ORGANIZATION: WHITTAKER CORPORATION
SIMI VALLEY, CALIFORNIA

REPORT NO.: 99901164/89-01	INSPECTION DATE: June 20-22, 1989	INSPECTION ON-SITE HOURS: 22

CORRESPONDENCE ADDRESS: Mr. Timothy E. Conver, President
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ORGANIZATIONAL CONTACT: Mr. Fred P. Rudek, Manager Quality
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NUCLEAR INDUSTRY ACTIVITY: Manufactures metal-sheathed cable and connector assemblies for numerous Combustion Engineering (CE) core exit thermocouple and reactor vessel level monitoring systems, and for General Electric in-core nuclear instruments. Sales are divided roughly equally between nuclear and aerospace applications, although the nuclear application was developed only within the last ten years.

ASSIGNED INSPECTOR: R C Wilson 9/28/89
R. C. Wilson, Senior Reactor Engineer Date
Reactive Inspection Section No. 2
(RIS-2), Vendor Inspection Branch

OTHER INSPECTOR(S):

APPROVED BY: Uldis Potapovs 9-29-89
Uldis Potapovs, Chief, Reactive Inspection Section No. 2 Date
(RIS-2), Vendor Inspection Branch

INSPECTION BASES AND SCOPE:

A. BASES: 10 CFR Parts 21 and 50

B. SCOPE: This inspection was made as a result of an allegation concerning lack of adequate quality assurance at Whittaker, including improper use of silicone material in place of hermetic seals, in safety-related cable and connector assemblies for nuclear power plants.

PLANT SITE APPLICABILITY: Numerous

A. VIOLATIONS:

None

B. NONCONFORMANCES:

None

C. UNRESOLVED ITEMS:

None

D. STATUS OF PREVIOUS INSPECTION FINDINGS:

None. This was the first NRC inspection of this facility.

E. INSPECTION FINDINGS AND OTHER COMMENTS:

1. Allegation Scope

The allegation consists of two parts, both related to the manufacture of cable and connector assemblies supplied for safety-related applications in nuclear power plants. The concerns are as follows:

a. It was alleged that a silicone sealant was used improperly and without the knowledge of customers, principally Combustion Engineering, Incorporated (CE), prior to September 1988.

b. It was alleged that Quality Assurance (QA) for the manufacture of the assemblies was inadequate.

These two concerns were conveyed to Whittaker and were addressed during this inspection.

To obtain relevant information concerning customer requirements, a previous inspection was conducted at CE on May 22-25, 1989 as documented in Inspection Report 999000401/89-01.

2. Use of Silicone Sealant by Whittaker

The inspector initially understood this allegation concern to relate to the cable end seal discussed in section E.1 of Inspection report 99900401/89-01. Information provided by Whittaker redirected the concern to address a silicone

coating applied to the ceramic bead inserts in the connector design manufactured from 1984 to 1988.

The product under discussion consists primarily of ceramic insulated, metal-jacketed multi-conductor electrical cables with connectors at both ends. Further description including applications is addressed in the inspection report cited above.

Prior to 1984, CE provided Whittaker with connectors from another manufacturer for assembly to the Whittaker cables. In 1988, Whittaker began manufacturing a new connector design which does not use the silicone sealant. The design introduced in 1984 included a metal header plate with holes for the electrical contacts. Each contact pin was surrounded by a small ceramic bead.

The assembly was oven-fired to fuse the ceramic and produce ceramic to metal hermetic seals. Depending on tolerances on the pin and hole diameters, header thickness, and quantity of ceramic, the molten ceramic could slightly under-or over-fill the annular gaps. The resultant meniscus could result in cracks in the surface glaze near its edge. The cracks could affect both leak tightness and electrical insulation resistance. The deficiency was detected by an insulation resistance (IR) test on the connector prior to its assembly to cable.

The inspector reviewed production control route cards for 181 connectors to assess IR test failure rates. Interviews with experienced production, manufacturing, quality, and engineering personnel did not produce a consensus regarding the percentage of connectors that failed the IR test or any trend in that percentage.

