UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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

REBUTTAL TESTIMONY OF MARK J. JACOBUS AND JAMES G. LUEHMAN
ON BEHALF OF THE NRC STAFF CONCERNING TERMINAL BLOCKS

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

A. Mark J. Jacobus, Senior Member of Technical Staff, Sandia National Laboratories. James G. Luehman, Senior Enforcement Specialist, Office of Enforcement.

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

A. (Both) A copy of each of our Professional Qualifications has been admitted previously into evidence as Staff Exh. 1.

Q3. What is the purpose of your testimony?

A. (Both) The purpose of our testimony is to rebut portions of the Alabama Power Company Testimony regarding violations of the environmental qualification (EQ) requirements for the States terminal blocks (Model Nos. NT and ZWM) and the

General Electric (Model No. CR151) terminal blocks at the Farley nuclear plant which in part led to the civil penalty that is the subject of this hearing. The APCo testimony which is the subject of this rebuttal testimony is contained in Direct testimony of Jesse E. Love, James E. Sundergill and David H. Jones on Behalf of Alabama Power Company (ff. Tr. 978) (hereafter L/S/J) and Direct Testimony of Philip A. DiBenedetto on Behalf of Alabama Power Company (ff. Tr. 1227) (hereafter DiBenedetto).

Q4. Could you please summarize APCo's position as you understand it?[1]

A. APCo is relying on several factors for their position. First, they claim that the terminal blocks were qualified as of November 30, 1985, based on their contention that the terminal blocks did not need to function at peak-LOCA conditions and based on what they consider Staff agreement of their position based on the January, 1984 meeting and the following correspondence. They next claim that even if the terminal blocks are required to function at peak-LOCA conditions, they should not be expected to have known that the blocks were not qualified. This actually presents two opportunities for them to claim that they did not know and they should not have known: first that they did not know the blocks had to be qualified for peak-LOCA conditions, and second, that if the blocks had to be qualified to these conditions, then they did not know and should not have known

[1]Unless indicated otherwise, the response to the questions are by Dr. Jacobus.

that blocks would not perform at the peak-LOCA conditions. Finally, they claim that the number of systems and components affected was minimal, implying that any violation was not significant.

Q5. Let us take things one step at a time. The APCo testimony focuses extensively on their contention that the terminal blocks are not needed at "peak-LOCA" conditions and therefore, their insulation resistance data at 150°F was adequate to qualify the blocks. Could you explain the progression of APCo's information to you that forms the basis for their position on this point?

A. At the time of the inspection, APCo's SCEW sheet formed the original basis for determining to what temperature the blocks must be qualified. The SCEW sheets (Staff Exhs. 69 and 70) for the blocks (or the electrical penetration assemblies of which they were a part) indicated that they had to be qualified to 378°F. The SCEW sheet for the States blocks further indicates that the blocks were only qualified to 307°F. A footnote indicates that the peak surface temperature of the blocks will not exceed the qualification temperature. The SCEW sheet for the General Electric electrical penetrations (which APCo claims also qualifies the terminal blocks) indicates that these blocks were qualified to 340°F. A footnote indicates that the peak surface temperature of the blocks will not exceed the qualification temperature. No additional documentation of their position that the blocks did not have to be qualified for peak LOCA conditions was provided

during the inspection, either in the qualification files or in response to written questions to the licensee that questioned the basis for qualification (Staff Exhs. 71 and 72). In response to EQ Question Number 26 (Staff Exh. 71), APCo indicated that the basis for selection of an acceptance criterion of $1x10^7$ Ω was contained in the response to EQ Action Items 018 and 067 (APCo Exh. 52). This document discusses the Conax test report, including the environments that the tested (Connectron) blocks were exposed to and the minimum insulation resistance measured for the blocks. Interestingly, there is no mention in that document of the temperatures when the insulation resistances were measured, nor is there any argument that the blocks are not required at peak LOCA conditions. The temperatures at which IR measures were performed is clearly not obvious from the plot that is cited from the Conax report.

At the meeting in Atlanta on November 25, 1987, APCo indicated that they still had faith in the Conax report for qualifying the blocks. At that meeting, they presented an enhanced version of the graph from the Conax report (APCo Exh. 56). This enhanced graph included several data points that were not included on the Conax graph. It also included the temperatures at which the insulation resistance measurements were performed, which also were not part of the Conax graph. Interestingly, this data was presented to the Staff at this meeting with no qualifications.

Following their presentation of the data, I pointed out that the data in the Conax report was invalid as stated by the test report. This point was discussed in my previous Direct Testimony. This was the first time that APCo acknowledged to the Staff that some of the data in their figure was invalid. APCo's Direct Testimony addresses this point for the first time, where in Mr. Love's response to Q107 (L/S/J p. 117), he states that with regard to the this plot (APCo Exh. 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, were not used in our selection of the value of 1E7 ohms.

It is extremely unclear to me why APCo would take a valid data figure, add invalid data to the figure (data that could have most definitely misled the NRC Staff because of the appearance of favorable IR data at 300°F), and then now claim that the data they had specifically added to the figure was irrelevant to their argument.

At the same meeting in Atlanta, APCo presented the data from the Sandia report (Staff Exh. 73) as part of the JCO (APCo Exh. 59). Although they still stood behind the Conax data for qualification, they provided an analysis of the Sandia data "to further exemplify the amount of conservatism built into the setpoint analysis" (APCo Exh. 59). This is the first time that APCo provided any

documentation that claimed that the blocks did not need to function at peak-LOCA conditions. They assessed the Sandia data and concluded that the blocks would function acceptably at 296°F and that the blocks were not needed at higher temperatures. This was based on an IR versus temperature plot that assumed the IR on a log scale to be linearly related to temperature.

When it was demonstrated that IR was in fact not related to temperature in this way, the meeting adjourned with APCo planning to replace the terminal blocks.

Aside from oral responses during the 1991 depositions of APCo witnesses, the APCo Direct Testimony is the first documentation provided to the NRC Staff that claims that the terminal blocks are not needed above some still lower temperature. I am aware of Mr. DiBenedetto's assertion that his January 8, 1988 report (Staff Exh. 47)

> . . . demonstrates that terminal blocks used in the APCo applications, that is pre-accident exposure and post-accident long term cooling, were capable of performing their intended functions. (DiBenedetto Q&A 143, p. 113).

However, his report addresses the issue of when the instrumentation circuit terminal blocks are required at Farley with reference to the Farley terminal block JCO (APCo Exh. 59). The JCO claimed that the terminal blocks were not required above 296°F. Mr. DiBenedetto does not assert, in his 1988 report, the temperature above which the terminal blocks are not required to function. APCo still has not defined what temperature they feel the blocks need to be qualified to,

based on the circuit-by-circuit analysis that they claim to have used as a basis for qualification all along.

Q6. You referred to APCo's response to EQ Action Items 018 and 067 (APCo Exh. 52). What was in APCo's response?

A. The APCo Response to EQ Action Items 018 and 067 (APCo Exh. 52) states with regard to IPS-107 that

> The test operations (Sect. 6.0) describes the phases of the test sequence during which insulation resistance (IR) measurements were made. Readings of IR were taken during the Phase I and II LOCA environment testing. Sect. 6.6 describes the LOCA environment test operation. Peak chamber pressure during Phase I testing reached 57.5 PSIG (290°F) at 120 seconds, and Phase I peak chamber temperature reached 300°F (56 PSIG) at 10 minutes from introduction of steam (Time 0). At 60 seconds from Time 0, chamber chemical sprays were initiated. Phase II LOCA testing began at 30 minutes, 45 PSIG (294°F), and at 30 minutes, 35 seconds, the pressure was reduced to 0 and temperature was ramped down to 144°F and was maintained between 140°F and 150°F for 240 hours. During this time, chemical sprays were continuously introduced into the chamber. IR measurements were taken on each test item during the Phase I and II LOCA tests (Sect. 6.6.12), IR Test Nos. 6 thru 16 of Appendix B (IPS-107).
>
> Appendix E of IPS-107 provides a compilation of the IR Test Data. Graph No. 1 of Appendix E provides 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 for aged and unaged specimens. From this graph, it can be seen that the minimum IR point recorded for a #16 AWG conductor and block was 3E7 ohms for aged specimens, and 1.5E8 ohms for the unaged specimens.

