Pennsylvania Power & Light Co.

1. PAGE 1 OF 32
2. BCN NO. 21
3. CHANGE PACKAGE NO. ______

BINDER CHANGE NOTICE

4. BINDER TYPE AND IDENTIFICATION:

BINDER NO.	SEC.	REV.	FILE	BINDER NO.	SEC.	REV.	FILE
EQDF 48		0	R34-1	SQRT	N/A		R25
EQEL			R34-1				
EQPL			R34-1				

5. ENVIRONMENTAL QUALIFICATION MAINTENANCE AND SURVEILLANCE (EQM&S) REQUIREMENTS MANUAL REVISION REQUIRED? [ ] YES [X] NO

6. IS CHANGE TO THE EQ INDEX OF SEIS REQUIRED? [ ] YES [X] NO

7. DESCRIPTION OF CHANGE:

See Attached

8. DETAILS FOR UPDATE OF BINDER:

See Attached

9. REVIEWER(S):

G. Morris 11/2/90 (ERCE)

10.

Len Bonn (ERCE) 11/2/90
ORIGINATOR DATE

Alan P. Derkacs 11/7/90
APPROVER DATE

FORM EPM-QA-224A, Rev. 5 BCN Formi(32)

7. Description of Change:

Add the analysis, "Environmental Qualification Analysis of 250 VDC Limitorque Motor Operators for Valves Located Outside of Containment of Susquehanna Steam Electric Station," dated October 31, 1990, contained in pages 5 thru 32 of this BCN to provide a basis for the environmental qualification for Limitorque motor operators to be extended to 250 VDC motors and switches used in the operators. The extended qualification is based on testing supplemented by analysis and meets the qualification requirements of 10CFR50.49 and Regulatory Guide 1.89, Revision 1. The analysis concludes that the 250 VDC motor operators are qualified for their outside of containment applications for the full range of dc system voltages included the peak system voltage of 288 VDC.

Concurrent with the preparation of the analysis in pages 5 thru 32 of this BCN, PP&L Calculation No. SE-B-NA-104, Revision 0 was under preparation and was issued on October 26, 1990. This calculation supersedes Bechtel Calculations Nos. 18-72, Rev. 2, and 200-081, Rev. 1, which were used as inputs to the analysis (References 2 and 3 to the analysis). The differences between PP&L Calculation SE-B-NA-104 and the Bechtel Calculation do not affect the results of the analysis based on the following:

For the HELB in the Main Steam Tunnel (Rooms I-520 and II-520), the new calculation results in a peak pressure of 6.5 psig with a duration of five seconds (See Figure A on page H). This profile is different from that in Figure 1 of the analysis; however, the analysis of the HELB condition contained on page 12 of the analysis envelopes the 6.5 psig, 5 second duration because the analysis is based on the transient associated with a 66 psig saturated steam condition for a five second period, which is much more severe. Therefore, the 250 VDC motor operators are qualified for their Main Steam Tunnel applications.

For the remainder of the rooms with HELBs, the peak pressures contained in Calculation SE-B-NA-104 (the new calculation) are lower than that used as inputs to the analysis (4.2 psig used as basis for the analysis with a 3.4 psig maximum in the new calculation). In the new calculation, the peak pressures decay to 1 psig or less within four seconds, and to 0.5 psig or less at nine seconds, and to atmospheric pressure in less than 30 seconds. The analysis is based upon a low pressure 0.5 psig condition that lasts for a full 60-second, which conservatively envelopes the low pressure conditions of the new profile. The peak of the new profile still is predominantly composed of pressurized dry air that is being compressed by the steam transient. Therefore, the analysis on pages 5 thru 32 of this BCN remains conservative and the operators are qualified.

Based on the above analysis and the analysis on pages 5 thru 32 of this BCN, the actuators are environmentally qualified for 250 VDC operation in their outside of containment applications.

The analysis in this BCN evaluates the effects of a line break on Limitorque operators which would be in the resulting pressurized steam/air cloud, but does not address the effect of direct impingement of the stream from a break on the Limitorque operator. The latter is a Jet Impingement issue rather than an EQ issue and is dealt with in Calculation LS-9247.

8. Details For Update of Binder:

When this binder is upgraded, incorporate the analysis on pages 5 thru 32, adjusted for the new HELB conditions from Calculation SE-B-NA-104, Revision 0, into the EQ Assessment Report. Calculation SE-B-NA-104 should be used as a reference in place of the Bechtel calculations listed as references 2 & 3 on page 24 of this BCN.

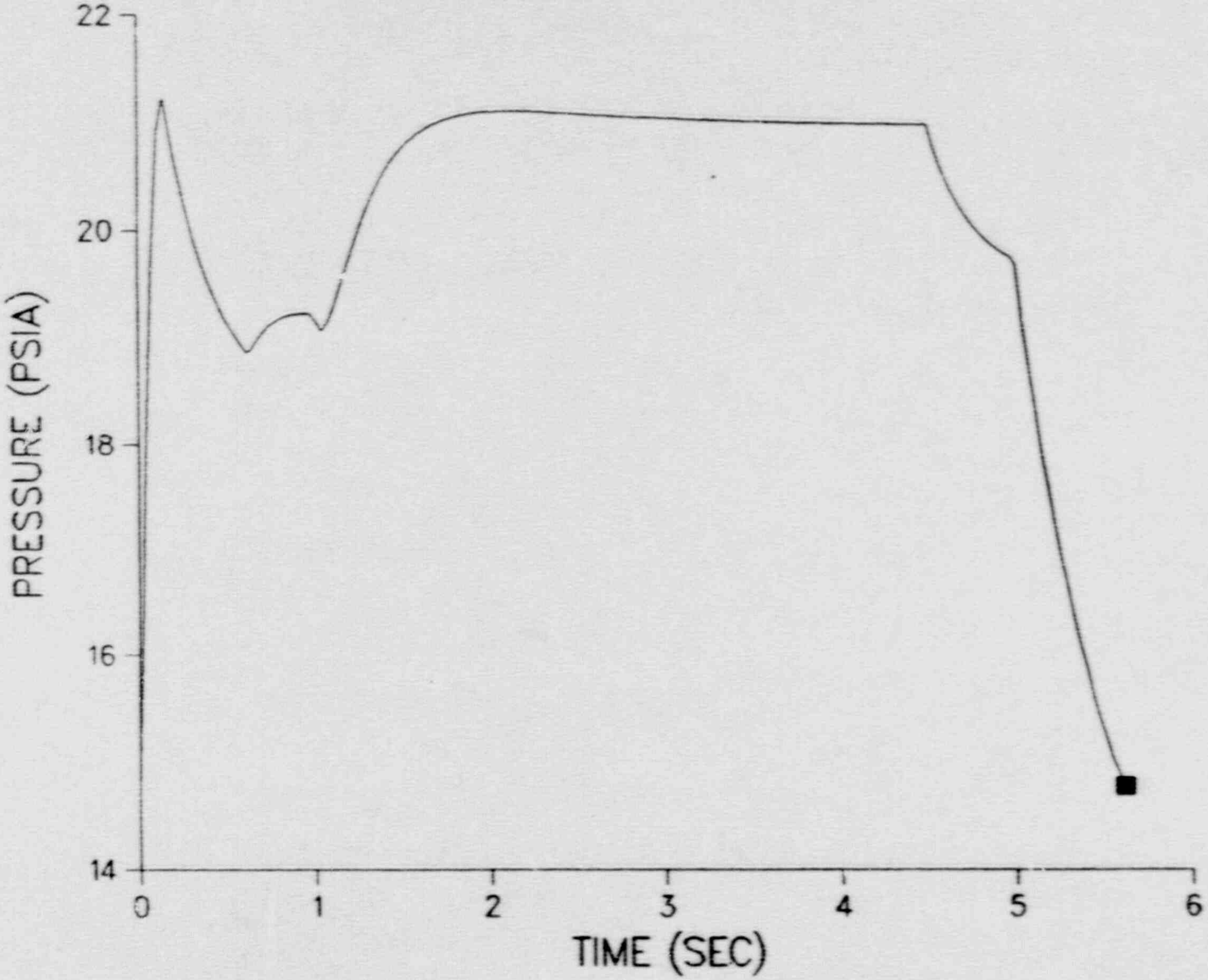
The pressure conditions listed in the Notes to Tables 1 and 2, in Table 3, and in Figures 1 and 2 of the attached analysis must be revised accordingly. The discussion of HELB conditions starting on page 6 of the analysis must be revised as well as the "HELB Humidity and Temperature Analysis", contain on pages 12 through 18, to agree with the new calculation.

