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August 5, 1988

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Jan 8/10/88

Mr. A. Bert Davis
 Regional Administrator
 U.S. Nuclear Regulatory Commission
 Region III
 799 Roosevelt Road
 Glen Ellyn, IL 60137

Subject: Dresden Station Units 2 and 3
 Quad Cities Station Units 1 and 2
 "Environmental Qualification of Butyl
 Rubber Insulated Cable"
NRC Docket Nos. 50-237/249 and 50-254/265

References (a): July 6, 1988 letter from H.J. Miller to
 Cordell Reed

(b): Material Presented at November 3, 1987
 meeting between Commonwealth Edison (CECo)
 the Nuclear Regulatory Commission (NRC)

Dear Mr. Davis:

The above referenced letter transmitted the results of an NRC review pertaining to the Environmental Qualifications (EQ) of Simplex and General Electric (GE) Butyl Rubber Insulated Cables at Quad Cities and Dresden Stations. Concerns were initially raised by the Region III EQ inspection conducted June 8 through July 28, 1987 at Quad Cities Station. This item was the subject of a November 3, 1987 technical meeting between Commonwealth Edison and the NRC and this letter is being provided in response to Reference (a).

Several issues were raised in Reference (a), particularly that NRC Staff believed the similarity analysis between the Wyle tested 5kV cables and the 600V cables did not fully meet the DOR Guidelines; and therefore EQ had not been adequately established for the 600V cables.

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As documented in the Environmental Qualification Binders, CQD-015111, CQD-014975, CQD-0155110, CQD-014973, Commonwealth Edison continues to believe that the 600V Simplex and General Electric Butyl Rubber insulated cables were adequately shown, at the time of the Quad Cities EQ audit, to be qualified to the DOR Guidelines in that:

- The test environment enveloped the service conditions and durations of accident with margin.
- The testing was conducted on a cable similar to that installed with respect to design and material of construction.
- The cable was tested in the sequence defined by its service condition as worst-case synergistic conditions, namely, radiation before aging and then accident test.
- Operational modes tested were representative of the actual application requirements.
- The installation interfaces used during the type test were representative of the actual installation.
- The cables were shown to be qualified for a complete spectrum of service conditions, through type testing and analysis.
- The various butyl rubber cables are original equipment installed prior to the issue of DOR Guidelines. Therefore, these cables are required to comply with only DOR Guidelines.

The 600 VAC butyl cables were qualified based on testing performed on 5kV cables. The applicability of the test results were established based on the following:

- The insulation thicknesses, jacket thicknesses and the construction of the 600V and 5kV were compared. It was shown that the 600V cable insulation would experience less electrical stress than the stress to which the 5kV cable insulation was subjected in the testing (Reference (b)). No credit was taken for cable jacket.
- The thermal effects, such as, oxidation rate, oxygen diffusion, and oxygen starvation, were addressed. Even after allowing for the loss of some of the insulation to oxidative effect, it was shown that the 600V cable insulation is subjected to less electrical stress than the insulation of the tested 5kV cables (Reference (b)). Even though cable jacket would prevent such oxidation, no credit was taken for its presence.

- The cables were shown to be qualified to the total integrated doses (TID) and the radiation dose rates expected at the locations of the 600V cables. No credit was taken for the jacket.

Various butyl rubber compounds behave similarly in terms of oxidative stability and radiation resistance and that large differences do not exist. Since the base polymer is the controlling factor in terms of aging, test results from the 5kV cables using butyl rubber as the primary insulation were extended to the qualification of the 600 VAC cables as is accepted by industry practice.

In conclusion, Commonwealth Edison continues to believe that the qualifications of the 600V butyl rubber cables meet DOR requirements.

Commonwealth Edison, in meeting its requirements under 50.59, has established surveillance programs for EQ equipment, which includes the 5kV and 600V butyl rubber cable. This program was discussed in the November 3, 1987 Technical Meeting. No cable failures have been identified at this time.

In order to address concerns raised by your staff, Commonwealth Edison will implement an augmented surveillance program to monitor the condition of the cables. The augmented Surveillance Program will be oriented towards monitoring of various types of butyl rubber cables. It will address the following:

- Requirements of the surveillance program
- Cable Selection and Location
- Number of Cable Samples and Interval of Surveillance
- Physical and Electrical Properties to be Monitored
- Responsibility for execution of the Surveillance Program
- Reviews of the Surveillance Results
- Qualification of Installed Cable based on Surveillance Results

The augmented Surveillance Program will be submitted to the NRC Staff for review and approval within forty-five (45) days of this transmittal. Commonwealth Edison anticipates that upon the review and acceptance of this program by the Staff that qualification status of the cable will be confirmed.