The conclusion of that document states:

> As the FNP terminal blocks used in E.Q. instrumentation and control circuits located inside containment have superior significant characteristics to the Connectron NSS3 block tested in IPS-107, and as the FNP E.Q. enclosure configurations do not subject the FNP terminal blocks to submergence and provide equal or superior protection to that provided to the NSS3 block in the tested configuration, the use of minimum IR #16 AWG NSS3 values from IPS-107 test report for calculation of DBE leakage currents on instrumentation terminations inside containment is acceptable.

Although the above does not explicitly state it, the impression I get when reading the above is that the insulation resistance was greater than 10^7 Ω at all temperatures up to 300°F. This, of course was not actually the case.

Q7. What are the regulations that govern whether the blocks had to be qualified for peak-LOCA conditions?

A. 10 C.F.R. § 50.49 is the requirement for qualification and is what must be followed. Section (k) does not require requalification for equipment that was previously qualified to NUREG-0588 (Staff Exh. 23) or to the DOR Guidelines (APCo Exh. 8). The DOR Guidelines applied to the terminal blocks in Farley Unit 1 and the requirements of NUREG-0588, Category II applied to the terminal blocks in Farley Unit 2.

Section 5.2.5 of the DOR Guidelines states that:

> Failure criteria should include instrument accuracy requirements based in the maximum error assumed in the plant safety analyses. If a component fails at any time during the test, even in a so called "fail-safe" mode, the test should be considered inconclusive with regard to

> demonstrating the ability of the component to function for the entire period prior to the failure.

Section 5.2(1) of the DOR Guidelines states that:

> The environment in the test chamber should be established and maintained so that it envelops the service conditions defined in accordance with Section 4.0 above. The time duration of the test should be at least as long as the period from the initiation of the accident until the temperature and pressure service conditions return to essentially the same levels that existed before the postulated accident.

Section 2.2(7) of NUREG-0588, Category II requirements states that:

> Performance characteristics of equipment should be verified, before, after, and periodically during testing throughout its range of required operability.

Section 2.2(9) of NUREG-0588, Category II requirements states that:

> The operability status of equipment should be monitored continuously during testing. For long-term testing, however, monitoring at discrete intervals should be justified if used.

Section 3(4) of NUREG-0588, Category II requirements states that:

> Some equipment may be required by the design to only perform its safety function within a short time period into the event (i.e., within seconds or minutes), and, once its function is complete, subsequent failures are shown not to be detrimental to plant safety. ... Equipment in these categories is required to remain functional in the accident environment for a period of at least one hour in excess of the time assumed in the accident analysis.

It is evident that, based on the above sections of the relevant guidelines, that the Commission expected equipment to be qualified for the entire accident, with only NUREG-0588 providing an exception. The exception still requires a

minimum 1-hour qualification, and therefore does not support APCo's arguments. The intent of the regulations is made somewhat more clear in Section (i) of 10 C.F.R. § 50.49, which discusses the JCO process. Five factors were outlined that should be considered, as appropriate, to demonstrate that "the plant can be safely operated pending completion of equipment qualification required by this section." Factor 4 is "Completion of the safety function prior to exposure to the accident environment resulting from a design basis event and ensuring that the subsequent failure of the equipment does not degrade any safety function or mislead the operator." Thus, an analysis, such as the one APCo is relying on for the qualification of terminal blocks, was only to be permitted for a JCO, not for qualification of the equipment.

At this point, I should discuss what Mr. Love states in his testimony in response to Q120 (L/S/J pp. 130-32):

> It must also be recognized that the instrument loops at issue here were covered by Reg. Guide 1.97. (APCo Exh. 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 <u>for the length of time its function is required</u>."

I think he is making a serious misinterpretation of Reg. Guide 1.97. The Reg. Guide does not state that equipment must be capable of functioning <u>only</u> when the instrument is believed to be required to function. It also does not state that the function of instrument circuits is time dependent. A correct restatement

of the words in Reg. Guide 1.97 is that equipment must continue to function properly until it is no longer needed. This would include functioning through the peak LOCA conditions for the terminal blocks that are required after that time.

Q8. Why should APCo have clearly known that the blocks had to be qualified to peak-LOCA temperatures?

A. In addition to the regulatory basis provided in Q&A 7 from a pure technical standpoint, the blocks have to be qualified to peak-LOCA conditions unless the utility can provide clear and convincing evidence to the contrary. I have previously outlined what such analyses would have needed to consider. The relevant information is also included in Q&A 26 below. As I stated in response to Q5 above, prior to the APCo Direct Testimony being submitted, APCo had not ever provided any documentation, other than the JCO and the SCEW sheets, indicating that the blocks did not have to function at peak-LOCA conditions. The SCEW sheets claimed the blocks were qualified to 307°F (States) or 340°F (General Electric), while the JCO claimed that the blocks did not have to function above 296°F.

Clearly, the regulations and IN 84-47 should have been well known to APCo and they form the basis for why APCo "clearly should have known." Further, Sandia report NUREG/CR-3691 (Staff Exh. 74), which both APCo and Bechtel agree was reviewed by Bechtel (Tr. 1130, ll.12-25), provide a very strong

basis as to why APCo "clearly should have known." This report's Conclusion 3 clearly indicated that "Most industry qualification tests do not monitor for low level leakage currents during LOCA simulation tests of terminal blocks. Without quantitative knowledge of these leakage currents, adequate analyses of their effects on instrumentation and control circuits cannot be performed." (Staff Exh. 74, page 117, Conclusion 3) However, in answering the question involving the Sandia reports, "did those documents, in any way, alter your view technically, of what needed to be done to address the instrument accuracy issues?" Mr. Love testifies "No." (Tr. 1130, l.22). This follows his recognition that the data APCo was relying on at the time was based on data taken after the completion of accident testing (L/S/J Q&A 94; pp. 104-05), not during the accident testing. I am not certain what Bechtel considers to be an adequate review of a document, but I would think that at the very least, the conclusions of the document would have to be read.

Q9. Given that the blocks have to be qualified to peak-LOCA conditions for the Farley applications, why is it that APCo "clearly should have known" that they were not qualified as of November 30, 1985?

A. Information Notice 84-47 was the initial notification that insulation resistance data during the accident test was necessary. The subsequent issuance of the Sandia reports, which Bechtel has testified to having reviewed (Tr. 1130, ll. 12-25),

further clearly outlined the concerns with operation at elevated temperature LOCA conditions. Conclusion 3 of NUREG/CR-3691 (Staff Exh. 74) was discussed in response to Q8 above. Conclusion 6 provided further information that "Terminal block leakage currents in a steam environment may degrade performance of instrumentation and control circuits to an extent sufficient to cause erroneous indications and/or actions." Figure 8-3 on page 85 of the same report (same as Figure 40 in NUREG/CR-3418) demonstrated vividly the effects of terminal block leakage currents on an actual pressure transmitter circuit. For these figures, only one terminal block was used in the circuit. Many Farley circuits contained two terminal blocks inside containment, effectively doubling the leakage currents that would be expected. The data from these figures is based on a General Electric EB-25 terminal block in the transmitter circuit and is intended as an illustration of the real effects of terminal blocks on such circuits. It clearly does not represent the Farley transmitter circuits exactly.

