S-30
50-348/364-CIVP
2/12/92

Staff Exh. 30

Bechtel Eastern Power Company
Engineers - Constructors

15740 Shady Grove Road
Gaithersburg, Maryland 20877-1454
(301) 258-3000

SEP 23 1987

In reply refer to AP-13541

Mr. W. G. Hairston, III
Alabama Power Company
600 North 18th Street
Post Office Box 2641
Birmingham, Alabama 35291-0400

Dear Mr. Hairston:

Joseph M. Farley Nuclear Plant Units 1 and 2
Bechtel Job 7597-011/021
Electric Hydrogen Recombiner Splices -
Justification for Continued Operation
(PCR 87-0-4441)
Bechtel File A-78, E-91
AP-13541

Attachment 1 is a revision to the Justification for continued operation forwarded by AP-13525 dated September 17, 1987. This revision is based on "As-built" information provided by APCO on the 1A Hydrogen Recombiner (see Appendix A). This includes the clarification that tape is not provided between the individual heater conductors.

If you have any questions or comments, please contact us.

Yours very truly,

Kf C: Gandhi
Project Engineer

KCG/AJD/DGB:sg
Enclosures
As stated above
cc J. R. Crane, w/1
J. D. Woodard, w/1
J. E. Garlington, w/1
R. G. Berryhill, w/1
D. H. Jones, w/1

NUCLEAR REGULATORY COMMISSION

Docket No. _____ Official Exh. No. 35

In the matter of ALABAMA POWER CO.

Case ✓ IDENTIFIED 2/11/92

Applicant _____ RECEIVED 2/12/92

Intervenor _____ REJECTED _____

Staff Off'r _____

Contractor _____ DATE 9-23-87

Other _____ Witness _____

Reporter L. E. Kip

SUBJECT: Evaluation of splices used on Hydrogen Recombiner heater leads to field cables

EQUIPMENT:

RECOMBINER	JUNCTION BOX
Q1E17K001A-A	Q1E17G001A-A
Q1E17K001B-B	Q1E17G001B-B
Q2E17K001A-A	Q2E17G001A-A
Q2E17K001B-B	Q2E17G001B-B

INTRODUCTION

Each hydrogen recombiner contains five three phase heater banks. Each heater bank is provided with a 4/C #8 AWG power cable (as described in Appendix D) terminated on Terminals 1, 2, 3 & 5 of the heater bank terminal block. The other end of each 4/C #8 AWG power cable is brought into the power junction box as leads A, B, C & N (Refer to Westinghouse drawing 1366C51). The power junction box is located on the outside of the recombiner enclosure (Refer to Westinghouse drawing 7189D19). Each heater lead is provided with a Hylug YAV8C-L3 ring tongue connector in the junction box. The field (power supply) cable consists of 4-1/C #1/0 (Cable Code J08) Okonite cables. Each single conductor of the field cable is connected to the corresponding electrical phase power leads from the five heater banks. The splice detail shown on Appendix A is typical for each electrical phase (A, B, C and neutral).

This evaluation assumes that the field cable to heater bank lead terminations have been made using a bolted lug connection which is insulated by Okonite T95/#35 tape materials. It is assumed that the details of Appendices A and B are applicable to both recombiners on each unit.

EVALUATION

During normal plant operation the hydrogen recombiners are de-energized. The recombiners are manually actuated after LOCA initiation, if required, based on the applicable emergency operating procedure. In addition, the recombiners are tested (every 6 months) and inspected (every 18 months) per technical specification paragraph 4.6.4.2. These tests and inspections, which verify operability of the recombiners, include heater sheath operation at design power conditions, visual inspections of the cables in the power junction box and recombiner enclosure, and insulation resistance checks of the heater electrical circuits.

Okonite's test report (NQRN-3) qualified a 5KV taped inline splice using T95/#35 tape materials. These tape materials have a qualified life of over 40 years at 90C operating temperature, 200 MRad's radiation exposure and a DBE with a peak of 345F and 114 psig.

The Farley total integrated dose of 50 MRads for inside containment is far less than 200 MRad's test level and Okonite's test temperature and pressure provide adequate margins over FNP design basis accident conditions of 317F (peak MSLB surface temperature) and 48 psig (peak LOCA pressure).

The 480 VAC splice configuration shown on Appendix A has T95 tape dimensions less than required by the 1000 VAC and 2000 VAC design details shown on Drawing A-172396 Sheet 1. In addition, it cannot be verified if each heater lead is wrapped with T95 tape to fill the annular gap between the individual heater cable conductors.

For the purpose of this evaluation it is assumed that five heater lead cables per splice are stacked and wrapped with T95 tape insulation and #35 jacketing material, and that the minimum dimensional requirements necessary to provide adequate electrical insulating characteristics for 480 VAC operation under normal plant service condition exist (Ref. Tech Spec Surveillance). With this configuration, the only potential concern exists under postulated accident environments when moisture incursion into the terminal lug area due to wicking or entrance via the annular gap between the heater power leads could be postulated.

Even though there is a potential path for moisture to intrude on the bolted splice area under the insulating tape, this intrusion is of no concern to the operation of each power cable phase splice since all individual like phase conductors are electrically connected at the bolted splice. Also, moisture in-leakage is not considered degrading to the material properties of the T95 tape itself since the splice is not subjected to cyclic voltage spikes which occur during energization and de-energization. Therefore, the only viable potential concern is a phase-to-phase or phase-to-ground short external to the splice. For these shorts to occur, a substantial current path due to moisture would have to be established from the bolted connection to the power junction box or to the bolted connection of another phase.

A moisture current bridge allowing substantial current flow leading to faulted condition from the splice to the box is not considered credible since the current bridge would have to be established from inside the tape bundle then traverse the external surface of the tape to some postulated point of contact with the metal box. Even if such a bridge could be established it would necessarily be current limiting to the extent that it would not impair the function of the heater circuit.

