause" of the "unqualified configurations." We agree with only half of this assertion. The root cause was not incomplete design drawings (an EQ responsibility), but misapplication of Electrical Notes and Details by craft (outside the sphere of EQ). A detail had been provided by APCo for both a tape and a Raychem in-line termination. The detail could have been applied by electrical craft rather than the V-type configuration. In addition, procedures were in place to obtain approval of deviations. Thus, the APCo program was correct and this really was not an area EQ should have been expected to address further prior to November 1985.

Also, the Staff has commented that more detailed walkdowns would have found these splices. However, when judged from a pre-deadline perspective, we don't believe this is a valid point. As we've discussed above in the relevant timeframe, detailed walkdowns were not the norm absent some specific concerns from the plant, the industry, or the NRC. APCo did not become aware of a splice/termination issue until July 1987 after a similar issue was identified at Calvert Cliffs.

Finally, note again that prior to 1985, EQ was not a discipline in which the same rigorous documentation standard of today was being applied. More accurately, prior to 1985, some degree of latitude in installation would typically be accorded to skill of the craft -- especially where, as here, reasonable engineering judgment could be exercised to determine that the installed splices would be qualified. In this context, prior to the deadline, it is not surprising that further emphasis was not placed on (and further documentation provided for) minor splice configuration deviations.

Q58. On page 17 of his testimony on this issue, Mr. Merriweather again asserts that he disagrees with your position -- as again articulated above -- that adequate installation instructions had been provided to the craft for EQ splices and terminations. Mr. Luehman makes a similar point on page 18. What is your reaction?

A: (Love, Jones) We disagree. Installation instructions were adequate. The Notes and Details provided the option of a qualified tape or Raychem in-line termination for these applications. Mr. Merriweather states on page 17 that a licensee representative indicated that the design "required" the use of heat shrink material in these applications. This is not true. The Notes and Details permitted, but did not require, a heat shrink splice. The Notes and Details also permitted the qualified in-line Okonite splice. This Staff assertion, therefore, does not support conclusions that installation instructions were inadequate or that there was a "breakdown" in the EQ program. In the final analysis, our point is that these installation procedures were adequate and APCo had a reasonable basis prior to the deadline to conclude that these terminations would be adequately made. Thus, this is not a violation APCo clearly should have been aware of prior to the deadline.

Q59. In the Order, the NRC Staff cites two NRC generic communications -- Circulars 78-08 and 80-10 (APCo Exhibits 4 and 41) -- as sufficient notice of a concern. Do you agree that these should have prompted walkdowns of splices/terminations at Farley?

A. (Love, Jones) We strongly disagree with that assertion. Both of these documents were very early EQ circulars, and we believe the NRC is reading entirely too much into them in order to support a "clearly should have known" finding from a present-day perspective.

IE Circular 78-08, dated May 31, 1978, listed, among several other specific concerns, certain instances of lack of qualification data and inadequate design of electrical connectors. (APCo Exhibit 4). It also listed certain unqualified electrical cable splices associated with electrical penetrations assemblies. These were very specific problems that APCo would have examined and dispositioned for its plants. It is simply not supportable, especially given standard industry and NRC practices of that time, to extrapolate from this circular a basis to say that APCo should have conducted walkdowns or clearly known of V-type terminations in its units (particularly in light of APCo's measures in place to address installation of terminations).

(Jones) Also, as I stated in my earlier panel testimony, APCo made a formal response to the NRC addressing IE Circular 78-08. NRC also performed an inspection at Farley in December 1980, wherein the Staff specifically evaluated equipment interfaces. (APCo Exhibit 11). At no time did the Staff indicate a problem with APCo's responses to the

Circular; likewise, it did not find problems with equipment interfaces at the site.

(Love, Jones) IE Circular 80-10 similarly fails to provide a basis on which to argue that APCo should have addressed V-type splices. IE Circular 80-10 (APCo Exhibit 41) discusses a specific event at the H.B. Robinson Nuclear Plant that involved use of the wrong class of insulating material in reconnecting the leads of a containment fan cooler following maintenance. The Circular makes no mention of walkdowns. In fact, it lists specific "recommended" actions. None are walkdowns of any kind. Moreover, no mention is made of the type of insulating material improperly used by the licensee at Robinson. APCo, and Bechtel, during that time would have read the Circular and concluded that at Farley an appropriate (i.e., qualified) material (Okonite T-95/No. 35) was used. This Circular would not have prompted reevaluation or walkdowns of all splices due to existing design documents and installation notes and details.

The Staff only seems to extract one line from Circular 80-10 in the Order, alleging that in that Circular the Staff had emphasized the "importance of properly installing and maintaining environmentally qualified equipment which clearly requires more than a review of QA records."

However, the Circular actually illustrates the usual approach. APCo recognized the importance of installing and maintaining EQ equipment. In the area of terminations, APCo had a specific means to do this: qualified termination methods and materials in conjunction with Electrical Notes and Details instructing electrical craft who were trained in making taped terminations how to make the tape termination when needed. The Circular even seems to stress the importance of construction and maintenance as something apart from EQ. In context, it simply is not a fair reading of IE Circulars 80-10 and 78-08 (APCo Exhibits 41 and 4) to argue that they suggested specific walkdowns of all electrical terminations/splices in the plant. Also, keep in mind that APCo did not believe that it had "splices" in the plant, as we discussed earlier.

Q60. With reference to the Staff's "clearly should have known" finding, did APCo have vendor supplied documentation demonstrating qualification of these terminations prior to the deadline?

A. (Love, Sundergill, Jones) Yes. There was vendor supplied documentation (NQRN-3) (APCo Exhibit 25) establishing qualification for the configurations specified by the Electrical Notes and Details. Thus, there was vendor qualification documentation for the terminations that APCo believed had been installed. Accordingly, APCo believed its terminations were qualified. APCo never had a basis prior to 1987 to believe that minor deviations between installed configurations of terminations and vendor documentation would be considered to be an EQ issue (much less a violation). When APCo became aware of this as a potential EQ issue in 1987, we promptly addressed it and determined that it was a non-issue.

Q61. Did the licensee perform adequate receiving and/or field verification inspections to determine that the installed configurations matched tested configuration?

A. (Love, Jones) As we have already stated, APCo's walkdowns (i.e., field verifications) of equipment were consistent with then-prevailing norms. In addition, the Electrical Notes and Details were design documents issued for use during construction and maintenance. Compliance with the Electrical Notes and Details was subject to APCo's Appendix B quality program. Applicable procedures were in place to govern implementation of the Notes and Details. This provided a reasonable basis to conclude that further field verifications were unnecessary. Likewise, there was, and is, no reasonable basis to conclude that field verifications were inadequate.

Q62. Finally, did APCo have any other notice, prior to November 30, 1985, that EQ deficiencies might exist in these terminations?

A. (Love, Jones) No. Other than the generic correspondence addressed above, the Staff points only to NUREG-0588. NUREG-0588 states that it is necessary to address equipment interfaces. (APCo Exhibit 42). However, APCo did address these interfaces. APCo chose to address interfaces by including them in Electrical Notes and Details rather than by including individual splices or terminations on the EQ Master List. As stated previously and by others, as of November 30, 1985, the Staff had approved the Farley Master List. APCo had no basis to investigate installed terminations until the Calvert Cliffs episode in 1987.

Q63. Is it your opinion then that the V-type termination issue is not one which APCo should be held to "clearly should have known" prior to November 30, 1985?

A: (Love, Sundergill, Jones) Yes, that is our opinion.

Q64. In your opinion, was this issue safety significant?

A: (Love, Sundergill, Jones) No. This issue revolved around the availability of paper documentation addressing all installed configurations and voltages. In fact, nothing identified by the Staff implicates the ability of these terminations to perform intended functions. The lack of potential impact on safety was initially apparent based on engineering judgment and Wyle's testing for CECo. This conclusion was subsequently confirmed, prior to NRC's November 1987 inspection, by Wyle's testing for APCo.

IV. 5-TO-1 PIGTAIL SPLICE (HYDROGEN RECOMBINERS)

Q65. In the Notice of Violation, the NRC Staff separately cited the terminations on the Hydrogen Recombiners (Violation I.A.2). Can you describe this issue?

A: (Love, Sundergill) The Westinghouse Hydrogen Recombiners at Farley basically consist of a bank of electric resistance heaters which provide thermal energy to drive the exothermic conversion of hydrogen and oxygen to water. This would be called upon to reduce any suspected concentrations of hydrogen gas which might be generated in the containment as a result of the postulated accident.

Each recombiner has five three-phase banks of resistance heaters. Therefore, there are five sets of heater leads per phase that must be powered from one incoming three phase power cable at the power junction box. As a result, when installed at Farley, electricians -- under the supervision of a Westinghouse representative -- created the 5-to-1 pigtail splice. For each phase, the five leads are bolted together to the incoming power cable to form the connection. The termination (splice) was then wrapped with the qualified Okonite T-95 tape and with Okonite No. 35 as an overlayer or protective jacket.

When APCo was researching the V-type configurations in July 1987, it conservatively self-identified this splice as another potential EQ issue. The EQ program had not specifically included an EQ file on this Okonite 5-to-1 splice configuration. However, APCo -- with assistance from Bechtel -- did conclude promptly that the splice was fully operable and, based on existing information, qualified.

Q66. What was the basis for Bechtel's conclusion that the 5-to-1 splice was qualified?

A: (Love, Sundergill) Bechtel's conclusions and analyses supporting qualification were contained in a justification for continued operation (JCO) dated September 23, 1987. (APCo Exhibit 41). This information was made available to the NRC inspectors. Note, however, that APCo never chose to formally document qualification of this splice. In response to the NRC inspectors, APCo instead replaced the 5-to-1 splices with qualified Raychem splices.

Q67. Explain Bechtel's technical evaluation.

A: (Love, Sundergill) For a full explanation we refer you to the September 23, 1937, JCO (APC Exhibit 43). However, several points are key.

First, there is no question that the materials utilized to make up this termination were fully qualified. Okonite's Test Report NQRN-3 qualified a 5kV taped in-line splice using T-95/No. 35 tape materials. (APCo Exhibit 25). The application in the Farley Hydrogen Recombiners was within the tested profile for these materials.

Next, for this termination, as with the V-type configuration, the only postulated concern is the potential, under accident conditions, for moisture intrusion. The splice essentially involves five V-type terminations together. The postulated moisture intrusion would be by wicking or by entrance through the gap between the heater power leads.

However, this postulated failure mode is of no functional significance for operation of each power cable phase splice since all individual like phase conductors are electrically connected at the bolted splice. Also, moisture in-leakage would not degrade the material properties of the T-95 tape itself since the splice would not be subjected to cyclic voltage spikes such as would occur during energization and de-energization.

As with the V-type configuration, the only functional concern is a phase-to-phase or phase-to-ground short external to the connection. However, as with the V-type terminations, this is an unlikely failure mechanism. A substantial and unlikely current path would need to occur from the bolted connection to the grounded junction box or to the bolted connection of another phase.

Third, Westinghouse had qualified the Hydrogen Recombiners well before the EQ deadline and documented its testing in WCAP-7709-L. (APCo Exhibit 44). This documentation was present in APCo's EQ files. In that testing, the connections at the power junction box and at the heaters were the same as at Farley (5-to-1 configuration), except that at the junction box the splice was made up in an unidentified wrap configuration. No problems were identified by Westinghouse. It can reasonably be concluded that moisture-related leakage currents either did not occur or, if they did occur, resulted in no heater operability problems.

As with the V-type splices discussed earlier, verification of the operability of this configuration was provided by Wyle Test Report [illegible] discussed earlier. (APCo Exhibit 27). This Wyle testing for CECo provided qualification information on V-type splices using the Okonite T-95 and No. 35 insulating or jacket material. These tested specimens had, by intent, pathways for possible moisture intrusion considered to be more severe than any that might have existed for the 5-to-1 configuration (with its five combined V-terminations). As discussed earlier, we believe that this testing supported acceptability of the Okonite T-95/No. 35 splices, including the splice on the Hydrogen Recombiners.

The final verification on the 5-to-1 splice is based on Wyle Test Report 17947-01 discussed earlier. (APCo Exhibit 39). Since this report also utilized the same Okonite T-95/No. 35 material, it provides additional assurance that the 5-to-1 splice configuration in the Westinghouse Hydrogen Recombiners installed at Farley Nuclear Plant were qualified to withstand the environment which they were postulated to experience.

Q68. Again, was this information made available to the NRC inspectors?

A: (Love, Sundergill) Yes it was. The first EQ inspection was conducted from September 14-18, 1987, as a result of APCo's identification of the V-type issue. Bechtel had completed the first version of the JCO (APCo Exhibit 45) on the Hydrogen Recombiners on September 17. This information was sufficient to sustain qualification by partial testing and analysis prior to the end of the audit. Although we later replaced this version with a more detailed version dated September 23, 1987 (APCo Exhibit 43), all pertinent information was made available by APCo and the conclusion was unchanged. On page 3 of the Staff's direct testimony on this issue, Mr. Merriweather fails to acknowledge receipt of the September 23 JCO. In any event, the issue was still being discussed during the formal EQ inspection in November 1987 and there was another exchange of information at that time.

Q69. How does the NRC Staff respond to these September 1987 JCOs in its direct testimony filed in this proceeding?

A: (Sundergill) On pages 3 and 9 of their direct testimony, Mr. Merriweather and Mr. Paulk state that the September 17, 1987, JCO was unacceptable. However, they have not addressed the acceptability of the September 23, 1987, JCO.

The September 23 version of the JCO was based on the same logic and resulted in the same conclusion as the September 17 version. However, the September 23 version contained a more detailed analysis (5 pages versus 2) and provided more supporting sketches and backup information (12 pages versus 1). (APCo Exhibit 43). Once again, we apparently have an example of a difference of opinion concerning the level of detail necessary to support an engineering judgement. In the original installation of the recombiners at Farley, it was believed that no documentation addressing the splice was necessary since the splice installation had been overseen by the Westinghouse field representative. When a JCO was requested by the Staff in 1987, the 3 page version dated September 17 was believed to be adequate by the team of Bechtel and APCo engineers who produced it. Finally, the September 23 version of the JCO was produced to supply information which the Bechtel/APCo team had not considered to be necessary. Since neither approval nor rejection of this version has been offerred in the testimony of Messrs. Merriweather and Paulk, it is possible that a reviewer in the 1992 time frame might require even more detail.

Q70. You noted that Westinghouse had previously qualified the Hydrogen Recombiners. Was that qualification based on testing?

A: (Love, Sundergill, Jones) Yes. As stated earlier, Westinghouse had tested the recombiners as documented in WCAP-7709-L (APCo Exhibit 44), which was in the Farley EQ files.

Q71. If Westinghouse had tested the Hydrogen Recombiners with a splice configuration for the power connections, why is there any EQ issue at Farley?

A: (Love, Sundergill) We knew that Westinghouse had tested the recombiners. We also knew that they had tested the equipment with a 5-to-1 connection because that was the only possible way the equipment could be connected. Westinghouse's installation instructions essentially specified that the installation be made in this manner, with a qualified splice. However, neither those installation procedures nor the WCAP in APCo's files showed exactly how the termination was made or the tape materials used in the Westinghouse tests. Therefore, we have a configuration/documentation issue of the type discussed above -- that is, very indicative of the evolution in the

Staff's expectations. This was identified in 1987 by APCo as a potential EQ issue.

Q72. Once the issue was raised, you were able to satisfy yourself that, despite the lack of direct traceability to the tested configuration, this was not a significant concern?

A: (Love, Sundergill) Yes, for the reasons discussed earlier and documented in the JCO.

Q73. Did you do anything at that time to also ascertain from Westinghouse what configuration was used in their testing?

A: (Sundergill, Jones) Yes. APCo promptly determined from Westinghouse that Westinghouse had used Scotch #70 tape to make a 5-to-1 termination in their recombiner qualification tests. This was documented in a letter from Westinghouse dated September 22, 1987. (APCo Exhibit 46).

(Sundergill) The important thing to recognize here is that the Okonite T-95 tape used by APCo was qualified for use at Farley while Scotch #70 was not. Therefore, I was certain that if the Westinghouse splice had passed the testing documented in WCAP-7709-L (APCo Exhibit 44), the APCo splice (using qualified materials) would be at least equally qualified.

Q74. This addressed the materials used by APCo. But .at about the actual connection configuration? Did you have equal assurance in that area?

A: (Love, Sundergill) Yes. As confirmed by Westinghouse, we knew that they had tested a bolted 5-1 connection. Configuration details beyond this level, for all the reasons we discussed above and documented in the JCO, was not a significant EQ concern. Moreover, as indicated by the very fact that Westinghouse did not choose to document the splice configuration precisely in WCAP-7709-L, this simply is a level of detail for EQ documentation far beyond what APCo, Bechtel and Westinghouse considered typical prior to the EQ inspections.

An additional point is also important here. The NRC's concern was that the tape configuration may not have matched that in the Westinghouse tests. However, as alluded to earlier, we verified that the only significant difference between the tested versus the installed configuration was that APCo used tape materials clearly qualified for the Farley applications. Furthermore, a Westinghouse site engineer oversaw the installation of the Hydrogen Recombiners at Farley. It is reasonable to assume that the on-site Westinghouse engineer would have been familiar with the installation of the equipment. The 5-to-1 splice is the primary electrical interface between the Hydrogen Recombiner and the plant. The site engineer would have overseen the making of the splice since it is the primary electrical interface for this equipment. It is reasonable to assume that he was satisfied.

In total, we believe that when this issue was identified in 1987, a reasonable EQ engineer would have concluded that the installed splice was equal to or better than the splice tested by Westinghouse. No further documentation should have been necessary.

Q75. In its Order, as adopted on page 7 of its direct testimony, the NRC Staff charges that the licensee's claim that the APCo splices are qualified by virtue of similarity to unidentified splices in Westinghouse reports WCAP-9347 (APCo Exhibit 47) and WCAP-7709-L (APCo Exhibit 44) are invalid because the reports "do not indicate the materials used or the configuration of the splices." How do you respond?

A: (Sundergill) This is yet another example of the Staff's unwillingness to apply engineering judgement -- judgement which in this case borders on common sense. First, as for the Staff's configuration concerns: if there are 5 wires which must be connected to one wire, then it is a completely straightforward conclusion that some sort of 5 to 1 configuration will result. It is also logical to assume that the heater leads would be grouped on one side and the field lead on the other. This conclusion was not only logical but later verified by Westinghouse when it provided the detailed description of the splice configuration used and qualified in its test. Raychem also adopted the 5-to-1 configuration when it produced a 5-to-1 heat shrink splice kit.

At any rate, I do not think the splice configuration is germane to the argument. That is, I do not think it matters whether the splice was in a 4-to-2 configuration, a 3-to-3 configuration or the 5-to-1 configuration. What is important in this issue is that there was essentially a set of V-type tape splices. The number of Vs on one side of the center point versus the other is inconsequential. No matter what the configuration, the quantity of Vs remains the same. The order that they are in and their spatial orientation are inconsequential as well. The issue is whether or not moisture could cause some sort of electrical fault which would prevent the heater from functioning (and, as we discussed, it would not). Therefore, there was no need to have the splice configuration information in the WCAPs since this information is irrelevant.

As for the Staff's charge that the materials used in the test report were unverified, this is also a non-issue. It did not matter what materials Westinghouse used since APCo utilized materials that were approved for use at Farley. Even if the WCAPs had identified the material in the Westinghouse splice, it would not have been used at Farley since there was no qualification file for it. So the lack of this information in the WCAPs was completely inconsequential. Therefore, neither of the Staff's claims are valid.

Q76. Was APCo's logic on this issue in "auditable form" at the time of the inspection?

A: (Sundergill) The Hydrogen Recombiners were qualified prior to the inspection. An issue had been raised by APCo prior to the inspection and dismissed. The conclusions with respect to qualification of the splice were explained and presented to the inspectors in the JCO before completion of the EQ inspections. APCo also specifically verified that the installed configuration was at least equal to or better than that tested by Westinghouse. A requirement for further detailed documentation to address concerns and questions raised at the audit, and that were easily dismissed from an engineering perspective, would simply exceed any reasonable standard for EQ documentation. Thus, the documentation, the conclusions, and the explanations were available for review during the November 1987 audit. Absent any specific Staff guidance on the meaning of "auditable," and since I consider that what was available would have been sufficient for a "reasonably skilled" engineer to evaluate, I conclude that the information was in an "auditable form."

Q77. Assuming this was a violation, was it a violation which APCo "clearly should have known" of prior to November 30, 1985?

A: (Love, Sundergill) Emphatically, no. Several reviews were conducted on the Hydrogen Recombiners by the NRC and its consultants prior to the EQ deadline. Correspondence from the NRC always accepted qualification of the recombiners. In this context, one cannot fairly argue that APCo "clearly should have known" of the issue prior to November 30, 1985. Likewise, APCo could not in the pre-deadline timeframe reasonably anticipate that the Staff would later expect further splice documentation.