The personnel interviewed stated that for connectors that failed the IR test, a silicone fluid coating was applied to the insulators, followed by an oven baking. The personnel stated that if the connector passed the second IR test it was accepted; if not it was scrapped. For the production control route cards reviewed by the inspector, all of the silicone treated connectors (slightly less than 10 percent of the total) passed the second IR test. The treatment process is straightforward. One manager stated that although not called out in procedures, it was considered a "standard rework," but its use was subject to approval by a manufacturing engineer.

The silicone fluid used by Whittaker is described in the manufacturer's product sheet as a water-repellant coating. Whittaker has used such products for 20 years, as evidenced by a 1969 manufacturing process specification for a similar coating, written to meet a Navy department specification. The same coating is covered by a 1982 Whittaker manufacturing process specification for treating machined ceramic parts used as filler blocks in the assemblies provided to CE; in that application the machining removes surface glaze, and the silicone treatment is used for cleaning and to provide a final surface conditioning. The silicone fluid and solvent addressed by the 1982 specification is the same as was subsequently used on the multiple-bead connector headers.

Manufacturing procedures did not formally address the silicone coating for connector headers until April 20, 1987 when a new manufacturing process specification was issued. Prior to that time procedures did not address the header coating, nor did they address whether or why it would be applied. The only documentation of its use appears to be hand-written additions on the otherwise typed production control route cards.

Whittaker management personnel explained that the division strongly relied on proprietary protection for its products for many years. Both military and civilian customers have agreed that the customer controls the product down to the top assembly level, and Whittaker controls below that level. Information provided to customers normally consisted of the following: top level assembly drawing, weld schedules and samples, acceptance test procedures and data, and rework procedures. (This statement appears to be consistent with files reviewed by the inspector at CE.)

Preparation of the 1987 coating specification appears to be an early step in improving internal process controls at Whittaker. The May 1988 CE audit clearly added impetus to that effort. Whittaker provided the inspector with a copy of a September 1988 specification control drawing that was submitted to and approved by an aerospace customer covering silicone treatment of connector header seals; this was cited as an example of a policy change toward providing more information to customers. The silicone treatment is not employed with the new single bead header connector design now supplied to CE.

With respect to 10 CFR 50.49 environmental qualification of the original (1984-87) Whittaker connector design, CE's qualification basis was addressed in an earlier Inspection Report 99900401/88-01 dated January 10, 1989. The qualification basis appears acceptable subject to the question of whether the qualification test specimens had received the silicone treatment. Whittaker personnel were unable to locate appropriate records; the search is complicated by a 1987 relocation. There is no basis for concluding that the test specimen connector headers had received the treatment, although it is possible, based on present knowledge. The possibility that treated connectors may represent an EQ concern does appear remote, for the following reasons:

a. Both CE qualification test programs, as well as Whittaker's recent testing of cable/connector assemblies for boiling water reactors, included machined ceramic blocks that were treated, and there is no evidence of poor electrical performance by those blocks.

b. The headers form only secondary seals in mated connectors, as would be of interest during plant operation.

c. Protective caps with O-rings and lanyards are provided to discourage moisture ingress when the connectors are not mated.

d. The silicone dioxide cable insulation is relatively insensitive to humidity, unlike other ceramic cable insulation. Whittaker personnel stated that it does not hydrolyze, and loses only about ½ to one decade of insulation resistance per year in ambient humidity if the cable end is completely open.

e. The multiple bead connectors are no longer being manufactured for nuclear use.

Another seal concern raised by the alleger involves repair of connectors by drilling, then plugging, holes in their sides. The inspector believes that this concern is the same as a problem cited in Inspection Report 99900401/89-01 at the end of section E.1, and the two will be addressed jointly.

A November 13, 1987 CE letter to Whittaker on Purchase Order (PO) 9770018-71186 refers to five connectors supplied without a crimp sleeve for the ground contact, unlike 19 others that were specified as identical, all under CE PO 9770018-71186. Whittaker contract records show that most of the connectors were manufactured and certified by both Whittaker and CE prior to the initial submittal of the drawing to CE. Some significant dates are as follows:

March 5, 1987 - Whittaker internal release of drawing 16-99-008000

June 4, 1987 - Whittaker test and inspection records and C of C

June 11, 1987 - CE Certificate of Equipment signed by engineering and quality control "based upon source surveillance being performed at the vendor's facility"

June 15, 1987 - First submittal to CE of drawing 16-99-00800

Following conditional CE approval, Revision A was made and was approved by CE on July 9, 1987. Of the 24 connectors shipped, 19 were built to Revision 0 and 5 to Revision A; the 2 differ in ground connection method.