Similarly it is not considered credible to postulate a moisture current bridge from inside one splice to an adjacent splice which would result in loss of Hydrogen Recombiner Heater operation during design basis accidents. The current bridge would have to extend from inside one splice across the external tape surface to a postulated point of contact with an adjacent tape bundle, across that external surface, then inside that splice to another point of exposure. Such a path is not nearly as likely as that discussed below.

It is considered credible to postulate a moisture induced current bridge along the individual conductors to the point where they come in contact with conductors from a different phase. The most likely point for the postulated leakage currents to occur would be within the cable jacket of the 4/c #8 AWG heater cable. This point is most likely because the individual conductors are held in contact with each other within the bounds of the jacket. Since all three phases as well as neutral are carried in each of the heater cables, any shorting scenario due to excessive leakage currents, phase-to-phase or phase-to-neutral, could be postulated to occur near the cable lead ends. To examine the problem of moisture intrusion in this instance, then it is necessary only to examine the situation from the point of intrusion on the unjacketed heater lead conductors to the point where the cable jacket begins.

In the hydrogen recombiners there are two general points of intrusion: at the power junction box and at the heater terminations. Since neither of these two points is directly exposed to spray, the only source for moisture is through the ambient moisture contained in the relevant environment which will vary from saturated to superheated conditions during the design basis accident. This ambient moisture is all-pervasive, so it can be postulated that all points of the conductors will be equally exposed where the jackets have been stripped back for terminations. Thus regardless

of the length of the unjacketed conductors, the probability of a postulated leakage current is equally likely.

In WCAP-7709-L Westinghouse has documented the test program and results of protypically qualifying a hydrogen recombiner generically the same as those installed at FNP. In that program the connections at the power junction box and at the heaters were the same as at FNP except that in the power junction box the splice was made up in an unidentified configuration. At both points unjacketed conductors were exposed to the test chamber accident conditions.

Since no problems with any of the terminations was experienced by Westinghouse, it can be concluded that moisture related leakage currents either did not occur or, if they did occur, resulted in no significant heater operation problems. Either way the results indicate that the installed configuration at FNP will be free from any postulated electrical malfunctions in the field power cable and heater lead system.

Additional verification that postulated moisture related leakage currents are not of concern for power terminations is provided by Wyle Report 17859-02P. Wyle Report 17859-02P (Qualification test program for Commonwealth Edison Company's PWR's) provides qualification information on V-shaped splices using T95 insulation tape and #33 jacketing material that were subject to moisture incursion since the crotch of the V was not filled with any insulating material. These V-shaped splices (specimens B4, B5, B6, and B7) are shown in Appendix C of this evaluation. The specimens were subjected to an accelerated thermal aging equal to 40 years plant life, radiation exposure of 200 MRads gamma and a DBE profile with a peak of approximately 360F and 58 psig. The specimens were energized during DBE test with input voltage between 528-544V AC. As discussed in Section IX, Paragraph 3.0 of the referenced Wyle Report all specimens except B4 passed the required acceptance tests. Specimen B4 failed 14 hours and 26 minutes into the test. Specimen B4 apparently arced at the crotch (located in very close proximity to the metal enclosure) of the splice to the NEMA 12 enclosure. This specimen had visual evidence of chemical burns from the chemical spray which apparently concentrated on the bottom ledge of the enclosure.

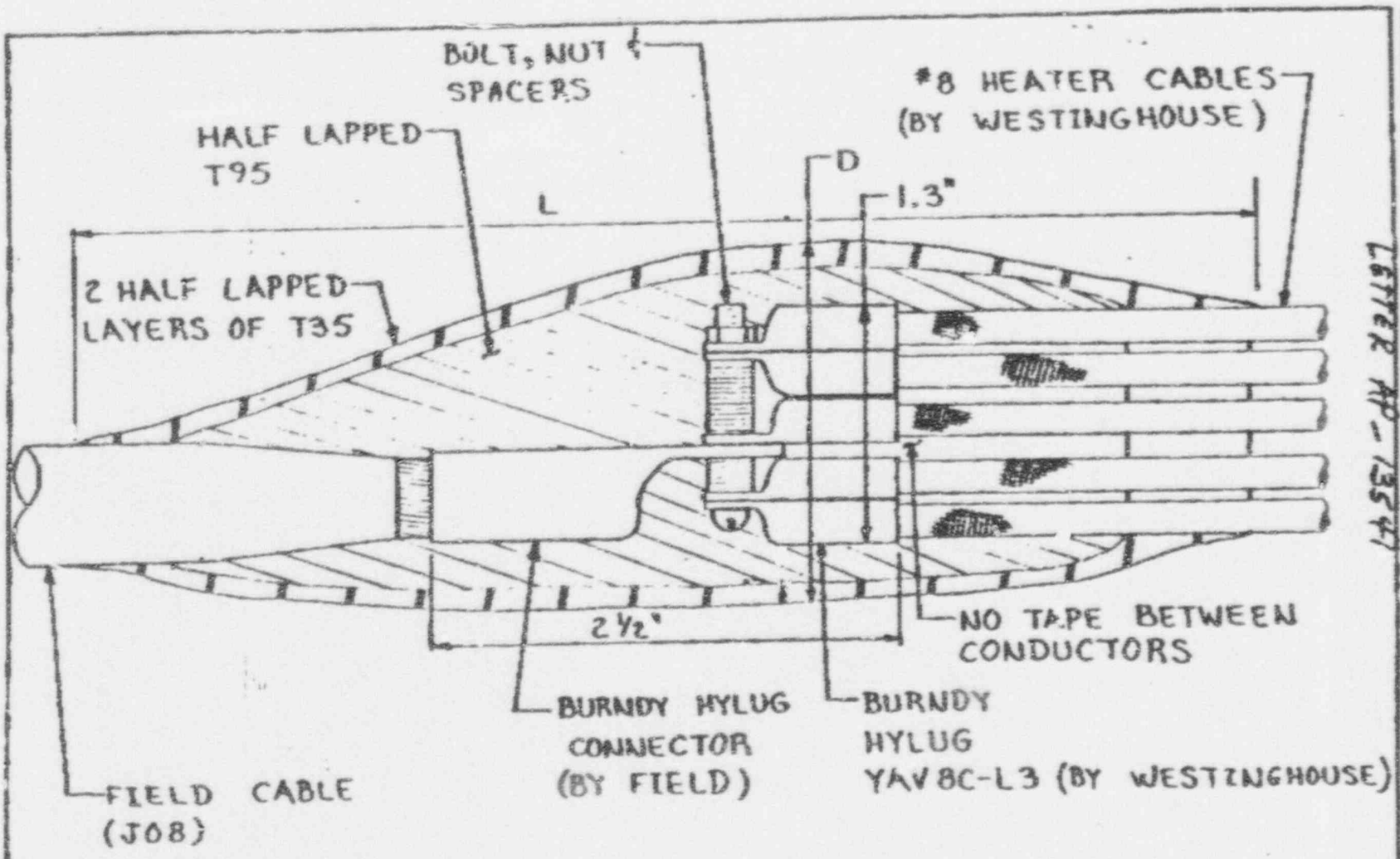
The splice shown in Appendix A is installed in the junction box such that the crotch area is not in close proximity to the bottom of the junction box. In addition, the plant