We also conclude that it was not unreasonable for APCo to rely on the expertise of the Westinghouse site engineer during installation of the recombiners. The site engineer would have been familiar with the splice requirements and passed that on to the electricians making the splices.

Q78. You mentioned prior NRC reviews and correspondence. Could you itemize what you are alluding to?

A: (Love, Sundergill, Jones) First, there was a letter from John F. Stolz (Chief, LWR Branch No. 1), dated June 22, 1978, (APCo Exhibit [illegible]), reflecting approval of the Westinghouse recombiner qualification reports. Note that in conjunction with this approval, the recombiners were specifically installed in accordance with a Westinghouse Electric Hydrogen Recombiner Technical Manual dated August 24, 1976. (APCo Exhibit 49).

Second, in December 1980, a Mr. T.D. Gibbons of the NRC specifically inspected both Unit 2 recombiners against IE Bulletin 79-01B. (APCo Exhibit 11). Two of the stated purposes of the inspection were to review proper installation and overall interface integrity. There were no violations identified. As mentioned earlier, the primary electrical interface for the Hydrogen Recombiners was the 5-to-1 splice.

Third, in the NRC's December 10, 1980 Technical Evaluation Report (TER, APCo Exhibit 12), no mention was made of the recombiner 5-to-1 splices. The power cable was specifically mentioned in the report as acceptable. Since the cable terminates directly in a 5-to-1 splice, it seems reasonable to conclude that if there had been a problem with the termination, the NRC Staff inspector would have mentioned it at that time.

Fourth, the Franklin Research Center TERs in 1983 (APCo Exhibits 16 and 17, at Bates pages 54533-54535, and at Bates pages 54971-54974), also specifically found the recombiners to be qualified. Franklin included a statement from APCo that the power cable and heater connector were qualified. No mention was made of the splice. APCo therefore could reasonably have concluded that, either the splice was acceptable or it was not a significant EQ issue.

Finally, the Hydrogen Recombiners were again found to be acceptable in the December 13, 1984, NRC Staff Safety Evaluation Report. (APCo Exhibit 21).

In light of this information, we find it implausible for the NRC Staff to suggest -- even assuming this was a violation -- that this was a violation of which APCo clearly should have been aware prior to November 30, 1985.

V. <u>TERMINAL BLOCKS</u>

Q79. Please describe briefly the terminal block issue (Violation I.B.1).

A: (Love, Jones) The NRC inspectors cited a lack of qualification testing or analysis to support use of States terminal blocks (Model Nos. NT and ZWM) and General Electric (GE) terminal blocks (Model No. CR151B) in instrument circuits. The Staff maintains, relying in part on the views of Mr. Jacobus of Sandia National Laboratories (Sandia), that these components will not maintain acceptable instrument accuracy during design basis accident conditions.

Q80. What is your response to this charge, in brief?

A: (Love, Jones) It is our position that the terminal blocks were qualified as of the EQ deadline, including for the instrument accuracy issue as it then existed. The terminal blocks at Farley had been tested and it had been demonstrated that they would adequately survive the accident environmental conditions. Prior to the EQ deadline, instrument accuracy was not considered to be an open issue for terminal blocks at Farley -- as evidenced in the Staff's reviews at that time.

The instrument accuracy issue has evolved as a technical matter since that time, and the alleged violation is clearly based on information that became available <u>after</u> the EQ deadline of November 30, 1985. At Farley, we addressed terminal blocks in instrument circuits as did the rest of the industry in accordance with NRC dictates -- by including their portion of the instrument loop error in the instrument setpoint calculations for emergency procedures, as discussed further below. These efforts were ongoing at the time of the audit. This issue is a classic evolving issue and cannot be held to be a matter that APCo "clearly should have known" of prior to November 30, 1985.

Further, as will be discussed below, even setting aside the relevance and effect of the EQ deadline, the Staff's current contentions boil down to only two technical issues concerning terminal block similarity and instrument accuracy at peak LOCA temperatures. We believe the Staff is in error on both of these points.

Q81. Let's begin with the basics. Could you please describe a terminal block and explain its function?

A: (Love) A terminal block typically provides an electrical junction for terminating cable runs onto equipment or electrical devices. It provides the interface between the equipment or device electrical leads and the field cable conductors.

The terminal block itself consists of an insulating material. Essentially, it is segmented and consists of a

Figure 1

series of poles to make electrical connections. Each pole serves one circuit. Figure 1 shows a typical terminal block -- in this case, the States Type NT and ZWM. The poles are separated by a "barrier strip" of insulating material. (On most designs, these barrier strips between poles extend from the main block body akin to fins.) The terminal block is enclosed in a housing, or junction box, and fitted with some form of cover.

Q82. What types of terminal blocks were installed at Farley?

A: (Love) As noted in the Notice of Violation, there are really three types of terminal blocks at issue here: the States Types NT and ZWM, and the GE Model CR151B blocks. Although the historical evolution of the issue for each type of terminal block is similar, it is best to approach the States and GE blocks separately.

Q83. Let's begin then with the States terminal blocks. Was there a difference between the two models cited in the NOV?

A: (Love) From an environmental qualification standpoint, no there was not. States developed the Type ZWM after the Type NT and offered the former as their "nuclear grade" terminal block. They changed the color of the barrier strip to make the ZWM visually distinct, but changed little else. The prime motivation behind marketing of the ZWM nuclear block was to address certain <u>seismic</u> qualification considerations.

Q84. How did APCo address States terminal blocks in its EQ program?

A: (Love, Jones) Following issuance of IE Bulletin 79-01B, terminal block/junction boxes inside containment or in a harsh environment were on the EQ Master List with the system in which they were installed. APCo utilized the States terminal blocks in low voltage power, control, and instrumentation applications. This was clearly shown in APCo's IE Bulletin 79-01B and NUREG-0588 submittals.

(Love) As I also discussed earlier, because States had introduced the ZWM terminal block, Bechtel conducted walkdowns of terminal blocks to specifically catalog what had been installed at Farley. Since NT types were installed and type ZWM blocks were selected for future applications, APCo qualified both types in their qualification documentation.

Q85. What qualification documentation existed for States terminal blocks prior to November 30, 1985?

A: (Love) We concluded in 1984 that, from an EQ perspective, the States Type ZWM and NT terminal blocks were identical and both were qualified by Wyle Test Report 44354-1 (March 8, 1979) (APCo Exhibit 50). Wyle had successfully tested the Type NT terminal block and this information was included in the Farley EQ files.

Note that there was some confusion as to what Wyle actually tested. The report stated that Type ZWM terminal blocks were tested. However, we concluded at the time that the blocks were actually Type NT. Be that as it may, there was and is no real issue as to whether the testing covered both models. Given that the two blocks are essentially the same, the prototype testing was sufficient for both. The inspectors were not concerned with this distinction.

There is absolutely no confusion that the Wyle testing included only low voltage power and control circuits. Testing was conducted at 137.5 volts DC. There were no terminal blocks in instrument circuits in the test. At the time, this was not viewed as a problem. If testing was successful at 137.5 volts, the testing would encompass the lower voltages (48 volts DC or less) of instrument circuits. The testing proved, and still proves, regardless of the type of circuit utilized in the test, that the blocks will not fail due to environmental conditions at Farley Nuclear Plant.

Q86. Did the NRC Staff review this documentation?

A: (Love) Based on the Staff's SER for Farley, they did review t[illegible]s documentation, or at [illegible]ast their contractor did. As I stated, the qualificat[illegible]tation on terminal blocks was submitted to the N[illegible]se to IE Bulletin 79-01B and NUREG-0588, clearly [illegible] the applications included low voltage contro[illegible]rument circuits. In fact, the Franklin TERs, forwarded t[illegible] APCo by the Staff in February 1983, specifically reflected an evaluation of the terminal blocks with respect to "instrument accuracy." (APCo Exhibit 16, at Bates pages 54685-54705; APCo Exhibit 17 at Bates pages 55096-55114). At least in light of the issue as it existed prior to the EQ deadline, this parameter was checked off in the TER as being acceptable.

Q87. Is it your position then that the "instrument accuracy" issue evolved subsequent to that time?

A: (Love) Absolutely. And most of this occurred well after the November 30, 1985 deadline. APCo was being inspected (and was subjected to enforcement) based on the most up-to-date thinking on this subject.

Q88. Before we discuss the evolution of the "instrument accuracy" issue, it might be helpful if you briefly explain the concept of "instrument accuracy" as it relates to insulation resistance or leakage current.

A: (Love) Instrument accuracy concerns, in this context, are the result of what is known as "leakage currents." As the types of cabling and electrical components used cannot be constructed with perfect insulation systems, very small amounts of current will be lost across the insulation. In an instrument circuit or loop, the small loss of current from the instrument loop between the sensor and the indicator will result in some degree of inaccuracy in the current signal from the sensor to the indicator.

Measurements of insulation resistance (IR) provide an acceptable means of determining leakage currents. By using a fixed DC voltage and measuring the resultant resistance in a circuit, the leakage current can be calculated from OHM's law ($E = IR$, where E is the fixed DC voltage, R is the measured insulation resistance, and I is the leakage current in amperes; $I = E/R$.)

Terminal block, cable insulation, and electrical containment penetration module insulation resistance decreases with increasing temperature and increases with decreasing temperature. And as predicted by OHM's law, terminal block, cable, and electrical containment penetration leakage current increases with increasing temperature, and decreases with decreasing temperature.

Therefore, as cable and terminal blocks (cable terminators) and electrical penetration assemblies all form a part of typical instrument loops for sensors located inside the containment building, some degree of signal loss occurs between the loop sensors and the control room indicators due to the leakage current in these items. These signal losses are the basis for the instrument accuracy concerns.

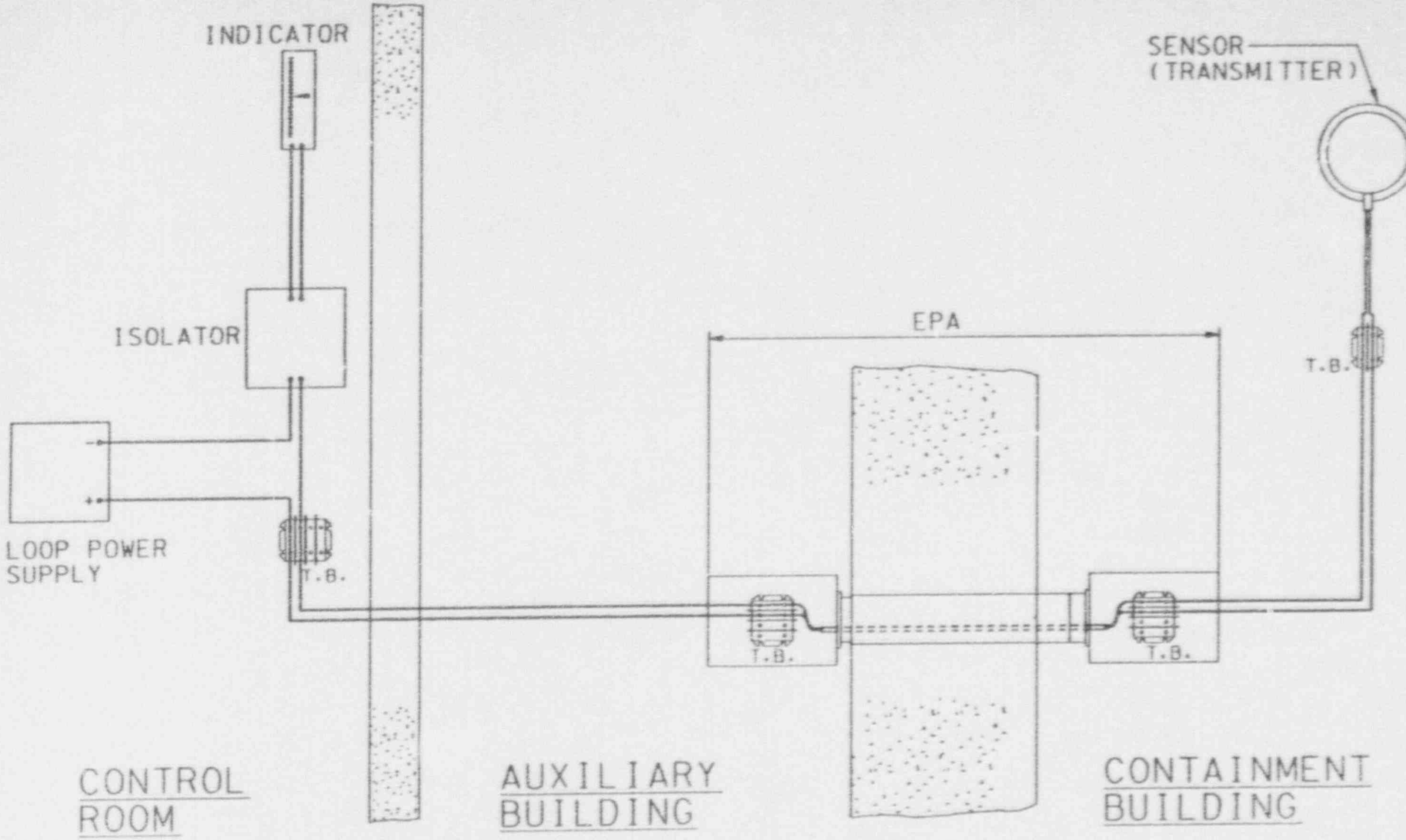
Q89. Was this concept understood when Bechtel was finalizing qualification of terminal blocks for Farley prior to the EQ deadline?

A: (Love) Instrument accuracy was not a new concept. However, in the evaluations and preparation of the 79-01B and NUREG-0588 submittals, when we were looking at terminal block qualification at Farley, total "loop effects" on instrument accuracy were not yet being considered quantitatively for EQ purposes.

Q90. Why not?

A: Most instruments or sensors, such as pressure/level transmitters or RTDs, exhibit inaccuracies due to environmental or radiation effects. As described earlier, these sensors also exist in a loop leading to the indicator or recording device located in the control room. A typical loop is illustrated in Figure 2. In addition to the sensor and the control room display, the loop would contain cable, terminal blocks located in junction boxes for physical protection, a power supply, and perhaps other devices such as signal isolators. From 1980 to 1984, it was generally assumed that the inaccuracy of the sensor producing the loop signal was far greater than any inaccuracy that would exist for the rest of the loop. Therefore, instrument accuracy was only considered to be an EQ issue for the instrumentation sensors, not the other loop components or the total loop.

Also, it should be noted that in this pre-deadline timeframe, insulation resistances were considered as discrete electrical parameters (i.e., not part of an overall loop calculation) in EQ testing of cables and electrical containment penetrations, based on accepted qualification standards such as IEEE-383 and IEEE-317, and were measured on terminal blocks as a part of qualification testing --



LEGEND:
T.B. - TERMINAL BLOCK
EPA - ELECTRICAL CONTAINMENT PENETRATION ASSEMBLY

FIGURE 2 - TYPICAL TRANSMITTER INSTRUMENT LOOP (SIGNAL PATH)

although not normally during the peak LOCA environmental test exposures. Measured insulation resistances were compared to the existing acceptance criteria. (This was presumably the basis for the Franklin TER acceptance of the States terminal blocks and the GE penetration assemblies for instrument accuracy.)

Q91. Did the NRC Staff concur with this approach?

A: (Love, Jones) Yes. As stated earlier, APCo submitted qualification information on the terminal blocks to the NRC, clearly designating applications of the blocks in instrument circuits. Franklin Research Center issued the TER. Consistent with the approach of the day, at that time Franklin did not regard "instrument accuracy" to be of concern for terminal blocks. (Presumably this was the intent of the check-off in the TER.) Again, it seems in retrospect that Franklin would have been inclined to inquire into this issue only for sensors or similar signal devices.

Q92. When did the loop accuracy issue, and more specifically the issue of the terminal block contribution to loop accuracy, arise?

A: (Love, Jones) In late 1983, and continuing through 1987, the industry and the NRC began looking at instrument accuracy in the context of Emergency Operating Procedures (EOPs) and in conjunction with evaluations of post-accident monitoring equipment pursuant to Regulatory Guide 1.97. Both the EOPs and the Reg. Guide 1.97 instrumentation were post Three Mile Island, NUREG-0737 matters. In that context we were evaluating what the operator would be seeing in his instrumentation. For EOPs, the industry was specifically revisiting the instrumentation setpoints established therein. This led to the idea that instrument accuracy should be addressed by including error bars on instrument setpoints in the EOPs to enlighten the operator as to potential inaccuracies. However, it wasn't until 1986 and 1987, subsequent to the EQ deadline, that there was a consensus emerging as to how the calculation of leakage currents from the complete <u>instrument loop</u> (including terminal block contributions) would be made. The EOP work for Farley was being done by Westinghouse.

Q93. Did APCo interact with the NRC on this issue?

A: (Love, Jones) Yes. The first meeting was in January 1984. One of the items discussed was environmental qualification of Reg. Guide 1.97 post-accident monitoring instrumentation. APCo discussed how instrument accuracy for this equipment was being handled. This was the beginning of the examination of the generic issue related to instrument setpoint uncertainty due to the accuracy effects of terminal blocks and other components of an instrument loop.

Q94. What resulted from this interaction with the Staff?

A: (Love, Jones) Shortly after the 1984 NRC meeting, and based on the understanding of the issue as discussed in that meeting, APCo provided Westinghouse with the insulation resistance (leakage current) data for the States terminal blocks from the Wyle Test Report discussed above (Test Report 44354-1). (APCo Exhibit 50). Westinghouse then factored this data into the EOP setpoint calculations.

It was clear at the time, to both the NRC during the January 1984 meeting and to Westinghouse for their work, that the insulation resistance (leakage current) data from the Wyle Test Report was for 137.5 volt DC circuits and was recorded post LOCA. APCo's letter of February 29, 1984, which attached minutes of the January 1984 meeting (APCo Exhibit 20), clearly showed this point. However, at this time, based upon the state of existing knowledge, this data was considered adequate for purposes of calculating the EOP setpoints. Again, the primary environmental error was still considered to be from the sensor. Moreover, the leakage current of the terminal block will decrease after peak LOCA conditions resulting in increased accuracy when the instruments will be relied upon. In this light, any differences between the leakage current for terminal blocks measured in the tests at 137.5 volts DC and those for 48 volt DC circuits at peak LOCA conditions could be and were assumed to be immaterial.

Q95. Did the January 1984 meeting end in a satisfactory resolution?

A: (Love, Jones) Yes. The Staff seemed to be satisfied that APCo was addressing the EQ aspects of the Reg. Guide 1.97 and EOP/instrument accuracy issue.

Q96. Did the NRC Staff raise any concerns about use of terminal blocks in instrument circuits at the January, 1984 meeting?

A: (Love, Jones) Absolutely not. There were no qualification questions raised regarding the terminal blocks. It was never suggested that the States terminal blocks were not qualified or that any further testing needed to be completed. There was, likewise, no suggestion that peak LOCA leakage current data was needed. In fact, APCo's February 29, 1984 letter (APCo Exhibit 20) documenting the minutes of the meeting were subsequently cited by the Staff in the cover letter for the December 13, 1984 SER (APCo Exhibit 21) as a basis for the Staff's conclusion that

APCo's resolutions of EQ issues were adequate and that the program was in compliance.

Q97. Shortly after that meeting, the NRC Staff issued Information Notice (IN) 84-47. (APCo Exhibit 51). How does it fit into the development of this issue?

A: (Love) IN 84-47 was issued in June 1984. It addressed terminal blocks in general in harsh environments. It was not restricted to their use in instrument circuits. However, based on testing at Sandia, the Information Notice raised the concern of the effects on instrument accuracy of leakage current in terminal blocks. The leakage currents identified in the Sandia tests indicated that terminal blocks could provide a significant contribution to instrument loop accuracy.

Sandia, and specifically Mr. Jacobus, have hypothesized that this leakage current in terminal blocks results from a conductive moisture film that develops on the surface of the block around the barrier strip between poles on the terminal block. Therefore, the leakage current is not a function of either the block insulation material or the barrier strip material.

The hypothesized moisture film would be due to steam and condensation.

Q98. How did APCo respond to IN 84-47?

A: (Love, Jones) The Information Notice was reviewed, as it obviously was of interest. However, this Notice did not lead us to believe that terminal blocks installed at Farley were now unqualified.

IN 84-47 did not require any specific response. Rather, it briefly summarized the test method and "significant" results of NRC-sponsored environmental qualification methodology research tests conducted on 24 terminal block models by Sandia. (APCo Exhibit 51). The test reports were not even available at the time the IN issued. These reports, NUREG/CR-3418 and NUREG/CR-3691, were not printed until August 1984 and September 1984 respectively.