Mr. DiBenedetto states in testimony in response to Q145 (DiBenedetto p. 113-14) that "As I stated previously, if the APCo terminal blocks were to be used during the peak conditions of the accident, the Staff's assessment would be correct and justified." Thus, he agrees that if the blocks had to be qualified to peak-LOCA conditions, then the blocks were not qualified as of November 30, 1985 and the Staff's position would be correct.

Although Information Notice 84-47 was the major alert to licensees on the issue of degraded insulation resistance, the NRC also issued Information Notice 85-39, Auditability of Electrical Equipment Qualification Records at Licensees' Facilities, on May 22, 1985. (Staff Exh. 77). This information notice states, in part, on page 3:

> An EQ test report, in and of itself, does not completely support a determination that equipment is qualified. In order to ensure that plant-specific requirements are adequately considered, the following types of additional information may be needed: . . . (4) effects of decreases in insulation resistance on equipment performance; . . . (6) applicability of EQ problems reported in IE information notices and bulletins and their resolution.

Q10. APCo has claimed that the number of systems and components affected was minimal, implying that any violation was not safety significant. How do you respond to their assertion? (L/S/J Q&A 121 pp. 132-34).

A. Of the 13 Type A, Category 1 variables that were identified in Table 1 of the Farley Regulatory Guide 1.97 submittal (Staff Exh. 75), multiple channels of 5 variables would be affected. As stated in the APCo response to EQ Action Items 018 and 067 (APCo Exh. 52), both units relied on terminal blocks in transmitter circuits for 2 channels of wide range reactor coolant system (RCS) pressure, for 3 channels of pressurizer pressure, for 3 channels of pressurizer level, for 3 channels of narrow range level in each of 3 steam generators, for 1 channel of wide range level in each of 3 steam generators (only in Unit 2), for 2 channels

of containment post-accident sump level, and for 2 channels of flow in each of 3 steam generators. Of these, RCS pressure, wide range steam generator level, narrow range steam generator level, pressurizer level, and containment sump level are the Type A, Category 1 variables. Type A variables are "those variables to be monitored that provide the primary information required to permit the control room operators to take the specified manually controlled actions for which no automatic control is provided and that are required for safety systems to accomplish their safety function for design basis accident events." According to RG 1.97, "Category 1 provides the most stringent [qualification] requirements and is intended for key variables."

Q11. What effects will the terminal blocks have on instrumentation circuits?

A. Referring to Figure 8-1 in NUREG/CR-3691 (Staff Exh. 74), which is a simplified schematic of a pressure transmitter circuit, the terminal blocks provide a leakage path R_{TB} between the supply conductor to the transmitter and the return conductor from the transmitter. Because of the voltage difference between the two conductors, leakage currents I_{TB} flow between them. The magnitude of the leakage currents varies with changes in the external environment, but the effect is always that the power supply has to supply more current I_L through the measuring resistor (I to V isolation amplifier) than if no leakage currents were present ($I_{TB} = 0$). Thus, the measuring resistor reads not only the current supplied

from the end device (I_T), but also the current that is leaking between the terminals of the terminal block (I_{TB}). Because the leakage current (I_{TB}) is always in the same direction, the readout device will always read a higher value of current (I_L) than that coming from the end device (I_T), resulting in the pressure (or level or flow) appearing higher than it actually is.

EVOLVING REQUIREMENTS

Q12. Let us move to other areas of the APCo testimony. They testify extensively regarding "evolving requirements" for loop accuracy calculations. Let us begin with the Sandia seminar. How do you respond to their testimony regarding the seminar?

A. In his Direct Testimony (L/S/J Q&A 100 pp. 109-10), Mr. Love indicates that, based on my deposition, he presumes that with regard to the instrument accuracy issue that the Sandia EQ seminar "contributed to the latest interpretation of this issue, and that the post-deadline EQ NRC inspections findings and violations were the method of communicating the latest thinking." (L/S/J p. 110). I think it is appropriate for me to restate the purpose and content of the seminar held at Sandia in 1987. The seminar had two primary purposes. The first was to provide training of new inspectors that had recently been assigned to EQ, particularly at the NRC Regional offices. The second was to make all inspectors aware of those areas where significant problems had been found during the first year or so of

first round inspections. This was simply to help inspectors make the best use of their time when performing inspections, rather than trying to start from the beginning at every inspection. The purpose of the seminar was not to define new interpretations of requirements, nor to require enhanced documentation from licensees at future inspections.

The information that was presented regarding the accuracy contribution of terminal blocks on instrument circuits was based virtually 100% on the Sandia terminal block test results in NUREG/CR 3418 (Staff Exh. 73) and NUREG/CR-3691 (Staff Exh. 74) and other industry tests that occurred prior to November 30, 1985. A copy of the material discussed at the seminar was provided to APCo during discovery (Staff Exh. 59). Based on the above, their assumptions as to what went on at the seminar regarding instrument accuracy are not correct.

Q13. In Q&A 34 of their Direct Testimony (L/S/J p. 43), Mr. Love and Mr. Sundergill testify as follows:

> Q34. Were there any other aspects of EQ that were "evolving" subsequent to the EQ deadline and prior to the 1987 Farley inspections?
>
> A34. (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 reflect what APCo "knew or clearly should have known" as of the November 30, 1985 deadline.

How do you respond to their testimony?

A. (Jacobus) The only thing that they state correctly is that Sandia "had conducted some tests." I believe the other statements to be incorrect. Sandia was not, in fact, developing data on terminal blocks after the EQ deadline. The final reports on terminal blocks were published in August and September of 1984, completing the Sandia terminal block testing program more than a year before the EQ deadline. Mr. Craft, the author of the terminal block reports, changed jobs in late 1984, leaving EQ entirely. No additional terminal block testing or data development was performed at Sandia from late 1984 up until the time of the inspections at Farley.

Sandia was involved in the inspection process for EQ beginning in about 1981, with very significant activity in late 1982 and into 1983. The earlier inspections were at vendors, A/Es, and test labs. In FY82, Sandia supported 11 inspections. In FY83, Sandia supported 40 inspections. Sandia was also involved with the first round EQ inspections at virtually every plant in the country.

(Luehman) Clearly, this assertion is not supported by the facts. Information Notice 84-47 which dealt with this subject was sent to APCo well before the deadline. Further, NRC inspectors had questioned the use of terminal blocks in instrumentation circuits in a number of pre-deadline inspections.

Finally, as supported by a number of APCo witnesses, numerous licensees had responded to the Information Notices 82-03 and 84-47, prior to November 30, 1985, by removing terminal blocks from these circuits and the NRC integrated their concern into 10 C.F.R. § 50.49 audits.

Specifically, with respect to pre-deadline inspections, the inspection report dated January 29, 1985 documenting an October 15-19, 1984 inspection at Calvert Cliffs (Staff Exh. 63), on page 12, states "The inspectors also reviewed an internal BG&E letter dated October 3, 1984, that states an FCR is being prepared to replace terminal blocks in instrumentation circuits by qualified splices."

As part of a joint affidavit on behalf of the Nuclear Utility Group on Environmental Qualification (NUGEQ) submitted to the NRC as an enclosure to an October 3, 1988 letter from the NUGEQ, Messrs. Noonan and DiBenedetto, APCo witnesses, and Mr. LaGrange, APCo affiant, commented on this subject. With respect to Information Notice 84-47, they state on page 15 of the affidavit (which also was submitted as part of APCo's response to the Notice of Violation (Staff Exh. 15)) "...virtually all licensees simply replaced instrumentation terminal blocks..." and more importantly, "The intent of the Notice was to call attention to this problem such that utilities would replace terminal blocks in instrumentation circuits with qualified splices. This specific problem was discussed during meetings held with each licensee but the broader issue of total instrument loop accuracy was not. ... The NRC integrated this concern for instrumentation circuit

terminal blocks into both its evolution of NTOL equipment qualification efforts and 50.49 compliance audits." (emphasis added).