conduit system and junction box offers much more resistance to moisture/chemical incursion into the junction box.

The power cable from the electrical penetration to the hydrogen recombiner is routed in a totally enclosed conduit system. The conduit length is minimum of 30 ft. The conduit leaves the side of the recombiner power junction box and is routed to the penetration junction box at a lower elevation. At no point is the conduit installation directly open to the containment environment. The plant installation prevents chemical sprays and condensation from directly entering the power junction box via the conduit. The tested configuration in the Wyle Report used a NEMA 12 enclosure with the test leads entering the enclosure via an 18" long, 1-1/2" conduit that was directly open to the test chamber environment.

CONCLUSION

The hydrogen recombiner heater lead system was qualified by Westinghouse WCAP 7709-L. Failure of splice configuration shown in Appendix A is not considered credible as discussed above. Therefore, reasonable assurance has been provided to establish that the hydrogen recombiner will perform its intended functions in the relevant environment.

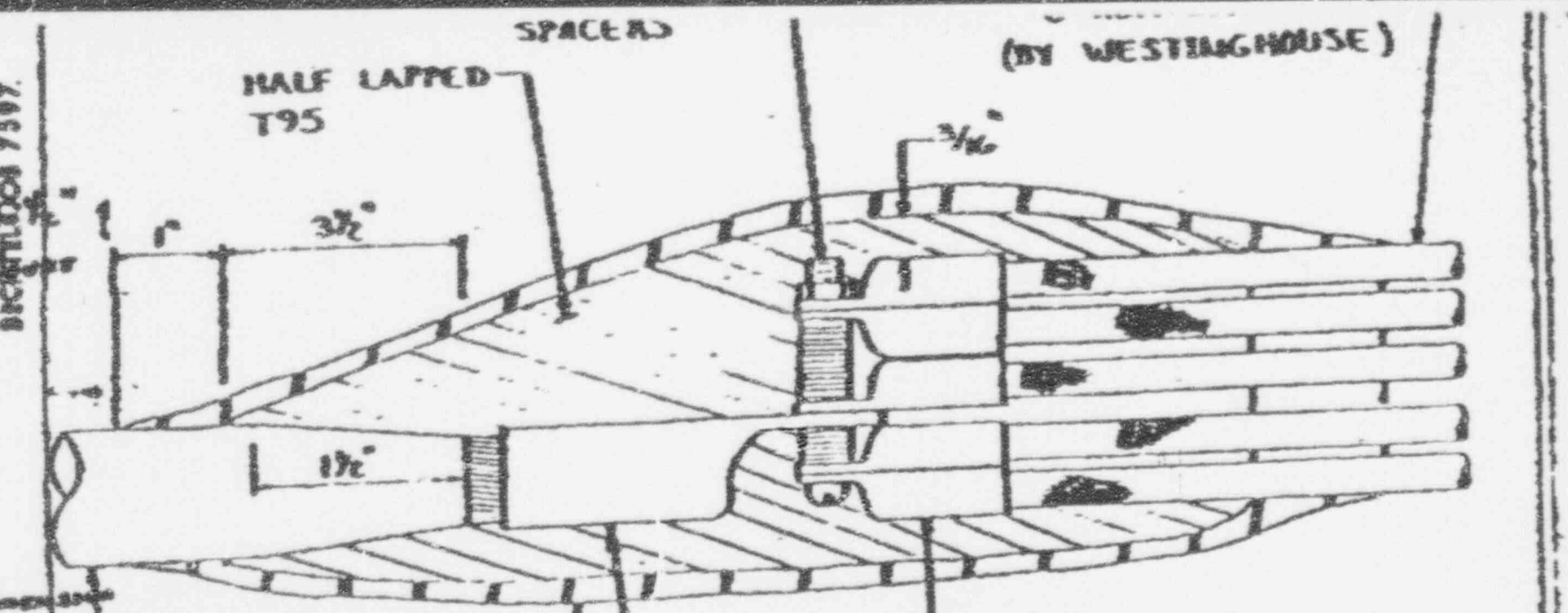


H_2 RECOMBINER 1A

PHASE	L #	D #
A	7"	2 3/8"
B	8"	2 1/16"
C	8 3/4"	2"
N	7"	2"