August 5, 1988

Reference (a) also indicated that the NRC continues to have concerns regarding butyl's long term radiation and thermal aging survivability. The letter indicated that these concerns are outside of the scope of the DOR Guidelines and Commonwealth Edison was asked to provide Region III Offices with samples of Simplex and GE butyl rubber cables to permit NRC sponsored testing. In response to this request, we have reviewed the availability of onsite cable that could be supplied to the NRC. No new butyl rubber cable is available in our storerooms for transmittal to the Region for testing. Additionally, Commonwealth Edison has no future plans to remove any of the existing butyl rubber cable. The only butyl rubber cable that is being removed at either Dresden or Quad Cities Station is cable that is removed at the end of its service life and therefore would not yield any meaningful test results. We would encourage the NRC to resolve the concerns regarding this matter on a generic basis.

Please direct any questions you may have regarding this matter to this office.

Very truly yours,

for M.S. Jurbak
H. E. Bliss
Nuclear Licensing Manager

lm

cc: T. Ross - NRR
B. Siegel - NRR
D/QC Senior Resident Inspectors

PURPOSE

THE PURPOSE OF THIS MEETING IS TO ADDRESS NRR CONCERNS
REGARDING THE APPLICABILITY OF EDISON'S SIMPLEX
BUTYL RUBBER CABLE TESTS TO EDISON'S 600V SIMPLEX BUTYL
RUBBER CABLES. (HOLAHAN TO MILLER MEMO, DATED 9/30/87).

SIMPLEX BUTYL RUBBER

CABLE QUALIFICATION

QUAD CITIES STATION

- I. INTRODUCTION AND BACKGROUND
- II. CABLE SPECIFICATION, MATERIAL, CONSTRUCTION AND DEGRADATION
- III. CABLE TESTS
- IV. APPLICABILITY OF TEST RESULTS
- V. INDEPENDENT REVIEW OF TEST RESULTS
- VI. DOR COMPLIANCE
- VII. NRR CONCERNS IN SEPTEMBER 30, 1987 LETTER
- VIII. SUMMARY AND CONCLUSIONS

BACKGROUND

- DOR GUIDELINES FOR ORIGINAL EQUIPMENT
(79-01B)
 - QUAD CITIES IS A DOR PLANT
 - BUTYL RUBBER CABLES AT QUAD CITIES ARE ORIGINAL EQUIPMENT INSTALLED PRIOR TO THE ISSUE OF DOR GUIDELINES
 - QUAD CITIES MEETS THE REQUIREMENTS OF THE DOR GUIDELINES
(THIS IS DISCUSSED IN DETAIL IN A LATER SECTION)

- SINCE QUAD CITIES IS A DOR PLANT, EQUIPMENT INSTALLED PRIOR TO DOR GUIDELINES 79-01B IS NOT REQUIRED TO COMPLY WITH IEEE STD 383-1974)

BACKGROUND

- ALL CABLE OUTSIDE PRIMARY CONTAINMENT
- NO CABLES IN 5×10^6 RADS AND HELB CONDITIONS (MAXIMUM 1.8×10^6 RADS)
 - 5KV SIMPLEX BUTYL RUBBER CABLES ARE LOCATED IN HIGH RADIATION - NON CONDENSING HUMIDITY ZONES (DRY)
 - 600 SIMPLEX BUTYL RUBBER POWER & CONTROL CABLES ARE IN QUAD CITIES
- HIGH HUMIDITY, HIGH TEMPERATURE, MODERATE RADIATION (WET) - 5% STEAM TUNNEL - HELB
- HIGH RADIATION - NON CONDENSING HUMIDITY (DRY) - 10% LOCA - RADIATION ONLY
- PE/PVC INSTRUMENT CABLES ARE NOT REQUIRED TO FUNCTION DURING A HELB AND ARE ONLY EXPOSED TO HIGH RADIATION - NON CONDENSING ENVIRONMENT

CABLE SPECIFICATIONS, MATERIAL
CONSTRUCTION AND DEGRADATION

o CEC_o CABLE SPECIFICATIONS

<u>CABLE CLASS</u>	<u>SERVICE</u>	<u>CEC_o SPEC. * NO.</u>	<u>INSUL/JACK.</u>	<u>IPCEA INSUL.</u>	<u>S-19-81 JACK.</u>
600V	120VAC 125VDC	EM-29115	BR/PVC	SEC 3.15	SEC 4.13.5
600V	208VAC 480VAC	EM-29105	BR/PVC	SEC 3.15	SEC 4.13.5
5000V	4160VAC	EM-29116	BR/PVC	SEC 3.15	SEC 4.13.5

*ALL SPECS. CONTAINED SIMILAR REQUIREMENTS FOR THE INSULATION AND JACKET COMPOUNDS

o BUTYL RUBBER INSULATION MATERIAL

- o 5kV AND 600V CABLE SPECIFIED AND MANUFACTURED IN SAME TIME FRAME
- o BUTYL RUBBER SPECIFIED TO MEET SAME REQUIREMENTS FOR EACH CABLE CLASS
- o BUTYL RUBBER CABLE MANUFACTURED BY SIMPLEX TO CEC_o SPECIFICATIONS
BUTYL RUBBER FOR 5kV AND 600V SAME