The IN indicated that surface moisture films formed on the terminal blocks during the simulated IEEE 323-1974 LOCA testing reduced insulation resistance during the steam exposure portion of the LOCA simulation, and provided some order of magnitude ranges for the measured leakage current and insulation resistances measured at 45 volts DC and 4 volts DC.

The action statements contained in IN 84-47 for licensees were:

> "1) review their facilities to determine if terminal blocks are used in low-voltage applications, such as in transmitter and RTD circuits, and 2) review terminal block qualification documents to ensure that the functional requirements and associated loop accuracy of circuits utilizing terminal block will not degrade to an unacceptable level due to the flow of leakage currents that might occur during design basis events."

As previously stated, the applications of terminal blocks in instrument circuits for Farley were already clearly identified in the original EQ responses to the NRC, and the existence of leakage currents associated with terminal blocks was also not a new finding. To the contrary, the Notice followed closely after our January 1984 meeting with the NRC Staff in which we specifically discussed how instrument accuracy contributions of terminal blocks in instrument circuits were being addressed (that is, based on available data and factored into EOP setpoints). As we stated, the Notice did not specify any additional actions. Thus, we concluded that we were already on the right path based on our meeting of only a few months earlier.

Q99. What path was APCo following on this issue?

A: (Love, Jones) As stated earlier, after the January 1984 NRC meeting, APCo sent Wyle's terminal block leakage current data to Westinghouse. Westinghouse was factoring this data into the EOP instrument setpoint calculations. By no means were we ignoring this issue. This was an issue to be recognized as it concerned the transient behavior of terminal block leakage currents and their effect on the functional and operational requirements of the associated instrument loops. However, as I mentioned earlier, we were not talking about gross terminal block failures.

Q100. How was this issue with the EOPs resolved?

A: (Love) To this day, it has not been definitively resolved. However, loop accuracy and EOPs were addressed on a generic basis in the 1986 and 1987 timeframe -- i.e., after the EQ deadline. Previous assumptions made in the overall instrument loop accuracy calculations regarding instrument cable, electrical containment penetrations, and cable termination device insulation resistance effects during harsh environmental conditions were being revisited by many licensees. The genesis of this activity is not entirely clear to me. Nevertheless, it appears to have resulted, in part, from evolution in the methodology or understanding of the methodology and assumptions being applied in performing the loop accuracy calculations, as well as from additional NRC interaction in this process. Based on information contained in the deposition of Mr. Jacobus of Sandia in this proceeding, it appears that seminars conducted by Sandia for NRC inspectors after the November 30, 1985, EQ deadline contributed to the latest interpretations of this issue, and that the post-deadline EQ NRC inspection findings and violations were the method of communicating the latest thinking.

Q101. How was the EOP issue being addressed at the Farley Nuclear Plant in 1987?

A: (Love) In the summer and early fall of 1987, we focused on completing cable calculations at Farley in order to determine the instrument accuracy effects of reduced cable insulation resistance for each RPS/ESFAS and EOP instrument loop. These calculations were submitted to Westinghouse for use in completing their ongoing instrument accuracy evaluations. The methodology for calculating cable effects on loop errors, which evolved in the 1986 and 1987 timeframe, was consistently being used by many licensees and was deemed acceptable for this determination by the NRC in the fall 1987 EQ inspections at Farley.

Q102. Could you please explain Bechtel's approach in 1987 to the leakage currents for terminal blocks during LOCA testing?

A: (Love) In essence, consistent with the latest thinking, we needed to find IR data for terminal blocks in low voltage instrument circuits, taken during LOCA testing, to include in the loop accuracy calculations. The Wyle data used in 1984 was not in low voltage circuits. To do this, based on the 1986-1987 interpretation of this issue, we consulted the corrective actions contained in IN 84-47. IN 84-47 indicated that where existing terminal block qualification testing does not provide supporting data for instrumentation leakage currents, the following possible corrective action could be considered:

> Obtain documentation from valid qualification tests already performed with substantiated data for leakage currents, and perform appropriate analysis . . . to demonstrate that acceptable loop accuracy and associated response times for instrument circuits utilizing terminal blocks are being maintained throughout various operating conditions.

Based on this direction, we reviewed available terminal block test reports and evaluated whether 1) the reports qualified the block and recorded insulation resistance during LOCA testing, 2) the terminal blocks tested were dimensionally similar to the States Type NT and ZWM and General Electric Model CR151B blocks at Farley, and 3) the test environmental parameters were enveloping and similar to the Farley design basis accident (DBA) environmental parameters. We found such a report: CONAX Test Report IPS-107 for the Connectron NSS-3 terminal block.

Q103. How does this approach compare with the Sandia testing referenced in IN 84-47?

A. (Love) In light of the Sandia testing and hypothesis (i.e., that leakage currents in terminal blocks were due to the moisture film), we specifically evaluated similarity of the Connectron terminal blocks to the Farley blocks based on the physical characteristics of the blocks. Sandia had concluded that the leakage current issue was not an issue created by degradation of insulating material. In October 1987, prior to the audit, we prepared an analysis which justified the conclusion that the Connectron blocks were similar to the States and GE blocks in their ability to resist a current flow due to an exterior moisture film. (APCo Exhibit 52). I'll reiterate here that this approach to qualification by analysis is not unusual and is acceptable under 10 CFR 50.49.

Next, we evaluated the environmental test profiles and EQ parameters recorded by CONAX. These enveloped the Farley parameters for the terminal blocks. We were also satisfied from looking at the pictures in the CONAX report that there was substantial evidence of moisture intrusion into the terminal (junction) box housing during the tests. This, in our judgment, assured that there was ample opportunity for a moisture film to develop.

Based on our engineering judgment as to the similarity of the terminal blocks and environmental conditions, as well as our knowledge of the instrumentation DBA functional requirements, we reviewed the compilation of the insulation resistance test data contained in the CONAX test report for the applicable instrument cable size (16 AWG). Graph No. 1 from CONAX Test Report IPS-107 provided a plot of the minimum IR data points for the 16 AWG test conductor and terminal blocks which were recorded during the DBA and Post DBA testing. (APCo Exhibit 53). From this graph (test numbers 9 through 16), it can be seen that the lowest values of the IR data points recorded were 2E7 to 3E7 ohms. During this portion of the DBA testing, the chamber pressure and temperature were reduced from 45 psig and 294°F to 0 psig and 140-150°F and maintained for 240 hours. During this phase of the LOCA testing, chemical sprays were continually introduced into the chamber. The chemical spray and the environment of the test chamber during this portion of the testing would have resulted in moisture entering the terminal block junction box and a moisture film should have existed on the terminal block. As noted above, evidence of moisture streaking is obvious in the photographs of the interior of the test terminal block junction box contained in the test report. Based on these IR values, we conservatively selected a value of 1E7 ohms for use by Westinghouse in determining the resultant effects c' terminal block leakage currents in their instrument loop accuracy calculations for Farley.

Q104. In the Order, the Staff argues that your similarity analysis between Connectron and States/GE blocks failed to analyze "design, material, and construction differences between the terminal blocks." This argument is reiterated on page 4 of the Staff's testimony by Mr. Jacobus. What is your reaction?

A: (Love) This is not correct. We had considered the differences identified by the Staff and concluded that they were not germane.

First, let me address the alleged material differences. As I have alre'dy explained, the postulated cause of the observed leakage currents was ionic conduction in the exterior moisture film. The Sandia report indicated that insulation resistance of the terminal block <u>material</u> was not the important factor. Based on this conclusion it is clear to me that a materials similarity analysis between the NSS3, NT/ZWM and CR151B terminal blocks is immaterial to the issue.

Second, the designs of these terminal blocks are otherwise quite similar. The Connectron block uses a step arrangement between poles or segments. A picture, taken from the vendor's catalog, is provided. (APCo Exhibit 54). I do not believe, however, that this would have any impact on the existence or non-existence of a conductive moisture film on the surface of the terminal block between the pole segments or on the relative performance in instrumentation circuits.

Finally, the allegation of differences in construction is groundle   In my view, this issue as raised by the Staff inspectors in effect challenges the efficacy of qualification by analysis. It seemed during the inspection, as it does now, that the Staff would only be satisfied by prototype LOCA testing for this IR parameter. This is not the requirement. It certainly never was the expectation before the November 30, 1985 EQ deadline.

Q105. During the EQ audit in 1987, didn't the NRC inspectors also fault APCo for lacking insulation resistance data for the terminal blocks as measured at peak LOCA conditions during a test?

NT/2WM and CR15B terminal blocks is immaterial to the issue.

Second, the designs of these terminal blocks are otherwise quite similar. The Connectron block uses a step arrangement between poles or segments. A picture, taken from the vendor's catalog, is provided. (APCo Exhibit 54). I do not believe, however, that this would have any impact on the existence or non-existence of a conductive moisture film on the surface of the terminal block between the pole segments or on the relative performance in instrumentation circuits.

Finally, the allegation of differences in construction is groundless. In my view, this issue as raised by the Staff inspectors in effect challenges the efficacy of qualification by analysis. It seemed during the inspection, as it does now, that the Staff would only be satisfied by prototype LOCA testing for this IR parameter. This is not the requirement. It certainly never was the expectation before the November 30, 1985 EQ deadline.

Q105. During the EQ audit in 1987, didn't the NRC inspectors also fault APCo for lacking insulation resistance data for the terminal blocks as measured at peak LOCA conditions during a test?

A: (Love) Yes they did. This apparently was a new generic position. The inspectors were not satisfied with the data we had forwarded to Westinghouse for their further evaluation of instrument accuracy. Apparently, only a LOCA test would have sufficed. This position is also taken in the Staff's testimony on this issue.

Q106. How did you respond to this concern?

A: (Love) In reference to the NRC February 1988 inspection report (APCo Exhibit 55, at p. 25), the inspectors have concluded that the CONAX report cannot be used to obtain a value of insulation resistance for terminal block instrument loop accuracy calculations, in part because the data point recorded at 300°F, the peak LOCA test temperature, was clearly defective as stated in the test report. The NRC Staff has concluded that in order to determine EOP setpoint accuracy, it is necessary to determine the loop accuracy effects based on the absolute peak of the worst case LOCA temperature/pressure profile.

As I will discuss further below, this position is unreasonable. The position has been adopted without regard for the design basis accident scenario which generates the temperature/pressure profile, the functional requirements of the instrument loops during those scenarios, or for the transient nature of terminal block leakage current. We selected a valid data point for IR from the CONAX test, based on conditions that will bound Farley conditions as they will exist at the time when the relevant instruments will be needed.

Q107. Was this issue discussed with the Staff during the November 25, 1987, meeting held at the NRC offices in Atlanta?

A: (Love) Yes, and a clarification is apparently required in regard to the IR versus time and temperature curve which was used in the presentation of this issue during the meeting. (APCo Exhibit 56). This curve, which was developed specifically for the meeting, did not contain any explanatory notes indicating that the peak LOCA portions of the IR data from the CONAX testing were indicated in the test report to be defective. This fact had no bearing on the substantive nature of the relevant issues because these IR data points, which were all equal to or greater than 5E9 ohms, <u>were not used</u> in our selection of the value of 1E7 ohms.

Q108. Mr. Jacobus in his testimony, on page 4, specifically observes that "the data that was taken from the CONAX report was taken at 150°F or less. Farley needed data at considerably higher temperatures." Do you have a basis to conclude that your insulation resistance values chosen from the CONAX report were adequate?

A: (Love) Yes. The Staff has apparently based their conclusions regarding the demonstration of the EQ performance of terminal blocks in instrument circuits entirely on the existence of one value of IR or leakage current obtained at the peak simulated LOCA temperature. Presently, as I began to explain above, there appears to be no regard for the functional requirements of the instrument loops in determining the appropriate value of IR or leakage current to be assumed in the 1987 loop accuracy evaluations. This position also disregards the reference in IN 84-47 to functional requirements.

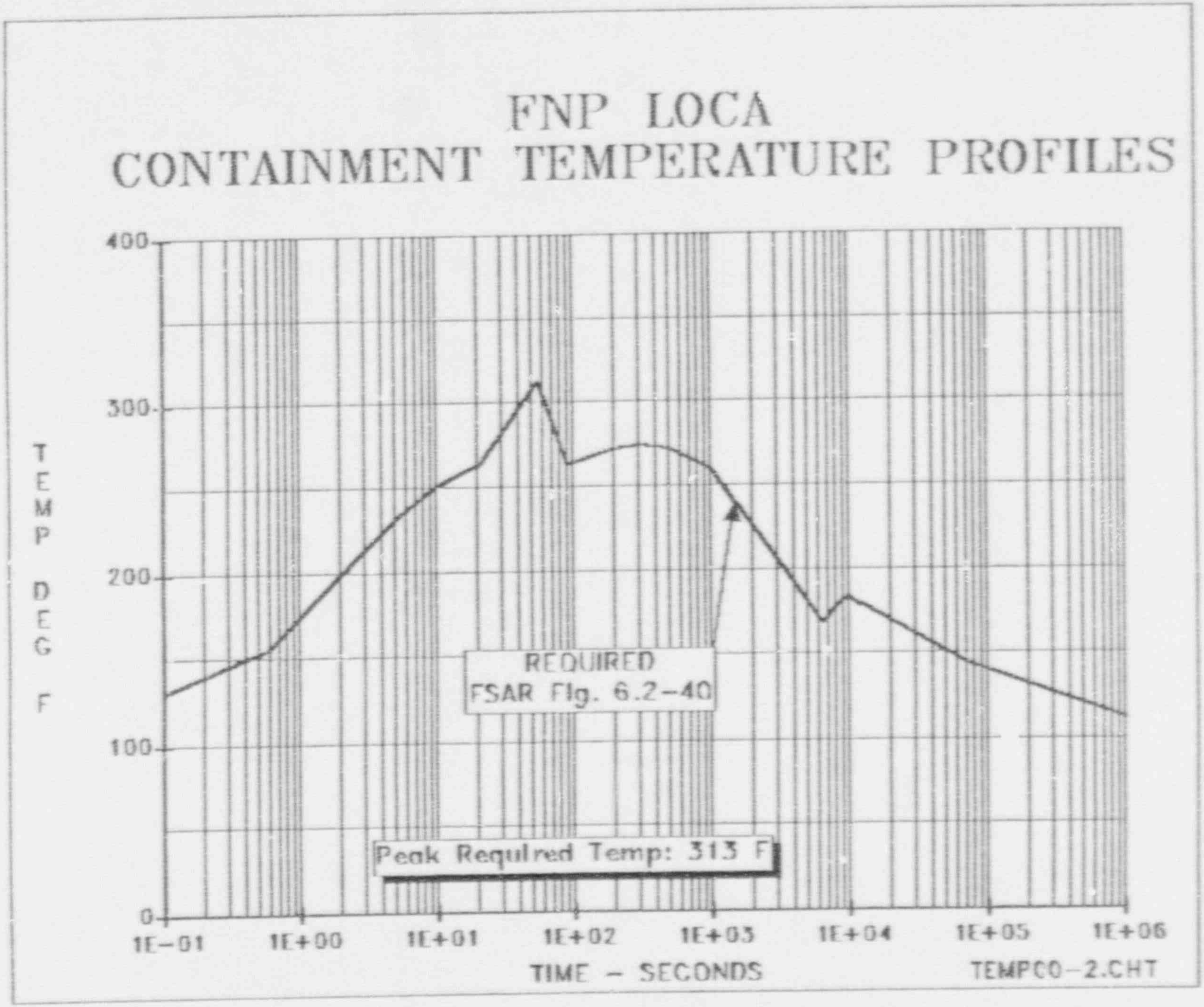
The Staff's reliance on a single IR value (or leakage current), obtained at the peak simulated LOCA temperature, ignores the fact that IR values and corresponding leakage currents do not remain constant during exposure to LOCA environmental conditions. The variance of IR with temperature is well substantiated by numerous EQ test reports for various types of terminal blocks. NUREG/CR-3691 (at page 40) states, "[t]here was a noticeable dependence of IR on temperature. The IRs at temperatures less than 110 degrees C (230 degrees Fahrenheit) tended to be 1/2 to 1-1/2 orders of magnitude greater than IRs at temperatures greater than 110 degrees C (230 degrees Fahrenheit). All of the terminal blocks tested exhibited similar temperature related performance trends, though there were block-related differences in absolute performance." Also, the report states (on page 40), "[d]uring the periods of cooldown to 95 degrees C (203 degrees Fahrenheit) and the post-test ambient temperature period, the insulation resistance values increased to 1E6 to 1E8 ohms but not to the pre-test values of 1E8 to 1E10 ohms."

Q109. If terminal block insulation resistance varies substantially with changes in temperature, then how do you select the appropriate value of terminal block insulation resistance to be used in the (post-EQ deadline) instrument loop accuracy calculations?

A: (Love) In my judgment, the selection is not a straightforward choice of peak LOCA values. Rather, operational knowledge should be applied in reviewing each instrument loop's functional requirements along with the environmental conditions associated with each specific design basis event. This knowledge then should be applied to determine which instrument loops are required by the operator for action or monitoring of the event. Engineering judgment must then be applied in selecting a realistic value of terminal block insultation resistance for the loop accuracy calculation. The value should be consistent with the predicted containment temperature <u>when operator information is of importance for mitigating the event</u>. Simply using a value of terminal block insulation resistance obtained during the peak temperature and pressure conditions of an EQ LOCA test profile which simulates a double-ended rupture of the largest pipe in the reactor coolant system (RCS) is not realistic.

Q110. Can you illustrate this?

A: (Love) Certainly. Figure 3 is a graph of the Farley LOCA containment temperature profile. As depicted on this graph, from the time of the assumed worst case design basis RCS pipe rupture, the containment temperature rises very quickly from normal operating temperature to the peak of 313°F. This rise occurs in approximately 55 seconds. Prior to reaching this peak temperature, all RPS/ESFAS instrumentation actuation setpoints have been reached and safeguards equipment is operational. Due to the inherent thermal lag time associated with heating up the RPS/ESFAS instruments, cable, electrical penetration assemblies and cable termination devices (terminal blocks or Raychem splices), these electrical components including the terminal blocks will have completed their performance function (automatic) before reaching significant temperatures which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TEMP DEG F
REQUIRED
FSAR Fig. 6.2-40
Peak Required Temp: 313 F
1E-01
1E+00
1E+01
1E+02
1E+03
1E+04
1E+05
1E+06
TIME - SECONDS
TEMPCO-2.CHT

FIGURE 3

could affect these functions. It should also be noted that no operator action based on these instruments is assumed or required during this normal ambient to peak LOCA phase of the design basis LOCA transient.

The next phase of the temperature transient, after peak temperature is reached, depicts the operation of containment sprays and ECCS and shows the resultant effect on the reduction of containment temperature. No operator action with regard to these functions is required until ECCS switchover from the RWST to containment sump is initiated. This would occur when the containment temperature is below 200°F for worst case LOCA, and is not dependent upon instrumentation located inside the containment building for operator action. Likewise, post accident monitoring instrumentation will not be relied upon for operator action at the 313°F containment temperature peak; it is relied on during the post-peak periods when the temperature is significantly reducing or tailing off.

Q111. Based on consideration of the instrumentation functions in conjunction with the test observations regarding the behavior of terminal block IRs and leakage currents as a function of temperature, should computations of overall instrument loop errors and uncertainties be based solely on the peak postulated containment temperature?

A: (Love) As I have already stated, no. Let me amplify a bit more.

Overall loop errors and uncertainties are made up of many terms including the environmental allowance (EA) term. The EA term would include the portion of the overall loop error or uncertainty associated with the terminal blocks as well as other loop components including cabling. If the magnitude of error considered in the EA term for terminal blocks, or any other single component in a circuit, is based on a single unrealistic value of IR or leakage current (at peak LOCA), this could result in determining an unrealistic overall instrument loop error and setpoint values, especially with orders of magnitude changes of IR in relation to temperature.

Therefore, in consideration of the instrument loop functional requirements throughout the design basis LOCA operating conditions, and the dependency of terminal block IR on temperature, the value of 1E7 ohms, which was selected from the post LOCA CONAX test data, was, in my view, adequate. Mr. Jacobus, in his testimony, finds fault with values taken at temperatures of 150°F or less. But I disagree.

Q112. Have others concurred with your conclusions?

A: (Love) Yes. The importance of picking a realistic value for IR became clear in 1987 due to the Westinghouse loop accuracy calculations. Westinghouse specialists, in a presentation on instrument accuracy conducted during the November 1987 EQ inspection for the Staff inspectors, provided the Staff with data which explained the current (post-EQ deadline) methodology for combining instrument loop errors. Westinghouse stated that the error contribution is about 0.05% at 1E7 ohms, and increases or decreases by one order of magnitude for each order of magnitude decrease or increase in insulation resistance. This is referenced on pages 43 and 44 of the February 1988 inspection report. Given this relationship between the IR and the calculated error contribution, one does not want to simply select IR at peak LOCA temperatures as a "conservatism." This could lead to unrealistic and potentially misleading calculated error contributions, which could result in misleading or inaccurate instrument set points. It should be noted that in the Staff's February 1988 inspection report, only the portion of the presented data regarding the increase in error due to a decrease in IR is stated. The converse is also true.