APPENDIX-A TO LETTER AP-1354-7 SHT 1 OF 1

APPENDIX-B TO SHT 1 OF
LETTER AP-1354

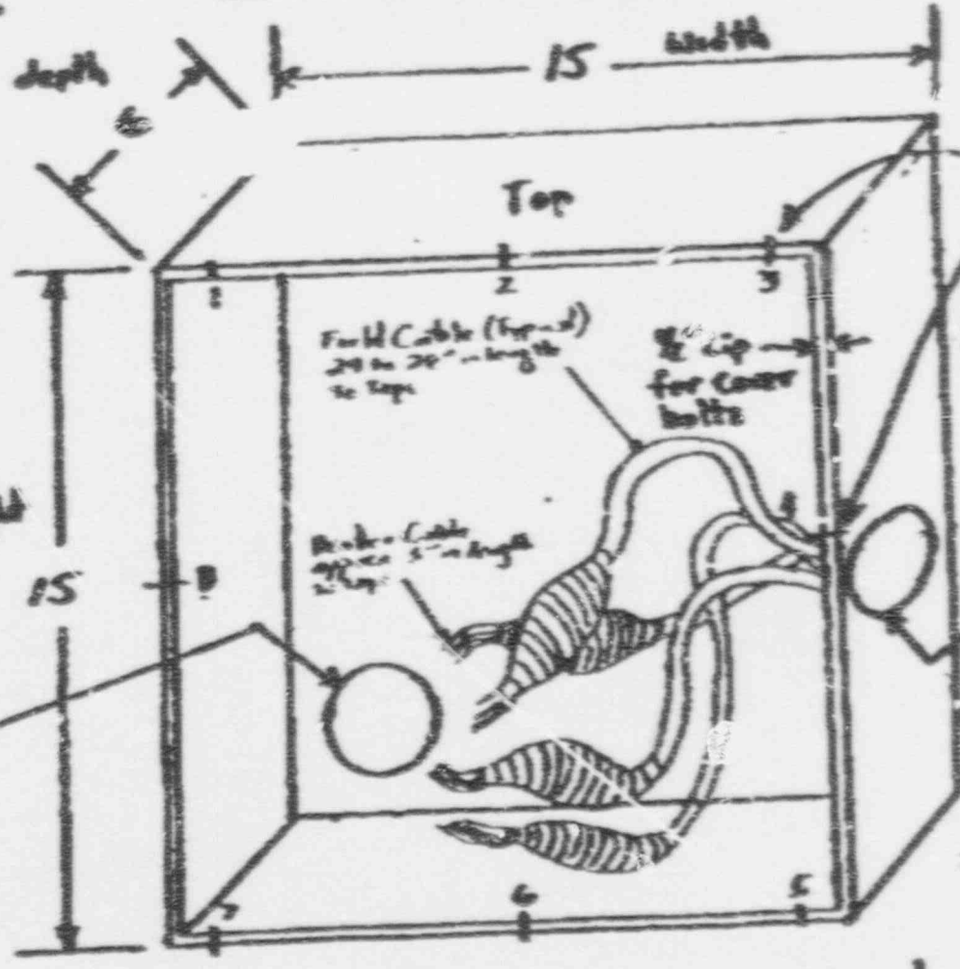


ASSUMED RECOMBINER TERMINATION CONFIGURATION

TYPICAL FOR 3 PHASES AND NEUTRAL

ATTENUATED BY
To Letter AP-13541

3/8 to 1/2" gasket material on Cover approx 1/8 Thk.



- All dimensions are approximate
- All dimensions are in inches

1/2 Recombiner Junction Box Configuration

Sketch Date 9/21/87

QUALITROL
Inspection Date 9/28/87

5.0 REPORT FORMAT

The test program was performed as specified in Reference 5.1 and as detailed in this report. T individual test results and the test procedure are presented in the following sections:

- o Section I - Baseline Functional Tests
- o Section II - Normal Radiation Exposure
- o Section III - Post-Normal Radiation Exposure Functional Tests
- o Section IV - Thermal Aging
- o Section V - Post-Thermal Aging Functional Tests
- o Section VI - Accident Radiation Exposure
- o Section VII - Post-Accident Radiation Exposure Functional Tests
- o Section VIII - Accident (LOCA) Test
- o Section IX - Post-Accident (LOCA) Functional Tests
- o Section X - Wyle Laboratories' Qualification Plan Number 178 Revision C

6.0 TEST SPECIMEN DESCRIPTION

The test specimens consisted of seven Byron/Braidwood samples (specimens B and 13 Zion samples (specimens Z1-Z13) as detailed in the following table. specimens, except B-5 which was constructed at Wyle Laboratories, were constr by Commonwealth Edison Company (CECO) technicians from the appl generating station.

Specimen Number	Splice Material	Configuration	Overlap*	See A LFig
B-1	Raychem WCSF-N	Single conductor #14 Rockbestos to 2-1 conductor #14 Rockbestos - WCSF-N splice	1/2"	
B-2	Raychem	Single conductor #14 Rockbestos to 2-1 WCSF-N conductor #14 Okonite - WCSF-N splice	1/2"	
B-3	Raychem	2 conductor #16 Rockbestos to 3-1 conductor WCSF-N #16 Rockbestos - WCSF-N splice	1/2"	
B-4	Okonite	#14 Okonite to #14 Okonite (lugged back to back) V-type splice with Okonite tape and no insulation tape in crotch	-	