Upon discovery of the different connector types by the third party to whom they were shipped, Whittaker prepared a Rework Procedure dated February 11, 1988 which was approved via a Technical Change Request to CE. The rework procedure was reviewed and discussed with the Whittaker manufacturing engineer who supervised connector assembly at the time of rework. It involved drilling an access hole through the side of the connector body, inserting a solder cup and threaded stainless steel rod, replacing potting material, and welding and blending the rod to the connector body. The potting material performed no sealing function; it filled void space to support wires.

The reworked connectors appear to be satisfactory. However, it is clear that Whittaker manufactured and shipped connectors to an unapproved drawing, and CE approved the shipment; evidently neither acted further until they were informed by a third party that two different types of connectors were delivered.

Summarizing the silicone treatment concern, the NRC inspector concludes the following:

a. An unknown quantity of connectors, possibly dozens, was supplied by Whittaker to CE with a silicone fluid treatment

applied to the connector header insulators. Written procedures did not address when or how to apply the treatment until April 1987. The treatment improved performance with respect to two procurement specification parameters, leakage and electrical insulation resistance.

b. The treatment was not used on the relatively small number of nuclear safety-related connectors supplied to General Electric Company, and is no longer used in the manufacture of any nuclear safety-related connectors.

c. The treatment is not believed to constitute a nuclear safety concern for reasons stated above.

d. Information gathered during investigation of the silicone sealant concern clearly demonstrates that both Whittaker and CE failed to satisfy Quality Assurance concerns related to this equipment. This subject is addressed in the next section of the inspection report.

3. Adequacy of Whittaker Quality Assurance

In detailing this concern, the alleger stated that during the first nine months of 1988 certain process specifications and workmanship standards were not available on the production floor, and that manufacture was accomplished to drawings handmarked by engineering to reflect customer order information. The NRC inspector determined at CE (see inspection report 99900401/89-01) that CE audits of of Whittaker in May and September of 1988 had revealed similar concerns, and CE and Whittaker had initiated actions to address the concerns.

Whittaker quality assurance personnel told the NRC inspector that some components were built to drawings marked and signed by the project engineer, but that final inspection was performed only to approved drawings, and items could not leave the area without an approved Engineering Change Order. Whittaker management personnel also stated to the NRC inspector that documentation had been "not truly adequate," and that documentation was "poor." Reliance was ultimately placed on production personnel to ensure that manufacturing operations were correctly performed. In turn, experienced assembly personnel stated that any deviation had to be approved by someone not on the production floor (engineering, manufacturing engineering, or project engineering). Assembly personnel also commented that they sometimes made notes to themselves on drawings.

Both the alleger and the 1988 CE audits noted that sales work orders were used to impart purchase order requirements to production, serving as the final inspection checklist.

Whittaker relocated from Burbank to Simi Valley, California -- about 30 miles -- in the spring of 1987. The move complicated access to some records. For example, during the NRC inspection a box of production route cards covering early 1987 could not be located, although adequate alternate information was provided to the inspector. The relocation was obviously another complicating factor in records control.

Whittaker management stated that the company has always been straightforward with customers in informing them that the basic processes are Whittaker's and are not subject to customer controls. In the case of the silicone fluid treatment, apparently CE was not made aware of the existence of the process until after the new single bead header connector design made the process no longer applicable to CE contracts.

All of the CE POs reviewed by the inspector invoke Revision D of CE Specification 00000-WQC-11.1, "Supplier Quality Control Program Specification for Quality Class 1 Equipment or Services" dated October 4, 1974. This specification for Quality Class 1 equipment covers much of the scope of Appendix B, but it provides CE with options concerning the extent of oversight applied to Whittaker. Insofar as CE did not review the processes and methods by which Whittaker manufactured equipment, deficiencies in those processes and methods were not identified by CE.

Even though CE may have elected not to address manufacturing processes, at least until 1987 or 1988, it is nonetheless clear that Whittaker's failure to have a procedure covering the silicone fluid treatment constitutes a nonconformance to section 6.5.1 to of the CE quality specification, which requires that activities affecting quality must be controlled by written procedure.