CABLE SPECIFICATIONS, ETC. (CONTINUED)

o CABLE CONSTRUCTION

- o SINGLE-CONDUCTOR - BR INSUL., PVC JACK.
- o MULTI-CONDUCTOR - BR INSUL., PVC COND. JACK.
PVC OVERALL JACK.

o INSULATION/JACKET THICKNESS

CABLE CLASS	THICKNESS		VOLTAGE STRESS IN INSULATION			
	INSUL. MILS	JACK. MILS	NOMINAL	4160V	480V	120V
5000V	171.8	47/125	14.54	7.0	---	---
600V	46.8	16/62.5	4.8	---	2.2	0.96

o DIELECTRIC STRENGTH OF BUTYL RUBBER (47 MILS INSUL.)*

RADIATION DOSE RAD	DIELECTRIC STRENGTH V/MIL
0	564
$5 \cdot 10^5$	618
$5 \cdot 10^6$	542
$5 \cdot 10^7$	129

*IEEE TRANS. PAS-88, NO. 5, MAY 1969, P. 535

CABLE SPECIFICATIONS (CONTINUED)

o DEGRADATION FACTORS

- o VOLTAGE STRESS, V/MIL
- o TEMPERATURE
- o RELATIVE HUMIDITY
- o RADIATION
- o OXIDATION

o MOST SEVERE COMBINATIONS OF ACCIDENT AND NORMAL CONDITIONS

<u>ENVIRONMENT</u> <u>OUTSIDE DRYWELL</u>	<u>CABLE</u> <u>CLASS</u>	<u>VOLT</u> <u>STRESS</u> <u>V/MIL.</u>	<u>TEMP</u> <u>°F</u>	<u>REL.*</u> <u>HUM.</u> <u>%</u>	<u>RADIATION</u> <u>RAD</u>
HELB STEAM TUNNEL	600V	4.8	304 5(MIN)	100(C)	1.8.10 ⁶
OTHER HELB	600V	4.8	285 25(MIN)	100(C)	1.6.10 ⁶
LOCA	5000V	12.09	104	100(NC)	39.10 ⁶
RADIATION ONLY	600V	4.8	135	95(NC)	13.10 ⁶

*C - CONDENSING

NC - NON-CONDENSING

CABLE SPECIFICATIONS, ETC. (CONTINUED)

- o HISTORICAL PERFORMANCE OF BUTYL RUBBER CABLE AT QUAD CITIES
 - o SERVICE LIFE TO DATE - 16 YEARS
 - o IN-SERVICE FAILURES - NONE TO DATE
TO DATE DUE TO MATERIALS
OR INSTALLATION
 - o OXIDATION INSULATION LOSS - NONE APPARENT
(SAMPLE FROM PLANT)

CABLE SPECIFICATIONS, ETC. (CONTINUED)

o CONCLUSIONS

- o BUTYL RUBBER CABLE AT QUAD CITIES SPECIFIED AND MANUFACTURED IN SAME TIME FRAME BY SIMPLEX
- o SAME MATERIAL FOR 5kV AND 600V CABLE
- o DEGRADATION FACTORS MORE SEVERE FOR 5kV CABLE
- o NO IN-SERVICE FAILURES TO DATE DUE TO MATERIAL OR INSTALLATION
- o NO EVIDENCE OF INSULATION LOSS DUE TO OXIDATION

CABLE TESTS

o PURPOSE OF TESTS

- o SHOW THAT THE BUTYL RUBBER AND POLYETHYLENE INSULATING MATERIALS USED IN THE SIMPLEX CABLES AT QUAD CITIES ARE QUALIFIED FOR THE ENVIRONMENTS TO WHICH THEY WILL BE EXPOSED AT QUAD CITIES.

CABLE TESTS (CONTINUED)

- o CABLES TESTED
 - o 10-YEAR-OLD CABLES TAKEN FROM QUAD CITIES.
 - o ORIGINAL EQUIPMENT
 - o SAME INSULATION MATERIAL AS INSTALLED
- CABLES

CABLE TESTS (CONTINUED)

- o TEST PROCEDURES
 - o RADIATION BEFORE THERMAL AGING TO REFLECT SYNERGISTIC EFFECTS
 - o DURING END OF LIFE TESTS CABLES ENERGIZED AT NOMINAL VOLTAGE AND CARRYING NORMAL LOAD RATED CURRENT
 - o POST TEST HI-POT. TEST FOR 5 MIN. IN TAP WATER

BUTYL RUBBER	5000V	2 TIMES SERVICE
POLYETHYLENE	3840V	69 TIMES SERVICE
 - o POST TEST FUNCTIONAL TESTS

CABLE TESTS (CONT'D)