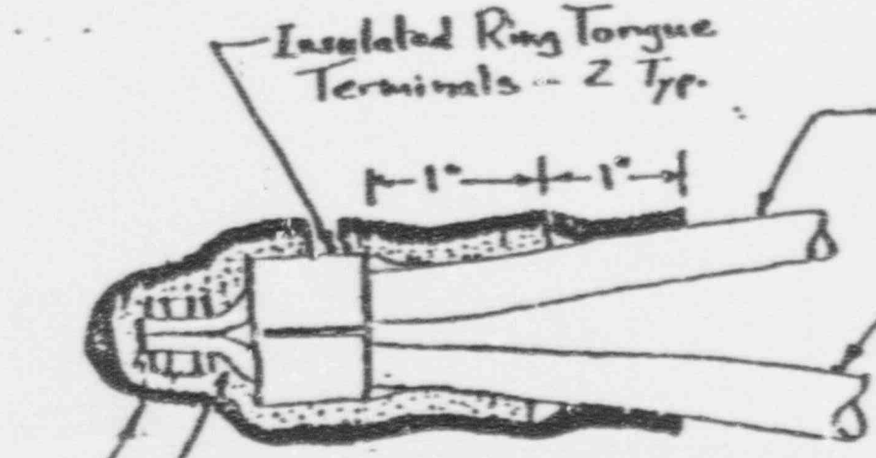
*Overlap refers to the amount of distance that the splice insulating material extended past the end of the metal used in the physical connection of the joined wires.

**Refers to the applicable sketch in Appendix I of this section.

6.0 TEST SPECIMEN DESCRIPTION (Continued)

Specimen Number	Splice Material	Configuration	Ovation	See App. I Figure
B-5	Okonite	#14 Okonite to #14 Nomax (pigtail from Limitorque) (lugged back to back) V-type splice with Okonite tape and no insulation in crotch	•	5
B-6	Okonite	#10 Okonite to #10 Okonite (lugged back to back) V-type splice with Okonite tape and no insulation in crotch	•	6
B-7	Okonite	500 • Okonite to 500 • Okonite V-type splice with Okonite tape.	•	N/A
Z-1	Raychem NPKV	#14 BIW (Boston Insulated Wire) single conductor to ASCO solenoid valve lead wire w/non-impregnated braid-Raychem stub type connector NPKV-2-10A	•	7
Z-2	Raychem NPKS	#14 BIW to #16 Kapton insulated wire-Raychem NPKS-1-11A	1/2"	8
Z-3	Raychem NPKS	#14 BIW to #16 Kapton Insulated wire-Raychem NPKS-1-11A	3/4"	9
Z-4	Raychem NPKS	#14 BIW single conductor to Static-O-Ring switch lead wire w/impregnated braid-Raychem NPKS-1-11A	1/2"	10
Z-5	Raychem NPKS	#14 BIW single conductor to Static-O-Ring switch lead wire w/impregnated braid-Raychem NPKS-1-11A	3/4"	11
Z-6	Raychem NPKV	#14 field conductor BIW to silicone hi-temp braid motor lead-Raychem NPKV-2-10A	•	12
Z-7	Kerite	#14 BIW to #14 BIW • V-type splice with Kerite tape	•	16
Z-8	Raychem NPKS	#14 BIW to #14 BIW-Raychem NPKS-1-11A with 180 degree bend	1/2"	13
Z-9	Raychem NPKS	#14 BIW to #14 BIW-Raychem NPKS 1-11A with 180 degree bend	1"	14
Z-10	Raychem NPKS	#14 BIW to #14 BIW-Raychem NPKS 1-11A with 180 degree bend	2"	15

Note:
Prior to [illegible] Apply Okonite Nuclear
Splicing Cement over Cable and Lugs.
Allow Cement [illegible] Dry before Taping



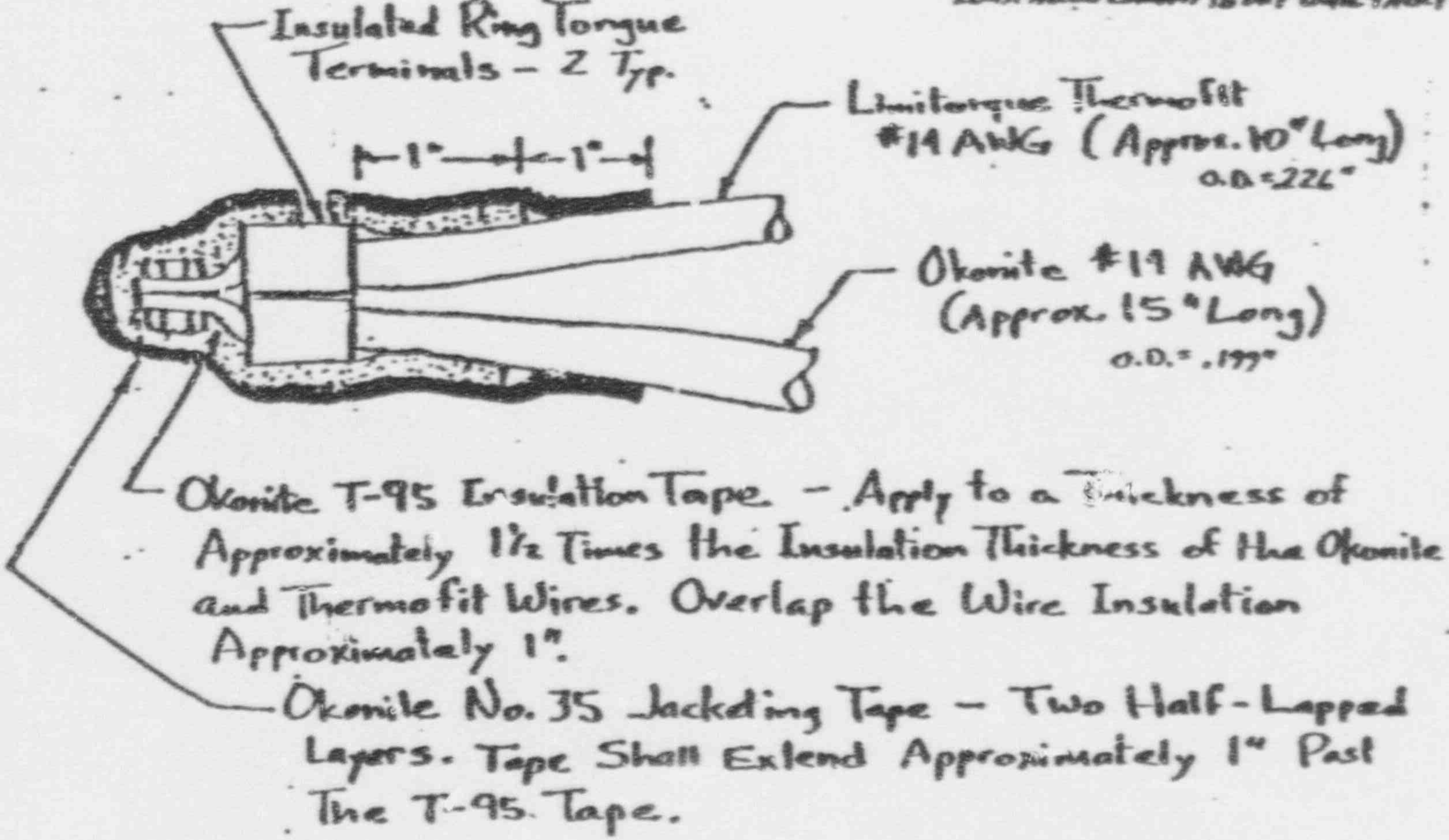
Okonite T-95 Insulation Tape - Apply to a Thickness of Approximately 1½ Times the Insulation Thickness of the Okonite and Thermofit Wires. Overlap the Wire Insulation Approximately 1".