Shipment of the connectors under PO 9770018-71186 without drawing approval is a nonconformance to Section 4.1.1.1 of the CE quality specification, which requires a vendor program that assures quality throughout all areas of contract performance. This is an anomaly for which Whittaker had no explanation.

The ongoing activities by Whittaker and CE appear to be correcting the deficiencies in Whittaker's quality program. Several changes were noted as examples of quality improvements: a revised set of controlled manufacturing procedures for connectors; computerized standard routing lists with specific references to applicable procedures; computerized sales order descriptions providing all department with summaries of contract requirements; the Quality Assurance manual revisions being reviewed by CE; and reorganization so that the Quality Assurance Manager now reports to the division president.

Summarizing the concern with respect to the adequacy of Whittaker's Quality Assurance, the NRC inspector concludes that deficiencies existed, most significantly with respect to the following:

a. Lack of a procedure covering silicone fluid treatment of connector headers prior to April 1987.

b. Shipment of connectors under PO 9770018-71186 without drawing approval in 1987.

These deficiencies are primarily historical in nature, and are considered to not have resulted in shipment of equipment that constitutes a nuclear safety concern. Numerous improvements in quality assurance have been noted since the CE audit in May 1988 and the NRC will continue to monitor Whittaker's and CE's actions in this regard.

F. PERSONS CONTACTED:

*+T. E. Conver, President
*+R. H. Mauldin, Vice President, Engineering
*+R. Snyder, Vice President, Customer Service Operations
*+F. P. Rudek, Manager, Quality
*+H. E. Simpson, Program Manager
*+J. Sobelman, Manager, Manufacturing Engineering
*+T. S. Whitehead, Manager, Manufacturing
*+G. P. Casey, Manager, Finance; Contract Administration
*+R. Lolley, Manager, Field Service and Training
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+J. Torres, Supervisor, RF and HJTC Manufacture
*+J. Thomsen, Supervisor, QA Test
+J. Denny, Manufacturing Engineer, Hermetics
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D. Carle, QA Inspection
I. Reinhart, Connector Assembly
*+C. Reinhart, Project Engineer
*+A. Harootion, Project Engineer
*+K. Wilson, Engineering Tech Staff
*+R. Couser, Senior QA Engineer
+F. Roy, Engineer (Patel Engineering, Contractor)

* attended entrance meeting
+ attended exit meeting

ORGANIZATION: COMBUSTION ENGINEERING, INC.
POWER SYSTEMS GROUP
WINDSOR, CONNECTICUT

REPORT NO.: 99900401/89-01	INSPECTION DATE: May 22-25, 1989	INSPECTION ON-SITE HOURS: 24

CORRESPONDENCE ADDRESS: Mr. Walter D. Mawhinney, Vice President
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ORGANIZATIONAL CONTACT: Steven A. Toelle, Manager, Operating Reactor Licensing
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NUCLEAR INDUSTRY ACTIVITY: Combustion Engineering, Inc. (CE) has had NSSS contracts for 16 domestic reactors, and has support service contracts for approximately 40 reactors worldwide.

ASSIGNED INSPECTOR: R C Wilson
R. C. Wilson, Senior Reactor Engineer, Reactive Inspection Section No. 2, (RIS-2) Vendor Inspection Branch — 9/4/89 Date

OTHER INSPECTOR(S):

APPROVED BY: Uldis Potapovs
U. Potapovs, Chief, RIS-2, Vendor Inspection Branch — 9-5-89 Date

INSPECTION BASES AND SCOPE:

A. BASES: 10 CFR Part 21 and Part 50.

B. SCOPE: 1. Review engineering and procurement records for thermocouple cable seals for safety-related applications.
2. Review 10 CFR Part 21 notification, dated April 20, 1989, concerning control element assembly slippage.

PLANT SITE APPLICABILITY: Palo Verde 1, 2, and 3 (docket 50-528, 529, 530); Turkey Point 3 and 4 (50-250, 251); South Texas 1 and 2 (50-498, 499); Salem 1 and 2 (50-272, 311); Indian Point 2 (50-247); WNP-3 (50-508).

 6pp.

A. VIOLATIONS:

None

B. NONCONFORMANCES:

None

C. UNRESOLVED ITEMS:

Control of procurement activities, see report paragraph E.1 (89-01-01).