In the November 25, 1987, meeting at the NRC Region II offices in Atlanta, Westinghouse stated that values of IR in the range from 1E5 to 5E5 would result in acceptable loop accuracy contributions from terminal blocks for Farley, based on their calculational methodology at that time. Westinghouse again reiterated the dependency of the loop error contribution on the selected IR value.

The violation at issue here appears to be based only on a failure to reach agreement in the instrument loop accuracy paperwork as to which value of IR should have appeared in the Westinghouse calculations in 1987. The selection of the IR data point for the 1987 loop accuracy calculations was entirely a 1987 issue and should not be the subject of enforcement for pre-deadline compliance.

Q113. In his testimony, at page 5, Mr. Jacobus explains his theory of why leakage currents during peak LOCA conditions must be known. He explains that "data must be obtained at the worst case conditions." What is your response?

A: (Love) Again, the Staff is basing their findings on the Sandia terminal block IR and leakage current data observed only during the peak of the test LOCA temperature profile, which was 341°F to 347°F. However, in doing so they ignored all other seemingly relevant observations, such as the dependence of the IR on temperature and the recovery of the IR values during the post-LOCA periods of cooldown as well as the functional requirements of the instrument loops. As I stated earlier, at Farley, the relevant Reg. Guide 1.97 instruments will not be relied upon at peak LOCA conditions and will be needed only during the IR recovery phase during cooldown.

Mr. Jacobus, in his testimony, at page 5, now recognizes that an exception to his 1987 desire for a peak LOCA IR value would apply "if the utility could clearly demonstrate that the equipment was not required to function during peak LOCA conditions and any inaccurate readings during peak conditions would not mislead the operators nor cause any undesired automatic operations." We showed exactly this to Mr. Jacobus during the November 1987 inspection and at the subsequent November meeting at Region II. The functional requirements analyzed were based on available Reg. Guide 1.97 (post-accident monitoring) and FSAR information. Westinghouse was at the meeting and based their discussions on the current EOPs and ongoing setpoint calculations.

Q114. Let's turn more specifically to the GE CR151B terminal blocks. I imagine that the issue is similar to that pertaining to the States terminal blocks.

A: (Love, Jones) Yes. The issue at the audit -- insulation resistance during peak LOCA conditions -- was identical. The evolution of the issue was, of course, also the same. APCo's documentation was, however, slightly different.

A picture of the CR151B terminal block, taken from the vendor's catalog, is provided. (APCo Exhibit 57).

Q115. Please explain.

A: (Love, Jones) For the GE CR151B terminal blocks, APCo did not have a separate EQ package. These blocks are part of the GE electrical penetration assemblies and were procured in that context. (The procurement specifications included all interfaces including terminal blocks and junction boxes as part of the assembly.) The blocks were prototype tested by GE as part of the penetration assembly qualification testing program. (APCo Exhibit 58). The qualification test reports were intended to cover the complete assembly.

Mr. Jacobus, on page 4 of his testimony on this issue, points out that he found the GE penetration test report in the Farley procurement files. There was some confusion in locating this report encompassing the GE terminal blocks at the time of the inspection because the blocks were addressed as part of the penetration assembly. However, it strikes us as odd that the Staff complains about this, yet acknowledges that the report existed (well prior to the inspection) and that it was physically in APCo's possession at Farley.

Q116. When was the EQ testing completed?

A: (Love) The GE testing for the assemblies was performed in the 1970's. These penetration assemblies were listed on the Master List and included in the IE Bulletin 79-01B and NUREG-0588 submittals. Again, the applications for electrical containment penetration assemblies were identified as low voltage power, control, and instrument circuits. The Staff and its contractors reviewed these submittals prior to the 1984 Staff SER. It can be assumed that qualified reviewers were aware of the applications in instrument circuits, and that the method of termination for low-voltage control and instrument circuit penetration assemblies was terminal blocks.

Q117. Were these terminal blocks addressed subsequently in the same fashion as were the States terminal blocks?

A: (Love) Yes. In the January 1984 meeting, APCo explained the manner in which instrument accuracies would be addressed in the EOPs. Essentially, we planned to use the data derived from the Wyle testing on States terminal blocks and apply it to all terminal blocks. In our engineering judgment, the States and the GE blocks (and ultimately the Connectron NSS-3) are functionally and dimensionally similar. Therefore, this approach seemed acceptable.

Subsequently, when this issue was revisited in the fall of 1987 (following development of the latest methodology at that time as to how instrument accuracies would be calculated for reflection in the EOPs), we again considered the GE CR151B terminal blocks. The fact that the conductive moisture film was now the postulated cause of leakage current per IE Notice 84-47 didn't change our conclusion regarding the similarity between the GE and States blocks.

The GE CR151B blocks were included in Bechtel's October 1987 evaluation of leakage currents (APCo Exhibit 52). The IR data for instruments circuits taken from the CONAX report was to be used for EOP purposes for the GE terminal blocks also.

Also, again from a functional performance and accuracy perspective, I believe it is incorrect to assume in the EOPs only the maximum leakage currents as might occur during peak design basis accident conditions. This is not the time when operators would be relying on the instruments to take actions.

Q118. How did APCo finally resolve this issue?

A: (Love, Jones) Following the audit, and to be responsive to the Staff, APCo replaced all of the States NT/ZWM and GE CR151B terminal blocks in EQ instrumentation loops located in potential harsh environment areas with qualified Raychem splices (terminations). As the Raychem splices also exhibit changes in IR or leakage currents under harsh environments which are similar to instrumentation cable, IR data for these instrument terminations were given to Westinghouse for inclusion in their instrument loop error and uncertainty calculations.

Q119. Do you believe that this issue constituted a violation?

A: (Love, Jones) No. We had qualified the terminal blocks prior to the EQ deadline in accordance with everything that was known or expected at the time. As the industry issue evolved with respect to instrument accuracies and EOPs, we addressed it -- in conformance with the analysis techniques permitted by the EQ rule, DOR Guidelines, NUREG-0588, and as discussed in IN 84-47.

As stated earier, in the January 11, 1984 meeting with the Staff, the method for resolving terminal block leakage currents was specifically discussed and agreed upon. The

NRC letter transmitting the SER, dated December 13, 1984, explicitly references APCo's February 1984 documented discussion of this meeting as a basis for approval. The October 1987 Bechtel analysis of the issue (APCo Exhibit 52) as it evolved after the November 30, 1985 EQ deadline, was available during the November 1987 audit. A separate justification for continued operation was also completed on November 24, 1987. (APCo Exhibit 59). Thus, all of the information made available adequately responded to the Staff's questions and demonstrated qualification prior to the end of the audit.

Moreover, we do not believe that, even under 1987 standards, IR data at peak LOCA temperatures was necessary or that similarity to the Connectron blocks was unsupported. Also, if this issue is alleged to be a documentation issue, we must reiterate that there was sufficient documentation available prior to the end of the audit. This would include the October 1987 Bechtel similarity evaluation, and the November 24, 1987 justification for continued operation. (APCo Exhibits 52 and 59).

Q120. In your opinion(s), was the issue identified by the NRC inspectors in November 1987 an issue APCo "clearly should have known" prior to the EQ deadline?

A: (Love, Jones) No. As we have stated, we still do not agree with the Staff's current technical positions on our 1987 instrument accuracy approach for terminal blocks. However, beyond this argument, Mr. Jacobus was and is applying the most recent knowledge and perspectives on instrument accuracy -- all of which post-dates the November 30, 1985 deadline. He seems to be applying and enforcing the most recent thinking on the subject, apparently without regard for the mutual NRC and APCo understanding and approach to addressing this issue as discussed in January 1984 and as inherently accepted by the December 13, 1984 SER.

(Jones) In this regard, Mr. DiBenedetto in his testimony will explain that even the Staff has recognized in the enforcement context that the instrument loop accuracy issue is not one that licensees could have known of and addressed prior to the EQ deadline. He will testify that, on the H. B. Robinson docket, the Staff withdrew a "first round" EQ violation based on a loop accuracy issue.

(Love) It must also be recognized that the instrument loops at issue here were covered by Reg. Guide 1.97. (APCo Exhibit 32). Reg. Guide 1.97 recognized explicitly, prior to the deadline for EQ, that the function of instrument circuits was time-dependent. Reg. Guide 1.97, Revision 2, stated, at page 2 (emphasis added), that "[i]t is essential that the required instrument be capable of surviving the accident environment in which it is located for the length of time its function is required." Prior to the deadline, APCo clearly had a basis to believe that the instrumentation did not need to be qualified for conditions in which it would not be required to function. Further, based on the discussions with the NRC Staff at the January 1984 meeting, and the then current understanding of Reg. Guide 1.97, both the NRC Staff and APCo reasonably concluded that the instrumentation would be adequate to perform intended functions for design basis events.

Q121. What is your view of the safety significance of this issue?

A: (Love) For all the reasons stated above, this issue is not significant. However, I think it is worth reiterating this conclusion in terms of the instrumentation components and systems affected by the terminal blocks at issue.

On page 20 (Q17, A17) of his testimony, Mr. Jacobus states that he never had complete details of all the components or systems affected by these terminal blocks. Therefore, his testimony does not show any correlation to systems/components affected or to the relevant 10 CFR 50.49 performance requirements of terminal blocks in Reg. Guide 1.97 post-accident monitoring instrument loops.

Next, Mr. Merriweather lists on the same page only three Reg. Guide 1.97 instruments affected by this issue. He states that among the instruments affected, and the minimum necessary for a safe shutdown of the Farley Nuclear Plant after a design basis event, are reactor coolant system subcooling, wide range reactor coolant system pressure, and narrow range steam generator level.

These Reg. Guide 1.97 instruments, indicated by Mr. Merriweather as being affected by this issue, were all capable of meeting their Reg. Guide 1.97 accuracy and system performance requirements for each design basis accident defined in the FSAR accident analysis. Therefore, for the relevent design basis events, the terminal block performance requirements of 10 CFR 50.49 have been met.

These examples of affected instrument loops exemplify the Staff's lack of correlation between the theoretical concerns of Mr. Jacobus regarding the performance of terminal blocks in transmitter circuits during generic worst case peak accident environmental conditions, and the required specific instrument performance requirements (as defined by Reg. Guide 1.97) for each design basis accident event.

Finally, we have determined that the terminal blocks at issue here implicated only a limited number of Reg. Guide

1.97 systems or components, making this a relatively low significance issue by the Staff's own methods for assigning significance. Even for these systems and components, there is no instrument circuit terminal block performance deficiency, and without a performance issue, there is no safety significance.

VI. <u>CHICO A / RAYCHEM SEALS</u>

Q122. Let's turn to the violation concerning the Chico A/Raychem seals on NAMCO limit switches (Violation I.B.2). Are you familiar with this issue?

A: (Love) Yes, very.

Q123. What is a Chico A / Raychem seal? What function does it serve?

A: (Love) Chico A / Raychem seals are conduit entry seals which were installed on NAMCO EA-180 limit switches at Farley. The seals are designed to prevent moisture from entering the internals of the NAMCO limit switches under postulated high energy line break or LOCA conditions.

Q124. Why were Chico A / Raychem seals installed at Farley?

A: (Love) In response to IE Circular 78-08 and IE Bulletins 79-01 and 79-01B, APCo evaluated the environmental qualification of installed limit switches at Farley. These evaluations were undertaken between 1979 and 1981. All limit switches installed in the plant lacking documentation capable of supporting the level of qualification called for by IE Bulletin 79-01B, DOR Guidelines, and NUREG-0588 were expeditiously replaced by APCo with NAMCO EA-180 limit switches.

In reviewing NAMCO's qualification test reports for the EA-180 switches, however, it became evident that the test configuration did not encompass installed conditions at Farley. In particular, ingress of moisture into the switch through the conduit opening was physically precluded during the EQ testing, due to the configuration utilized in NAMCO's test chamber. Knowing the application of these limit switches at the plant, APCo recognized that it could not duplicate the test chamber configuration in installed applications. Because the effect of moisture ingress on switch functional performance was not determined by the NAMCO qualification testing, APCo also recognized that it would somehow have to limit the ingress of moisture into the NAMCO limit switches during design basis events. We designed the Chico A / Raychem seal to do this.

Q125. How did APCo, with the assistance of Bechtel, undertake the development of the Chico A / Raychem seal?

A: (Love) Between 1979 and 1981, when APCo was installing qualified NAMCO EA-180 limit switches at Farley, there was no standard configuration conduit seal, widely available on the market or in the industry, for preventing moisture intrusion into such limit switches. Bechtel began looking at various ways to seal the entrance to the switch. I will note that this was a generic issue in the industry and APCo's approach was highly proactive.

Q126. What alternatives were considered for Farley as a means to seal the entrance to the EA-180 limit switches?

A: (Love) Following the provisions of the DOR Guidelines and NUREG-0588, which permit the use of tested materials supplemented with analysis and partial testing, Bechtel began looking at ways to seal the NAMCO EA-180 limit switches. Several alternatives for sealing the conduit entrances were explored.

CONAX manufactured several seal assemblies. One of these was an industrial grade power lead pressure seal consisting of an organic gland material which could be compressed against the insulated wires passing through the gland to form the moisture and pressure seal. The gland material and the wire insulation material could be selected based on environmental and radiation considerations. However, thermal and seismic aging qualification data, as well as other qualification data to support the qualification requirements of NUREG-0588 and the DOR Guidelines, was not readily available.

CONAX was also producing the ECSA seal referred to by Mr. Wilson in the Staff's testimony at page 22. However, for NAMCO EA 180 limit switch applications, as Mr. Wilson also pointed out in his testimony at page 22, this seal was heavy, bulky, very costly and difficult to install. In addition, marketing by CONAX of this seal was limited and delivery lead times were long because this was not a standard item. (Keep in mind that we were trying to have an environmentally qualified seal as soon as possible. The EQ deadline at that time was June 30, 1982; not November 30, 1985.)

Naval applications of cable stuffing tubes for bulkhead pressure seals were also evaluated. The stuffing tubes used an organic compressive gland material which was compressed around the electrical cable by tightening the stuffing tube fitting. However, the type of armored cable used in the naval applications was not similar in construction to the cable used in the commercial nuclear power industry. It did not appear that an effective seal could have been achieved with qualified nuclear power industry cable systems.

The possibility of using sealing compounds, such as silicone rubber and other room temperature vulcanization (RTV) compounds or epoxies, to seal around the cable conductors as they enter the limit switch cable entrance inside the conduit nipple, was also considered. However, from past experience with RTV sealing compounds and testing of fire penetration seals and containment drywell penetration conceptual designs using these types of compounds, sealing problems would occur at the postulated maximum HELB/LOCA pressures. Epoxies were used by the testing laboratories to seal test leads from autoclaves and LOCA test chambers and thus were exposed to HELB/LOCA simulations; however, these same epoxies were not thermally aged or irradiated prior to their application. Therefore, limited data regarding qualified life and radiation capabilities existed for the epoxies.

In the process of exploring alternative sealing methods, I became aware of an installation using Raychem heat shrink material to pressure seal a pipe end for a non-nuclear application. Being familiar with Raychem nuclear qualified heat shrink applications and products and aware of the availability of qualification test documentation for Raychem heat shrink materials, I discussed the possibility of using a Raychem cable breakout boot, made from nuclear qualified materials, as a limit switch conduit entrance seal with Bill Dittman, a Raychem nuclear products application engineer. The response was positive and Bechtel, with input from Raychem, prepared the information necessary for APCo to procure the necessary Raychem cable breakout boots and related materials manufactured from nuclear qualified heat shrinkable materials.

Q127. Could you please describe the configuration of the Raychem seal as developed for this application?

A: (Love) Yes. There were two basic configurations of the Raychem conduit entrance seal. Both configurations were identical with the exception of the addition of the Chico A sealing compound in the later design (which is the design at issue here).

Referring to Diagram 2, the seal assembly consists of a one inch diameter threaded pipe nipple, Item 1, which is threaded into the NAMCO limit switch conduit entrance. A Raychem cable breakout boot, Item 2, covers the end of the pipe nipple opposite to the limit switch and the four electrical wires which traverse the inside of the pipe

DIAGRAM 2

nipple, each passing through one of the four legs of the Raychem cable breakout boot. The cable breakout boot is heat shrunk over the end of the one inch conduit nipple. In the heat shrinking process, the Raychem cable breakout boot seals the end of the pipe nipple and the entrance of the electrical wires through each leg of the boot. To insure that moisture does not traverse through the interstices of the stranded conductors of the electrical wires, as described in NRC IE Circular 79-05, the lugs on the field ends of each electrical conductor are also crimped, soldered and covered with Raychem shrink tubing (not shown in Diagram 2).

An overall sleeve, Item 3, consisting of Raychem heat shrink tubing is then applied over the cable breakout boot and a section of the 1 inch pipe nipple. This sleeve, Item 3, was incorporated into the design based on discussions with Raychem. It serves two functions: (1) to provide an additional mechanical resistance to movement of the cable breakout boot at elevated temperatures, and (2) to provide a base shim for the flexible conduit compression fitting, Item 4. The primary function of Item 4 is to provide a means of attaching the flexible conduit which houses the electrical field wires, to the limit switch. As Item 4 attaches to the conduit nipple with a compression clamp which goes around the Raychem sleeve, Item 3, and compresses the sleeve against Item 1, the clamp adds an additional mechanical restraint to maintain the sleeve in its installed position on the conduit nipple.

This configuration, as described and depicted in Diagram 2 with the exception of Item 5, was installed on the NAMCO EA-180 limit switches, located inside the containment and main steam valve rooms at Farley, which were required to be environmentally qualified pursuant to IE Bulletin 79-01B, DOR Guidelines, and NUREG-0588, Category II. The timeframe for these installations was approximately 1980 and 1981.

Q128. Did you change this seal design after the initial installation?

A: (Love) The only change to this configuration, incorporated after the initial installation of the switches and seals, was the addition of Crouse-Hinds Chico A sealing compound (also referred to as Chico A). As shown in Diagram 2, the Chico A, Item 5, was installed in the 1 inch threaded pipe nipple as a modification to the Raychem seals installed on the NAMCO EA-180 limit switches included in the EQ program and located inside containment. The Chico A sealing compound was added, as further discussed below, to prevent the possibility of breaching the Raychem cable breakout boot seal integrity under high temperature and external pressure conditions. All other aspects of the revised configuration are identical to those discused above and depicted in Diagram 2.

The addition of Chico A to the design was made because it had become known in the later part of 1981 that, due to the manufacturing process for extruding the breakout boot, the material thickness in the center of the four legs of the breakout boot was less than at other parts of the boot. In 1981, Raychem had experienced failures of breakout boots under high temperature and differential pressure conditions caused by thinning of the boot material and the reduced material thickness in this specific area of the boot. The Chico A sealing compound installed behind the breakout boot reinforced this area against external pressure.

Q129. In your opinion, was the Raychem seal material environmentally qualified?

A: (Love, Sundergill) Yes, in the overall limit switch seal configuration. The seal was qualified by separate effects testing. IE Bulletin 79-01B and the DOR Guidelines allow for separate effects testing.

To explain, one of the primary considerations in selecting the Raychem cable breakout boot for the seal was the availability of existing qualification reports for the WCSF-N type shrink tubing material used to manufacture the cable breakout boots. These reports documented environmental qualification testing of the breakout boot material addressing all parameters: thermal aging, radiation, steam/pressure/ temperature, and chemical sprays.

Also, the nuclear qualified cable breakout boot was qualified by Raychem Report EDR 5033, dated April 1981 (also numbered as Wyle Test Report No. 58442-2) (APCo Exhibit 60). In this qualification testing, the cable breakout boot was applied to seal the end of a multi-conductor cable. The material successfully passed the qualification testing and the EQ test parameters enveloped the Farley-specific EQ requirements for radiation, steam/pressure/temperature, and chemical sprays. Based on this testing, the adequacy of the Raychem material and cable breakout boot to withstand EQ testing more severe than the postulated Farley EQ parameters was demonstrated. However, this was only a portion of the separate effects testing relied upon for qualification.

(Love) We also had knowledge of the following: (1) non-nuclear and nuclear applications of the Raychem cable breakout boot, (2) the NAMCO limit switch functional requirements and physical and material design, and (3) the plant interface requirements of the NAMCO limit switches.

Based on all of this, we determined that the only additional qualification testing that was required for the Farley-specific application was a submergence test simulating the postulated flooding conditions for design basis feedwater line breaks in the main steam valve room. A test plan was developed and a test chamber fabricated at Farley in order to perform the submergence testing. This testing was performed and successfully completed in the spring of 1981. (APCo Exhibit 61).