Also, add the Wyle Labs test report identified as reference 10 on page 23 of this BCN to the upgraded EQ binder as an exhibit. The Wyle report is currently held in the EQ sub-group by A. P. Derkacs pending completion of an agreement with WPPSS which will permit us to reproduce the document for our records.

apd/frk009a(18)

Figure A.

STEAM TUNNEL HIGH ENERGY LINE BREAK ANALYSIS (SUMMER CONDITIONS)



ENVIRONMENTAL QUALIFICATION ANALYSIS OF 250 Vdc LIMITORQUE MOTOR OPERATORS FOR VALVES LOCATED OUTSIDE OF CONTAINMENT OF SUSQUEHANNA STEAM ELECTRIC STATION

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INTRODUCTION AND APPROACH

This document provides the basis for the environmental qualification of 250 Vdc Limitorque motor operators for valves used outside containment at the Susquehanna Steam Electric Station (SSES). The environments evaluated herein are those associated with HELBs and the secondary effects of a LOCA in the rooms where the equipment is located. The components of interest are the 250 Vdc motors, and the limit and torque switches used in these actuators. This analysis includes the following:

- o Identification of the MOVs with a safety function under HELB conditions and under LOCA conditions.
- o Identification of the limits of the associated HELB environments.
- o Identification of the limits of the secondary affects of LOCA.
- o Evaluation of the secondary effects of a LOCA on the 250 Vdc motor operators.
- o Description of the 250 Vdc motor actuator configurations.
- o Evaluation of the effects of the HELB profile on switch housing components.
- o Comparison of SSES conditions to test results from similar HELB profiles from manufacturer's type tests and from tests by another plant.

Based on these analyses, this document concludes that the 250 Vdc actuators are qualified for their safety-related functions at SSES. This conclusion holds for the full range of dc voltages expected at SSES including the peak dc system voltage of 288 Vdc.

Certain Limitorque motor operators for valves at SSES Units 1 & 2 have 250 Vdc motors and control circuits. These valves are listed in Tables 1 and 2 by room and motor manufacturer. The endnotes listed by the room numbers refer to Table 3, which provides the environments for the rooms as taken from the Susquehanna Equipment Qualification Harsh Environment Zones prints [1]. All of these valve operators are located outside of containment. Therefore, none are subjected to direct LOCA conditions. There are two "harsh" environments associated with a group of these valves. Some of these valves must be operable during and following a HELB in their room. Some must be operable during secondary effects associated with LOCA conditions.

HELB CONDITIONS

The peak temperature of each HELB that is applicable to SSES 250 Vdc Limitorque motor operators lasts less than 1 minute. The pressure for each HELB has a 1 to 2 second initial spike followed by a low pressure plateau followed by a decay to atmospheric pressure in 1 minute or less. The following table lists the rooms and associated HELB conditions. The rooms are placed into two groups, Group 'a' and 'b' for convenience of analysis.

Room Group	HELB Condition	Associated Rooms
a	300°F-15 sec, 8.2 psig-0.25 sec, 0.7 psig-0.75 sec, 2.6 psig for 3.5 sec, ramp to atmospheric at 5.6 sec	I-411, I-520, II-411, II-520
b	300°F-60 sec, 4.2 psig-1 sec, 0.5 psig-59 sec	I-11, I-106, II-11, II-106
b	300°F-60 sec, 2.2 psig-1 sec, 0.5 psig-59 sec	I-202, I-204, II-202, II-204
b	240°F-25 sec, 0.6 psig-0.5 sec, atmosphic pressure thereafter	I-12, I-107, II-12, II-107

Bechtel Calculation No. 18-78 [2], Rev 1, provides more detailed pressure curves for the Group 'a' HELBs than are contained in Reference 1. The Group 'a' rooms are in vertical portion of the Main Steam Tunnel. In this calculation, the pressure in these rooms change from atmospheric to 8.2 psig and back to 0.5 psig in less than 1/4 second. At 1 second, the pressure increases to 2.6 psig and remains there until 4 seconds afterwhich the pressure decays to atmospheric at 5.6 seconds. The profile for this HELB is shown in Figure 1. The 8.2 psig peak pressure is associated with the pressure wave being pushed by the steam just after the break occurs. As such it is predominantly dry air that is followed by the steam. Therefore, the actual superheated steam environment occurs during the 0.7 and 2.6 psig portions of the profile.

Bechtel Calculation No. 2113 [3] for Susquehanna, Rev. 1, Sheets 96 through 105, provide the temperature curves for the Group b HELBs. The temperatures in the rooms reach their peak temperatures in 12 to 30 seconds. Per the calculation, each room has temperature detectors that cause isolation of the associated HELB upon detection of elevated temperature. The calculation bases the duration of the events upon either depletion of the steam inventories or isolation of the break as appropriate. The calculations are based upon frictionless steam flow from the time of the break until the pressure wave is transmitted from the break and back again. There after the flow is based upon the cumulative frictions from the break to the point of release to the atmosphere. The rooms either are vented via a vertical vent duct on the building exterior or via another room that then feeds to the vent duct. The friction of the room vents, the vent duct and its weather cover are modeled in the calculation. Sheets 86 through 95 of the Calculation provide the pressure plots for the HELBs. These plots show that the peak pressures are only associated with the pressure wave at the start of the event. Thereafter, the pressure drops to 2.2 psig or less for the next second, and 0.5 psig or less until the isolation of the breaks which occur within 60 seconds. As such, the peak pressure, which is the driving function for forcing moisture into components is only available for 2 seconds or less. Thereafter, a pressure only slightly greater than atmospheric occurs until isolation of the break within 60 seconds or less. The profile that envelopes all of the Group 'b' rooms is provided in Figure 2. As with the Group 'a' profile, the peak pressures of the Group 'b' rooms are associated with the pressure wave of the air being driven from the rooms by the steam. The 0.5 psig portions of these profiles are at superheated steam conditions, rather than the peaks.

After the break is isolated, temperatures will decay rapidly to slightly higher than the original room temperatures and then decay back to near normal temperatures in the course of hours to a few days. Following a HELB in a particular room, the associated pumps in the rooms will not be operated because the postulated HELBs are in lines that are connect to the pumps. Therefore, the primary heat sources for the rooms (i.e., operating pumps) are not available to cause heating of the room. Most of the energy from the HELB discharge will be vented to the atmosphere as the steam exhausts through the building vent stacks.

As soon as the pressure condition of the HELB profiles is gone, the driving function that would tend to drive moisture into the operators would be eliminated. Therefore, with respect to the HELB condition, only the periods of pressurization are of importance with respect to driving moisture into the components.

The temperature following the isolation of a HELB will rapidly d[illegible] the pressure of the steam drops to atmospheric pressure and replacement steam ce[illegible] flow. Therefore, at the end of 60 seconds or less, the ambient temperatu[illegible] drop immediately to 212°F, the saturation temperature of 0 psig steam. The ambien[illegible]perature will continue to drop rapidly with the room returning to near normal temperatu[illegible]within approximately an hour. Within 24 hours the temperature within the room should be [illegible]arly restored to the original temperature as the building structures absorb the residual heat. The short duration of the temperature and extremely short duration of the pressure assure low deposition of energy to the MOVs causing little temperature rise to occur prior to the end of the pressure and temperature spikes. The predominant effect from these HELBs will be a high humidity environment at the end of the event. The humidity condition and the temperature under the HELB conditions will be evaluated further in this document for the Limitorque 250 Vdc operators.