Okonite No. 35 Jacketing Tape - Two Half-Lapped Layers. Tape Shall Extend Approximately 1" Past The T-95 Tape.

APPENDIX-C SHT 3 OF
TO LETTER AP-13541

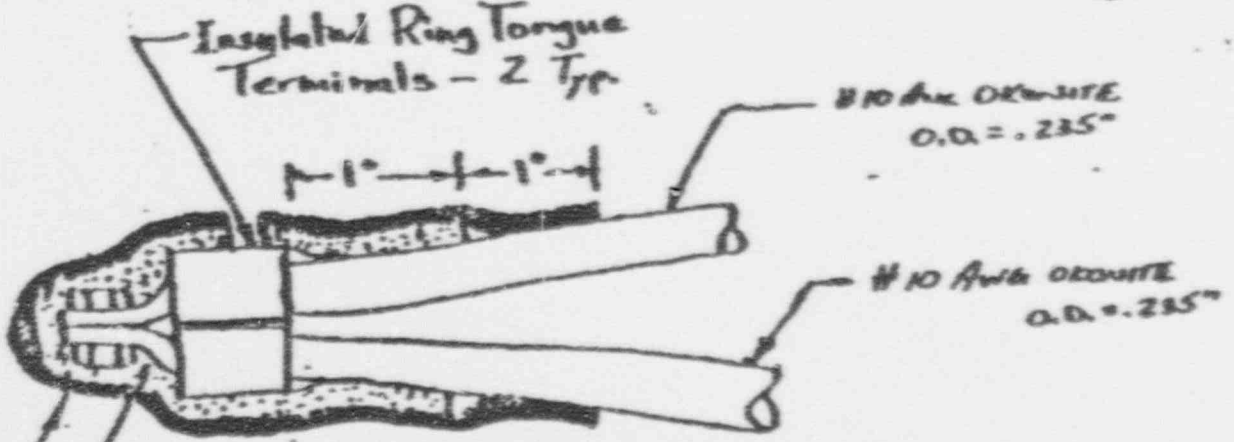
APPENDIX C SHT 4 OF
TO LETTER AR-13541

Note:
PRIOR TO TAPING APPLY OKONITE
SPLICING CEMENT TO CABLE AND
LUGS. ALLOW CEMENT TO DRY UNTIL TACKY



Specimen B5

Note: Prime to Armature Coil Apply Okonite Natural Splicing Cement to Coils and Leads. Allow Cement to Dry Before Taping.