• TEST PARAMETERS VS. SERVICE DEGRADATION FACTORS FOR BUTYL RUBBER CABLE

ENVIRONMENT		VOLT	REL.	
OUTSIDE DRYWELL		STRESS V/MIL	TEMP. ° F TIME	HUM. % RADIATION RAD
HELB STEAM	TEST	12.09	304 < 30 MIN.	100 (c) 5.5x10 ⁶
TUNNEL	SERVICE	4.43 ⊕	304 < 5 MIN.	100 (c) 1.8x10 ⁶
LOCA				
RADIATION	TEST	14.54	257**	- 44.9x10 ⁶
ONLY	SERVICE	7.0 △	135*	95(nc) 39.0x10 ⁶

⊕ - 600 V CABLE

INSULATION + JACKET
THICKNESS = 62.5 MILS

* - 135 ° F FOR ONE YEAR

** - DURING THERMAL AGING

△ - 5KV CABLE

INSULATION + JACKET
THICKNESS = 344 MILS

(c) - CONDENSING

(nc) - NON-CONDENSING

CABLE TESTS (CONTINUED)

o TEST RESULTS

o SIMPLEX BUTYL RUBBER CABLE PASSED

HI-POT. TEST (LEAKAGE CURRENT 2 MA)

FUNCTIONAL TESTS

IR TEST

o POLYETHYLENE CABLE PASSED

HI-POT. TEST (LEAKAGE CURRENT 0 MA)

FUNCTIONAL TESTS

IR TEST

o CONCLUSIONS

o SIMPLEX BUTYL RUBBER INSULATING MATERIAL

IS QUALIFIED FOR THE ENVIRONMENTAL CONDITIONS

AT QUAD CITIES

o POLYETHYLENE INSULATING MATERIAL IS QUALIFIED

FOR THE ENVIRONMENTAL CONDITIONS AT QUAD CITIES

APPLICABILITY OF TEST RESULTS

- TEST PARAMETERS
 - EXCEEDED ENVIRONMENTAL CONDITIONS TO WHICH ALL SIMPLEX BUTYL RUBBER CABLES AT QUAD CITIES WILL BE EXPOSED.
 - DEMONSTRATED THAT SIMPLEX BUTYL RUBBER MATERIAL IS QUALIFIED AS A CABLE INSULATION AT QUAD CITIES.
- 600V POWER AND CONTROL SIMPLEX BUTYL RUBBER CABLES
 - SERVICE REQUIREMENTS LESS SEVERE THAN 5kV CABLES
TESTED
SPECIFICALLY VOLTAGE STRESS.
RADIATION
- QUALIFICATION OF 600 SIMPLEX BUTYL RUBBER CABLE
 - TEST RESULTS QUALIFIED SIMPLEX BUTYL RUBBER CABLE FOR QUAD CITIES ENVIRONMENT.
 - TEST PARAMETERS ENVELOPE THE SERVICE CONDITIONS OF THE 600V CABLE BY A WIDE MARGIN.

APPLICABILITY OF TEST RESULTS (CONTINUED)

- o CONCLUSIONS
 - o TEST RESULTS ON SIMPLEX BUTYL RUBBER CABLE QUALIFY BOTH 5KV AND 600V CABLE FOR THE ENVIRONMENTAL CONDITGINS AT QUAD CITIES.

INDEPENDENT REVIEW OF APPLICABILITY
OF TEST RESULTS

- o BECAUSE THE NRR RAISED QUESTIONS ABOUT CECO'S JUSTIFICATION OF THE APPLICABILITY OF THE TEST RESULTS FOR THE 5kV SIMPLEX BUTYL RUBBER CABLES TO THE 600V SIMPLEX BUTYL RUBBER CABLES CECO ASKED FOR AN INDEPENDENT REVIEW OF ITS CONCLUSIONS. THREE INDEPENDENT REVIEWS WERE PERFORMED.

- o MAJOR CABLE MANUFACTURER (OKONITE)
 - o REVIEWED APPLICABILITY DOCUMENTATION AND CONCURRED WITH CECO'S JUSTIFICATION.

- o INDEPENDENT TEST LABORATORY (WYLE)
 - o REVIEWED RESULTS OF TESTS IT PERFORMED
 - o PREPARED AN ASSESSMENT REPORT ON THE APPLICABILITY OF 5kV RESULTS TO 600V CABLE
 - o CONCURRED WITH CECO'S JUSTIFICATION

- o CONSULTING FIRM (WESTEC)
 - o REVIEWED APPLICABILITY
 - o CONCURRED WITH CECO'S JUSTIFICATION

INDEPENDENT REVIEW (CONTINUED)

o CONCLUSIONS

- o CECO CONCLUDED THAT TEST RESULTS ON SIMPLEX BUTYL RUBBER MATERIAL QUALIFIED NOT ONLY THE 5kV CABLE TESTED, BUT ALSO THE 600V CABLE WHOSE SERVICE REQUIREMENTS ARE ENVELOPED BY THE 5kV CABLE SERVICE REQUIREMENTS AND THE TEST PARAMETERS.
- o THREE QUALIFIED INDEPENDENT PARTIES CONCUR WITH CECO'S CONCLUSIONS.
- o ALL SIMPLEX BUTYL RUBBER CABLE AT QUAD CITIES QUALIFIED FOR ENVIRONMENTAL CONDITIONS AT QUAD CITIES.