SECONDARY EFFECTS OF LOCA

The locations of the 250 Vdc motor operators only experience secondary effects of a LOCA in containment. These effects in the associated rooms are predominantly from radiation. The most severe temperatures in these rooms during a LOCA event is from 139-141°F. The rooms with less severe LOCA event related temperatures have peak temperatures of 123-130°F. None of these temperatures represent severe conditions for an industrial motor operated valve, especially in comparison to the worst case normal temperature of 130°F for Rooms I-411, I-520, II-411, and II-520. Regarding LOCA effects temperatures, these rooms would fit the 10CFR50 definition of mild environment (i.e., A mild environment is an environment that would at no time be significantly more severe than the environment that would occur during normal plant operation, including anticipated operational occurrences.). Therefore, temperatures during LOCA events are not of concern. However, some of the rooms have moderate radiation dose during LOCA events predominantly from recirculation of radioactive fluids. The rooms with the highest radiation levels associated with LOCA conditions have doses ranging from 1.7E6 to 3.7E6 rd gamma with 4.3E5 rd beta. The rooms with less severe radiation doses have doses ranging from 1.7E3 to 1.5E4 rd gamma with 4.3E5 rd beta.

CONCLUSIONS RELATED TO ENVIRONMENTAL CONDITIONS

Based on the above, the two separate conditions that need to be evaluated for the 250 Vdc motors are the limited duration pressure and temperature spikes from the HELBs, and the radiation doses associated with LOCA conditions. The HELB humidity and temperature effects will be analyzed separately from the LOCA radiation condition because the HELB and LOCA conditions do not occur simultaneously. The following subsections provide these analyses.

LOCA RADIATION ANALYSIS

The rooms with the highest total integrated normal and accident doses are Rooms I-501 and II-501 with normal doses of 3.5E6 rd gamma, and accident doses of 3.5E6 rd gamma and 4.3E5 rd beta. These doses envelop all of the doses for the remainder of the rooms; therefore, the radiation assessment for the 250 Vdc Limitorque motor operators will be based on this gamma and beta dose.

Table 4 is a list of valves that are affected by radiation only during a LOCA or small break accident (SBA). This table was derived from an analysis of accident functions. The MOVs listed in Table 4 do not have HELB functions. The valves listed in Table 5 also would experience radiation during their LOCA functions. While most of the MOVs perform their LOCA functions within one hour of the on-set of a LOCA, nearly all are required for the full duration of an SBA. To perform a conservative analysis of SBA conditions, the bounding 180 day, total integrated LOCA dose for gamma and beta radiation will be used as basis of the qualification. The beta dose will be reduced by a large factor by the motor and switch cavity housings. However, again for conservatism, beta and gamma radiation will be summed and used as the total limit. The combined normal and accident doses is 7.43E6 rd.

For organic materials contained within motors, large doses of ionizing radiation will lead to embrittlement and ultimately cracking of the insulation and support materials. For most materials of the types used in motors, this condition would not occur until well above 200 Mrd. Even for values above 200 Mrd, embrittlement would not be of concern until through cracks developed in the insulation, and even then, motor failure would only occur if the insulation became wetted. Under the LOCA scenarios for the subject MOVs, while high humidity could occur in the associated rooms during the event, there would be no steam or pressurized condition. Therefore, there would be no driving function to force humidity into the MOV. Therefore, even if severe embrittlement were to occur at Susquehanna, 250 Vdc motor failure would not be expected. With regard to the limit and torque switches, the Melamine, Fibrite and phenolic materials of the insulation and structural system is also tolerant of radiation to well in excess of 200 Mrd. This insulation would not be exposed to high humidity conditions during LOCA events.

The tests of ac and dc MOVs performed by Limitorque in their various programs show that the motor and switch insulations are tolerant of at least 200 Mrd. The following summarizes the radiation test level by motor type and Limitorque test:

Test No.	Irradiation (Mrd)	Motor Manu.	Motor Description
600376A	204	Reliance	Class H Radiation Insulation, Tested at 480 Vac post irradiation IR = 500 Mohms (motor), 200 Mohms (switches). Saturated steam test followed. (Melamine switches)
600456	204	Reliance	Class RH insulation, 460 Vac, post-irradiation IR, 400 Mohms (motor leads), 180 Mohms (switches). (Melamine switches)
B0003	20	Reliance	Class B, 480 Vac, post-irradiation IR 500 Mohms (motor), 500 Mohms (switches) (unit connected to actuator) (Phenolic switches)
B0003	20	Reliance	Class B, 480 Vac, post-irradiation IR 490 Mohms (separate motor in test not on actuator)
B0003	20	Electric App.	Class B, 480 Vac, post-irradiation IR 490 Mohms (separate motor in test not on actuator)
B0009	10	H. K. Porter	Class H, 125 Vdc, 150 Mohms (shunt and field), 200 Mohms (switches). (Melamine switches)

These data indicate that 10 Mrd to 204 Mrd have no significant effect on the electrical properties of the motor windings and switch insulation. The Reliance Class H, RH and B systems are representative of the insulations used in the Reliance 250 Vdc motors at SSES. The H. K. Porter motor is representative of the Peerless motors in use at SSES in that H. K. Porter produced Peerless motors and the motor line became known as Peerless. The Reliance 480 Vac motors are representative of the winding materials in the Reliance 250 Vdc motors. By nature the materials selected for use in Class B and higher ratings are both temperature and radiation resistant. Thermosetting winding insulation and coatings are used in motors to attain the temperature ratings required for Class B, F and H ratings. Class R and RH ratings are based on Class F and H temperature classifications with materials specifically chosen to withstand high radiation levels (i.e., 200 Mrd). Thermosetting materials are used as wire insulation and as impregnation materials for the overall winding. Once these materials are baked in the curing process, they do not soften when reheated. These materials have been chosen for use because of their resistance to thermal aging with additional thermal aging resistance as the Class level increases. Class B insulations have a hot spot rating of 130°C, Class F 155°C, and Class H 180°C [4]. In general, thermosetting materials used in Class B and higher level insulations have good radiation resistance with Class R and RH insulation systems having good radiation resistance by purposeful design. Table 3-1 of EPRI Report NP-4172, "Radiation Data for Design/Qualification of Nuclear Power Plant Equipment" [5], provides a listing of thermosetting insulations. Review of the list of thermoset materials against the radiation withstand data contained on pages B-10 through B-132 of Reference 5 shows that as a class thermoset materials retain their engineering properties through 10 Mrd with most of the materials retaining their properties to 100 Mrd or more. The most limiting material was polyester resin with a 20% loss of elongation at 8 Mrd. Even if polyester resin had been used in a Class B motor a 20% loss of elongation would not lead to cracking or inability to withstand coil motion during inrush at the start of operation. Further data contained in Reference 5 shows that the particular polyester resin maintained 50% elongation at 1,000 Mrd indicating that the loss of properties is gradual with increasing radiation level and providing further confidence that such a material would not affect the ability of a motor to operate in a radiation environment. All of the other materials retained their properties to levels at or above 10 Mrd. These data indicate that the windings will not crack nor embrittle to the point where mechanical failure would occur upon operation of the motor. Therefore at the maximum radiation dose at SSES of 7.43 Mrd, the winding insulation will maintain its structural integrity, and as such will also maintain its electrical insulation capability by maintaining electrical separation between conductors in the winding. These same thermosetting materials would also be used as supports for the brush rigging system and would retain their properties for these applications as well.

The 480 Vac motor windings are subjected to a peak voltage of 679 volts phase to phase and 391 volts phase to ground which is well above the voltage stress at the 250 Vdc level. The post-irradiation insulation test for the Porter (Peerless) motor indicates that even at the 250 Vdc level, the insulation leakage was 1.7 microamps, which is negligible. For any of the insulation material types used, as long as the mechanical integrity of the insulation remained, no signification change in dielectric strength would be expected. A dry, unembrittled insulation will retain its electrical capabilities. These are the conditions that would occur under the secondary effects of a LOCA at SSES for these motors.

The insulation resistance of the limit and torque switches in these tests show that irradiation to levels well beyond the SSES normal and 180 day, secondary effect of LOCA TID of 7.43 Mrd has no significant effect. The lowest insulation resistance for the limit and torque switches following radiation of 180 Mohms indicates that the maximum expected leakage current across any segment of a torque or limit switch is 1.4 microamps at 250 Vdc.

Based on the above information, the Susquehanna 250 Vdc Limitorque actuators, whether supplied with Class B, H, or RH motors, are qualified for the radiation doses from secondary effects of a LOCA environment.

MOTOR AND SWITCH HOUSING SEALING

The 250 Vdc motors in use on the Susquehanna 250 Vdc motor operators are of totally enclosed non-ventilated construction. There are no vents in the motor housing and the motor lead opening on the motor endbell is potted to prevent moisture intrusion.