An additional concern leading to the design change mentioned above then arose. Having knowledge of the application for the cable breakout boot as a limit switch seal at Farley, Raychem began to develop a standard environmental interface seal kit in approximately the same time frame as the Farley qualification activities and seal installations. During its development of the standard nuclear environmental seal in 1981, Raychem discovered the material weakness of the boot in the center of the boot legs when the seal is subjected to elevated temperatures and pressures. This phenomenon was not experienced in the EQ testing of the cable breakout boot when installed on a multi-conductor cable because of the support and backing on this part of the breakout boot provided by the cable filler materials and conductors. Due to knowledge of this phenomenon and the urgency of implementing a qualified solution at Farley, additional testing was conducted at Farley in December 1981. This additional testing, under elevated temperature and pressure conditions, demonstrated that Chico A sealing compound installed behind the Raychem boot would eliminate the tearing at the center of the boot experienced by Raychem in its development efforts.

Given the successful results of this testing, Chico A sealing compound was installed as a backfit to the Raychem seal in 1982 for all EQ NAMCO EA-180 limit switches installed in the containments at Farley. The Chico A/Raychem seal configuration is a qualified cable entrance seal for all EQ NAMCO EA-180 limit switches inside the containments at Farley. This same seal configuration, without the Chico A sealing compound, is a qualified seal for all EQ NAMCO EA-180 limit switches inside the main steam valve room (because of the different pressure/temperature profile).

Raychem continued independent developmental and testing efforts for their Nuclear Environmental Interface Seal (NEIS) kits in 1982 using only Raychem materials (no Chico A) in the seal configurations. The results of later NEIS testing performed by Raychem do not invalidate the qualification of the Farley Chico A/Raychem seal design. Moreover, the fact that Raychem ultimately did not market their NEIS kit does not somehow invalidate APCo's qualification of its seal design, as alluded to by Mr. Wilson on page 20 of his testimony. We cannot speculate about Raychem's marketing decisions.

Q130. To summarize at this point then, what were you relying upon to show qualification of this seal?

A: (Love) First, we had Raychem's qualification of the breakout boot -- Raychem Report EDR 5033, dated April 1981. (APCo Exhibit 60). This demonstrated qualification of the boot materials. Next, at Farley we performed the submergence test to demonstrate the ability of the seal/limit switch to exclude moisture. (APCo Exhibit 61). Then, we had the December 1981 testing at Farley to demonstrate that the Chico A backing resolved the pressure/temperature problem. (APCo Exhibit 42).

Q131. Could you please describe the submergence test you conducted on the Raychem breakout boot at Farley?

A: (Love) The submergence test was conducted by APCo at Farley and was documented in Test Report 2BE-1049-3 (APCo Exhibit 61). It was referenced in the Franklin TER for limit switches in the main steam valve room that were subjected to submergence. (APCo Exhibit 17, at Bates pages 55054 and

55058). Mr. Wilson does <u>not</u> refer to this test report in his testimony. This report did exist and was in the Farley file system at the plant during the inspection in 1987.

The test specimens for these tests, which consisted of NAMCO EA-180 limit switches with Raychem seals as depicted in Diagram 2 (with no Chico A installed), were thermally aged and submerged in 10 feet of 210°F water for 24 hours. The test vessel, which was electrically heated with the temperature thermostatically controlled, was fabricated by APCo from a large steel pipe piece with end flanges and a 10 foot stand pipe. During submergence testing, the electrical insulation resistance of the limit switch conductors was measured and the limit switch was actuated approximately every 4 hours to demonstrate functional capability. The limit switch functioned without anomaly throughout the duration of the test. Upon disassembly, after submergence testing, no evidence of any moisture incursion into the limit switch existed.

Q132. Did the submergence test of the Raychem breakout boot, as installed on NAMCO limit switches, address any qualification factors other than submergence?

A: (Love) Yes. The test specimen used in the submergence test was thermally aged. Also, contrary to claims by Mr. Wilson in his testimony (e.g., page 6), electrical performance was verified during submergence.

It was not necessary to test any environmental factors, other than submergence because, as I stated previously, the Raychem boot material was environmentally qualified under all other relevant conditions, including temperature, radiation, pressure, and chemical spray. Raychem's qualification test report (EDR 5033, dated April 1981) (APCo Exhibit 60) documented this conclusion for the type of material used in the breakout boot. The submergence test was conducted in order to simulate postulated flooding conditions for the main steam valve room with design basis feedwater line breaks, to qualify the NAMCO EA-180 limit switch, Raychem seal and cable conductors for submergence.

Q133. Was Raychem involved in APCo's submergence testing of the breakout boot material?

A: (Love) No, although Raychem was, in general, aware of APCo's activities. In view of this new application of Raychem's breakout boot, Raychem started exploring the marketability of the material for the nuclear industry. In connection with this marketing effort, Raychem started doing its own testing on what was later called the NEIS seal assembly as I mentioned earlier.

Q134. What parameters were the breakout boot subjected to in the Raychem testing?

A: (Love) The breakout boot was first subjected to qualification testing as a cable end seal. Later, Raychem performed testing with the breakout boot installed over pipe nipples in conjunction with their developmental efforts for the NEIS seal assemblies. During these tests, the breakout boot was subjected to all EQ parameters: thermal aging, radiation aging, steam, pressure, temperature, and chemical sprays.

Q135. What were the results of Raychem's tests on the NEIS seal assembly?

A: (Love) The only Raychem test result which is significant to the Farley application of the breakout boot was encountered in the Raychem testing conducted in 1981. As discussed above, during early NEIS testing, a failure of the boot occurred consisting of a rupture in the area of the boot at the center of the boot legs. The root cause of this failure was determined to be related to a reduction of the material thickness of the boot in the area of failure. The reduced thickness of the boot material in this area was a result of the extrusion process used in manufacturing the breakout boot. Due to the reduced material thickness in the center of the boot legs, additional softening of the material in this area due to simulated LOCA test temperatures coupled with the material stresses imposed by the application of simulated LOCA pressures resulted in the rupture of this area by implosion.

Q136. You mentioned that APCo responded to Raychem's test results by adding Chico A to the design and doing more tests. Can you describe APCo's testing of this design addition in more detail?

A: (Love) As soon as it became aware of the Raychem test that resulted in the boot rupture, APCo immediately instigated further tests at Farley on the Raychem seal configuration employed for the EQ NAMCO limit switches. This 1981 testing at Farley, addressed in the December 30, 1981 Bechtel Test Report, transmitted under cover numbered APCo/Bechtel AP-6704, was included in the qualification files. (APCo Exhibit 62).

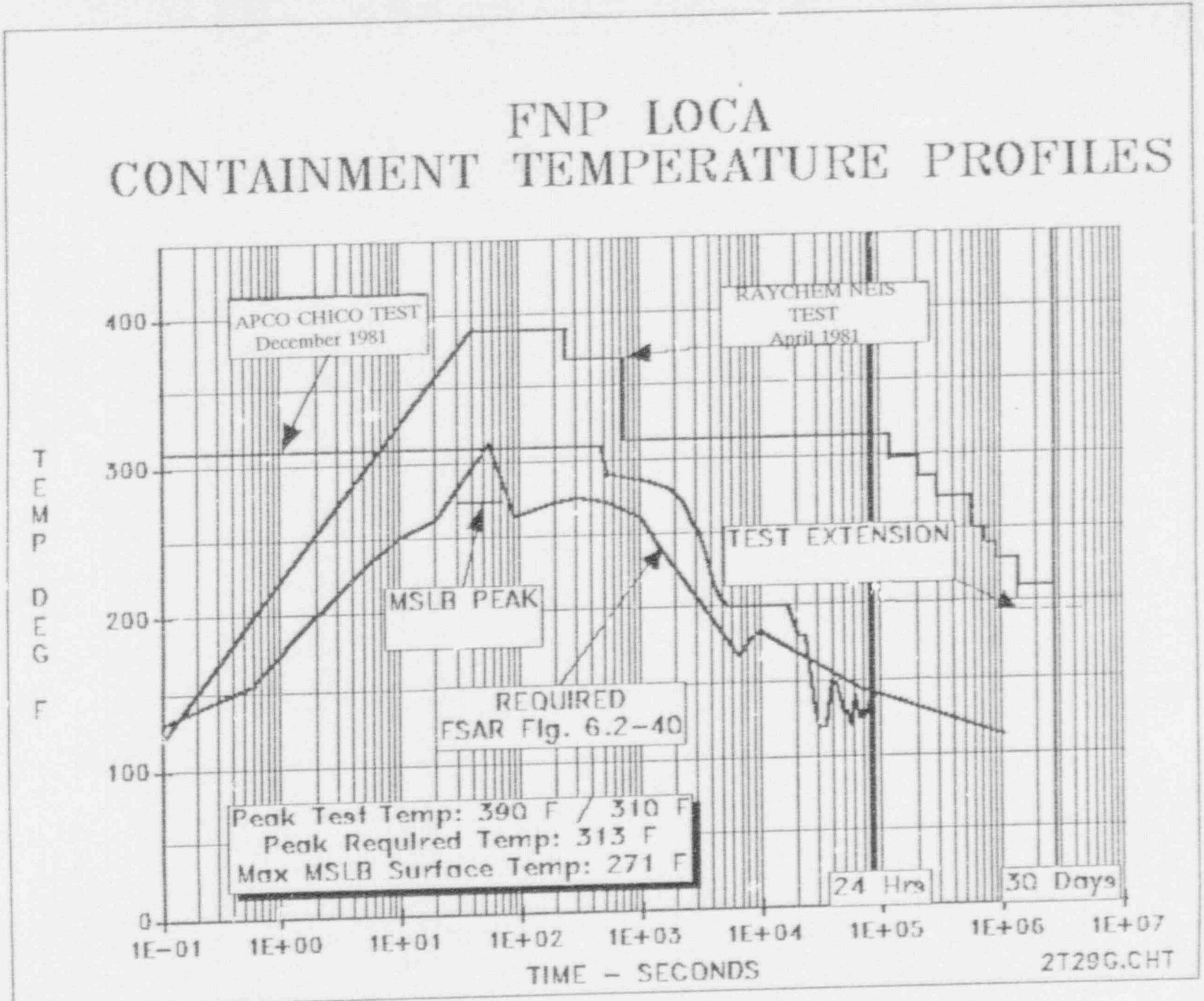
In this testing, initial tests were performed on the Raychem seal assembly without Chico A sealing compound. Two test runs were made and failures of the breakout boot occurred in the same area, i.e., at the center of the boot between the legs, as predicted by the Raychem NEIS testing. During these tests, it became apparent that the test chamber required modification to permit a more rapid temperature excursion in order to better approximate the design basis accident temperature profile. Thus, the chamber was modified to allow rapid insertion of the test specimen into the preheated chamber. Subsequent to this modification, a third test specimen -- identical to the first two -- was tested. The third specimen also failed in the center of the boot between the legs.

Having refined the test apparatus to closely simulate the design basis accident temperature and pressure profiles, and having confirmed through this initial testing that the failure experienced at Raychem was also applicable to the Farley-specific seal configuration, a fourth test specimen was prepared which was identical to the first three, with the exception that Chico A sealing compound was installed in the pipe nipple as a backing to the Raychem breakout boot. The fourth test specimen, <u>for which qualification credit is being taken</u>, was subjected to the same test procedure and temperature and pressure profiles as the third test specimen. (Mr. Wilson, in his testimony at pages 9, 16, and 17, refers to the 45 minute heat up of the chamber and test specimen. He apparently is referring to test specimens 1 and 2. However, the test which was credited in qualification was test specimen 4. This test did not use a 45-minute heat up.)

Specifically, the 24 hour test for the Raychem/Chico A seal began at 0846 on December 17, 1981, when the chamber internal air temperature reached 310°F and the test specimen was installed. At 0847, the chamber was pressurized to 60 psig with compressed air. Chamber pressure was maintained at 60 psig for 7 minutes. At 0857, a temperature cooldown, transpiring over the course of several hours, was initiated until the chamber temperature reached approximately 180°F. The chamber pressure was also slowly reduced at a rate of approximately 5 psig in 10 minute intervals until the test chamber pressure reached 15 psig. The chamber pressure was maintained at 15 psig until further cooldown of the chamber was initiated from 180°F down to approximately 130°F. During this phase of the chamber temperature reduction, the chamber pressure was maintained at 5 psig. See Figures 4 and 5 illustrating temperature and pressure test profiles versus Design Basis Accident (DBA) temperature and pressure profiles in the December 1981 testing. The data in these figures was available in the December 30, 1981 Bechtel Test Report. (APCo Exhibit 62). No failure of the breakout boot or seal leakage was experienced as a result of this testing.

Q137. Was any moisture or steam introduced into the test chamber?

A: (Love) No. The parameters investigated by APCo in this second round of testing, in December 1981, were properly



FNP LOCA
CONTAINMENT TEMPERATURE PROFILES
TEMP DEG F
400
300
200
100
0
APCO CHICO TEST
December 1981
RAYCHEM NEIS
TEST
April 1981
MSLB PEAK
TEST EXTENSION
REQUIRED
FSAR Fig. 6.2-40
Peak Test Temp: 390 F / 310 F
Peak Required Temp: 313 F
Max MSLB Surface Temp: 271 F
24 Hrs
30 Days
1E-01
1E+00
1E+01
1E+02
1E+03
1E+04
1E+05
1E+06
1E+07
TIME - SECONDS
2T29G.CHT

FIGURE 4

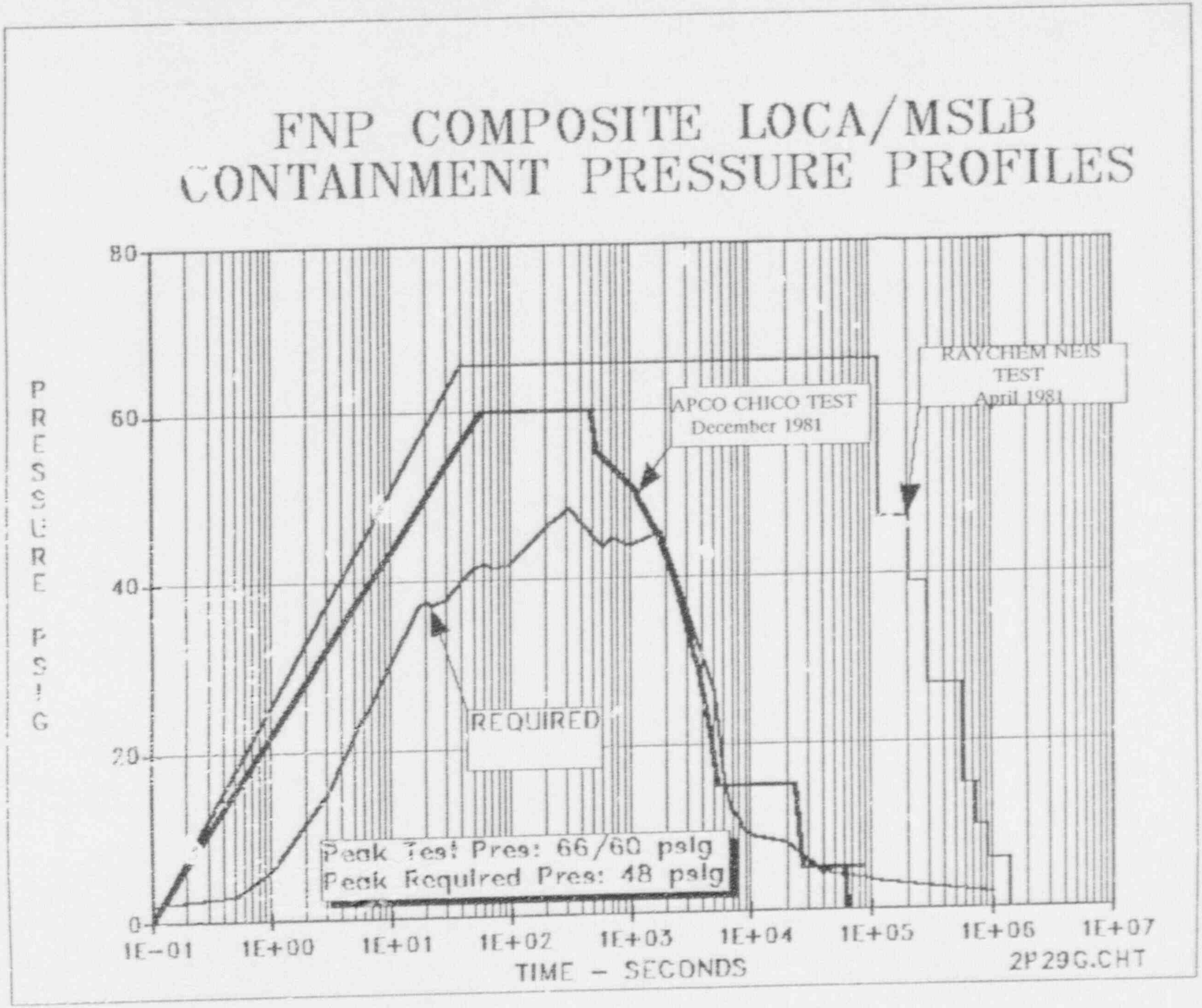

FNP COMPOSITE LOCA/MSLB
CONTAINMENT PRESSURE PROFILES
PRESSURE PSIG
80
60
40
20
0
APCO CHICO TEST
December 1981
RAYCHEM NEIS
TEST
April 1981
REQUIRED
Peak Test Pres: 66/60 psig
Peak Required Pres: 48 psig
1E-01
1E+00
1E+01
1E+02
1E+03
1E+04
1E+05
1E+06
1E+07
TIME - SECONDS
2P29G.CHT

FIGURE 5

focused on temperature and pressure effects and did not relate to moisture, or any other environmental factors, as these factors were not then in question.

To explain, the December testing addressed only the recent Raychem failures. The issue raised by the Raychem test failures was the susceptibility of the Raychem breakout boot material to temperature and pressure when installed over a pipe nipple; that is, the problem of implosion at the center of the boot due to material softening and a lack of backing support under these conditions. As I stated above, the material was well qualified for all other conditions and the breakout boot itself had been adequately qualified for moisture, steam and chemical spray. As discussed earlier, our prior submergence test of the Raychem seal installed on a NAMCO EA-180 (APCo Exhibit 61) specifically demonstrated that moisture intrusion through the seal would not be a problem for postulated submerged conditions in the main steam valve room, and there were no potential submerged locations requiring qualification for submergence in the containment. Since it had already been proven that the seal (unbreached) prevented the incursion of moisture, it was only necessary to show that the seal, as reinforced with Chico A, could not be breached due to temperature/pressure effects.

Q138. Was the Chico A compound qualification considered before using it as a backing material for the Raychem seal?

A: (Love) Yes. Based on my knowledge of this material and of relevant qualification testing done in conjunction with drywell penetration designs for BWRs, I was aware that Chico A compound had been qualified to radiation conditions that envelope those in a design basis accident at Farley. Chico A compound also was qualified successfully for BWR applications as the primary drywell penetration sealing compound with a peak of 30 psig steam at 330°F for one hour. In the BWR application, which consisted of many varied numbers, sizes, and types of cables in each steel conduit penetration, a minimal amount of leakage was permissible to maintain design conditions.

Chico A compound is a mixture of hydrated oxides, similar to portland cement. It is an inorganic compound and is UL listed in combination with Crouse-Hinds EYS explosion proof conduit fittings requiring compliance with hydrostatic pressure tests and air leakage tests per UL Standard C86. Chico A is essentially chemically inert and the UL listing does not restrict the types of cable jacketing material to be sealed with the compound. Chico A has many years of history in use with all kinds of cable jacketing materials with no known incompatibilities. It is an expansive compound in the curing process which eliminates voids between the conduit-to-compound and compound-to-cable interfaces resulting in an excellent sealing surface.

For the Farley-specific application inside the conduit nipple as a backing material to the Raychem cable breakout boot, the functional requirement is to reduce the boot material stresses in the area of the boot at the center of the boot legs under elevated temperature and pressure conditions. The Raychem boot seal material, which was qualified for radiation, steam, pressure, temperature and chemical sprays, provided a positive leak-tight moisture exclusion seal. The Chico A will therefore not be exposed to direct steam or chemical sprays in the Farley configuration as the Raychem boot seal will prevent such exposure. Therefore, the only additional qualification data required for Chico A, which was not demonstrated in the APCo testing, was related to radiation. As explained above, the Chico A compound is an inorganic compound with radiation capabilities which were demonstrated by previous testing documented in Southwest Research Institute (SWRI) Project No. 03-4974-001 Test Procedure, and SWR letters dated February 1, 1979 and July 13, 1979. (APCO Exhibit 63). The Chico A compound was fully qualified for its intended function as a subcomponent of the Farley seal.