DOR COMPLIANCE

o QUALIFICATION BY TYPE TESTING (SEC. 5.2 OF DOR)

DOR REQUIREMENT

- TEST ENVIRONMENT SHOULD ENVELOP SERVICE CONDITIONS AND DURATIONS FROM INITIATION OF ACCIDENT UNTIL ENVIRONMENT RETURNS TO SAME LEVELS THAT EXISTED PRE-ACCIDENT.
- TEST SPECIMENS SHOULD BE THE SAME MODEL AS INSTALLED EQUIPMENT WITH RESPECT TO DESIGN AND MATERIAL OF CONSTRUCTION.
- DEVIATIONS BETWEEN INSTALLED AND TESTED EQUIPMENT SHOULD BE EVALUATED IN THE QUALIFICATION DOCUMENT.

QUAD CITIES COMPLIANCE

- IT DID. REFER TO WYLE TEST REPORT AND PREVIOUS SECTIONS OF THIS PRESENTATION.
- PREVIOUS DISCUSSION HAS SHOWN THAT 5kV SIMPLEX BUTYL RUBBER CABLE RESULTS ARE APPLICABLE TO 600V SIMPLEX BUTYL CABLE.
- NO DEVIATIONS. TESTED AND INSTALLED INSULATION SYSTEMS ARE IDENTICAL. (SEE PREVIOUS SECTIONS.)

DOR COMPLIANCE (CONTINUED)

DOR REQUIREMENT

- COMPONENT SHOULD BE EXPOSED TO THE ENVIRONMENT IN THE SEQUENCE DEFINED BY ITS SERVICE CONDITION.
- IF COMPONENT MATERIALS NOT SUSCEPTIBLE TO SIGNIFICANT RADIATION DAMAGE AT SERVICE CONDITION LEVELS, IT (RADIATION) SHOULD BE APPLIED AT ANY TIME DURING THE TYPE TESTING.
- IF COMPONENT MATERIALS SUSCEPTIBLE TO RADIATION DAMAGE, RADIATION DOSE SHOULD BE APPLIED PRIOR TO OR CONCURRENT WITH EXPOSURE TO ELEVATED TEMPERATURE, PRESSURE, STEAM/AIR CONDITIONS.

GUAD CITIES COMPLIANCE

- THE CABLES WERE, WORST-CASE SYNERGISTIC CONDITIONS WERE USED, NAMELY, RADIATION BEFORE AGING AND THEN END OF LIFE TEST.
- CABLE MATERIALS ARE SUSCEPTIBLE TO RADIATION DAMAGE. TEST CONDUCTED WITH RADIATION BEFORE AGING TO REFLECT WORST-CASE SYNERGISTIC EFFECTS.
- SEE ABOVE.

DOR COMPLIANCE (CONTINUED)

DOR REQUIREMENT

- THE SAME SPECIMEN SHOULD BE USED THROUGHOUT THE TEST SEQUENCE.
- COMPONENTS CONTAINING MATERIALS SUSCEPTIBLE TO SIGNIFICANT DEGRADATION DUE TO THERMAL AND RADIATION AGING. QUALIFIED LIFE MUST BE ESTABLISHED ON A CASE-BY-CASE BASIS.
- OPERATIONAL MODES TESTED SHOULD BE REPRESENTATIVE OF THE ACTUAL APPLICATION REQUIREMENTS.

QUAD CITIES COMPLIANCE

- THEY WERE. REFER TO WYLE TEST REPORT. 8 DIFFERENT SPECIMENS WERE USED FOR 8 DIFFERENT EXPOSURES.
- CABLE MATERIALS ARE SUSCEPTIBLE TO SIGNIFICANT THERMAL/RADIATION DAMAGE. TESTS DONE TO MAXIMIZE SYNERGISTIC EFFECTS BY RADIATING BEFORE THERMAL AGING. SUCH TESTS WERE PERFORMED ON BUTYL RUBBER AND POLYETHYLENE MATERIALS; CASE-BY-CASE FOR THREE HARSH AREAS.
- THEY WERE. EACH CABLE TYPE WAS OPERATED DURING THE TESTS AT ITS SERVICE VOLTAGE OR GREATER AND ITS EXPECTED LOAD CURRENT IN CABLE TRAY AS INSTALLED AT QUAD CITIES.