The switch housing covers are equipped with a gas permiable seal that limits rapid ingress of moisture, but allows the housing to breath. The conduit connections to the switch housing are not required to be sealed. The following analysis assumes that steam is allowed to rapidly enter the switch compartment in an unrestricted manner. Therefore, unsealed conduits and damaged or missing compartment seals would be allowable without affecting the environmental qualification status.

HELB HUMIDITY AND TEMPERATURE ANALYSIS

Scope and Applicability

Table 4 lists the valves that have no HELB related safety functions. These valves do not need to be qualified for HELB conditions. Table 5 lists those valves that have safety functions when subjected to HELB environments. There are only six valves with HELB functions: HV E41 1F003, HV E41 2F003, HV E51 1F008, HV E51 2F008, HV G33 1F004, and HV G33 2F004. Each of these valves has a diverse ac motor operated valve in series on the associated line located inside containment. These diverse valves receive the same closing signals as their dc counterparts and will not experience the HELB environment. Table 5 also lists the function of the valve and duration of the HELB function. The longest duration of a HELB function is 2 minutes.

The HELB environments associated with the six valves are as follows:

Valves	Environment
HV E41 1F003, 2F003 HV E51 1F008, 2F008	300°F-60 sec, 2.2 psig-1 sec, 0.5 psig-59 sec, atmospheric thereafter.
HV G33 1F004, 2F004	212°F-40 sec, 2.2 psig-1 sec, 1 psig-0.5 sec, 0.4 psig 38 sec, atmospheric thereafter.

While the Table 4 valves do not require qualification for HELB conditions, they are qualified for the condition under the analysis which follows. The analysis is based upon free passage of steam into the compartment during the 0.5 and 2.6 psig periods of the HELBs even though the flow will be restricted by any bottom entry conduits. In reality, the pressure drop along the conduit will be such that moisture will gradually enter the compartment during the minute rather than fill it and continue to condense.

Switch Housing Analysis

Steam and Condensation

At the onset of the postulated HELBs for Susquehanna, there is a 1 to 1.5 second pressure wave, accompanied by a rapid increase in ambient temperature. The enveloping condition is as follows:

0-4 s	Ramp to 240°F
4-16 s	Ramp from 240°F to 300°F
16-60 s	300°F
60 s	Drop to 212°F
60 s to 1 hr	Drop to normal + 15°F

The drop in temperature at 60 seconds will occur very rapidly as the pressure decays to 0 and there is no replacement steam. The temperature will drop to 212°F, the saturation temperature of 0 psig steam. Thereafter, the temperature will drop rapidly to near normal temperatures as the structures and equipment absorb the heat.

For the Susquehanna HELBs, the pressure that would cause moisture to be driven into the MOVs has a 1 to 2 second peak followed by a 0.5 psig lasting for less than 1 minute. The following are the enveloping pressure conditions:

Group 'a' Rooms:

0-0.25 sec	8.2 psig
0.25-1 sec	0.7 psig
1-5 sec	2.6 psig
5-5.5 sec	Return to atmospheric pressure

Group 'b' Rooms:

0-1 sec	4.2 psig
1-2 sec	2.2 psig
2-60 sec	0.5 psig
60 sec	return to atmospheric pressure

The 0.25 second duration of the 300°F, 8.2 psig superheated transient of the Group 'a' Rooms is predominantly a pressurized air wave being forced through the room in front of the initial blast of steam. Because the pressure wave is composed of mostly dry air and has a short duration, no appreciable amount of steam will enter the switch housing. Similarly, the 1 second 4.2 psig and 1 second 2.2 psig periods for the Group 'b' Rooms would also be composed of predominantly dry air and are of too short of a duration to force significant amounts of steam into the cavity. For the Group 'a' Rooms, the 4 second 2.6 psig period could cause some steam to the cavity through any open bottom entry conduit. Similarly for the Group 'b' Rooms, the 0.5 psig 58 second period could cause some steam to be condensed in the switch cavities. These conditions will be evaluated further.

With regard to temperature, the superheated steam looses energy rapidly in the vicinity of colder structures and components, dropping to the saturated steam temperature corresponding to the pressure. This effect is demonstrated in Limitorque's B-0027 Report of superheated ambient temperature tests [6]. In this test, a temperature instrumented actuator was subjected to a 385°F, 66 psig 3 minute transient. When the test chamber reached a peak temperature of 390°F, the limit switch compartment ambient reached 312°F per Figure 3 of Reference 6. Table B.1B of Reynolds' "Thermodynamics" [7] states that 66 psig steam has a saturation temperature of 312°F. Accordingly, 300°F, 2.6 psig steam impinging upon the surface of the actuator at the end of 1 second would cause at most a

220°F [per Table B.1A of Reference 7] saturated steam/air mixture at the surface of the motor operator. The following is a list of the saturated temperature that the pressures associated with the Susquehanna HELBs will support:

Pressure	Saturated Temperature [7]
2.6 psig	220°F
2.2 psig	219°F
1.0 psig	215°F
0.5 psig	214°F

For the Group 'a' Rooms, the 2.6 psig, 4 second period would support a condensing steam temperature of 220°F. When the pressure drops to atmospheric, the steam temperature will drop to 212°F immediately and then drop rapidly in temperature because the steam supply has been removed.

For the Group 'b' Rooms, the pressure drop at 2 seconds to 0.7 psig, the temperature at the surface of the operator would drop to 214°F for the remainder of the 1 minute period. Again, when the pressure drops to atmospheric the temperature will immediately drop to 212°F and then drop rapidly towards normal temperature because the steam supply has been removed.

The following will analyze the potential condensation within the switch housing under the conservative assumption that the housing is open to the environment. In reality, with the bottom entry conduits being the only entry path to the switch housing, much of the moisture in the steam will condense in the conduits prior to reaching the switch cavity, and the steam entering the far end of the conduit will force the dry air in the conduit into the switch housing causing a back pressure that will prevent entry of the moist steam. (This phenomenon occurs because of the low pressures and the short durations involved. High pressure longer duration steam conditions will compress the air in the cavity and enter it causing much more severe condensation conditions.)

Assuming free entry of the steam, the surface of the switches and other components would begin to warm as the steam begins to enter the cavity. The body of the components below the surface would not experience a significant increase in temperature in the first minute. This condition is again demonstrated by Limitorque's superheated steam tests described in Reference 6, in which the motor operator was exposed to 385°F, 66 psig steam. At the onset of the test, the switch compartment ambient temperature reached 300°F within 45 seconds. At the same time, the thermocouples on the surface of the switch components had only reached 160°F from a starting temperature of 100°F. At the end of a full minute the surface temperature of the switch components had only reach 180°F. Based on the Limitorque superheated steam tests and given the assumption that steam flows freely into the compartment, the switch component surfaces would be expected to experience well less than a 180°F peak temperature during a postulated Susquehanna HELB. Thereafter, the temperature will rapidly drop because the energy source is removed. Again these values are related to a test in which the exterior of the motor actuator was being exposed to 385°F, 66 psig steam, a much more severe condition than that expected at Susquehanna. For the Group 'a' Rooms, interpolation of these data to a 130°F starting point, the highest normal ambient temperature for any of the rooms, and a 219°F peak ambient saturated temperature associated with a 2.6 psig pressure, indicates that the surface temperature of components within the switch compartment of the operator would at most be approximately 153°F. For the Group 'b' Rooms, the peak surface temperature with a starting temperature of 115°F would be approximately 155°F.

During the first seconds of a HELB in either Group 'a' or 'b' Rooms, the steam environment outside the switch compartment would be restricted from entering the compartment by the conduit. While resistance to flow is not readily identifiable, it is obvious that the full pressure of the pressure spikes will not occur within the compartment. However, the 2.6 psig, 4 second condition for the Group 'a' Rooms, and the 0.5 psig, 58 second condition for the Group 'b' Rooms could be expected to cause steam entry. During these periods, new steam would enter the cavity as the existing steam condensed. While much of this steam would condense in the conduit and not enter the cavity, this analysis assumes that all of the condensation occurs within the cavity. When the pressure in the rooms drops to atmospheric pressure at the end of the events, no further moisture will enter the cavity.