It is also my engineering judgment that a NAMCO EA-180 limit switch and a cable configuration sealed only with Chico A sealing compound in the conduit entrance to the switch is qualifiable and the switch would be capable of performing its intended function under Farley design basis accident environmental parameters.

Q139. Did the NRC Staff inspectors raise specific questions during the inspection regarding this seal configuration?

A: (Love) Yes. Those concerns, at least as initially stated, were documented in the Staff's February 1988 inspection report (APCo Exhibit 55, at pp. 38 through 42), and subsequently in the Order. In addition, similar concerns are again restated, often several times each and in slightly different ways, by Mr. Wilson in the Staff's testimony. I believe these concerns have no technical basis. I also believe that a failure to comprehend the design and qualification methods and to communicate the need to examine existing available documentation in order to clarify the qualification of the Raychem/Chico A seal occurred during the inspection process. The test reports and documentation included in the APCo files at the time of the inspection provided ample EQ documentation based on any fair requirement.

Q140. Well, let's turn to the Staff's stated concerns. First, did the absence of steam or moisture in the APCo Chico A/Raychem seal testing conducted in December 1981 adversely affect the conclusions drawn from the test?

A: (Love, Sundergill) Absolutely not. It was obvious that such parameters did not have to be addressed in this test since they had already been addressed in previous testing. See Raychem Test Report EDR 5033 for the breakout boot over a cable (also numbered as Wyle Test Report 58442-2). (APCo Exhibit 60). The DOR Guidelines allow for separate effects testing without analysis. NUREG-0588, Category II, allows for partial testing supplemented by analysis.

Moisture intrusion was also specifically and successfully addressed in the APCo submergence test performed on the Raychem breakout boot as utilized by APCo before the addition of the Chico A compound. See Bechtel 2BE-1049-3 (APCo Exhibit 61). Subsequent APCo and Raychem testing demonstrated that temperature and pressure were the only discrete failure mechanisms applicable to the limit switch seals. As explained in previous testimony, the addition of the Chico A compound in the seal configuration backed up the Raychem material and prevented its implosion under pressure/temperature conditions. In short, there was no reason to introduce steam or moisture into the test chamber for the December 1981 tests. (APCo Exhibit 62). This was not the purpose of these tests, and there was no reason at that time to analyze steam or moisture effects, alone or in conjunction with other parameters such as pressure, on the Chico A / Raychem seal configuration.

Q141. In your opinion, should chemical spray have been applied to the Chico A / Raychem seal in order to test its effect on the bonding of the Raychem breakout boot to the metal conduit nipple?

A: (Love, Sundergill) No. As APCo fully explained in its January 8, 1988, letter to D.M. Verrelli, NRC Region II (APCo Exhibit 64), corrosion of the zinc coating on the galvanized steel nipple is negligible at the specified Farley chemical spray pH level. Moreover, even in testing where corrosion had been noted, no leakage due to corrosion or due to lack of bonding occurred.

Tests to determine the effect of chemical spray during a postulated accident on galvanized steel have been conducted by Sandia, Raychem, and Wyle. Mr. Wilson and the Staff have referred to Wyle Test Report 58730 as the basis for their concern. (Staff Exhibit 34). That report addressed Raychem testing of 12 NEIS kit assemblies with galvanized rigid steel conduit nipples, including a 30 day LOCA/MSLB exposure with chemical spray for the entire 30-day period. (At Farley, by constrast, the postulated spray duration is 24 hours or less.) In this testing, there was no documented evidence of leakage during the LOCA/MSLB exposure in the test specimens due to corrosion of the zinc galvanic layer or due to lack of bonding between the adhesive and the galvanized conduit nipples. Because the properties and duration of Farley's chemical spray are enveloped by these test parameters, it is evident that the impingement of chemical spray on the Raychem/Chico A seal is not detrimental to the configuration. Thus, it was not necessary to introduce chemical spray into the test chamber at Farley; the contention that the Farley test was flawed due to the lack of chemical spray is unfounded.

In his testimony, in a least six different places (pages 7, 20, 23, 27, 28, and 30), Mr. Wilson again raises this issue of degradation of the zinc galvanizing on the pipe nipple. The concern again seems entirely based on Wyle Test Report 58730 (which is also labeled as Raychem EDR 6062). (Staff Exhibit 34). Again, we do not believe Test Report 58730 supports a claim that corrosion is a problem. In the report, there is a discussion of the test results for the twelve test specimens. Also, there is a reference to "extensive degradation of the zinc galvanizing on the pipe nipple, including the area under the NEIS kit seal." (Id.

at 2). However, there is no linkage shown or drawn between this anomaly and the test failures. All test leakage failures under the harsh environment conditions were, in fact, completely unrelated to nipple corrosion or Raychem bond failure/degradation. The four reported failures under these conditions were due to a leak in the insulated wire and three instances of leakage at the threaded flange connection of the specimen to the test chamber. In no instance was there a failure recorded due to the corrosion that worries Mr. Wilson. In sum, with respect to Farley Nuclear Plant, the reported degradation anomaly was of no functional signifance as demonstrated in the tests.

Q142. Wyle Test Report No. 58730, referred to by Mr. Wilson (Staff Exhibit 34), was not in the EQ files at the time of the Farley inspection. Was it necessary for the report to be included in the files?

A: (Love, Sundergill) Wyle Test Report 58730 is a controlled distribution document which consequently was not in APCo's file but was available from Raychem. It was cited in APCo's January 8, 1988, letter to the NRC responding to the questions raised by the Staff inspector concerning the perceived effects of chemical spray on the adhesive bond between the Raychem boot adhesive and the conduit nipple.

However, Test Report 58730 was not relied upon by APCo for qualification purposes because chemical spray was determined not to be a technically valid concern. (Our determination, as discussed above, was based on published data proving that there was no concern from corrosion of the galvanized electrical conduit nipple, or from lack of Raychem bonding to the pipe nipple, due to chemical spray at the Farley-specific pH level. Also other Raychem tests, which were in the Farley files, proved that chemical spray induced degradation of the Raychem material, including the adhesive, were similarly not of concern.) Therefore, it was not necessary for APCo to include the test report in Farley's EQ files. We do not believe that the inspector can claim a qualification file was deficient simply by raising an issue that is not supported by available information.

Q143. The NRC Staff in the inspection report and in testimony also alleges that the APCo temperature and pressure test of the Farley seal design failed to simulate the initial thermal shock of a LOCA, given a slow temperature increase, and thereby did not adequately account for differential thermal expansions of the metal, plastic, a .d cement portions of the seal. The inspection report also stated that APCo's test was in fact non-conservative because softening of the Raychem plastic by temperature will occur after the pressure peak. What is your response?

A: (Love, Sundergill) As discussed earlier, the NRC Staff in Mr. Wilson's testimony still fails to recognize that for the credited test specimen (test specimen 4 in the report) (APCo Exhibit 62), the test chamber was pre-heated to 310°F prior to insertion of the test specimen, and that the test specimen, which was initially at room temperature, was inserted and peak pressure (60 psig) applied within one minute of insertion. The thermal mass of the vessel was much greater than that of the test specimen and, in addition, the vessel temperature was controlled by a thermocouple and a temperature controller/recorder which applied more heat input from the electrical heaters when needed to maintain the vessel internal temperature. The specimen was clearly exposed to a rapid temperature increase from room temperature to 310°F, which conservatively simulated the initial thermal shock of a postulated LOCA transient for Farley Nuclear Plant.

In fact, the initial shock to the materials was far more severe than would be achieved in most other tests where the configuration is inserted into a test chamber at ambient temperature and then the entire mass of the test chamber, plus the sample to be tested, is heated to a specified level. Since only the temperature of the sample needed to be elevated during the Farley test -- the mass of the chamber being already at the required temperature -- the time for the sample to reach the required temperature was less than if it had been in a commercial test chamber. Consequently, the temperature ramp was more severe for the Farley test than would have been achieved otherwise.

Next, the Staff in the inspection report and in its testimony raises the issue of softening of the Raychem material only after the pressure peak. The Staff argues that the test was non-conservative because the pressure would not be applied at the time the material is most vulnerable to the implosion problem. However, the Staff is wrong. APCo's test appropriately followed the design basis accident (DBA) temperature and pressure profiles and therefore was conservative. Softening of the Raychem material will occur after the initial application of peak temperature and pressure, both in the postulated DBA and in the APCo test sequence, because the material does not soften instantaneously. The Staff has also failed to recognize that in the December 1981 Bechtel test, the third test specimen which consisted of only a Raychem seal without the Chico A, did experience softening and failure. The point of this test run was to repeat the pressure failure observed by Raychem. Then, the fourth test specimen was exposed to the same test sequence and to the same temperature and pressure profiles as the third Raychem test specimen. Specimen 4 with the Chico A added successfully passed the test.

It is also important to observe that on page 39 of the inspection report, as quoted again on page 11 of Mr. Wilson's testimony, there is an incorrec implication. The Staff implies that after test specimen 3, which failed as anticipated, APCo modified the test sequence for the Chico test specimen. This is not true. Test specimen 4 was subjected to the same, appropriate, pressure/temperature profile as test specimen 3 -- and it passed the test.

Q144. In your opinion(s), did the test adequately account for the simultaneous application of peak pressure and temperature, as would be expected during a LOCA?

A: (Love, Sundergill) Yes, the test achieved simultaneous temperature and pressure peaks. Referring again to Figures 4 and 5, it is clear that the APCo test conditions enveloped the Farley desigr basis LOCA temperature and pressure profiles.

Q145. On page 16 of his testimony, Mr. Wilson states that in reviewing the Bechtel test report (on the December 1981 t~sting), it appears to him that the test specimens were exposed to elevated temperatures for as long as 45 minutes prior to the application of air pressure. This would, in his estimation, not be conservative from a thermal shock standpoint. What is your response?

A: (Love) Mr. Wilson is correct that such a profile was followed for test specimens 1 and 2, and that such a profile would not be conservative for thermal shock. However, as I said above and as explained in the same test report, subsequent to these tests, the test sequence and test chamber were modified to allow rapid insertion of the test specimen into the test chamber. These changes were made prior to test runs 3 and 4. As also explained above and in the test report, test specimen 4 is the test credited for qualification.

Q146. What about the simultaneous application of peak pressure and peak temperature in a steam/moisture environment? According to the NRC Staff's inspection report and testimony, such testing is necessary to determine whether moisture leakage through the seal would occur during a period of differential expa[illegible] between the pipe nipple and the seal material.

A: (Love, Sundergill) In order for moisture intrusion to cause a functional problem with the NAMCO limit switches, a pathway must exist for sufficient quantities of moisture to enter the switch to cause a loss of function. The December 1981 testing demonstrated from a functional perspective that there were no leakage paths created due to differential expansion during DBA temperature/pressure profiles, including the initial thermal shock to the test specimen.

Regardless of any failure mechanisms that Mr. Wilson can postulate (such as due to differences in temperature expansion coefficients of the Raychem, steel, and Chico components of the seal), there were in the test no leakage paths created by differential expansion due to temperature and pressure.

Also, on pages 12, 17 and 18 of his testimony, Mr. Wilson identifies a vague concern related to differential thermal expansion of the seal components and the possibility of the compression adapter bearing down on the Raychem sleeve. However, Mr. Wilson's concerns are unsubstantiated and his testimony is inherently illogical. In this testimony (at page 17), Mr. Wilson acknowledges that the Raychem material will shrink during exposure to elevated temperatures and also that the heat conductivity coefficient of steel is far greater than that for cements or plastics. It would appear, therefore, that the conduit clamp should be expanding as the Raychem sleeve is shrinking, eliminating any concern about the clamp cutting the Raychem material. In any event, no such "cutting" anomaly was observed in the pressure/temperature tests at Farley following DBA profiles.

The APCo pressure/temperature tests were not conducted in a moisture/steam environment. However, leakage was monitored during these tests by monitoring pressure leakage. There is no functional difference between testing for air leakage versus steam leakage. Moreover, the limit switch assembly with a Raychem seal installed, as stated previously, was subjected to moisture in the prior submergence testing. (APCo Exhibit 61). The latter testing included testing of electrical function in the submerged condition for a simulated high energy feedwater line break in the main steam valve room. In addition, all of the seal materials, as well as the NAMCO limit switch and the electrical limit switch cable which make up the switch assembly, were tested separately to all required parameters including steam and chemical sprays.

Q147. Is it meaningful that qualification to NUREG-0588, Category I, could not be based on the test results you have described? The Staff made this contention in the inspection report, citing the lack of specimen aging, the failure to perform a complete test sequence on a single specimen, as well as certain testing QA/QC deficiencies.

A: (Love, Sundergill, Jones) No. This is not a meaningful finding. Qualification to NUREG-0588, Category I, was not required for either Farley unit. For that reason, the comment in the inspection report is completely irrelevant.

(Love, Sundergill) Nevertheless, we would like to point out that Raychem's documented testing of the breakout boot material addressed specimen aging. (APCo Exhibit 60). Raychem also performed testing on a single sample. The Chico A material is an inorganic compound, so aging is not relevant. It also has the capability to withstand temperature, pressure and radiation levels many times higher than those postulated for Farley. As a result, pressure was the only parameter which required testing for Chico A. Neither factor was considered to be exacerbated by the configuration of the APCo test set-up and both were, therefore, not addressed in the testing. As for the so-called QA/QC deficiencies, the testing performed by APCo was conducted in accordance with QA/QC procedures and witnessed by a QC Inspector and a QC Engineer.

Q148. Do you agree that the data collected during the Chico A / Raychem seal type testing was defective, given a lack of seal leakage data, as the Staff contends on page 41 of its inspection report, and again on page 13 (item 2) of its testimony?

A: (Love, Sundergill) No, we do not agree that the test data or the test methodology was defective. As stated previously, the applicable failure mode which would permit moisture incursion, as experienced in Raychem testing, was due to a sudden rupture of the breakout boot. The sudden rupture would result in a sudden pressure increase on the test pressure gauge which would be equivalent to the test chamber pressure. Therefore, a calibrated leak detection pressure gauge, with a range of 0 - 30 psig plus or minus 0.25%, was used. It is significant to note that Raychem used this same testing philosophy in their test documented in Report No. EDR-6063. (APCo Exhibit 65). Raychem also believed (EDR-6063, at p. 17) that small amounts of leakage would result in large pressure increases.

The leak detection pressure gauge was connected to the non-pressurized side of the test specimen and contained a fixed volume of air. As the test specimen and the pressure gauge and tubing were initially at room temperature and 0 psig when the specimen was inserted into the 310°F pre-heated test chamber, the air contained in the fixed volume of the test specimen and the pressure gauge/tubing was heated by the hotter test chamber air after insertion. As the air enclosed in the leakage detection fixed volume heated up, it increased in pressure, and the pressure gauge correspondingly indicated the resultant pressure associated with the heated air temperature of the fixed volume.

The small pressure indications recorded during the test are not indicative of seal leakage as the Staff suggests, but only illustrate classic "gas laws." In fact, at one point near the end of the test sequence, a problem with the plant air supply to the test chamber resulted in a temporary pressure loss (0 psig) for a period of minutes in the test chamber. During this loss of air pressure in the test chamber, the leak detection system gauge pressure indication of 0.2 psig remained unchanged. If in fact the seal had been experiencing small amounts of leakage, as the Staff suggests, the leak detection pressure gauge should have reflected the loss of air pressure in the test chamber. The measured leakage pressure was not affected by the loss of test chamber pressure because, as stated above, the pressure indications were not due to seal leakage, but rather, were proportional to the temperature of the air in the fixed volume of the leak detection system which was unaffected by the loss of chamber air pressure. The Staff apparently failed to consider these aspects of the test data when reviewing the December 1981 Bechtel test report.

Q149. In the inspection report and in Mr. Wilson' testimony, there is concern that adequate measures were not taken to maintain uniformity between the APCo tested Raychem/Chico A seal configuration and the installed seal configurations. Is this a valid concern?

A: (Love, Sundergill) No. The Electrical Tray and Conduit Details and Notes, which are controlled documents, provided the requirements for the field installation of these seals and specified the details and procedures necessary for constructing the seals in the plant. The procedures contained in these documents also gave explicit instructions on how to mix, measure, and install the Chico A compound into the limit switches regardless of the installed orientation of the switch.

In Mr. Wilson's testimony, he acknowledges that he reviewed four sheets of plant installation drawings during the November 1987 inspection. He later states in his testimony that during discovery in this proceeding, he reviewed Bechtel drawing A-177541, "Joseph M. Farley Nuclear Plant Tray & Conduit Details and Notes," about 200 sheets, various revisions (APCo Exhibit 66), of which only four sheets were reviewed during the inspection. In his testimony, Mr. Wilson states that he did not review this drawing in detail, since it was obviously well after-the-fact and the vast majority of it had nothing to do with Chico A/Raychem seals.

In its entirety, Drawing A-177541, is a living, controlled, as-built document for Farley Nuclear Plant and, as such, in its current revision will not appear the same in 1991 as it did in the fall of 1987, nor as it appeared prior to the

November 30, 1985 EQ deadline. However, all revisions are maintained for the life of the plant. The applicable pre-November 30, 1985 revisions were available for inspection at Farley Nuclear Plant in November 1987, including a complete copy of the latest applicable revision. These notes and details at that time contained much more than four pages related to the installation of Raychem/Chico A seals, and specifically included the instructions for mixing, measuring, and installing the Chico A cement into the seals. These instructions were by no means "after-the-fact." Mr. Wilson states that the details were not complete enough to ensure proper configuration and installation control when, in fact, it appears that he has never reviewed the document in its entirety or the proper revisions. We believe these documents were more than sufficient to assure accurate and consistent installation of the seals.

In addition, Mr. Wilson in his testimony raises some specific concerns regarding various aspects of the Electrical Tray and Conduit Details and Notes. These concerns were clearly adequately addressed in the Details and Notes and in the available supporting documentation.

On page 6 of Mr. Wilson's testimor), he states that sheet 23K still does not show the Raychem keeper sleeve. This issue is also repeated on page 10 (A9) and page 26

(A16). Sheets 23S and 23P provide the Raychem part number for the cable breakout kit (NCBK-04-04). This kit number includes the keeper sleeve. Raychem installation instructions were packaged with each kit. Therefore, it was not necessary for, nor the intent of, this detail to provide a complete pictorial representation of the Raychem breakout kit subcomponents.

In his testimony, Mr. Wilson states on page 7 (A8), that there was, "inadequate definition of test specimen design and assembly, and its similarity to installed plant equipment," on page 14 (A9), item 1, that, "Drawing A-177541, sheet 23S-1, Rev. 0, does not control the minimum quantity of Chico mixture" and that "since the Chico mixture is injected through the side of the limit switch into the assembled Raychem boot and conduit, using a hypodermic syringe and tubing, the technician cannot easily see when the seal cavity is filled." On page 23, A14, item 2, Mr. Wilson states that, "[F]irst, the design specifications for both the plant equipment and the Bechtel test specimen were incomplete in that the compression fitting part number (and, in some instances, the vendor) was not specified, the configuration of Chico cement in the seal was not controlled, the drawing numbers given in the test report were discrepant with plant drawings provided to the inspector, etc." Mr. Wilson continues on page 24, that, "[S]econd, no evidence has been provided that Raychem design and installation instructions such as usage (diameter) range and surface preparation were followed." He also found on page 24: "Chico cement . . . was later added via veterinary syringe and tygon tubing; it is hoped that this crude assembly technique would not be continued."

Mr. Wilson's statements are not substantiated. The Raychem/Chico A test specimen qualified by the December 30, 1981 APCo test was constructed using Raychem cable breakout kit NCBK-04-04, which as noted above included installation procedures. In addition, it was constructed using sheets 23S-1 and 23S-2 of drawing A-177541, which provided procedures for mixing and installation of the Chico A cement, including the quantity of cement and the method of application (a veterinary syringe with tygon tubing, which we do not believe to be "crude"). The Details and Notes assured duplication of the process followed during the test and therefore provided the means to control the similarity of the test sample to the installed plant equipment.

Under these instructions the seal cavity would be observed during installation. In addition, Drawing A-177541, sheets 23S-1 and 23S-2, also specifically provided instructions to remove limit switches mounted in positions which did not allow vertical installation of the Chico A cement to allow visual inspection of the cement filling. These sheets explicity addressed the proper installation of the Chico A cement regardless of the switch's installed location and provided the required details for preparation and installation of the Raychem material and adequately specified the type of compression fitting to be installed.

Moreover, we see no basis for concern about measuring the quantity of Chico A and applying the cement with a syringe and tygon tubing. This is a relatively simple operation and more precise metering of Chico A is not critical to seal effectiveness. The syringe and tubing allowed injection of a measured amount of the Chico A behind the boot. The visual inspection assured that the Chico material went to the right place.