Q14. In Direct Testimony (L/S/J Q&A 80, pp. 93-94), Mr. Love and Mr. Jones testify that

> 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.

Similarly, in his Direct Testimony (DiBenedetto p. 100), Mr. DiBenedetto states that

> Subsequently, instrument accuracy became an "evolving" technical issue that needed to be addressed by industry as a generic matter. By 1984, industry had initiated efforts to address the instrument accuracy issue through Emergency Operating Procedure (EOP) setpoints and error margins. This effort did involve some consideration of accuracies of terminal blocks. APCo -- through Bechtel and Westinghouse -- proceeded on the same path as did others in the industry...

Based on Sandia's experiences with the inspection process, as well as other contact with industry, how would you characterize how the rest of the industry addressed terminal blocks in response to Information Notice 84-47?

A. Without going into detailed results of inspections, I would simply note that I do not know of any plant that uses terminal blocks in 4-20 mA transmitter circuits that require harsh environment qualification and are located inside containment. I recall being told during many inspections that all inside containment terminal

blocks in 4-20 mA circuits had been replaced in response to IN 84-47. In many cases, plants went beyond replacing only the terminal blocks in 4-20 mA circuits. Some replaced all terminal blocks in all instrumentation circuits inside containment and some even replaced terminal blocks in control circuits. Still others replaced selected terminal blocks outside containment in instrument circuits. This is very different than the Farley approach.

In terms of performing loop accuracy calculations involving contributions of calibration equipment and other secondary effects, I would agree that APCo probably began such calculations in the same time frame as the rest of the industry. However, that is not the issue in these proceedings. The issue is specifically for not properly considering the effects of terminal blocks on the accuracy of instrument circuits. The NRC Staff expected to see acceptance criteria established for the terminal blocks (based on their required function) and then a demonstration that the terminal blocks meet those specified functional performance requirements during accident conditions as is required by regulations. If the only way APCo felt they could establish the functional performance requirements of the terminal blocks was to perform a detailed analysis of the entire circuit and if they did not have the capability to do that analysis prior to November 30, 1985, they could have chosen to remove the terminal blocks, as many other utilities chose to do. Information Notice 84-47 and their review of the Sandia reports clearly should have given them ample reason to doubt the

capability of their installed terminal blocks. These documents indicated that the terminal blocks likely formed a "weak link" in the instrument loop. All utilities that I know of, with the exception of APCo, took appropriate action to respond to IN 84-47.

Q15. In his Direct Testimony (L/S/J Q&A 89, p. 100), Mr. Love testifies that total loop effects, which include terminal block IR data, were not yet being considered when finalizing the qualification of terminal blocks. What did Information Notice 84-47 suggest with regard to total loop effects?

A. IN 84-47 specifically suggested that licensees "review terminal block qualification documents to ensure that the functional requirements and **associated loop accuracy** of circuits utilizing terminal blocks will not degrade to an unacceptable level due to the flow of leakage curren... that might occur **during design basis events**" (emphasis added). Note that the suggested activities were very specific.

Q16. In Q&A 102 (L/S/J pp. 110-12), Mr. Love testifies that

> 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 taken during LOCA testing. To do this, based on the 1986-1987 interpretation of this issue, we consulted the corrective actions contained in IN 84-47...

How do you respond to this testimony?

A. It seems ridiculous to me that only in 1986-1987 would a utility finally consider performing the corrective actions that had been clearly identified in an information notice issued 2-3 years earlier. It would seem that it took them 2-3 years to finally figure out that the corrective actions listed in IN 84-47 applied to them. Even when they did finally recognize the need for the insulation resistance data during LOCA testing, they took the data from a report on terminal blocks in which insulation resistance was measured only at temperatures below 150°F.

Q17. At the end of his response to Q112 (L/S/J p. 124), Mr. Love testifies that

> 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.

Do you agree?

A. IN 84-47 was issued more than a year before the deadline and specifically stated that licensees should "review terminal block qualification documents to ensure that the functional requirements and associated loop accuracy of circuits utilizing terminal blocks will not degrade to an unacceptable level due to the flow of leakage currents that might occur during design basis events." What this said to licensees is that terminal blocks can be a large contributor to loop inaccuracy and that terminal blocks should be considered in that light as a part of the ongoing

10 C.F.R. § 50.49 reviews being performed by licensees at that time (prior to the EQ deadline). If APCo was incapable of performing this action prior to the EQ deadline, they could have chosen to replace the terminal blocks (as many other licensees chose to do).

The decision not further cite APCo in the violation for not having "performance specifications under conditions existing during and following design basis accidents" for terminal blocks as required by 10 C.F.R. § 50.49(d)(1) was consistent with the Modified Enforcement Policy of generally considering all information that the licensee had available at the time of the audit. At the meeting in Atlanta shortly after the audit, APCo had established a performance specification of $5x10^5$ Ω for the terminal blocks. If APCo would not have come up with an appropriate performance specification, then they might also have been cited for that deficiency.

Q18. In response to Board examination, Mr. Love discussed his use of the word "consensus" with regard to "how the calculation of leakage currents from the complete instrument loop (including terminal block contributions) would be made." He testifies that

> Previous to the 1986-87 timeframe, there were assumptions made in the calculations that the cables and other components that may be in the harsh environment in the instrument loop, such as connectors or terminal blocks or cable splices, were -- their contribution to the error was insignificant as compared with the

> sensor itself due to the adverse environment effects. (Tr. 1139, ll.14-21).

He again testifies in response to Judge Carpenter's question

> JUDGE CARPENTER; Would you say that the errors associated with these terminal blocks that were at issue and are now at issue before us pre-November, 1985, EQ-deadline were thought to be small but in fact were unknown?
>
> WITNESS LOVE: The exact contribution from the terminal block was thought to be small in the previous terminal. (Tr. 1141, ll.2-8).

Following Mr. Love's response, Mr. Jones testifies

> WITNESS JONES; I agree. I think you're correct. (Tr. 1141, l.9).

How do you respond to their testimony?

A. I think they clearly have the facts wrong. IN 84-47 clearly informed utilities that "the NRC staff recognizes that leakage currents do exist during LOCA/MSLB simulations and that the leakage currents may be of significance in some applications." It went on to suggest what utilities should do as I have previously discussed. A methodology for calculating the effects of degraded insulation resistance on various circuits was presented in NUREG/CR-3691 (Staff Exh. 74).

The testimony of Mr. Jones bears this out when he testifies that "I don't think that it's the calculation that has evolved. It's the amount of contributions of which components that has evolved over a period of time." (Tr. 1140, ll.3-6). His statement is exactly correct in this case. In response to IN 84-47, terminal blocks were either replaced or appropriately considered as part of the loop

accuracy calculations by other utilities. At that point, most utilities began considering the effects of cables, electrical penetrations, and splices also. In the evolution of loop accuracy calculations after the EQ deadline, items such as process measurement accuracy, sensor calibration accuracy, sensor temperature effects, sensor pressure effects, sensor drift, rack calibration accuracy, rack comparator setting accuracy, rack temperature effects, and rack drift began to be considered in the loop calculations (Staff Exh. 76). APCo has not been cited for failure to consider these type of effects. They have only been cited for failing to consider the effects of terminal blocks, the issue identified in IN 84-47.

In addition to Mr. Jones' testimony, Mr. DiBenedetto's testimony at Q&A 118 (DiBenedetto p. 98) states that with regard to moisture films and IN 84-47 that "This notice, which came out in June 1984, was the first generic notice of the issue." He then goes on in Q&A 119 to respond to the question "Was this the first time instrument accuracy, or at least the contribution of terminal blocks to instrument accuracy, was ever considered to be a significant problem?" with "Generally, that is correct." Thus, he confirms that Mr. Love's testimony at Tr. 1139 and Mr. Jones' agreement with that testimony are indeed incorrect.