The amount of steam condensed during the period is proportional to the average surface temperature of the components in the housing, the enthalpy of the steam and the size of the compartment. The largest 250 Vdc actuator in use is an SMB-3. The volume of the switch compartment is 16" x 11" x 11" = 1,936 in or 1.12 cu ft [8]. Conservatively assuming that 20% of this volume is filled with the limit and torque switches and wire, the volume of free space is 0.9 cu ft.

For the Group 'b' Rooms, the maximum amount of steam will enter the volume and condense under the assumption that the 300°F, 0.5 psig steam is rapidly entering the compartment and heat is being absorbed rapidly to bring the steam to the saturation of 214°F. The total amount of steam that condenses in the cavity will be proportional to the heat absorbed by the components in the cavity and the cavity walls. The actuator will slowly begin to heat during the 1 minute HELB; it will not attain a uniform temperature through out its volume. However, by conservatively assuming that a portion of the mass of the cover, switches, wire and actuator wall have been heated to the 155°F surface temperature identified above, a conservative value for condensation can be determined. For the purposes of this analysis, an 85°F initial temperature is assumed. The following surface masses were conservatively assumed to have been uniformly heated to 155°F during the HELB:

Cover	2 lbs (also being heated externally)
Switches with gearbox	2 lbs
Wire	0.2 lbs
Actuator wall	3 lbs.

The total mass heated to 155°F is 7.2 lbs. The change in temperature was 70°F resulting in absorption of 504 BTUs ((155-85°F))x 7.2 lbs.).

The mass of steam condensed during condensation from 300°F to 155°F is equal to the heat absorbed during reduction of temperature of the steam from 300°F to 212°F (45 BTU/lb) plus the heat absorbed in condensing the 212°F steam to 212°F water (970.3 BTU/lb), plus the heat absorbed in further cooling the water to 155°F (57 BTU/lb). Given that 504 BTUs were absorbed by the compartment and components, the mass of steam condensed equals:

$$\frac{504 \text{ BTU}}{(45 + 970.3 + 57) \text{ BTU/lb}} = 0.47 \text{ lbs}$$

Given that a pound of water has a mass of 62.32 lb/cu ft, the volume of this liquid is 0.0075 cu ft, or 13 cu in. The area of the bottom of the compartment is 176 square in. Spreading the water over the surface results in a depth of no more than 0.07 in, which is insufficient to flood any component in the switch housing. Because the air in the cavity will remain there during the event, only a small percentage of the volume will be filled with steam. At 0.5 psig, the volume will be at a pressure of 1.03 atmospheres, providing approximately 7% by volume of water vapor. The available space for condensing steam coupled with condensation dropout in the conduits will reduce the condensed steam by a factor of approximately 10, resulting in a more realistic 1.3 cu in of condensation. Even if the actuator were turned to cause the water to lay in a cup the worst case depth would be less than 1.8 inch. This height would occur only when a corner of the switch housing were pointing directly down. Evaluation of component configurations shown in Limitorque Bulletin 871 show that the gear box of the limit switch assures that no energized portion will be flooded or near flooded. Likewise, the locations of the torque switch circuits and terminal blocks assure that they will not be flooded.

These conclusions are conservative because:

- o Rapid in-leakage of the steam rather than gradual pressurization and moisture ingress has been assumed,
- o The assumed surface temperature of the switches is very conservative with respect to the expected value (i.e., instantantaneous heating to a uniform temperature of 155°F was assumed), and
- o The mass that has absorbed heat has been assumed to uniformly attain the peak surface temperature rather than having a temperature gradient proportional to the depth from the surface.

Each of the assumptions causes the over estimation of the amount of condensed water and indicates that at worst, a high humidity, moist condition rather than a flooded or wet condition will occur.

A similar analysis can be performed for the Group 'a' Rooms except that the duration of the event must be taken into account. Again, the transient of the Limitorque superheat test [6] can be conservatively used to provide data. The rate of change in temperature of the components in the switch housing during the transient is 140°F/minute with a 385°F, 66 psig condition outside the housing and a 300°F condition within the housing. Assuming that the Susquehanna housings were unsealed, and using the data from this much more severe condition, the maximum change in surface temperature of the components in 5 seconds would be 5(140°F/60 sec) or 11.7°F. Assuming that the surface mass was uniformly heated and using the surface mass described above (7.2 lbs), the heat absorbed during the transient is 84 BTU. Assuming that the room was at 130°F (the peak normal temperature for the Group 'a' Rooms), the peak surface temperature would be 141.7°F. To determine the heat absorbed, the same formula derived above would be used except that 70.3 BTU/lb would be absorbed to cause the temperature to drop from 212°F to 141.7°F. The amount of water condensed is:

$$\frac{84 \text{ BTU}}{(45 + 970.3 + 70.3) \text{ BTU/lb}} = 0.08 \text{ lbs},$$

which is much less than that calculated for the Group 'b' Rooms. Therefore, no switch housing component flooding could occur for the 250 vdc actuators in Group 'a' Rooms.

Because there is no flooding of the electrical components, only a humid environment would occur within the switch housing. There are no caustic sprays nor any kind of spray condition involved with the HELBs. Therefore, only water vapor on surfaces is of concern. The continuous current ratings of the limit and torque switches is 0.55 A at 230 Vdc and 0.2 A at 550 Vdc per Reference [9]. The switches control position indicating lights and contactors located in the associated motor control center. The maximum expected continuous current on any contact is less than 0.5 amp, which occurs when the contactors are energized during the stroking of the associated valves. The ratings indicate that there is more than sufficient insulation capability for 250 Vdc applications. During the Limitorque LOCA tests, the limit and torque switches were powered from a 120 Vac source that was independent of the motor voltage. The peak ac voltage would have been 1.41 times the rms value or 169 V during the duration of the LOCA tests. Periodic 500 Vdc insulation resistance tests were also taken during these tests. In Limitorque Report B0003 in which phenolic switches were tested, the limit and torque switch IRs were 100 kilohms each after 15 minutes exposure to 250°F, 25 psig steam. In Limitorque Report B0212 in which the Fibrite switches were tested, the minimum insulation resistance was 200 kilohms for the limit switch and 40 kilohms for the torque switch with an ambient condition of 301°F at 59 psig for 20 minutes which was preceded by two 460°F, 72 psig 3 minute transients. Chemical spray was also in operation during the insulation resistance measurement.

In the test for the phenolic switches, the insulation resistance would have allowed no more than 2.9 mA leakage (288 Vdc/100 k-ohms) at any of the switch leads. In the test of the Fibrite switches, the leakage current for the limit switch leads would have been 1.5 mA (288 Vdc/200 k-ohms), and for the torque switches would have been 7.2 mA (288 Vdc/40 k-ohms). It must be noted that in the case of the phenolic switches, the surface temperature of the switch would have been at least 95°F (250°F-155°F) greater than that of the Susquehanna 250 Vdc switches at the end of the HELB, and that the Fibrite switches the test temperature would have been 155°F (310°F-155°F) greater. At minimum these differences would have accounted for a decade drop in insulation resistance, which for organic materials is inversely proportional to temperature. An example of this phenomenon is shown in Sandia tests of terminal blocks [10]. In a steam environment at 341°F, the terminal blocks had an insulation resistance of 3.5 kilohms. When the temperature dropped to 320°F the insulation resistance increased to 9 kilohms. When the temperature dropped to 302°F, the insulation resistance increased to 15 kilohms. The total drop of 39°F caused a 4.3 times improvement in insulation resistance. The design of the terminal blocks and the Limitorque switches uses similar principals in which surface and volume resistances are used to insulate contacts from one another. Under this phenomenon, the actual leakage currents during the Susquehanna HELBs will be between 0.15 and 0.7 mA per circuit, which is satisfactory in control circuits.

The short duration of the safety function given a HELB also provides assurance that no significant deterioration of function will occur when the valves are needed. The valves that must function during a HELB fulfill their function in less than 2 minutes. These functions are automatically initiated upon detection of elevated temperatures in the cavity. According to Bechtel Calculation No. 2113, the initiation signals for closure of the valves occurs within 1 to 8 seconds of the start of the HELB. Therefore, the functions of the actuators are complete in a short period of time. Even when a 1 hour time margin is applied in accordance with Regulatory Guide 1.89, Rev 1 to their duration of operation, the actuators will only experience 1 hour and 2 minutes of exposure to a high humidity environment.