Q150. At the time of the 1987 EQ inspections at Farley, did documentation exist to support a conclusion that the Chico A / Raychem seals in the plant were qualified as of November 30, 1985?

A: (Love, Sundergill, Jones) Yes. The test reports verifying qualification of both the Chico A compound and Raychem material were available not only at the time of the inspections, but also before the November 30, 1985, EQ deadline. These included Wyle Test Report 58442-2 (April

1981) (also numbered as Raychem Report EDR 5033), APCo/Bechtel AP-6704 (documenting the December 1981 tests), Bechtel 2BE-1049-3 (documenting APCo's submergence tests), and SWRI Project No. 03-4974-001 (February 1979) (documenting radiation qualification of Chico A). DOR guidelines and NUREG-0588, Category II, specifically approved the use of tested materials plus partial testing and analysis. Accordingly, these documents together clearly demonstrated that the Chico A / Raychem seal was environmentally qualified as of November 30, 1985.

Q151. Is this documentation adequate, in your view, to satisfy the requirements of 10 CFR 50.49?

A: (Love, Sundergill, Jones) Yes. Based on the content of the documents in the EQ files, a reasonable engineer, familiar with environmental qualification and the functional requirements of the seals, would recognize that the Chico A/Raychem seals installed at Farley satisfied the requirements of 10 CFR 50.49, not only today but also as of November 30, 1985.

In Mr. Wilson's testimony he states that the Farley design was "novel." We agree. It was a unique design, specifically developed to achieve a qualified seal as soon as possible. We feel it was incumbent upon the Staff in

1987 to exercise extra effort to review designs with which they are unfamiliar, rather than simply dismissing them in a prejudicial fashion (apparently in favor of later, more widely available commercial designs). If that effort had been extended, in an unbiased fashion, we feel that the Farley seal design would have been found to be acceptable, and acceptably documented.

Q152. Were the alleged documentation deficiencies identified in the NOV safety significant?

A: (Love, Sundergill) No. We believe these seals were fully qualified; however, given our technical conclusion that, at a minimum, the seals were qualifiable, any documentation deficiencies were insignificant from a safety perspective. Moreover, with respect to documentation, what we see here is a new standard that really seems to call for u[illegible]s (and document our response to) any concern that any inspector might articulate -- before a concern is articulated. We could have addressed documentation "deficiencies" here by supplementing the file with existing information. The documentation "deficiencies" were not significant from an EQ perspective

Q153. In your opinion, did APCo clearly know or should it have known, as of November 30, 1985, that the Farley Chico A/Raychem seals were in violation of 10 CFR 50.49?

A: (Love, Sundergill, Jones) Based on our previous testimony, the answer is no. We have maintained, even prior to the EQ deadline, that these seals were fully qualified (no matter what the definition of that word). That remains our position. In this light, there was absolutely no basis upon which the licensee could have known that these seals were not environmentally qualified as of November 30, 1985.

VII. LIMITORQUE MOTOR OPERATORS

A. T-Drains

Q154. Please briefly describe this issue.

A: (Sundergill) The Notice of Violation cited several reasons for lack of qualification of Limitorque motor-operated valves (MOVs). One of the reasons was that at Farley certain MOVs did not have T-drains installed. In essence, the NRC Staff interprets Limitorque Test Report B0058 (APCo Exhibit 67) as <u>requiring</u> T-drains because the MOV sample tested had T-drains installed. The Staff in the Order relies on this test report for the proposition that

"T-drains [must] be installed to accommodate the extreme temperatures and pressures of a design basis event environment." (APCo Exhibit 34, Appendix A, at p. 34).

Based on the Order, the Staff seems to focus this issue on the technical conclusion; i.e., operability of the MOVs under the accident profile without T-drains. However, in its direct testimony on this issue, the NRC Staff also argues that our operability conclusion was not sufficiently documented prior to the inspection.

Q155. How do you respond to the Staff's assertions?

A: (Sundergill) First, from an operability standpoint, it makes no difference whether or not T-drains were installed. Second, with respect to documentation, verification of operability was possible from information available in APCo's EQ files prior to November 30, 1985. Subsequent to the inspection, we added further documentation addressing the Staff's concern; however, this was documentation beyond what was necessary as of the EQ deadline.

Q156. Starting with the basics, what is a T-drain?

A: (Sundergill) A T-drain is a solid, cylindrical piece of metal which is threaded on one end so that it may be screwed into the metal housing of the Limitorque motors. It is approximately 1 inch long and 1/2 inch in diameter. A hole about 1/8 inch in diameter is drilled through the diameter of the plug about 1/8 of an inch from the unthreaded end. A second hole of the same diameter as the first hole is drilled along the plug axis from the threaded end to a point where it intersects the hole drilled along the plug diameter. These two holes form the T configuration which gives the drain its designation.

Q157. In general, what is the purpose or function of a T-drain installed in a Limitorque MOV?

A: (Sundergill) The basic function of a T-drain, installed in a Limitorque motor operator, would be to provide a pathway for moisture drainage from the motor housing of the actuator.

Q158. Did APCo install T-drains on the Limitorque actuators inside containment at Farley?

A: (Sundergill) No.

Q159. Then what is the basis for qualification?

A: (Sundergill) Limitorque had qualified its actuators both with and without the installation of T-drains. Specifically, Limitorque Test Report 600198 (APCo Exhibit 68) documents the qualification of Limitorque actuators without T-drains while Limitorque Test Report 600456 (APCo Exhibit 69) qualifies the components with T-drains. Both of these reports envelope Farley accident conditions. Therefore, it is acceptable to install Limitorque motor operators with or without T-drains, because Limitorque has tested and qualified them both ways.

Q160. Did Test Reports 600198 and 600456 mention T-drains?

A: (Sundergill) No. Neither of these reports originally mentioned whether or not T-drains had been installed in the tested sample. This is an indication of the importance Limitorque attached to the issue at the time -- namely, it did not see fit to mention the T-drains at all. Nonetheless, during the first round EQ inspections, the Staff inspectors began focusing on this issue at many facilities. They apparently viewed it as an undocumented variation in the installed configuration. This was a new issue that clearly evolved after the EQ deadline.

Q161. In your professional opinion, should APCo have installed T-drains in the Limitorque actuators at Farley?

A. (undergill) No, it was not necessary to install T-drains in the Limitorque actuators at Farley Nuclear Plant. Aside from the fac , as I will explain later in my testimony, that the components are environmentally qualified with or without the installation of T-drains, T-drains would serve no practical purpose at Farley. T-drains serve as pathways for the drainage of moisture from actuator motor housings. The drain holes in the T-drains are very small in diameter and would not provide a very effective means to serve this purpose.

This conclusion is substantiated in Test Report 600456, the test involving the use of T-drains. This report documents the existence, in testing, of approximately 1/8 inch of condensation in the motor housing at the conclusion of testing. The T-drains possibly provided an ingress point for moisture rather than a drain. In fact, the motor itself showed evidence of moisture incursion during the test. Nevertheless, valve performance was satisfactory. Therefore, since moisture was present in the motor housing and performance was unaffected, even with T-drains, it may be reasonably inferred that the installation of T-drains to drain water is unnecessary.

My conclusion is further supported by Mr. Levis' testimony in which he reports that he called Limitorque and "asked if T-drains were required." Staff testimony at page 8. In response, he was informed by the vendor that if the Limitorque operators were configured for T-drains, then they "should" be installed. Limitorque did not tell Mr. Levis that T-drains were "required" to be installed. I suspect that the Litimorque recommendation was offered more as a maintenance matter than as a qualification matter.

Q162. What about Limitorque Test Report B0058? Mr. Merriweather of the NRC staff claims that section 6 of the report "requires that T-drains be installed to accommodate the extreme temperature and pressures of design basis event environment." Staff testimony at p. 7. Is he correct?

A. (Sundergill) No. Even though Test Report B0058 qualified actuators with T-drains installed, it does not conclude, state or prove that the lack of T-drains is a fatal omission. Test Report 600456, which is a part of Test Report B0058, did have T-drains installed during accident testing. However, Test Report 600198, which was performed prior to Report 600456, did <u>not</u> have T-drains installed. The latter report was in the Farley EQ files at the time of the Farley EQ audit and had been in general circulation since its issuance in 1969.

Evidence was presented to the NRC inspectors at the time of the audit which verified that Test Report 600198 was applicable to Farley. Specifically, in late 1985 and early 1986, the Nuclear Utility Group on Equipment Qualification (NUGEQ) explored the T-drains issue as a generic industry matter. They determined from Limitorque that Test Report 600198 involved MOVs without T-drains and Test Report 600456 involved MOVs with T-drains. This information was made available to the industry by NUGEQ. An April 1986 NUGEQ report entitled, "Clarification of Information Related to the Environmental Qualification of Limitorque Motorized Valve Operators," documented this position. (APCo Exhibit 70). On page 7 (footnote 3) of that report, NUGEQ states, "[t]he omission of T-drains in other situations will not necessarily prevent proper actuator operation or violate environmental qualification." The same footnote goes on to state that the lack of T-drains is acceptable provided "[t]he required environmental parameters are bounded by other reports (e.g., 600198, B003 or F-C3271) which did not utilize T-drains." During the Farley inspection we provided proof to the inspectors that Test Report 600198 bounds the accident conditions at Farley.

Again, is noteworthy that the installation of T-drains on tested actuators was only disclosed in conversations with Limitorque. Installation of T-drains is not revealed anywhere in Test Report 600456 or Test Report B0058. Limitorque did not deem it significant enough to document in their reports. The subsequent attention to this issue comes from sources other than the manufacturer who best knows the capability of the equipment. This lack of significance to Limitorque also brings into question the Staff's contention that APCo clearly should have known of the issue.

Q163. Therefore, is it your professional opinion that the Limitorque motor operated valves in the Farley Nuclear Plant were qualified as of November 30, 1985, with or without the installation of T-drains?

A. (Sundergill) Yes.

Q164. Mr. Levis has testified that "[t]he documentation in the file did not support qualification of the Limitorque valve operators as installed at the Farley Nuclear Plant." Staff testimony at 3. Were any of the Limitorque reports you have identified in your testimony included in the Farley EQ files at the time of the 1987 inspections?

A. (Sundergill). Yes, the reports were available to the Staff during the 1987 inspection. As I mentioned earlier, Limitorque Test Report 600198 (APCo Exhibit 68) was in the Farley EQ files at the time of the audit. Furthermore, in

April 1986, NUGEQ produced its report discussing various aspects of Limitorque qualification. (APCo Exhibit 70). In that document, NUGEQ concluded that if the Test Report 600198 test parameters envelope plant-specific parameters, then it is acceptable to install actuators without T-drains. The NUGEQ report also specifically states (at page 6) that Limitorque does not recommend T-drains for MOVs tested without T-drains. The NUGEQ document was in the Farley EQ files at the time of the inspection.

Q165. Was the documentation in the EQ file at the time of the audit sufficient for a "reasonable engineer" to ascertain qualification?

A. (Sundergill) In my opinion, it was. This was simply not a significant issue. The Limitorque test reports and NUGEQ information should have been more than sufficient to address this issue.

Q166. Turning to Test Report 600198 (APCo Exhibit 68), Mr. Merriweather has testified that it does not bound the environmental parameters of the design basis accident postulated for Farley. Staff Testimony at p.10. Do you agree?

A. (Sundergill) Certainly not. The test parameters in Test Report 600198 envelope Farley design basis accident conditions for temperature and pressure. Furthermore, Limitorque tested the actuators without T-drains for seven days which, when extrapolated by Arrhenius techniques, is an equivalent duration much in excess of the postulated Farley accident duration. This result is due to the fact that the test temperature employed in Test Report 600198 remained at a high level for a significantly longer period than would be experienced during a design basis accident at Farley.

Q167. Mr. I .s also focuses on Test Report 600198. Staff Testimony at 4. Specifically, he does not agree with APCo's evaluation of and reliance on the report "primarily due to the fact that the test without T-drains [600198] was only 7 days in duration versus the 30 days required." Is this a valid objection?

A: (Sundergill) No, it is not. In his testimony for the Staff, Mr. Levis has stated that he does not agree that Test Report 600198 could be used by APCo to demonstrate that T-drains were not required at Farley. His argument is primarily based on the test being 7 days in duration versus the 30 day accident duration at Farley. The argument, which was presented during the November 1987 inspection and which I still endorse, was to show by Arrhenius techniques that the test which was reflected in Test Report 600198 was more severe in terms of time and temperature than the postulated accident at Farley.

The Arrhenius technique is an acceptable practice, endorsed by the Staff, to show that conditions of high temperature for short durations are equivalent to conditions of lower temperature for a longer period of time. It is specifically endorsed for the extension of accident profiles in a document from Gary M. Holahan, Office of Nuclear Reactor Regulation, to Samuel J. Collins and Leonard J. Callan, NRC Region IV, "Qualification of Tape Splices for Use in Instrument Circuits Subject to Harsh Environments, Waterford Steam Electric Station, Unit 3 (TAC No. M75348)," dated May 16, 1990. (APCo Exhibit 40). In that document, the Staff accepts that the stabilized portion of the test curve may be extended by Arrhenius techniques. This was the portion of the test curve which Bechtel used at the November 1987 inspection to show that the test reflected in Test Report 600198 encompassed the postulated Farley accident conditions.

As noted, the April 1986 NUGEQ document confirmed that Test Report 600198 can be used to show that T-drains are unnecessary in Limitorque motor operated valves, if the conditions in the test report envelope the plant specific conditions. The NUGEQ document was a published report which reflected industry thinking in the November 1985 timeframe. As such, the Staff should have been aware of it and the acceptability of our argument should not have been questioned -- save for a verification that the Arrhenius calculation was numerically correct.

The NUGEQ document was subsequently revised in 1989, but the pertinent section on T-drains remained unchanged.

Q168. The Staff also questions APCo's reliance on Test Report 600198 because of its concern that "the long term affects [sic] of moisture intrusion were not adequately addressed as the tested versus installed configuration with espect to orientation and conduit system diffe: `. . . ." Staff testimony at p.6. Is this concern valid?

A: (Sundergill) Again, this concern is not valid. In addition to his primary concern about the 7/30 day differential, Mr. Levis' testimony also focuses on the moisture intrusion issue described in your question. This concern derives from an incidental comment concerning our supposition that T-drains possibly formed the primary source of water entry into the actuator and motor. While we still hold that this supposition is valid, it was and is by no means our main argument. As stated before, our main argument is based on extending the testing documented in Test Report 600198 to envelope the postulated Farley accident conditions.

As also mentioned before, NUGEQ has stated that Test Report 600198 was valid to prove that T-drains are not required. Since the 600198 test was for a 7 day period and since there is no plant that I am aware of which postulates an accident of only 7 days duration, NUGEQ is clearly endorsing the principal of extending the test. Since the primary purpose of this extension is due to the T-drain issue, which is fundamentally an issue of moisture intrusion, NUGEQ has implicitly recognized that extension of the test encompasses potential moisture degradation as well as that caused by temperature extremes. Indeed, the Staff itself accepts this position in its May 16, 1990, Waterford document cited above (APCo Exhibit 40). The accident conditions during a postulated DBA include a steam environment accompanied by caustic sprays for periods of the accident which vary from plant to plant. By endorsing the principle of test extension, the Staff acknowledges that effects on equipment due to steam, spray, and condensation may be similarly extended. Thus, the Staff's concerns about the long term effects of moisture intrusion have been addressed by APCo.

Q169. In the Staff's direct testimony, Mr. Merriweather provides an extensive list of "examples" of systems affected by the

Limitorque valve operators at issue. Staff testimony at p.9. Is this issue as far-reaching as Mr. Merriweather implies?

A: (Sundergill) No. Mr. Merriweather has included some systems in his testimony that were shown by analysis as not requiring T-drains. Mr. Levis has adopted the following portion of the inspection report in his direct testimony:

> "During the course of the inspection the team was presented with additional information by the licensee to justify their installed configuration. The team was satisfied with the information presented for these MOVs which had a short term operating requirement."

Staff testimony at p. 6. Thus, several systems identified by Mr. Merriweather in his list have already been accepted by Mr. Levis as short-term acting devices not requiring T-drains.

To put this issue into proper focus, it is instructional to view its overall extent. There are 208 MOVs on the Farley Master List (for both units). Of this total, 144 are located outside of the containment or main steam valve room (MSR) and therefore do not see moisture. Consequently, there are only 64 MOVs installed in the MSRs or in the containments that could see a moisture environment. An operability analysis was performed for these MOVs (32 per unit). It was determined that of these, there was only a total of 3 valves per unit that could be subject to this moisture incursion phenomenon that would need to function over an extended period in the moisture environment. Of these 3, 2 are in the reactor cavity dilution system and 1 is in the containment air sample system. Therefore, in actuality, there are only 2 systems (per unit) implicated by this T-drain issue. Thus, the extent of the issue is much more limited than implied by Mr. Merriwenther in his testimony.

Q170. Did the NRC review Limitorque MOVs at Farley prior to the EQ deadline?

A: (Sundergill, Jones) Yes. First, a review was reflected in a Staff audit report dated December 10, 1980 (APCo Exhibit 12). It referenced Limitorque Test Report 600198. More importantly, this audit report, or "Technical Evaluation Report," signed by Mr. N. Merriweather, stated that the motor operated valves were qualified as installed at that time. Components reviewed during the on-site inspection were examined for proper installation, interface integrity, location and manufacturer's nameplate data. (APCo Exhibit 12, at p. 6). Implicit in the TER was the understanding that MOVs were examined for both proper installation and interface integrity. Because no mention was made of T-drains, it is reasonable to infer that they either were not considered to be an issue or were not considered to be significant.

In addition, the NRC Staff issued a second inspection report on January 15, 1981, detailing the results of an inspection conducted by T.D. Gibbons at Farley on December 2-5, 1980. (APCo Exhibit 11). The inspection report specifically called out 12 Limitorque MOVs which were inspected for proper installation and overall interface integrity. Id. at pages 2-4. No violations or deviations were identified.

Q171. To the best of your knowledge, did the Franklin Research Center ever evaluate Limitorque Test Report 600456?

A: (Sundergill) Yes it did. In TER-C5257-509, Franklin evaluated Limitorque Test Report 600456, which included T-drains in the test configuration. (APCo Exhibits 16 and 17). Franklin did not identify T-drains as being a significant issue at the time. The NRC's December 1984 SER (APCo Exhibit 21) then accepted APCo's positions resolving all Franklin TER deficiencies.

Q172. In your opinion, did APCo clearly know or should it have known as of November 30, 1985, that the installation of

T-drains was requisite to the environmental qualification of the Limitorque motor operators at Farley?

A: (Sundergill) No. Limitorque Test Reports 600198, 600456, and B0058, as well as the April 1986 NUGEQ report, the Staff audits in 1980, and the Franklin TER collectively attest to the fact that the presence of T-drains is inconsequential. Therefore, there is no suggestion that APCo "clearly knew or should have known" that the installation of T-drains was necessary to satisfy the requirements of 10 CFR 50.49. Also, the prevalence of this finding during the NRC's first round EQ inspections at utilities other than APCo belies wide-spread prior notice that it would be a concern.

Q173. Were the alleged deficiencies cited in the Farley NOV safety significant?

A: (Sundergill) No. For the reasons I have already stated, the lack of T-drains is itself not safety significant.

Furthermore, the Staff has carefully avoided referring to the NUGEQ report throughout its testimony -- even though the report was issued in April 1986. The NUGEQ report reflected the industry and Limitorque concensus existing as of November 1985, and was subsequently revised in 1989 without affecting the section on T-drains. This NUGEQ report, dismissing the T-drain issue, has never been rejected by the NRC. Because at the inspection (and since) the Staff clearly should have known of the information embodied in the report, the alleged T-drain deficiency should not even have constituted a minor documentation deficiency.

Moreover, as I noted ea.lier, we ha wn that the T-drain issue is in actuality of relevance only to two MOVs per unit. Obviously, this alleged violation is devoid of safety significance.

B. Terminal Blocks

Q174. Please describe this issue briefly.

A: (Jones) In the Notice of Violation the NRC Staff cited unidentified terminal blocks inside Limitorque MOVs installed inside containment at Farley. These terminal blocks were not the same as were used during the Limitorque qualification tests.

APCo has acknowledged that at the time of the EQ audit in 1987 there were three terminal blocks in Limitorque operators inside containment for which qualification was in question. However, it is my opinion that the NRC had no basis to conclude that APCo "clearly should have known" of these terminal blocks inside the Limitorque MOVs. The MOVs had been procured directly from Limitorque -- there was no indication of a need to conduct walkdowns involving disassembly of these operators.

Q175. Were the MOVs qualified when they were procured from Limitorque?

A: (Jones) Limitorque MOVs in general were qualified. Limitorque provided the motor operators with qualification documentation. (APCo Exhibit 71). The test report (Test Report B0119) supported qualification of all subcomponent parts including terminal blocks.