D. STATUS OF PREVIOUS INSPECTION FINDINGS:

Not applicable.

E. INSPECTION FINDINGS AND OTHER COMMENTS:

1. Thermocouple cable end seals

The first topic addressed in this inspection was hermetic seals for cable assemblies used in two safety-related systems supplied by CE, core exit thermocouple (CET) and reactor vessel level monitoring (RVLM) systems. Both systems use multiple lengths of metal jacketed, mineral insulated cable with threaded electrical connectors. The cable assemblies are fabricated for CE by Electronic Resources Division of Whittaker Corporation.

Either the cable ends or the cable-connector junctions must be hermetically sealed to prevent moisture contact with the cable's silicon dioxide ceramic insulation and resultant degradation of insulation resistance. Procurement criteria [including specifications, drawings, and purchase order (PO) requirements] for the following POs from CE to Whittaker were reviewed:

Plant	PO	Date
Palo Verde 1	9170287-14273	03/26/81
Palo Verde 2	9170288-14373	03/26/81
Palo Verde 3	9170289-14473	03/26/81
Palo Verde 1	9271857-14273	09/10/82
Palo Verde 2	9271858-14373	09/10/82
Palo Verde 3	9271859-14473	09/10/82

Plant	PO	Date
Turkey Point 3	9270855-16081	04/28/82
Turkey Point 4	9270854-16081	04/28/82
Turkey Point 4	9270282-16081	02/13/84
South Texas 1	9471519-4884	08/27/84
South Texas 2	9471520-4884	08/27/84
Salem 1	9770018-71186	01/15/87
Salem 2	9770019-71186	01/15/87
Indian Point 2	9874769-D9421	05/23/88

CE engineering personnel were interviewed concerning both generic matters and these specific procurements. Each CE PO invoked 10 CFR Part 21. Each order also applied CE's "Quality Assurance Requirements for Suppliers of Nuclear Safety-Related (CE Quality Class 1) Items and Services," Specification WQC-11.1 Revision D, dated October 4, 1974, Quality Class 1 was specified. Each PO also applied specification 00000-FEA-6102, "Engineering Specification for In-Core Instrumentation Interconnecting Cable Assemblies," Revision 04, dated January 15, 1982. Each PO also invoked a CE assembly drawing providing plant-specific information such as quantity and length of cable assemblies, connector suppliers and types, and connector pin assignments.

Originally CE supplied all of the connectors to Whittaker, as specified in paragraph 2.3.1 of Specification 6102 Revision 4. No credit was taken for connector hermetic seal capabilities. Paragraph 4.2.5 of Specification 6102, Revision 4 specifies that the ends of each cable shall be hermetically sealed to prevent moisture absorption, prior to connector attachment. In 1984 CE documented environmental qualification of thermocouple cable assemblies using Whittaker-manufactured connectors; see NRC Inspection Report No. 99900401/88-01, dated January 1, 1989 for discussion. The new Whittaker connectors replaced Litton-Veam connectors in most instances. G&H Technology Corporation connectors continue to be used for the RVLM disconnect nearest the reactor, and in some cases Swagelok connectors (not assembled by Whittaker) are used for connection to CET sensors. CE personnel explained that connectors manufactured by Whittaker provide an adequate hermetic seal for the cable, and a separate cable end seal is not required.

Typical recent Whittaker Acceptance Test Procedures (such as ATP 16-26-00712 for the Indian Point 2 PO 9874769-D9421, covering bridge M1 cable P/N 16-26-00712-5, S/N 00001 -- data taken October 13, 1988) cover helium leak testing only after connector attachment. This reflects the hermetic seal capability of the Whittaker connectors now used. Of the POs reviewed by the inspector, only the 1984 Turkey Point 4 order recognized the conflict between Specification 6102, Revision 4 and post-1984 actual practice. Technical Change Request (TCR) No. 9470282-2, dated March 13, 1984, to PO 940282-16081 states that Specification 6102, Revision 4 paragraph 2.3.1 should be changed to read as follows: "The connectors used to terminate the ends of the cable specified in this specification and applicable drawings shall be purchaser supplied if not provided by the supplier." However, even the Turkey Point 4 order did not relax the requirement of specification paragraph 4.2.5 for separate cable end seals.