DOR COMPLIANCE (CONTINUED)

DOR REQUIREMENT

- FAILURE OF A COMPONENT AT ANY TIME DURING THE TEST, THEN THE TEST SHOULD BE CONSIDERED INCONCLUSIVE FOR THE ENTIRE PERIOD PRIOR TO THE FAILURE.
- THE INSTALLATION INTERFACES USED DURING THE TYPE TEST SHOULD BE REPRESENTATIVE OF THE ACTUAL INSTALLATION.

QUAD CITIES COMPLIANCE

- NOT APPLICABLE. NEITHER THE SIMPLEX BUTYL RUBBER OR POLYETHYLENE CABLE FAILED DURING OR SUBSEQUENT TO THE TEST IN THE HI-POT. OR FUNCTIONAL TESTS.
- THE CABLES WERE INSTALLED IN CABLE TRAYS IN THE SAME MANNER AS THE ACTUAL INSTALLATION.

DOR COMPLIANCE (CONTINUED)

o QUALIFICATION BY COMBINATION OF METHODS
(TEST, EVALUATION AND ANALYSIS)

DOR REQUIREMENT

- EQUIPMENT MAY BE SHOWN TO BE QUALIFIED FOR A COMPLETE SPECTRUM OF SERVICE CONDITIONS, EVEN THOUGH IT WAS ONLY TYPE TESTED FOR HIGH TEMPERATURE, PRESSURE AND STEAM.
- QUALIFICATION FOR RADIATION AND CHEMICAL SPRAY MAY BE DEMONSTRATED BY ANALYSIS.

QUAD CITIES COMPLIANCE

- THE BUTYL RUBBER INSULATING MATERIAL WAS SHOWN TO BE QUALIFIED FOR THE ENVIRONMENTAL CONDITIONS AT QUAD CITIES FOR ALL BUTYL RUBBER CABLE APPLICATIONS.
- TEST RESULT APPLICABILITY ANALYSIS USED TO QUALIFY 600V BUTYL RUBBER CABLE.

QUALIFICATION OF SIMPLEX BUTYL 5KV CABLES

CONCERN 1: WYLE TEST DID NOT MEET SECTION 5.2.3 OF DOP GUIDELINES WHICH STATES "RADIATION DOSE SHOULD BE APPLIED PRIOR TO OR CONCURRENT WITH EXPOSURE TO THE ELEVATED TEMPERATURE PRESSURE AND STEAM ENVIRONMENT" FOR MATERIALS WHICH ARE KNOWN TO BE SUSCEPTIBLE TO SIGNIFICANT RADIATION DAMAGE AT THE SERVICE CONDITION LEVELS.

CABLES HAD UNDERGONE 10 YEARS NATURAL AGING AT THE PLANT SITE BEFORE BEING SUBJECTED TO ACCELERATED RADIATION, THERMAL AND STEAM EXPOSURE WHICH DEVIATED FROM THE SECTION 5.2.3 DOSE REQUIREMENTS.

RESPONSE: RADIATION AGING WAS FOLLOWED BY THERMAL AGING AND THEN BY LOCA/PELR EXPOSURE IN THE WYLE TEST PROGRAM (PAGE II OF WYLE TEST REPORT.)

- TEST SEQUENCE IS THE RECOMMENDED SEQUENCE FOR CABLES BY SANDIA LABS

- TEST CABLES WERE TAKEN FROM PLANT SITE FOLLOWING 10 YEARS NATURAL AGING

- NO NEW CABLES AVAILABLE

CONCERN 2: TEST DID NOT MEET IEEE-383 RADIATION DOSE RATE REQUIREMENTS.

RESPONSE: INDUSTRY STANDARDS REQUIRE THE DOSE RATE NOT TO EXCEED 1×10^6 RADS / HR (BOTH FOR NORMAL AND DBE DOSE).

- TEST RADIATION DOSE RATE WAS BETWEEN 0.506×10^6 & 0.821×10^6 RADS/HR (WYLE TEST REPORT PAGES V-10 THRU V-14, TEST GROUPS IV, V, VI, VII, VIII)

QUALIFICATION OF SIMPLEX BUTYL 5KV CABLES (CONT'D)

CONCERN 3: NOT TESTING THE THINNEST INSULATION PRODUCT PER IEEE-333.

RESPONSE: THE 5KV TEST SAMPLE IS A REPRESENTATIVE SAMPLE OF THE INSTALLED 5KV CABLES AT QUAD CITIES. THIS MEETS THE DOR GUIDELINES.

VOLTAGE STRESS ON THE INSULATION IS MORE IMPORTANT THAN INSULATION THICKNESS.

CONCERN 4: TEST DID NOT MEASURE LEAKAGE CURRENT AS SPECIFIED
IN IEEE-383.

RESPONSE: ● IEEE-383 DOES NOT REQUIRE LEAKAGE CURRENT MEASURE-
MENT DURING DBE TEST.