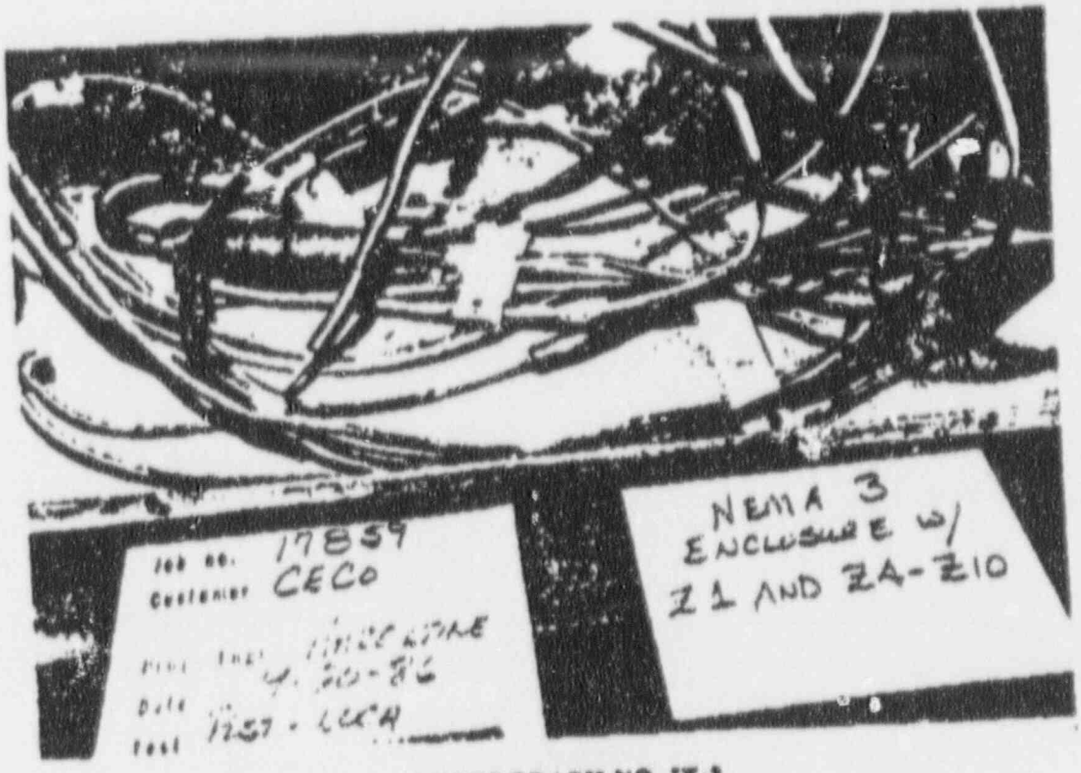
Okonite T-95 Insulation Tape – Apply to a Thickness of Approximately 1½ Times the Insulation Thickness of the Okonite and Thermofit Wires. Overlap the Wire Insulation Approximately 1".

Okonite No. 35 Jacketing Tape – Two Half-Lapped Layers. Tape Shall Extend Approximately 1" Past The T-95 Tape.