Q176. Isn't it true then that APCo did not walk down the installed MOVs?

A: (Jones) Yes, that is true. As discussed above, it was not the practice prior to the EQ deadline to walk down all installed equipment, absent some indication of a problem. This would have been particularly true with equipment procured as qualified directly from the vendor. Also, even if walkdowns had been conducted, disassembly to inspect internal subcomponents would not have been the norm.

Q177. The NRC Staff has referred to IN 83-72 (APCo Exhibit 72) as providing notice of the need to look at Limitorque MOVs. Do you agree that this should have prompted some action by APCo?

A: (Jones) No. IN 83-72 identified a concern regarding unidentified terminal blocks in Limitorque motor operators inside containment. Specifically, the Staff there reported that a few licensees had discovered terminal blocks inside Limitorque MOVs that were not the same as those qualified by the Limitorque test reports. While it was not clear how the different terminal blocks were placed into the equipment, speculation at the time focused primarily on modifications by the licensees (e.g., during maintenance) or by third-party vendors.

Farley Nuclear Plant was not affected by this concern. Its MOVs had been procured from Limitorque. There was no third party involvement after the original installation. APCo's program was such that modifications were not to be made absent designer approval. I believe that -- at least prior to the EQ deadline -- APCo had reasonable assurance that the Limitorque MOVs at Farley were not implicated by IN 83-72.

Q178. How did APCo subsequently find this condition at Farley?

A: (Jones) After the EQ deadline, IN 86-03 was issued by the NRC, identifying potential deficiencies with the internal wiring of Limitorque MOVs. (APCo Exhibit 73). In response to the industry/NRC concern, APCo conducted walkdowns of all its Limitorque MOVs in both units. While the primary focus of the walkdowns was internal wiring, APCo also identified other internal components, when practical, such as terminal blocks.

The following year, the terminal block issue became more clear during first round EQ inspections at other facilities. APCo also had become involved in the issue by its participation in NUGEQ. APCo elected to conduct a more detailed walkdown of Limitorque MOVs to, among other things, identify all internal terminal blocks by make and model number.

Q179. What did these walkdowns reveal?

A: (Jones) All but three terminal blocks in Limitorque MOVs inside containment were positively identified as being qualified. The three unidentified blocks at issue (distributed between both units) were thought to be qualified Marathon terminal blocks, but we could not positively identify a model number. While reasonable assurance existed that these terminal blocks were in fact qualified, APCo conservatively opted to remove the leads from these blocks and installed qualified splices.

Q180. The NOV and the Staff's testimony do not specify the MOVs in issue with unqualified terminal blocks. Were they any others identified by APCo other than the three inside containment?

A: (Jones) During our 1986 walkdown of Limitorque MOVs in response to IN 86-03, we also identified six Limitorque MOVs (three in each unit) with Buchanan terminal blocks installed. These terminal blocks were qualified by the Limitorque test report only for inside containment applications. However, based on my recollection, I do not believe that these MOVs were the focus of the Staff's discussions during the inspection. Moreover, there is clearly no basis for a "clearly should have known" finding for these outside containment terminal blocks. Even IN 83-72, relied upon by the Staff for its "clearly should have known" finding for the inside containment MOVs, was restricted by its terms to unidentified terminal blocks in Limitorque MOVs inside containment.

Q181. What is your conclusion on this issue?

A: (Jones) I do not believe there is a true EQ issue here. Moreover, if there was one, it was limited to three unidentified Marathon terminal blocks. Reasonable assurance existed that these blocks were indeed qualified blocks. This was not a significant issue. The presence of these internal terminal blocks in Limitorque MOVs inside containment was also not something APCo "clearly should have known" prior to November 30, 1985.

VIII. CONTAINMENT SUMP LEVEL TRANSMITTERS

Q182. The next violation cited in the Notice of Violation (Violation I.C.3) concerns the wide range and narrow range containment sump level transmitters. Please explain this issue.

A: (Sundergill) The containment sump level transmitters on both Farley units are GEMS type level transmitters. Essentially, the violation and the Staff's direct testimony on this issue cite two conditions that were deviations from the tested (and qualified) configuration for these transmitters: 1) low silicone fluid level in four transmitters, and 2) the presence of the V-type termination configuration in some transmitters.

The first issue is an installation/maintenance issue; not an EQ issue. The second issue has been previously addressed. This is just one example where the V-type terminations were used by the electrical craft in installation of the equipment. We do not need to reiterate that discussion here.

Q183. Turning then more specifically to the silicone oil issue, please describe the oil condition as found by APCo.

A: (Sundergill, Jones) Basically, silicone oil is in the transmitters to serve a sealing function. It protects the internal components. APCo found four GEMS transmitters that were not properly installed -- the silicone oil was not at the level it should have been. Of these, the level in two of the transmitters was only low by about one inch.

Q184. Setting aside the silicone fluid level, were the GEMS transmitters otherwise qualified?

A: (Sundergill) Yes. Documentation was in place prior to the EQ deadline. There apparently is no issue regarding qualification of the GEMS transmitters that were installed as directed by the installation procedures.

Q185. With respect to the four suspect transmitters, you stated that the deficiency is more properly characterized as an installation/maintenance issue rather than an EQ issue. What do you mean by this?

A: (Sundergill) As Mr. Love and I discussed in the introductory sections of our testimony, the approach to EQ at APCo and in the industry prior to the EQ deadline was to document qualification of equipment included on the Master List. The focus was not on installation of the equipment, other than to assure that appropriate procedures or instructions existed for installation. In this case, instructions existed that should have prevented the low silicone oil.

Moreover, prior to November 30, 1985, every different potential installed configuration would not have been addressed in the EQ documentation. In this context, the four specific examples of installation deficiencies in the GEMS containment sump level transmitters do not properly reflect on APCo's EQ program. The existence of the silicone oil condition does not indicate a deficiency in the EQ process.

Q186. Was the condition of the four transmitters with low silicone oil safety significant?

A: (Sundergill) No. The Staff accurately describes the function of the containment sump level indicators on page 6 of its testimony on GEMS level transmitters. Nevertheless, it erroneously leaves one with the impression that the GEMS indicators were the _only_ items of equipment capable of performing the described function. This is incorrect. If any of the four transmitters failed to function, there still would be no adverse safety consequences. These level transmitters provide only a redundant indication for transfer from the injection to the recirculation phase. The Reactor Water Storage Tank level indication is the primary means to serve this function. The latter indication is provided by redundant Class IE devices which are not located in a harsh environment and consequently their functionality will be unaffected by accident conditions.

Q187. Was the silicone oil level deficiency a condition APCo "clearly" should have been aware of prior to November 30, 1985?

A: (Sundergill) In my opinion there is no reason why APCo "clearly" should have known of this deficiency through its EQ program. Again, this issue goes back to APCo's reliance on installation instructions to assure that installation would be consistent with qualification documentation. I believe APCo's practice was fairly typical. Also, there is again a suggestion from the Staff that the scope of walkdowns conducted prior to the EQ deadline was not sufficient. However, viewed in proper context, APCo's practices were not out of the norm or otherwise unreasonable.

In particular in this case, any walkdowns conducted necessarily would have involved removal of equipment covers in order to observe fluid level. While today this might seem to be good practice, this simply wasn't being done in EQ walkdowns prior to November 30, 1985. As we stated earlier, walkdowns were geared toward assuring a correlation between installed equipment (make and model) and qualification documents. Installation and maintenance were addressed by separate instructions and procedures and were not part of the 10 CFR 50.49 program.

IX. <u>PREMIUM RB GREASE ON FAN MOTORS / ROOM COOLERS</u>

Q188. According to the NOV (Violation I.C.4) and the direct testimony of Mr. Paulk and Mr. Luehman, APCo violated 10 CFR 50.49 by not having documentation in its EQ files demonstrating qualification of Premium RB grease for use in fan motors inside containment and room coolers outside of containment. Do you agree with this conclusion?

A: (Sundergill) No. The Premium RB grease at issue performs no electrical function. Therefore, grease is outside the scope of equipment required to be qualified pursuant to 10 CFR 50.49. That is, the performance of this equipment can be addressed as a maintenance matter -- as it, in fact, was at Farley. There did not need to be documentation in EQ files.

Nevertheless, as I will explain later in my testimony, APCo had sufficient documentation in the Farley EQ files at the time of the EQ inspection demonstrating that the Premium RB grease used in the components at issue was equivalent to that recommended by the vendors (Chevron SRI-2). JCOs were written in September 1987 documenting pre-existing conclusions concerning the acceptability of Premium RB grease for these applications. (APCo Exhibits 45 and 43). These JCOs were included in the Premium RB EQ package which was available for NRC review during the November 1987 audit.

Q189. Let's start with the basics. Is grease an item of electrical equipment?

A: (Sundergill) Grease is not an item of electrical equipment. It serves only as a lubricant. Grease performs no electrical function. Nor does it provide any electrical properties such as conductivity, insulation, capacitance, or inductance. Grease only performs a mechanical function.

To clarify this point, let me note that the safety related function of the fan motors, for example, is to turn the fan blades which are connected to the motor shaft. If the blades do not turn, even if the motor is running, the safety function of the unit will not be performed. Yet nowhere does the Staff even imply that the fans should be included in the EQ program. It is clearly recognized that the fans perform a mechanical function and thereby are beyond the scope of the rule. The same logic holds true for grease: it has no electrical properties, it performs no electrical function, it is outside the scope of the EQ rule.

Q190. Prior to November 30, 1985, are you aware of any instance in which the NRC Staff stated that a lubricant was an item of electrical equipment required to be environmentally qualified?

A: (Love, Sundergill) No.

Q191. Prior to November 30, 1985, are you aware of any instance in which the NRC Staff or its contractor ever cited a deficiency or took any other action as a result of a licensee's failure to include lubricants on the Master List?

A: (Love, Sundergill) No.

Q192. Therefore, would you agree that grease is outside the scope of equipment required to be qualified by 10 CFR 50.49 and does not have to be included on the Master List for the Farley Nuclear Plant?

A: (Sundergill) Yes. Because grease only performs a mechanical, rather than an electrical function, it is outside the scope of equipment required to be qualified pursuant to 10 CFR 50.49. Therefore, grease was not required to be included on the Master List for Farley.

This is not to say that the grease need not perform its function. We are simply saying that such a result is not compelled by 10 CFR 50.49, and EQ documentation is not necessary. The proper performance of grease is a maintenance matter that was addressed (properly) by APCo in that context.

Q193. On page 3 of the Staff's direct testimony on this issue, Mr. Paulk contends that because the motor must be qualified, and because "[t]he motor includes bearings and lubricant," the lubricant must also be qualified. What is your response?

A: (Sungergill) I believe that this grossly stretches the concept of EQ. In Regulatory Guide 1.89, Section C.6(a)-(b), the Staff expressly recognizes that equipment subcomponents do not have to be qualified in accordance with the provisions of 10 CFR 50.49 in order to maintain the overall equipment qualification of the parent component. (APCo Exhibit 35). Moreover, as I have already explained, grease only serves a mechanical function, not an electrical one. As an item of equipment with a mechanical function, grease need only be evaluated relative to its ability to perform its function in accident conditions. Mr. Paulk accepts this methodology in the last paragraph on page 3 of his testimony on this issue when he states that after thermal and radiation aging "the entire motor is assembled using new lubricant, and the assembled motor is then subject to a harsh environment." As will be corroborated by Dr. Robert O. Bolt, a nationally recognized lubrication expert, testing grease in the equipment is not the only way to demonstrate its capability to function under accident conditions.

Q194. To the best of your knowledge, can Premium RB grease perform its required function in the accident environment postulated at Farley?

A: (Sundergill) Yes. Data published by Texaco and available at the time of the 1987 inspection at Farley provides evidence that Premium RB grease could function in Farley accident conditions. (APCo Exhibit 74). Since the Premium RB grease has been demonstrated as being capable of fulfilling its required mechanical function, it is equivalent to SRI-2 in its capability to function under accident conditions.

Q195. On page 4 of the Staff's direct testimony on this issue, Mr. Paulk alleges that, "the licensee did not replace the qualified grease with the Premium RB grease in accordance with the vendor instructions .... " He further contends that, in accordance with these instructions, "the licensee should have removed the old grease and replaced it with the new grease, run the motors for 100 hours and then replaced the grease again. The licensee did not provide any documentation to demonstrate that this procedure was followed in replacing the Chevron SRI-2 grease with Premium RB grease." How do you respond?

A: (Sundergill) Quite frankly, this accusation has been difficult to respond to in the time available. It was raised for the first time in the direct testimony and seems to suggest a new direction for this issue. This accusation seems to relate to either APCo's practices for installation of grease or to potential ill effects of mixed grease.

As stated in Mr. Paulk's testimony, the NOV stated only that APCO, ". . . did not have documentation in a file to demonstrate qualification of Premium RB grease for use on fan motors inside containment and room coolers outside containment." At that time, there seemed to be no concern regarding the method of installing grease into these motors. Such a concern would be clearly outside the realm of EQ. (Nowhere that I am aware of has the Staff, IEEE, or any other organization contended that installation practices, such as installing lubricants, pulling a cable or torquing a screw, are EQ issues.) Likewise, I am not aware of the existence of any mixed grease in this equipment at the time of the EQ inspection or aware of the Staff raising such a concern at that time. However, to the extent that Mr. Paulk's concern now is mixed grease, Dr. Bolt addresses the issue in his testimony, and I refer you to it.

Mr. Paulk's testimony was also difficult to respond to because he failed to identify the source of the vendor instruction. Was it Joy or Reliance? In any event, after considerable effort in trying to resolve this issue, we contacted Mr. Mike McGovern of Reliance, the manufacturer of the motors for both the containment cooler fans and the room coolers. Mr. McGovern sent us Instruction Manual B-3620-19, dated March 1989, for the room cooler fan motors; this revision of the manual contained the special instructions mentioned by Mr. Paulk in his testimony. The information was as stated by Mr. Paulk except, significantly, the reference was a recommendation, not a requirement, and there was no mention of impact on qualification. Moreover, we have not yet been able to ascertain the date this vendor recommendation first appeared. It did not appear in the prior version of the Instruction Manual immediately available to us (B-3620-8).

The revision of the Instrument Manual referenced by Mr. Paulk is noteworthy in one particular other than as noted by Mr. Paulk. On the same page of the Instruction Manual as the information Mr. Paulk referenced, is a list of recommended lubricants. Texaco Premium RB is included on that list along with Chevron SRI-2. At least by 1989, Reliance was in agreement with the 1985 APCo conclusion that Chevron SRI-2 and Texaco Premium RB were equivalent lubricants for use in their equipment.

Q196. On page 5 of the Staff's direct testimony on this issue, Mr. Paulk claims that, "APCo did not provide any analysis or documentation from its files to support qualification of the fan motors or room coolers using grease other than that tested." Is that correct?

A: (Sundergill) No. As I explained earlier, the September 1987 JCOs documented the acceptability of Premium RB grease for application at Farley. (APCo Exhibits 45 and 43). These JCOs were produced and submitted to the inspectors during the September 1987 review and were available for NRC review during the November 1987 inspection. More importantly, the September 1987 JCOs documented pre-existing conclusions regarding the qualification of grease -- an item of equipment that performs a mechanical, rather than an electrical, function. Given the mechanical nature of the grease, reliance on published data was warranted and a § 50.49 similarity analysis was not necessary.

Q197. Specifically, what did the September 1987 JCOs conclude?

A: (Sundergill) The JCOs demonstrated that Texaco Premium RB grease is capable of retaining all required lubricating properties during and following all postulated accidents to which it might be exposed at Farley.

Q198. Are you aware of any documentation, besides the JCOs, supporting the use of Premium RB grease in fan motors and room coolers at Farley?

A: (Sundergill) Yes I am -- in a letter and attached table, dated June 10, 1976, from Thomas P. Gregory, Consumer Marketing Engineer for Texaco, to Frank Wetford of APCo. (APCo Exhibit 75). Texaco recommends the use of Premium RB grease for use in the RHR pump room coolers, containment spray room coolers, and charging pump room coolers. This recommendation was provided by Texaco with the express acknowledgement that the vendor-recommended lubricant was Chevron SRI-2.

Q199. Are you aware of any additional documentation supporting the use of Premium RB grease in fan motors and room coolers at Farley?

A: (Sundergill) Yes. Wyle Test Report 40196-1, dated December 12, 1988, documents the environmental testing of various greases and oils for use at Farley, including Premium RB grease. (APCo Exhibit 76). This test was performed in an expeditious manner to satisfy an NRC commitment. Its parameters envelope a composite of plants, including Farley. The Wyle Test Report verifies the vendors' previous conclusion that Premium RB grease is an acceptable substitute lubricant for use in Farley's fan motors and room coolers.

Q200. To the best of your knowledge, were the results of the Wyle Test Report ever reviewed by a lubrication expert?

A: (Sundergill) Yes. Dr. Bolt reviewed the final Wyle Report in December 1988 and found it both acceptable and in agreement with his expectations.

Q201. Do you agree with the NRC Staff that APCo "clearly knew or should have known" of documentation deficiencies pertaining to its use of Premium RB grease prior to November 30, 1985?

A: (Sundergill, Jones) Absolutely not. The Staff's December 1980 inspection report (APCo Exhibit 11) specifically references post-LOCA dilution fan motors -- which were manufactured by Joy. Similarly, the December 1980 TER reviewed the containment cooler fan motors, the post-LOCA mixing fan motors, and the hydrogen dilution fan motors -- all manufactured by Joy as well. In addition, neither the Franklin TER nor the Staff's December 1984 SER mentioned grease. This leads one reasonably to infer that either grease had been inspected and approved or that grease was not considered to be an item of electrical equipment included in the scope of 10 CFR 50.49. Because inspection of the grease would have required disassembly of the motors, a level of review not required by the NRC at that time, the latter inference is more likely.

The Staff itself, in its Order, does not make a convincing case for its "clearly should have known" finding. Even if a specific lubricant is identified by an equipment vendor, this does not establish -- in our view -- that a licensee should then clearly know that the equipment would not be qualified with different, equivalent greases.

Q202. Was there documentation pertaining to Premium RB grease in the Farley EQ files at the time of the 1987 inspections?

A: (Sundergill) Yes. The September 1987 JCOs I described earlier in my testimony were available for review during the November 1987 inspection. In addition, published data was available to both APCo and the NRC inspectors comparing Chevron greases to Texaco Premium RB. This data demonstrated that both lubricants are National Lubrication Grease Institute Grade 2 and have similar temperature and radiation tolerances. (APCo Exhibits 74 and 77).

Q203. Assuming this issue constituted a documentation deficiency, is it safety significant?

A: (Sundergill) No. The alleged documentation deficiencies concerning Premium RB grease are not safety significant. At the time of the 1987 EQ inspections, or shortly thereafter, there was a substantial basis on which to conclude that Premium RB grease was not a qualification concern. Conclusions already reached and documented in the JCOs available during the inspection were confirmed by the December 1988 Wyle Test Report. In addition, Dr. Bolt independently confirmed APCo's determination that Premium RB grease was acceptable for use in the fan motors and room coolers at Farley. He reiterated APCo's conclusion that Premium RB grease is capable of providing lubrication for extended periods of time at high temperatures. In sum, the issue of Premium RB grease is completely lacking in safety significance. The issue appears to relate only to documentation, and in this regard I'll reiterate that prior to November 30, 1985, EQ documentation specifically addressing lubricants was neither normal nor expected.

Q204. On page 6 of the Staff's testimony on this issue, Mr. Paulk claims that the alleged deficiency is safety significant. In particular, he contends that, "without the containment fans, the licensee would not have been capable of maintaining the containment temperature and pressure within design limits. Without the room coolers, certain equipment (e.g., pumps) required to mitigate the accident would not have sufficient cooling to remain operable." Are these conclusions correct?

A: (Sundergill) No. First, there is no support for the assumption that the coolers or fans would fail.

In addition, containment fan calculations have been prepared and run by Bechtel which demonstrate that the containment design parameters at Farley are not exceeded in the event that all containment fans are simultaneously inoperable. Thus, Mr. Paulk is mistaken when he states on page 6 of his testimony that, "the licensee would not have been capable of maintaining the containment temperature and pressure within design limits" without containment fans.

Furthermore, the accident temperature and pressure profiles, which were revised as a result of this calculation, subsequently have been compared to the qualification profiles for the EQ equipment in containment at Farley. As a result, it has been determined that the equipment is still qualified given the revised profiles. Based on the containment fan motor calculations, the Staff's conclusion regarding room coolers is pure supposition.

Therefore, I must reiterate my previous conclusion that the alleged documentation deficiency is not safety significant.

Q205. Does this conclude your testimony?

A: (Love, Sundergill, Jones) Yes.