● THE TEST CABLES WERE ELECTRICALLY STRESSED AT 173%
OF THEIR SERVICE REQUIREMENTS DURING THE DBE TEST.
AND LOADED WITH RATED SERVICE CURRENT

● POST TEST HI-POT.

5 MIN. IN TAP WATER AT 5000V

➤ 200% OF SERVICE DUTY

● POST TEST LEAKAGE CURRENT < 2 MA

● POST TEST FUNCTIONALS SATISFACTORY

QUALIFICATION OF SIMPLEX BUTYL 5KV CABLES (CONT'D)

CONCERN 6: TEST DID NOT INCLUDE MANDREL BEND TEST FOLLOWED BY 80V/MIL WITHSTAND TEST AS REQUIRED BY IEEE-333-1974.

- RESPONSE:
- WYLE TEST DID NOT INCLUDE MANDREL BEND TEST FOLLOWED BY 80V/MIL TEST. THIS IS NOT A DOR REQUIREMENT.
 - EXCEPTION TO 80V/MIL TEST NOT TO EXCEED 5KV WAS TAKEN IN THE TEST PLAN (SECTION 3.5.5, PAGE 27 OF WYLE TEST PLAN 45916-03.)
 - TEST CABLES HAD BEEN SUBJECTED TO THE MECHANICAL STRESSES OF INSTALLATION WHICH IS WHAT THE MANDREL TEST SIMULATES - TEST CABLES ALSO SUBJECTED TO STRESSES OF REMOVAL AFTER 10 YEARS IN PLACE.

QUALIFICATION OF 600V SIMPLEX BUTYL INSULATED

POWER AND CONTROL CABLES

CONCERN 1: INDUSTRY TESTING SHOWS BUTYL RUBBER SUSCEPTIBLE TO DAMAGE BETWEEN 5×10^6 AND 10^7 RADS. 600V CABLES AT QUAD CITIES MUST WITHSTAND A T.I.D. BETWEEN 1.8×10^6 AND 1.3×10^7 RADS.

RESPONSE: INDUSTRY PUBLISHED DATA ON BUTYL RUBBER SHOWS:

- NO CHANGE IN DIELECTRIC STRENGTH (IMMEDIATELY AFTER IMMERSION IN WATER) UP TO 5×10^6 RADS. AFTER 50×10^6 RADS (IEEE TRANSACTIONS ON POWER APPARATUS AND SYSTEMS, VOL. PAS-88, No. 5, MAY 1969.) STILL HAD DIELECTRIC STRENGTH OF 129 V/MIL.
- WYLE TEST EXPOSED THE BUTYL 5KV CABLES TO 44.9 MEGARADS AND THE SPECIMENS SUSTAINED 5KV FOR FIVE MINUTES UNDER TAP WATER. (14.54 V/MIL VS. SERVICE FOR 600V CABLE OF 4.43 V/MIL.)

QUALIFICATION OF 600V SIMPLEX BUTYL INSULATED
POWER AND CONTROL CABLES (CONT'D)

CONCERN 2: WYLE TEST NOT PERFORMED ON THE THINNEST INSULATION PRODUCT.

- RESPONSE:
- VOLTAGE STRESS IN V/MIL IMPOSED ON BUTYL RUBBER INSULATION KEY PARAMETER -- NOT INSULATION THICKNESS.
 - PRIMARY INSULATION AND CABLE JACKETING IDENTICAL FOR BOTH 5KV AND 600V CABLES.
 - DURING HELB AND LOCA TESTS, SIMPLEX BUTYL RUBBER INSULATION STRESSED TO 12.09 V/MIL VS. 4.43 V/MIL FOR 600V CABLE SERVICE - > THREE TIMES.

QUALIFICATION OF 600V SIMPLEX BUTYL INSULATED

POWER AND CONTROL CABLES (CONT'D)

CONCERN 3: WYLE TEST DID NOT ACCOUNT FOR OXIDATION DEGRADATION OF POLYMER MATERIALS IN THE AGING ANALYSIS.

RESPONSE:

- TO THE BEST OF OUR KNOWLEDGE THERE IS NO PUBLISHED DATA TO VERIFY THE OXIDATION DEGRADATION OF BUTYL MATERIAL UNDER VARIOUS DOSE RATE AND TEMPERATURE CONDITIONS.
- PVC JACKET PREVENTS CONTACT BETWEEN BUTYL RUBBER AND OXYGEN - NO OXYGEN, NO OXIDATION.
- WYLE TEST ON 5kV CABLES HAD NO VISIBLE DEGRADATION OR DAMAGE INDICATING THAT EFFECT OF OXIDATION WAS MINIMAL OR NONE.
- WYLE TEST WAS CONDUCTED IN THE SANDIA RECOMMENDED SEQUENCE.