Q19. In response to Q147 (DiBenedetto pp. 115-17), Mr. DiBenedetto testifies that "the Staff withdrew a violation associated with instrument loop accuracy in apparent

recognition of the fact that the licensee could not have known of the issue prior to the EQ deadline." Did the violation at Robinson have anything to do with the use of terminal blocks in instrument circuits?

A. No. The issue at Robinson was very different. Robinson had performed adequate loop calculations (except for a problem with how they treated penetrations). What they had failed to do was to provide documented plant requirements for comparison with the calculated loop accuracy. At Farley, terminal blocks were being used inside containment in instrument circuits without properly considering the effects of the terminal block leakage currents, an issue clearly and unmistakably identified in IN 84-47.

SIMILARITY ARGUMENTS

Q20. Let us now consider the APCo testimony regarding the Conax test of Connectron terminal blocks. In Q&A 103 (L/S/J pp. 112-14), Mr. Love tries to justify that the APCo similarity analysis was correct because it considered the physical characteristics of the Connectron vs. the States and GE blocks. He goes on to indicate that their "approach to qualification by analysis is not unusual and is acceptable under 10 CFR 50.49." How do you respond to his testimony?

A. I completely agree that a complete and correct analysis may be used to establish similarity. The issue is whether their analysis was complete and correct. It was not because it did not consider the fact that the Connectron blocks have every

other terminal at a different elevation, while the GE and States blocks both have terminals that are all at the same height. The "compact step-type configuration" is a feature that is clearly delineated in the Connectron literature. Further, differences in how moisture collects on different terminal blocks was not addressed. Presumably, "engineering judgement" was used to discount these factors. I do agree that every element of engineering judgement need not be documented in great detail, but I do firmly believe that they should be able to provide a sound engineering basis that demonstrates that their engineering judgement was reasonable.

Q21. In Q&A 104 (L/S/J pp.114-15), Mr. Love testifies that

> We had considered the differences identified by the Staff and concluded that they were not germane.
>
> First, let me address the alleged material differences.... The Sandia report indicated that insulation resistance of the terminal block material 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 CR151 terminal blocks is immaterial to the issue.

How do you respond to his testimony?

A. I have no idea how he came to the conclusion that there were "alleged material differences." He refers to my Direct Testimony on page 4, in which I can find no mention of the word "material." Similarly, in my deposition, pages 112-116, similarity was discussed, with no mention of material differences. Mr. Love then

goes on to discuss the Sandia report and what it states about material differences, which is completely irrelevant in light of the fact that I have never brought up material differences.

Q22. Mr. Love goes on to discuss that he feels that the differences in height between the adjacent terminals would not have "any impact on the existence or non-existence of a conductive moisture film... or on the relative performance in instrumentation circuits." (L/S/J p. 115). How do you respond to this part of his testimony?

A. I agree with the first part of his statement regarding whether a film will exist. However, the second part of his statement is not correct. In APCo's original similarity analysis they recognized that the distance between terminals was an important parameter. What APCo did not consider is that the step design effectively increases the distance between adjacent terminals. Taken to a ridiculous extreme, let us assume that there was a 1 foot height difference between adjacent terminals. Then the effective distance between terminals would be about 1 foot even if the center-to-center spacing were only 1/4 inch. Using the APCo logic would then imply that a single level terminal block with 1/2 inch between terminals would be better than the step design with effectively 1 foot between terminals.

Q23. Mr. Love then goes on

> 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. (L/S/J p. 115).

How do you respond to this part of his testimony?

A. In fact, APCo had such test results in their procurement file at the time of the inspection. Which would one prefer to believe, data on the actual terminal blocks at appropriate LOCA conditions, or data taken on significantly different terminal blocks at conditions much less severe than would actually exist during a design basis accident? I do not believe that it takes too much "engineering judgement" to answer that question.

As an example of the differences in construction, the GE and Connectron blocks are molded as a single piece of insulating material, barriers and all. In contrast, the terminal bases and barrier materials are formed separately for the States blocks and then these are attached with screws to a base metal plate. This results in what NUREG/CR-3418 (Staff Exh. 73) and NUREG/CR-3691 (Staff Exh. 74) term a sectional terminal block, as defined on page 12 of NUREG/CR-3691. Differences such as these were not addressed in the similarity analyses.

Q24. Under cross examination you were asked about the conditions under which a similarity analysis might be possible. (Tr. 737). Could you explain the distinction between your answer "if the terminal blocks are exposed to fairly mild conditions, from a technical standpoint, there's very little that you have to do to show similarity," (Tr. 373, l.22), and your statement "If the blocks are exposed to fairly severe conditions, you have to do much more." (Tr. 738, l.2)?

A. The distinction is drawn in that under more severe conditions, the terminal blocks are near their performance limits. Thus, even subtle differences between blocks can make a difference as to whether the circuits will maintain acceptable accuracy. We must recall that in going from an IR of 10^5 Ω to an IR of 10^4 Ω, Westinghouse has indicated that the error goes from roughly 5% to 50%. Thus, fairly small changes in terminal block IR in this range have much more significant effects on the loop accuracy than do changes in IR from say 10^7 Ω to 10^6 Ω. This latter change would have essentially no effect on the overall accuracy of the circuit, because other factors would be dominant. Thus, when the terminal blocks (or any other equipment items) are near their performance limits, the judgement to use similarity arguments must be made much more carefully than when the equipment is well within its performance limits. The similarity analysis must also be much more rigorous.

This also explains why I agree that if the terminal blocks only had to function at 150°F, then the similarity analysis, while not adequate for similarity

at higher temperatures, would have been considered adequate at the lower temperatures. This is not meant to imply that the blocks would behave exactly the same, but rather that the differences between the IRs at this temperature would not have any significant effect on the circuits they were a part of.

Q25. How important is the similarity analysis in terms of the violation?

A. The similarity analysis is not important to the violation. Even if the similarity analysis were completely acceptable, the fact that the Connectron blocks only had insulation resistance data up to 150°F renders the test useless from the point of view of qualifying the APCo terminal blocks for temperatures near 300°F.

REQUIRED QUALIFICATION TEMPERATURE/ ARGUMENTS THAT BLOCKS WERE QUALIFIED/JCO

Q26. In reviewing the APCo Direct Testimony, what conclusion do you come to about when APCo claims the terminal blocks have to be qualified?

A. APCo's Direct Testimony still does not give the temperature that they contend the blocks have to be qualified to for instrument accuracy considerations. It does appear to claim, in Mr. Love's response to Q110 (L/S/J pp. 120-21), that some of the terminal blocks are not needed until the "temperature is below 200°F for worst case LOCA" and that "post accident monitoring instrumentation will not be relied upon for operator action at the 313°F containment temperature peak; it is relied upon during the post-peak periods when the temperature is significantly

reducing or tailing off." His response, even at this late date, does not consider the following factors:

a. the qualification regulations, as explained above in Q&A 7

b. the possibility of operators taking inappropriate actions in response to incorrect readings

c. the effects of different accident sequences and whether the terminal blocks might have to function at higher temperatures in these alternative accident sequences (a design basis LOCA can only be used as a bounding accident if it is demonstrated that the equipment performs throughout the accident test)

d. warnings to the operators that the instruments could be inaccurate at the high containment temperatures

e. whether any of the instrument circuits containing terminal blocks are connected to alarms and/or any type of recorder and how these factors might contribute to misleading of the operators, either in diagnosing or responding to various accident conditions

Q27. Focusing on items b. and d. of your previous response, is there any APCo documentation that you can cite that supports that warnings in the EOPs (or as they are generically referred to by Westinghouse, Emergency Response Procedures (ERPs)) would have been necessary and that there was potential for incorrect operator action?