Testing of Junction Boxes under HELB Conditions

Reference [11] describes a series of tests performed by the Washington Public Power Supply System on components in junction boxes under HELB conditions. These tests are of interest because the junction boxes had unsealed conduits and 3/8-inch drain holes making the conditions similar to that of an unsealed limit switch housing. The test specimens were as follows:

Test Unit 1

Box - 20 x 20 x 5 inch Hoffman NEMA 12 with 2 inch elbow with a watertight fitting (Note: There was no sealant in the elbow. Steam could pass around the wires entering the elbow and flow into the box.) The box also had a 3/8" drain hole in the bottom.

Circuits - GE CR151A terminal block connected to a thermocouple.
Weidmuller SAK 2.5 terminal block connected to a thermocouple.
Weidmuller SAK 4 terminal block connected to a Rosemount transmitter.
Weidmuller SAK 10 terminal block connected to a Rosemount transmitter.

Note: The connected components were located outside of the test chamber. The terminal blocks and associated connections were within the boxes that were exposed to the HELB conditions.

Test Unit 2

Box - 24 x 12 x 5 inch NEMA 4 Hoffman box with a 2-inch conduit elbow with watertight fittings on the top (24 inch) side and a 3/8-inch drain hole. The conduit was unsealed.

Circuits- GE CR151B terminal block connected to a 135 Vac/ 140 Vdc voltage loop and a Rosemount transmitter.
Buchanan B112 terminal block connected to a 135 Vac/140 Vdc voltage loop, a Rosemount transmitter, an HFA, and an HMA relay.

Test Unit 3

Box - 16 x 12 x 5 inch NEMA 4 Hoffman box with a 14 inch piece of Anaconda 3/4 inch Type UAP flexible conduit extending from the bottom connected to a NAMCO EA740 limit switch, which was mounted horizontally. The flexible conduit was unsealed. The entry conduit to this box was mounted on the side of the box at the top right hand corner. The entry conduit was unsealed. Photograph I-33 of the report shows a 3/8-inch drain hole.

Circuit - The NAMCO switch was energized at 135 Vac.

The circuits except for the thermocouples were equiped with leakage current detection. The Test Units were sequentially exposed to the following profiles:

HELB Profile 1. Peak Temperature - 220°F

Period	Temperature
0-70 sec	205°F/0 psig
70 sec-3 min	205°F/1.4 psig
3 min-5 min	200°F/1.4 psig
5 min - 2 hr 40 min	200°F ramping to 145°F/ 0.2 psig
2 hr 40 min to 16 hrs	145°F/0.2 psig

HELB Profile 2

Period	Temperature/Pressure

0 - 2 min	270°F/3.4 psig
2 min to 2 hrs 40 min	215°F ramping to 150°F/ 0 to 1 psig (varying)
2 hrs 40 min to 16 hrs	145°F/0.4 psig

During and after the exposure to HELB Profile 1, there were no eratic operation of the connected devices. The acceptance criteria of no more than 30 mA from terminal to terminal or terminal to ground was met. In fact, the leakage current during the test was less than the limit of detection which was 50 microamps. (A 1.7 milliamp was detected on one circuit but was determined to be a problem with the detection circuit rather than the specimen.) HELB Profile 2 was administered immediately after the completion of the HELB Profile 1 test. Again, no misoperations or detectible leakage currents were observed.

Immediately following the application of the HELB Profile 2, the chamber was openned and the Test Units were inspected. The following was observed:

- o There was no evidence of moisture in the NAMCO EA740 limit switch. No evidence of any electrical tracking or breakdown was observed. The associated terminal box had a light moisture film (Per Photograph I-33)

- o The inspection of the box of Test Unit 1 revealed a small spot of residue, that dripped off the cables in the box, having an area of a few square inches. There was no signs of heavy wetting. (Per Photograph I-31)

- o The inspection of the box of Test Unit 2 revealed a small indication of residue that again dripped off the cables, which again had a area of a few square inches. There were no signs of heavy wetting. (Per Photograph I-32)

The tests show that under steam pressure conditions that were more severe and much longer duration that insignificant amounts of steam condense in the terminal boxes, and that this steam has no significant effect on leakage current to ground. At 140 Vac, less than 0.05 milliamps of leakage current occurred to ground.

Conclusions from the HELB Testing of the Terminal Boxes

While the temperatures of the tests were somewhat lower than that of the SSES HELBs (205 and 270°F for the tests and 300°F for the worst case SSES HELBs), the pressures and duration of the tests are more than adequate compensation. The testing of the terminal boxes indicates that the analysis of the effects of the SSES HELBs on the Limitorque actuators is extremely conservative and that at most a light moistening will occur within the switch housing. The terminal boxes that were tested have similar volumes (1936 cu in for the motor operator switch housing, and 960, 1440, 2000-cu inches for the tested boxes). The pressure profiles were more severe for the boxes than the 60-sec duration 0.5 psig and 4-sec duration 2.6 psig profiles of SSES by a large margin. Given that the 2-inch conduits and drain holes for the test boxes were unsealed and provided free access to the steam, it is obvious that the original air in the boxes helped prevent significant amounts of steam from entering, and that the duration of the HELBs was short enough to prevent continuous condensation and replacement of steam such that puddles would accumlate within the boxes. The low leakage currents indicate that little moisture actually accumlated on the terminal blocks and leads during the tests. The 16 hour high humidity condition following the HELB transients during the test also provide confidence that the continued presense of moisture outside of a box (including the switch housing of the motor operators) will have no significant effect on the components inside the box. These test results provide the confidence necessary to conclude that the switches within the 250 Vdc motor operators at SSES will successfully withstand the short duration HELBs postulated for the station.

Thermal Effects

The effects of a thermal spike to the organic switch components is minimal. The internal wiring used in the motor operators is fully qualified for Susquehanna LOCA environments and is either Rockbestos SIS, Raychem Flamtrol, or Anaconda NSIS per PP&L Specification No. C-1065 [12]. Being fully environmentally qualified for a LOCA, the wire insulation will be unaffected by the moist, warm environment in the switch housing. The limit and torque switches are either Fibrite or phenolic, both of which have been qualification tested to full LOCA conditions (see further discussions of torque and limit switch capability below).

Terminal blocks or splices are allowed to be used for motor connections in the 250 Vdc MOVs. When splices are used only fully qualified Raychem or taped splice configurations are allowed to be used. When terminal blocks are used, only Marathon 300 or 1600, Buchanan 0222 or 0524, or GE EB-5 qualified terminal blocks are allowed to be used.

The thermal effects of the pressure/temperature spike of the Susquehanna HELB are extremely minimal by comparison to those of a LOCA qualification test in which a 340°F saturated steam condition exists for 3 hours (Limitorque Test 600376A) or a 330°F saturated steam condition is held for 3 hours (Limitorque Test B0009 for DC Actuators). Therefore, no physical damage would occur to switch housing organic components including the limit and torque switch blocks from the conditions within the switch housing that were induced by the HELB.

Motor Analysis

The wireways of the dc motors supplied by Limitorque are potted preventing draining of limit switch compartment liquids into the motor. The 250 Vdc motors are sealed units and do not have drains. Therefore, the motors will not experience the moist condensing conditions during the HELB. Steam condensing on their surface will cause a small increase in surface temperature. Due to the large mass, the surface temperature will probably be less than 163°F at the end of the HELB pulse. Due to the short duration of the HELB, the motor will not absorb a significant amount of heat and the internals of the motor will experience only a small temperature rise.

Appendix IV of Limitorque Report B0009 provides before-LOCA and after-LOCA pictures of the internals of the Peerless dc motor used as a test specimen. Figure 1 shows the brush rig and commutator after 2000 aging cycles but before irradiation. Figures 3 and 4 show the same view after radiation and seismic testing, respectively. Figure 9 shows the commutator and brush rig after the 25 hour LOCA exposure which included:

- o 0 to 1 hr - Ramp to 340°F
- o 1 to 2 hr - 340°F
- o 2 to 4 hr - 330°F
- o 4 to 7 hr - 310°F
- o 7 to 25 hr - 212°F.