QUALIFICATION OF 600V SIMPLEX BUTYL INSULATED
POWER AND CONTROL CABLES (CONT'D)

CONCERN 4: WYLE TEST MAY NOT ENVELOP THE NATURAL AGING CONDITIONS OF THE 600V CABLES SINCE THE 5KV RADIATION DOSE RATE IS TWO ORDERS OF MAGNITUDE LESS THAN THE 600V CABLE DOSE RATE.

- RESPONSE:
- THE TOTAL DOSE QUALIFIES THE CABLES.
 - IT IS NOT PRACTICAL TO TEST THE CABLES AT THE ACTUAL DOSE RATE OF 15 RADS/HR.
 - A REVIEW OF PUBLISHED INDUSTRY DATA SHOWS NO CHANGE IN PROPERTIES OF BUTYL RUBBER WITH RESPECT TO DOSE RATE.

QUALIFICATION OF SIMPLEX PE/PVC INSTRUMENT CABLES (CONT'D)

CONCERN 1: TEST DID NOT MEET DOR GUIDELINES BECAUSE LEAKAGE CURRENT AND IR MEASUREMENTS NOT MONITORED DURING HELB SIMULATION.

RESPONSE:

- MEASUREMENT OF LEAKAGE CURRENT AND IR ARE NOT DOR GUIDELINE REQUIREMENTS
- IR MEASUREMENTS WERE TAKEN BEFORE AND AFTER RADIATION TEST (SECTIONS IV AND VI OF WYLE TEST.)
- CABLES SUSTAINED 3840 VDC FOR FIVE MINUTES UNDER TAP WATER WITH 0 MA LEAKAGE AFTER HELB TEST.
- THE MAXIMUM APPLICATION VOLTAGE FOR THESE CABLES IS 55 VDC.

QUALIFICATION OF SIMPLEX PE/PVC INSTRUMENT CABLES (CONT'D)

CONCERN 2: CABLE ACCURACY CAN NOT BE PREDICTED SINCE CABLE LEAKAGE CURRENT WAS NOT MONITORED DURING HELB SIMULATION. 10-20% ACCURACY USED BY CECO CANNOT BE VERIFIED.

RESPONSE: ○ CABLES ARE NOT REQUIRED TO PERFORM ANY FUNCTION DURING AN HELB AND ARE NOT EXPOSED TO AN HELB AT QUAD CITIES.

● CABLES ARE NEEDED ONLY FOR POST LOCA RADIATION HARSH ENVIRONMENTS.

● IR MEASUREMENTS WERE TAKEN BEFORE AND AFTER RADIATION AGING.

● LOWEST IR MEASURED = $9^0 \times 10^8 \Omega / 15'$ AT 74^0F .

● USING IEEE-43, IR OF THE CABLE AT 150^0F IS $52.94 \text{ M}\Omega / 15'$

● USING THE WORST CASE CABLE LENGTH, THE ABOVE IR YIELDS INSTRUMENT INACCURACY OF LESS THAN 1%, WHICH IS LESS THAN THE 10-20% INACCURACY ALLOWED BY ANS 4.5.

QUALIFICATION OF SIMPLEX PE/PVC INSTRUMENT
CABLES (CONT'D)

CONCERN 3: JUSTIFICATION AND EXPLANATION SHOULD BE PROVIDED TO
SUBSTANTIATE THE ASSUMPTION THAT DURING THE DBE, THE
100% RELATIVE HUMIDITY WILL BE NON-CONDENSING.

RESPONSE: THESE CABLES ARE EXPOSED TO RADIATION ONLY DUE TO
A LOCA INSIDE PRIMARY CONTAINMENT. THESE CABLES
ARE OUTSIDE PRIMARY CONTAINMENT AND NOT EXPOSED TO
LOCA HUMIDITY.

(APPENDIX B OF BECHTEL SPEC. 13524-
069-N202, REV. 03, PAGE 2).

QUALIFICATION OF SIMPLEX PE/PVC INSTRUMENT
CABLES (CONT'D)

CONCERN 4: MAINTENANCE, SURVEILLANCE, AND INSPECTION PROGRAM TO IDENTIFY ANY SYNERGISTIC RELATED CABLE DETERIORATION BE ENHANCED SINCE SYNERGISTIC EFFECTS HAVE BEEN SHOWN TO OCCUR AT 2.5×10^6 RADS BETWEEN PE & PVC AND THE QUAD CITIES MAXIMUM DOSE IS 1×10^7 RADS.

RESPONSE:

- ALTHOUGH A TECHNICAL ISSUE, SYNERGISTIC EFFECTS ARE NOT PART OF DOR GUIDELINES.
- THE PE CABLES WERE AGED IN THE SEQUENCE RECOMMENDED BY SANDIA REPORT (NUREG/CR-2158, SAND80-2149.) WHICH MAXIMISES SYNERGISTIC EFFECTS.

SUMMARY & CONCLUSIONS

- CABLES ARE OUTSIDE THE PRIMARY CONTAINMENT
- INDEPENDENT REVIEW
- COMPLIED WITH DOR GUIDELINES