A. Attachment 2 to the JCO (APCo Exh. 59) is a letter from Westinghouse to APCo. This letter states in part that:

> For RCS Subcooling, Steam Generator Narrow Range Level and Wide Range Pressure, it is recommended that for Farley Unit 1 that a containment temperature criterion be defined that is indicative of current leakage resistance of less than $5x10^5$ Ω. A value of greater than $5x10^5$ Ω results in an instrument inaccuracy that will allow the current ERP values to be used by the operator to take action as specified in the ERPs. **The temperature or a corresponding containment pressure criterion should be used as guidance to the operator using the ERPs on when to consider that additional error above that already accounted for in the ERPs may exist.** Under conditions exceeding these criteria, no action which could reduce the margin of safety, specifically termination of safety injection based on RCS Subcooling or stopping of all auxiliary feedwater based on Steam Generator Narrow Range Level or stopping of RHR pumps based on Wide Range Pressure, should be performed since the errors may exceed those accounted for in the ERPs....(emphasis added)

APCo has not provided any evidence that from November 30, 1985 until the time of the inspection that such warnings were a part of the ERPs. In fact, it is apparent that they were not. Further, it should be again noted that such an argument, consistent with 10 C.F.R. § 50.49(i)4, is a JCO argument, not a qualification argument.

Q28. With regard to the figure presented in the JCO and discussed in the meeting in Atlanta (APCo Exh. 59), Mr. Love was questioned by the board regarding this plot. Is there any reason to believe that a graph of insulation resistance versus temperature is linear on a semi-log plot? (Tr. 1144-56).

A. I have not seen any data that would suggest that it is over the range of temperature from 203-347°F. The experimental data that I have examined suggests that it can be quite non-linear. For example, extensive data is presented of IR versus temperature in NUREG/CR-3418 (Staff Exh. 73) (which is also SAND83-1617), from pages 88-93. This data is reasonably consistent in indicating that IRs above a temperature of about 120°C (248°F) were not highly dependent on temperature.

In addition to the data from the Sandia tests, the General Electric test report dated November 6, 1973, that was in the Farley files, indicates that the IR of the blocks at temperatures from 260-340°F would be in the range of 2×10^4 Ω, with very little dependence on temperature over this range. The ambient temperature IRs in the GE test were on the order of 10^9 Ω, clearly indicating that the plot must become quite non-linear at some lower temperatures.

I believe that the two test reports cited above demonstrate that IR cannot be assumed to be linear, and I do not believe Bechtel had any valid basis for assuming that it was. It should also be noted that the data on the figure they presented was not for either of the two types of blocks that were used in the

Farley plant. I have to continue to wonder why, with two test reports available that gave data for both of the exact blocks that were used in the Farley station, that Bechtel would attempt to use similarity analyses to qualify the blocks. They initially attempted to use similarity to the Connectron blocks tested by Conax, and then they tried to use similarity to the General Electric blocks tested by Sandia. Both Sandia and General Electric had performed tests of both the GE CR151 blocks and the States ZWM blocks. At a temperature of 300°F, both of these test reports indicate that the IRs of both types of blocks would be too low to meet the APCo acceptance criterion for terminal block IR. It should also be emphasized that the GE test exposed the blocks to only one DBA cycle, a factor that APCo claims they considered important in assessing the Sandia test results, which they claimed had subjected the blocks to three DBA cycles.

Attachment 3 to the JCO (APCo Exh. 59) is a memo from Mr. Love that provides his explanation for not using the data on GE CR151B terminal blocks and States ZWM terminal blocks tested in the Sandia Phase 1 tests. He states that the data "was not used due to the inaccuracies associated with the SNL electrical test circuitry that measured leakage current values during Phase I testing." In actual fact, there were no abnormal inaccuracies associated with the circuitry. I think what he meant to state is that the Phase I testing used a serpentine connection of the terminal blocks (see Figure 10 on page 21 of NUREG/CR-3418, Staff Exh. 73), resulting in five parallel conducting paths for leakage currents,

rather than only one, resulting in overly conservative data if the data is uncorrected. However, Conclusion 6 in the report (Staff Exh. 73) on page 126 states in part that "The comparison between the serpentine circuit connection and the once-through connection is consistent with expected results based on parallel conducting path arguments..." Thus, the data from the Phase I testing can be reasonably multiplied by 5 to account for the parallel conducting paths, resulting in realistic average values of IR for the GE CR151B and the States ZWM terminal blocks.

It is interesting to note that in the JCO (APCo Exh. 59), APCo states on page 3 that "Figure 1 represents a correlation between temperature and IR conservatively assuming a logarithmic relationship between temperature and IR." Clearly, they have no basis whatsoever to claim that assuming the relation to be logarithmic is in any sense conservative.

In response to a question from Judge Carpenter, Mr. Love states that "there may be some curvilinear aspect of it, however, I do not believe the profile would be anywhere near as radical as that which is predicted by using the numbers across all of the DBA profiles that were consecutively applied to these terminal blocks." (Tr. 1219-20). This is quite in contrast to their statement in the JCO (APCo Exh. 59) that "Figure 1 represents a correlation between temperature and IR conservatively assuming a logarithmic relationship between temperature and IR." (emphasis added).

Mr. Jones (the transcript that I currently have incorrectly attributes it to Judge Carpenter) states that "I would just like to add that at the time Sandia put this report together, I would think if they thought it was important and it wasn't linear, they would have recorded more than two datapoints." (Tr. 1221-22). His statement is ridiculous. Sandia literally measured thousands of datapoints in these tests. Data at multiple temperatures was measured during the test profile, which essentially followed IEEE Std. 323-1974--APCo simply chose to ignore this data at multiple temperatures, claiming it was too conservative for their use. It was not Sandia's requirement at the time the tests were performed to provide qualification data for APCo or any other utility. However, if APCo, or any other utility, chose to use the data, it was their responsibility to take all of the available data into account.

Q29. Mr. Love, in his clarification testimony, claims that they did not consider the detailed IR data as a function of temperature because

> ...there is obviously something that's happened to the recovery capability of the terminal block by the time it's gotten to the Phase III DBA. The significance of this is, that is essentially subjecting this same terminal block to three very severe design basis accidents and then using insulation resistance data across that complete timeframe and saying that is representative of the cooldown period of the terminal block, which I believe not to be valid. (Tr. 1222).

How do you respond to this?

A. The fact of the matter is that they had no basis whatever to conclude that the plot should have been linear. The data in the test report that the data was extracted from and the data in the General Electric report that was in the Farley files both indicate that the plot is not linear over the range that they assumed it to be linear. They have provided neither a technical basis nor any data to support their assumption that it was linear, much less any justification that such an assumption was conservative.

Q30. In response to Q113 (L/S/J pp. 124-25), Mr. Love claims that with regard to your statement that "if the utility could clearly demonstrate that the equipment was not required to function during peak LOCA conditions and any inaccurate readings during peak LOCA conditions would not mislead the operators nor cause any undesired automatic operations," that "We showed exactly this to Mr. Jacobus during the November 1987 inspection and at the subsequent November meeting at Region II." Also, in response to Q146 (DiBenedetto pp. 114-25), Mr. DiBenedetto claims that "APCo has maintained from the inception of its EQ program ... that the terminal blocks installed at Farley would be required at the onset of the accident and not again until post-accident long-term cooling." Mr. DiBenedetto also claims to have discussed this point with you (DiBenedetto Q&A 128; p. 106). Did they show you any such evidence either during the inspection or at the subsequent meeting?