APPENDIX-C TO SHT 51
LETTER NO-19541

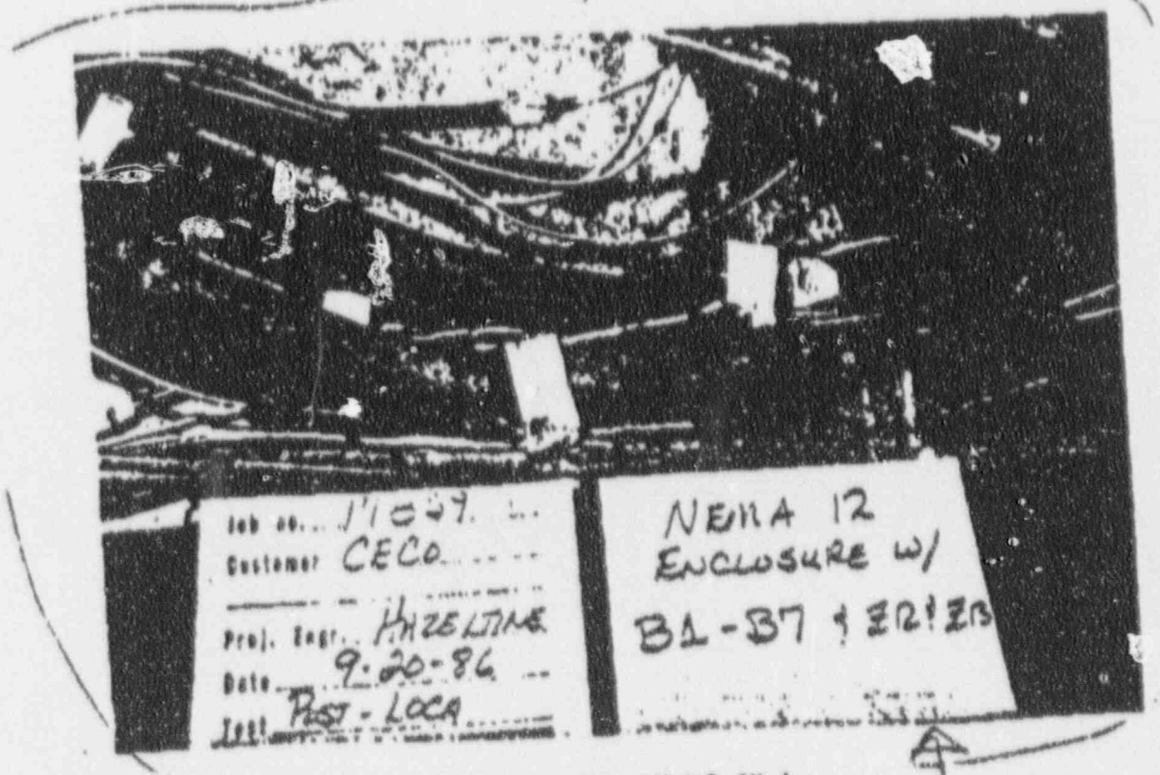
SPECIMEN B6

APPENDIX-C SHT 6 OF
TO LETTER AR 13641



PHOTOGRAPH NO. IX-3

CLOSE-UP VIEW OF THE BOTTOM LEDGE OF THE NEMA 3 ENCLOSURE



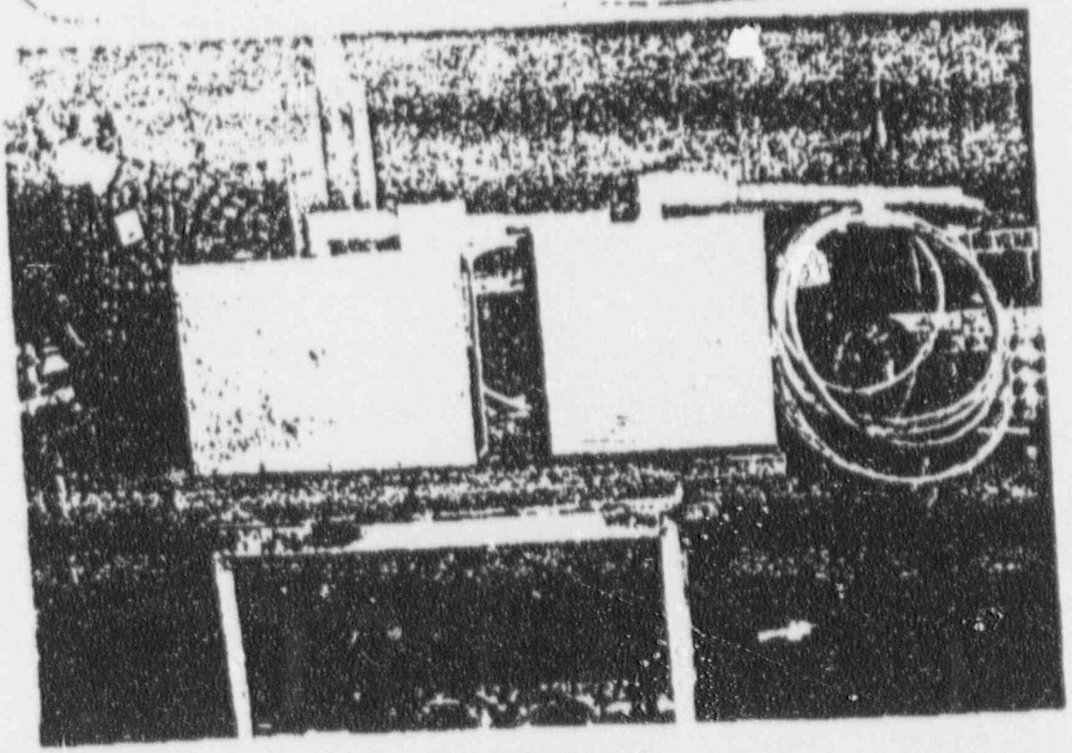
PHOTOGRAPH NO. IX-4

CLOSE-UP VIEW OF THE BOTTOM LEDGE OF THE NEMA 12 ENCLOSURE

APPENDIX-C SHT 7 OF
TO LETTER AP-13541

PHOTOGRAPH NO. VIII-3

INTERNAL VIEW OF NEMA 12 ENCLOSURE WITH SPECIMENS B1-B6, Z12 AND Z13 MOUNTED ON LOWER LEDGE. B7 WAS MOUNTED WITH THE SPLICE END VERTICAL IN THE ENCLOSURE



PHOTOGRAPH NO. VIII-4

EXTERNAL VIEW OF NEMA 3 AND NEMA 12 ENCLOSURES ON TEST FRAME

TELECOPY WPI 284-22

TELECOPY MED-PTE-1958 PAGE 1 OF 2 SEP 22 1987

SUBJECT: EHRS POWER CABLE 9-22-87

WESTINGHOUSE DWGS 7188D62, REV. 7

1366C51G01 REV. 6

TO: D. G. LOKAY

cc J. D. NASTASY

FILE: ALA-917-2

RECEIVED BY TELECOPY
9-22-87
BECHTEL JOB 7597

THE SUBJECT POWER CABLING IS LOCATED INSIDE THE RECOMBINER. ONE CABLE RUNS FROM EACH OF THE FIVE HEATER BANKS (MODEL A RECOMBINER) TO THE RECOMBINER JUNCTION BOX FOR A TOTAL OF FIVE (5) CABLES PER RECOMBINER.

CABLE DESCRIPTION

4/C #8 AWG 480 VOLTS POWER CABLE; RADIATION, HEAT AND MOISTURE RESISTANT

CONDUCTORS -- #8 AWG 7/0.0486 NICKEL PLATED COPPER
CONDUCTOR OD IS 0.145 INCHES NOM

INSULATION -- HEAT AND RADIATION RESISTANT POLYIMIDE
(CONDUCTOR) TAPE, 3 MIL WALL COVERED WITH GLASS BRAID SATURATED WITH A HEAT AND RADIATION RESISTANT VARNISH. CONDUCTORS CODED BY COLORED TRACERS IN THE GLASS BRAID.

BARE CONDUCTOR OD IS 0.145 INCHES NOMINA
BARE CONDUCTOR PLUS POLYIMIDE TAPE
OD IS 0.164 INCHES NOMINAL.
BARE CONDUCTOR PLUS POLYIMIDE TAPE PLUS
GLASS BRAID OD IS 0.175 INCHES NOMIN.

CONDUCTORS CABLED WITH GLASS FILLERS

JACKET — — — EXTRUDED HEAT AND RADIATION RESISTANT SILICON RUBBER, 60 MIL WALL.
FOR ADDED PROTECTION AND SERVICEABILIT A GLASS BRAID SATURATED WITH A HEAT AND RADIATION RESISTANT VARNISH IS APPLIED OVER THE SILICONE RUBBER.

CABLE OD — — 0.580 INCHES NOMINAL

AS REPORTED BY WCAP-7709L SUPPLEMENT 6, THE POWER CABLES AI SUBJECT TO DETERIORATION DUE TO AGING THEY ARE COVERED BY IEEE-383, "STANDARD FOR TYPE TEST OF CLASS 1E ELECTRIC EQ FIELD SPLICES AND CONNECTIONS FOR NUCLEAR POWER GENERATING STATIONS" AND HAVE BEEN GENERICALLY QUALIFIED TO SECTION 2.4 OF THIS STANDARD. NRC ACCEPTANCE OF GENERIC CABLE QUALIFICAT TO IEEE-383-1974, SECTION 2.4 IS REPORTED IN NRC LETTE EVALUATION OF WCAP-7709L, SUPPLEMENTS 5, 6, AND 7, WITH ENCLOSED EVALUATION DATED 22 JUNE 1978.

WORK CONTINUING ON AGREED WORK SCOPE ....

REGARDS

P. J. LAIN P J Lain