The tests were performed under saturated steam conditions. As such, they are much more severe in duration and energy content than the conditions expected at Susquehanna under th HELB conditions. Even though the conditions of the test were very much more severe tha those expected at Susquehanna, the photographs in the report show that the progressive tes segments caused no significant deterioration of the commutator and brush system, includin Figure 9, the post-LOCA photograph. These photographs are proof that the sealing of the motors is adequate to withstand the rigors of a much more severe condition. Therefore, t sealing of the motors is more than adequate for the minimal stresses represented by the Susquehanna HELBs. This analysis applies to any of the insulation types in use, Class B R, and RH, in that, at most, the insulation system experiences a dry, temperature excursi of 20°F, which is well within its rating. There is no moisture involved, nor is there a significant thermal transient.

CONCLUSIONS

Based on the above analyses, the 250 Vdc Limitorque motor operators for valves qualified for their safety functions under associated HELB and LOCA secondary effects environments. The very limited duration and intensitiy of the associated HELBs couple with the short duration of the safety function period assures that no significant amount degredation leading to common mode/cause failure exists. With regard to the radiation associated with secondary effects of a LOCA environment, the maximum total integrat dose of 7.43 megarads is insufficient to induce embrittlement or loss of insulation capa in the materials of construction of the motor and switches of the valve operators. The apply to the full range of dc system voltages including the peak voltage of 288 Vdc. Accordingly, these Limitorque 250 Vdc motor operators are environmentally qualified their applications.

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- o 1 to 2 hr - 340°F
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- o 4 to 7 hr - 310°F
- o 7 to 25 hr - 212°F.

The tests were performed under saturated steam conditions. As such, they are much more severe in duration and energy content than the conditions expected at Susquehanna under the HELB conditions. Even though the conditions of the test were very much more severe than those expected at Susquehanna, the photographs in the report show that the progressive test segments caused no significant deterioration of the commutator and brush system, including Figure 9, the post-LOCA photograph. These photographs are proof that the sealing of these motors is adequate to withstand the rigors of a much more severe condition. Therefore, the sealing of the motors is more than adequate for the minimal stresses represented by the Susquehanna HELBs. This analysis applies to any of the insulation types in use, Class B, F, R, and RH, in that, at most, the insulation system experiences a dry, temperature excursion of 20°F, which is well within its rating. There is no moisture involved, nor is there a significant thermal transient.

CONCLUSIONS

Based on the above analyses, the 250 Vdc Limitorque motor operators for valves are qualified for their safety functions under associated HELB and LOCA secondary effects environments. The very limited duration and intensitiy of the associated HELBs coupled with the short duration of the safety function period assures that no significant amount of degredation leading to common mode/cause failure exists. With regard to the radiation doses associated with secondary effects of a LOCA environment, the maximum total integrated dose of 7.43 megarads is insufficient to induce embrittlement or loss of insulation capabilities in the materials of construction of the motor and switches of the valve operators. The results apply to the full range of dc system voltages including the peak voltage of 288 Vdc. Accordingly, these Limitorque 250 Vdc motor operators are environmentally qualified for their applications.

REFERENCES

1 Susquehanna S.E.S. Unit 1 & 2 Reactor Bldg. Equipment Qualification Harsh Environment Zones, PP&L Drawing No. C206130, Sheets 1 to 20 Rev. 1.

2 Bechtel Job No. 8856, Susquehanna Units 1 & 2, Calculation No. 18-78, Rev. 2, Mainsteam Line Break (MSLB) Analysis for Main Steam Tunnel (MST), 3/7/83, which is incorporated into Bechtel Job No. 8856, Susquehann Units 1 & 2, Calculation No. 200-17 (Staff Calc. No. 2112), MSL Break Analysis for MST, 6/7/81.

3 Bechtel Job No. 8856, Susquehanna, Calculation No. 200-081 (Staff Calc. No. 2113), Rev. 1, Compartment Pressure and Temperature, 5/4/81

4 IEEE Standard 117-1974, Test Procedure for Evaluation of Systems of Insulating Materials for Random-Wound AC Electric Machinery.

5 "Radiation Data for Design and Qualification of Nuclear Plant Equipment," EPRI NP-4172SP, Electric Power Research Institute, August 1985.

6 Limitorque Valve Actuator Temperature Related to High Superheat Ambient Temperatures, Report No. B-0027, Rev. A., Limitorque Corporation Test Laboratory, October 18, 1978.

7 Reynolds, William C., Thermodynamics, McGraw-Hill Book Company, Second Edition, 1968.

8 Limitorque Bulletin 871, Type SMB, Valve Controls, Limitorque Corporation, 1980.

9 "Typical Specification, Gate/Globe/Sluice-Gate/Multi-Turn Actuators," Limitorque Corporation, TS-100A, April 1, 1983, SEA-EE-183, Page C16.

10 Figure 3.3.16 of NUREG/CR-4301, Status Report on Equipment Qualification Issues Research and Resolution, L. L. Bonzon et al, November 1986.

11 Wyle Test Report No. 48365-01, "Qualification Test Program on Terminal Blocks, NAMCO Limit Switch and Instrumentation Sealing Compound for the Washington Public Power Supply System for Use in the WNP-2 (Outside Containment)," September 8, 1986.

12 PP&L Specification No. C-1065, File No. R1-1, "Technical Specification for Limitorque MOVs Environmental Qualification Inspection," Rev. 3, 5/12/89

TABLE 1. LIST OF SUSQUEHANNA 250 Vdc MOTORS, UNIT 1

Device Identity No.	Room	HELB	LOCA Rad. (rd)	Motor Manufacturer
HV E41 1F011	I-10[1]	N/A	1.9E6	RELIANCE
HV E41 1F001	I-11[2]	B	1.7E3	RELIANCE
HV E41 1F004	I-11			RELIANCE
HV E41 1F042	I-11			RELIANCE
HV E41 1F059	I-11			PEERLESS
HV 15012	I-12[3]	E	2.9E3	RELIANCE
HV E51 1F010	I-12			RELIANCE
HV E51 1F031	I-12			RELIANCE
HV E51 1F045	I-12			RELIANCE
HV E51 1F046	I-12			PEERLESS
HV 15768	I-17[4]	N/A	1.9E6	RELIANCE
HV E41 1F007	I-102[5]	N/A	1.5E4	PEERLESS
HV E41 1F008	I-102			RELIANCE
HV E51 1F012	I-102			RELIANCE
HV E51 1F022	I-102			RELIANCE
HV E41 1F012	I-106[6]	C	1.7E3	RELIANCE
HV E41 1F066	I-106			RELIANCE
HV E41 1F075	I-106			RELIANCE
HV E41 1F079	I-106			RELIANCE
HV E51 1F060	I-107[7]	E	2.9E3	RELIANCE
HV E51 1F062	I-107			PEERLESS
HV E51 1F084	I-107			PEERLESS
HV E51 1F059	I-107			RELIANCE
HV E11 1F008	I-202[8]	D	1.7E6	RELIANCE
HV E11 1F049	I-202			PEERLESS
HV E51 1F008	I-202			RELIANCE
HV E41 1F003	I-202			RELIANCE
HV E11 1F023	I-204[9]	D	1.7E6	RELIANCE
HV B21 1F019	I-411[10]	A	3.7E6	PEERLESS
HV G33 1F004	I-501[11]	F	3.5E6	PEERLESS
HV E41 1F006	I-520[12]	A	3.7E6	PEERLESS
HV E51 1F013	I-520			RELIANCE