A. We did not receive any such analyses during the inspection. It is interesting that they claim to have shown me this analysis, but they have not provided any exhibit to back up their statement. I can only conclude that they did not have such an analysis. As noted previously, APCo, at the Region II meeting, did appear to claim that the blocks would only be needed at 296°F and below, but they could not demonstrate acceptable IRs at 296°F. In addition, they did not provide detailed technical justification as to why the blocks did not have to be qualified to peak LOCA conditions as detailed in Q&A 26 above.

Q31. In response to Q130 (DiBenedetto p. 107), Mr. DiBenedetto testifies that with regard to the NRC's position of when instruments need to function "They apparently did not believe APCo's position on when the instruments would be relied on by operators. I cannot explain what, if anything, was the technical basis for their position." Could you clarify?

A. Please see Q&A 26 above. In addition, at the meeting in Atlanta, APCo was claiming that they did not need the blocks except at temperatures below 296°F, but they could not demonstrate qualification at 296°F. Thus, acceptance or rejection of their argument regarding when the blocks had to function was irrelevant at that point.

Q32. In his response to Q139 (DiBenedetto p. 111), Mr. DiBenedetto states that "APCo used the same conservative peak LOCA insulation resistance data for these blocks..." Is his statement correct?

A. Here he makes a strong implication that there was data at peak LOCA conditions, which is absolutely wrong, as he acknowledged in response to Q133 (DiBenedetto p. 108).

Also, in response to Q147 (DiBenedetto pp. 115-17), Mr. DiBenedetto testifies that "prior to the inspection APCo had a reasonable basis to conclude that instrument accuracy data for these terminal blocks at peak LOCA conditions was not necessary. And if such data was deemed necessary, it had provided conservative estimates based on similarity to tested terminal blocks." His statement that "if such data was deemed necessary, it had provided conservative estimates based on similarity to tested terminal blocks" almost directly states that the Conax test data was taken at peak LOCA conditions, rather than only at temperatures up to 150°F. It should be extremely clear by now that what he is referring to is not peak LOCA insulation resistance data.

Q33. In response to Q103 (L/S/J pp. 112-14), Mr. Love testifies that

> 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 Exh. 53). From this graph (test numbers 9 through 16), it can be seen that the lowest value 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....

Do you have any comments on his description of the test?

A. If I did not know better, I would interpret his testimony as implying that valid IR measurements were performed at temperatures above 150°F. It should be made very clear that that was not the case.

Q34. Does Mr. DiBenedetto's final statement in response to Q129 (DiBenedetto pp. 106-07) follow from the information presented?

A. No. The fact that they presented documentation that the end devices will perform "within their specified accuracy requirements during accident testing" in no way implies that "peak LOCA insulation resistance data was unnecessary." In fact, if they are assuming that the instruments need to function during all accident conditions, then clearly peak LOCA IR data is necessary. On the contrary, they are effectively claiming throughout their testimony that the end devices do not have to be qualified for peak LOCA conditions, for if they did have to be qualified, then the terminal blocks would also have to be qualified.

Q35. In response to Q110 (L/S/J pp. 120-21), Mr. Love testifies that "Due to the inherent thermal lag time... terminal blocks will have completed their performance function (automatic) before reaching significant temperatures which could affect these functions." Will terminal blocks have this thermal lag effect?

A. The temperature of the block will, of course, lag the temperature of the environment. However, moisture films will form on the terminal block very rapidly when steam is introduced in the vicinity of the terminal blocks. This is exactly the same phenomenon that occurs when one breathes moist breath onto a cold window and causes the window to fog. I believe that everyone knows how rapidly the fog forms in such a case. The fog is nothing more than a moisture film on the window. The thermal lag of the material in either case has little bearing on the film formation. Thus, Mr. Love's testimony has no valid technical basis.

Attachment 2 to the JCO (APCo Exh. 59), a letter from Westinghouse, also stated that:

> A review of the Reactor Protection System and Emergency Safeguards Features functions has determined that the significant functions required for harsh environment events (pressurizer pressure - Low SI and steam generator water level - Low-Low) are required only before 5 minutes after the event occurrence for pressurizer pressure - Low SI and 60 seconds for steam generator water level - Low-Low. This early time of use in the event should ensure that the function necessary will be performed before a significant error from leakage current develops.

Obviously, Westinghouse had no basis for the last statement above. (Presumably, both Westinghouse and APCo are making the statements regarding thermal lag based on the fact that most components experience such effects. The thermal lag effects have never been demonstrated to be applicable to terminal blocks and both theoretical considerations and experimental data demonstrate that they will not be applicable. For an example of experimental data, see Figure 25

on page 47 of NUREG/CR-3418, SAND83-1617 (Staff Exh. 73). It should also be noted that by 5 minutes into the event, the LOCA conditions have already passed the peak temperature. But APCo claims the terminal blocks are not needed at peak LOCA conditions, contrary to the Westinghouse analysis, which effectively states that they are.

Q36. During cross-examination, (Tr. 726-27), you were questioned as to whether you had performed correlations between the terminal blocks at issue and particular circuits and when these circuits had to function. You stated that you had not. Why had you not done this prior to the enforcement action?

A. APCo had never provided any analysis to us that indicated that they claimed the blocks did not have to be qualified to at least 296°F (the value APCo claimed at the November 1987 Atlanta meeting) for instrument accuracy effects. Thus, when we determined that the blocks were not qualified to even that temperature (whether we agreed that they only had to be qualified to that temperature or not), we do not have any reason to perform additional analysis to attempt to come up with a qualification argument on behalf of APCo by considering individual circuits and the effect of instrument inaccuracy on those circuits. That is simply not our job. In addition, the regulations and applicable standards do not provide allowance for such qualification arguments.

Responses to Q&A 5, 7, 10, 26, 27 and 35 above provide more information on the circuits affected, when they need to function, and why the APCo analyses were not acceptable.

Q37. In response to Q34 (DiBenedetto pp. 34-35), Mr. DiBenedetto testifies that with regard to his report or summary (APCo Exh. 64) that "The lowest recorded insulation resistance was on the order of 1E5 ohms. This is a value Westinghouse supported during the audit and during the enforcement conference." How do you respond to this?

A. It is interesting that he claims that this value was supported by Westinghouse at the audit in light of Mr. Love's testimony during examination by the board, where he testifies with regard to Figure 1 of the JCO (APCo Exh. 59), that "When we prepared this basic graph, we were not aware that the result of the Westinghouse calculation was going to be 5 times 10 to the 5th ohms, in which case they came backwards to the graph and came up with 296, and they did not have the test report." He further testifies "That is correct" in response to Judge Carpenter's question "To be sure that I understand, you're saying that your group prepared this graph **in the absence of any notion about what values of resistance might be critical with respect to loop accuracy?**" (emphasis added). (Tr. 1149-50).

The 5E5 value used by Mr. Love is the value Westinghouse actually supported. The 1E5 value comes from a Westinghouse letter, which is

Attachment 2 to the JCO (APCo Exh. 59). The attachment to that letter at the end of the third paragraph states that "If the ERP values for RCS subcooling **are changed** for Safety Injection termination, then a leakage current resistance of $1 \times 10^5\ \Omega$ or greater would be acceptable for use." (emphasis added). Thus, with the ERPs as they were, the value of $1 \times 10^5\ \Omega$ would not have been acceptable.

Q38. In Q112 (L/S/J pp. 123-24), Mr. Love is asked "Have others concurred with your conclusion?" Do you agree with his response?

A. Presumably, his "conclusion" was that data at 150°F was adequate. He responds "Yes...." to the question. He then seems to imply that "Westinghouse specialists" agreed with his conclusion, but he never states that. In fact, he never explicitly states anybody that agreed with his conclusion. I do not believe that the testimony that follow his yes response supports that response in any way.