Failure to update Specification 6102, Revision 4 thus caused two types of conflicts in POs involving Whittaker-manufactured connectors. First, paragraph 2.3.1 conflicted with the CE assembly drawing referenced in the PO regarding the source of connectors. Second, paragraphs 2.3.1 and 4.2.5 conflicted with what both CE and Whittaker intended for both connector types and cable leak test requirements. The affected POs reviewed by the inspector are Turkey Point 4 (1984, leak test only), South Texas 1 and 2, Salem 1 and 2, and Indian Point 2. While no corrective action is required for the hardware shipped to these facilities, CE advised that these discrepancies are being addressed in a specification revision currently in progress, and had been noted in an internal QA audit.

The inspector questioned CE engineering regarding the use of shrink tubing and potting materials for either hermetic or environmental seals in CET and RVLM systems. Neither type of seal material is used for either purpose in CE-supplied systems built by Whittaker. Both are used in various applications to restrict motion, provide strain relief, fill voids to prevent moisture collection, and the like.

The inspector questioned CE concerning their audits of Whittaker. The CE Quality Operations Department has audited Whittaker in 1983, 1984, 1986, 1987, and twice in 1988. Whittaker was

removed from CE's Approved Suppliers List in 1988, and CE has subsequently performed 100 percent source inspection of all parts. Whittaker recently appointed a new Quality Assurance (QA) manager and CE is reviewing a revision of Whittaker's QA manual.

The inspector noted another instance of apparent Whittaker QA nonconformances in the CE files reviewed: a CE letter referred to connectors built (and shipped) to an unapproved drawing.

CE's control of procurement activities will be carried as an Unresolved Item to be addressed in a future NRC inspection. In the interim an NRC inspection of Whittaker is planned which will provide additional information on the subject. (99900401/89-01-01)

2. Part 21 Notification on Control Elements Assembly (CEA) Slippage

On April 20, 1989, CE submitted a 10 CFR Part 21 notification concerning slippage of two CEAs in different groups in Palo Verde 1. The inspector interviewed CE engineering personnel and reviewed a CE Nuclear Safety Committee review memo dated April 21, 1989. In conjunction with the licensee, Arizona Nuclear Power Project (ANPP), CE developed an explanation for the event.

The event is believed to be restricted to plants using the four coil CE drive motor (CEDM) design unique to the three Palo Verde units and WNP-3 (which is not yet operating). During assembly the insulation of the lower lift coil lead wires is believed to be damaged by an inside thread as the wires are fed through a hole. The threads are subsequently covered by a nipple, preventing further abrasion of the insulation. The lower lift coil is unique to the four coil CEDM, and is the only coil believed to move during rod motion. Intermittent shorting of the damaged coil lead wires to the nipple is believed to be the source of electrical noise that adversely affects the rod control system. Evidence supporting this hypothesis includes a plant history of intermittent ground faults and evidence of damage including arcing in two lower lift coils removed from Palo Verde 2.

Each of the 88 rods in a CE core has a three diode controller fed by a 240 volt three phase bus common to all 88 rods. Each phase has a zero cross detector that senses when the phase

voltage crosses zero and triggers gate circuits for the diode controllers. Adjustable delays in the gate circuits for each individual rod control the actual dc voltage applied to the CEDM coils. Since the noise caused by intermittent shorting of a defective lift coil is introduced into the common three phase bus, the rod with the lowest CRDM voltage based on the gate circuit delay adjustments is most likely to be affected by noise anywhere in the power system. Thus in addition to possible slippage of the rod experiencing intermittent short circuits, one or more additional rods without regard for group assignments could also slip. Testing by CE with low-resistance ground paths supports this explanation.

The analysis described above indicates that an intermittent fault in the lower lift coil can cause the affected rod to slip and can cause slippage of one or more additional rods. Although similar rod control systems are used in other plants, the four coil CEDM design appears to be a necessary contributor and that design is used only at Palo Verde and WNP-3.

Final resolution of the problem depends on further analysis and testing by ANPP and CE. The inspector concluded that analysis to date supported the 10 CFR Part 21 report in restricting the probable scope to Palo Verde and WNP-3.

F. PERSONS CONTACTED

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* C. W. Ruoss, Manager, Mechanical Engineering and Technology
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*Attended entrance meeting on May 22, 1989
+Attended exit meeting on May 25, 1989