Q39. During examination by the Board, Mr. DiBenedetto testifies that "If the equipment such as the terminal blocks we're talking about, performs its intended function well before it sees the adverse environment, then the documentation that that's when it performs its function, that's all that's necessary." (Tr. 1289, ll.8-12). Did APCo in fact provide you any documentation that the terminal blocks perform their intended function well before they see the adverse environment?

A. No. I believe that I covered that point in some detail in my response to Q5. However, I should further note that APCo is not even claiming that the blocks perform their function prior to seeing the adverse environments. Most, if not all, of the terminal blocks are needed for post-accident monitoring also.

MISCELLANEOUS

Q40. In Mr. Love's testimony to Q113 (L/S/J pp. 124-25), he testifies that

> ...the Staff is basing their findings on the Sandia terminal block IR and leakage current data observed only during the peak of the 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....

Do you agree with his statements?

A. Absolutely not. The NRC Staff is not basing its findings at all on the IR data observed during the peak LOCA conditions of the Sandia terminal block tests. In fact, as noted previously, the Farley plant files had documentation that the IR of the blocks at temperatures from 260-340°F would be in the range of 2×10^4 Ω. The Staff is actually basing its findings on the information in IN 84-47, the information contained in the GE test report and summarized in the GE Penetration report, the lack of demonstrated similarity to the Connectron terminal blocks, and the fact that no IR data was even available for the Connectron blocks at temperatures above 150°F. When APCo appeared to claim at the Atlanta meeting

that they needed terminal block data at only 296°F or below and they then proceeded to use Sandia data to claim that the terminal blocks would have acceptable IRs at 296°F, they were in fact the ones who used the Sandia data at the peak temperature to make their case. All I did was to fill in the data at the lower temperatures, which they had incorrectly interpolated.

Q41. In his response to Q136 (DiBenedetto p. 110), Mr. DiBenedetto states that "To a reasonable engineer versed in EQ, there was sufficient auditable documentation." Do you have any comments on his statement?

A. (Jacobus) I am a reasonable engineer versed in environmental qualification and it is my opinion that there was not "sufficient auditable documentation" at Farley for reasons that I have already discussed.

(Luehman) Dr. Jacobus' findings were reviewed and approved by NRC Staff technical management prior to issuing the inspection report of the November 1987 inspection (Staff Exh. 12), the Notice of Violation (Staff Exh. 2), and the Order Imposing Civil Monetary Penalty (Staff Exh. 3).

Q42. In response to Q115 (L/S/J pp. 126-27), Mr. Love and Mr. Jones testify that:

> For the GE CR151B terminal blocks, APCo did not have a separate EQ package. These blocks are part of the GE electrical penetration assemblies... The blocks were prototype tested by GE as part of the penetration assembly qualification testing program. (APCo Exh. 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 is was physically in APCo's possession at Farley.

Similarly, in response to Q140 (DiBenedetto pp. 111-12), Mr. DiBenedetto testifies that

> As I recall, at the time of the audit APCo was not readily able to locate the file [for GE terminal blocks]. However, this administrative matter in my opinion should not be treated as an EQ deficiency. The terminal block information was located in the qualification file for the penetrations. Moreover, at the time of the audit I was personally aware of the existence of the test report qualifying GE CR151B terminal blocks from my general EQ experience. (APCo Exh. 58).

How do you respond to their testimony?

A. I do not agree with several things they state. First, I found the GE **terminal block** qualification report in the procurement files, not the **penetration** report. The penetration report, I believe, was included in the file for the penetrations all along. The penetration report is dated March 27, 1975.

I do not know if the terminal block testing was part of the penetration assembly qualification testing program, but the detailed results of the terminal block testing were not included in the penetration test report that they have cited as qualifying the terminal blocks (APCo Exh. 58). Therefore, not enough information is presented to conclude that the blocks are qualified. However, it

is a fact that the results (in terms of minimum recorded insulation resistance) of the terminal block tests were reported in the penetration test report. It is also a fact that the penetration test report quotes minimum insulation resistance values for the terminal blocks of $2x10^4$ ohms at 500 Vdc. This value is well below the required APCo acceptance criterion of $5x10^5$ ohms.

Other than the above stated results, the only other information regarding the terminal block tests that was included in the penetration report (APCo Exh. 58) was a statement of the type of blocks that were tested and an indication that the environmental profile was the same as that used in the penetration test. Thus, the terminal blocks were not qualified by the penetration file. In fact, the single item of test data that was included in the penetration report relating to the terminal block performance was not used in any way by APCo.

Regarding their testimony that "the staff complains about this, yet acknowledges that the report existed...," (L/S/J p. 127) we never disagreed that it is perfectly allowable to include terminal block qualification information in the penetration file. The fact of the matter is that the information in the penetration file did not demonstrate qualification of the terminal blocks. Further, the only data point it contained demonstrated that the blocks were not qualified. The terminal block report that I found in the procurement file did provide more detail of the terminal block test, but the conclusion that the blocks were not qualified remained unchanged. In fact, had the terminal block report that I found

demonstrated the adequacy of the terminal blocks for the application, I would have agreed that the problem was merely a documentation and auditability issue and treated it as such.

I do not understand the basis for Mr. DiBenedetto's statement that "at the time of the audit I was personally aware of the existence of the test report qualifying GE CR151B terminal blocks from my general EQ experience. (APCo Exh. 58)." (DiBenedetto p. 112). As described above, there is only one performance data point in the GE penetration test report that relates to terminal blocks, and this single data point was not even used by APCo in their evaluation. Further, if APCo had used this point, they would have only been able to come to the conclusion that the blocks were not qualified for their application.

Q43. During cross examination, Mr. Love responds to the question "Is it not correct, also, that test that was referred to for the G.E. blocks had a minimum insulation resistance of 2 times 10 to the fourth ohms?" with "No. That is not correct." (Tr. 1123). Is his response accurate?

A. Referring to the test report directly (APCo Exh. 58), it clearly states on page 11 of 14 with regard to the terminal block tests that "Autoclave qualification tests simulating LOCA defined in para. 4.4 events 1 thru 4 were conducted on General Electric CR151 and States Co. type N.T. and recorded a minimum insulation

resistance $2x10^4$ Ω @ 500 VDC." Therefore, I do not understand his response of "No. That is not correct."

Q44. During cross examination, Mr. Love responds to the question "...if you relied on this report, are you not saying then that the 2 times 10 to the 4th, at least in 1985, was sufficient to qualify the G.E. blocks?" with "I'll say it was sufficient, yes." (Tr. 1126) What is your response to this?

A. Clearly, the IR of 2 times 10 to the 4th ohms was not adequate to qualify the blocks in 1985. This is a value that would cause significant instrument error as confirmed by Westinghouse. A proper evaluation of that data in response to IN 84-47 would have come to that conclusion.

Q45. During redirect, Mr. Love testified that

> And I might add, that that[sic] doesn't mean that we feel that -- all of the data contained in the Sandia report should be used as absolute values. Because, in my opinion, there are difficulties with that report, which one should not rely on the absolute values of data that are contained in that report for drawing conclusions. (Tr. 1135)

What is your response?

A. Presumably, this constitutes at least part of his basis for only selecting two data point out of a report that has literally hundreds of data points. He also does not specify what the "difficulties with that report were" and whether he really means "difficulties with the application of that report to the Farley plant." These are two

very different statements. In one case, he is essentially accusing Sandia of publishing invalid data. In the alternative, he is merely stating that the valid data that is published is not applicable. In stating that one should not rely on the absolute values of the data in the Sandia reports, he apparently does not consider how the data might be properly interpreted. Q&A 28 above provides a perfectly reasonable approach to interpreting the Sandia data.

Q46. Does this complete your testimony regarding this matter?

A. (Both) Yes.