TABLE 2. LIST OF SUSQUEHANNA 250 Vdc MOTORS, UNIT 2

Identity No.	Room	HELB	LOCA Rad. (rd)	Motor Manufacturer
HV E41 2F011	II-10[1]	N/A	1.9E6	RELIANCE
HV E41 2F001	II-11[2]	B	1.7E3	RELIANCE
HV E41 2F004	II-11			RELIANCE
HV E41 2F042	II-11			RELIANCE
HV E41 2F059	II-11			RELIANCE
HV 25012	II-12[3]	E	2.9E3	PEERLESS
HV E51 2F010	II-12			RELIANCE
HV E51 2F031	II-12			RELIANCE
HV E51 2F045	II-12			RELIANCE
HV E51 2F046	II-12			PEERLESS
HV 25768	II-17[4]	N/A	1.9E6	RELIANCE
HV E41 2F007	II-102[5]	N/A	1.5E4	PEERLESS
HV E41 2F008	II-102			RELIANCE
HV E51 2F012	II-102			RELIANCE
HV E51 2F022	II-102			PEERLESS
HV E41 2F012	II-106[6]	C	1.7E3	PEERLESS
HV E41 2F066	II-106			RELIANCE
HV E41 2F075	II-106			RELIANCE
HV E41 2F079	II-106			RELIANCE
HV E51 2F059	II-107[7]	E	2.9E3	RELIANCE
HV E51 2F060	II-107			PEERLESS
HV E51 2F062	II-107			PEERLESS
HV E51 2F084	II-107			PEERLESS
HV E11 2F008	II-202[8]	D	1.7E6	RELIANCE
HV E11 2F049	II-202			PEERLESS
HV E41 2F003	II-202			RELIANCE
HV E51 2F008	II-202			RELIANCE
HV E11 2F023	II-204[9]	D	1.7E6	RELIANCE
HV B21 2F019	II-411[10]	A	3.7E6	PEERLESS
HV G33 2F004	II-501[11]	F	3.5E6	PEERLESS
HE E41 2F006	II-520[12]	A	3.7E6	PEERLESS
HV E51 2F013	II-520			PEERLESS

HELB Codes and Notes for Tables 1 and 2

Code	HELB Condition	Associated Rooms
A	300°F-15 sec, 8.2 psig-0.25 sec, 0.7 psig-0.75 sec, 2.6 psig-3.5 sec, atmospheric thereafter.	I-411, I-520, II-411, II-520
B	300°F-60 sec, 4.2 psig-1 sec, 0.5 psig-59 sec, atmospheric thereafter.	I-11, II-11
C	300°F-60 sec, 2.2 psig-2 sec, 0.7 psig for 58 sec, atmospheric thereafter.	I-106, II-106
D	300°F-60 sec, 2.2 psig-1 sec, 0.5 psig-59 sec, atmospheric thereafter.	I-202, I-204, II-202, II-204
E	240°F-25 sec, 0.6 psig-1.5 sec, atmospheric thereafter.	I-12, I-107, II-12, II-107
F	212°F-40 sec, 2.2 psig-1 sec, 1 psig 0.5 sec, 0.4 psig 38 sec, atmospheric thereafter.	I-501, II-501

The source of location data for Tables 1 and 2 was a printout from the EQ Limitorques from the MOV Index dated [illegible]/4/90, with the exception that the locations for valves HV G33 1F004 and HV G33 2F004 were determined by review of isometric drawings for the reactor water cleanup system and PP&L Drawing C206130, Rev. 1.

The source of the motor manufacturers' data was Page 2 of NCR 88-0181 as updated.

The environments listed in Tables 1 and 2 were extracted from PP&L Drawing C206130, Rev. 1.

TABLE 3. ENVIRONMENTS FOR SUSQUEHANNA
250 Vdc MOTORS

1 I-10, II-10 Core Spray Pump Room,
EQ Zone R1a

Normal [60/104°F, 10/90% RH, 8.8E2 rd]
LOCA [141°F peak, 90/100% RH, 1.1E5 rd/hr gamma peak, 1.9E3 rd/hr beta peak, 1.9E6 rd gamma, 4.3E5 rd beta TID @ 180 days]
HELB [Not applicable]

2 I-11, II-11 HPCI Pump Room,
EQ Zone R1b

Normal [60/100°F, 10/90% RH, 8.8E2 rd]
LOCA [125°F peak, 90/100% RH, 4.4E3 rd/hr gamma, 1.9E3 rd/hr beta, 1.7E3 rd gamma, 4.3E5 rd beta TID @ 180 days]
HELB [300°F for 60 sec, 4.2 psig for 1 sec, 0.5psig for 59 sec]

3 I-12, II-12 RCIC Pump Room
EQ Zone R1h

Normal [60/104°F, 10/90% RH, 8.8E2 rd]
LOCA [123°F, 90/100% RH, 6.9E3 rd/hr gamma peak, 1.9E3 rd/hr beta peak, 2.9E3 rd gamma, 4.3E5 beta TID @ 180 days]
HELB [240°F for 25 sec, 0.6 psig for 0.5 sec, atmospheric there after]

4 I-17, II-17 Core Spray Pump Room,
EQ Zone R1a

Normal [60/104°F, 10/90% RH, 8.8E2 rd]
LOCA [128°F peak, 90/100% RH, 1.1E5 rd/hr gamma peak, 1.9E3 rd/hr beta peak, 1.9E6 rd gamma, 4.3E5 rd beta TID @ 180 days]
HELB [Not applicable]

5 I-102, II-102 General Access Area
EQ Zone R1m

Normal [60/100°F, 10/90% RH, 8.8E2 rd gamma]
LOCA [119°F peak, 90% RH, 1.4E2 rd/hr gamma peak, 1.9E3 rd/hr beta peak, 1.5E4 rd gamma, 4.3E5 rd beta TID @ 180 days]
HELB [Not applicable]

6 I-106, II-106 HPCI Penetration Room
EQ Zone R1b

Normal [60/100°F, 10/90% RH, 8.8E2 rd gamma]
LOCA [125°F peak, 90/100% RH, 4.4E3 rd/hr gamma peak, 1.9E3 rd/hr beta peak, 1.7E3 rd gamma, 4.3E5 rd beta TID @ 180 days]
HELB [300°F for 60 sec, 2.2 psig for 2 sec, 0.7 psig for 58 sec]

7 I-107, II-107 RCIC Penetration Room
EQ Zone R1h

Normal	[60/104°F, 10/90% RH, 8.8E2 rd gamma]
LOCA	[123°F peak, 90/100% RH, 6.9E3 rd/hr gamma peak, 1.9E3 rd/hr beta peak, 2.9E3 gamma, 4.3E5 rd beta TID @ 180 days]
HELB	[240°F for 25 sec, 0.6 psig for 0.5 sec, atmospheric thereafter]

8 I-202, II-202 RHR Piping and Penetration Room
EQ Zone R1c

Normal	[60/115°F, 10/90% RH, 3.5E4 rd gamma]
LOCA	[139°F peak, 90/100% RH, 8.6E4 gamma peak, 1.9E3 beta peak, 1.7E6 rd gamma, 4.3E5 rd beta TID @ 180 days]
HELB	[300°F for 60 sec, 2.2 psig for 1 sec, 0.5 psig for 59 sec]

9 I-204, II-204 RHR Piping and Penetration Room
EQ Zone R1c

Same as I-202, II-202

10 I-411, II-411 Pipeway 719' Level
EQ Zone R3

Normal	[40/130°F, 10/90% RH, 1.8E6 rd gamma]
LOCA	[130°F, 100% RH, 1.1E5 rd/hr gamma peak, 1.9E3 rd/hr beta peak, 3.7E6 rd gamma, 4.3E5 rd beta TID @ 180 days]
HELB	[300°F 15 sec, 8.2 psig for 0.25 sec, 0.7 psig for 0.75 sec, 2.6 psig for 3.5 sec, ramp to atmospheric at 5.6 seconds elapsed time]

11 I-501, II-501 Reactor Water Clean-up Rooms
EQ Zone R1e

Normal	[60/104°F, 10/90% RH, 3.5E6 rd]
LOCA	[131°F, 90/100% RH, 3.6E2 rd/hr gamma, 1.9E3 rd/hr beta, 3.5E6 rd gamma, 4.3E5 rd beta TID @ 180days]
HELB	[212°F for 40 sec, 2.2 psig for 1 sec, 1 psig 0.5 sec, 0.4 psig 38 sec]

12 I-520, II-520 Pipeway R3 for Ele. 745' 7"
EQ Zone R3

Same as I-411, II-411

TABLE 4. RADIATION ONLY MOVs

Unit 1 MOVs with 250 Vdc Motors Note: This table also applies to Unit 2 valves with similar numbers.

The following valves have no safety function during HELBs in the associated room. They are required to operate during the secondary effects radiation environment associated with LOCAs.

Device Identity No.	Description	Room
HV 15012	RCIC TURBINE STOP VALVE	I-12
HV 15768	CONTMT ATMOS CTL ISO VLV	I-17
HV E11 1F008	RHR PP SHTDWN CLG SUCT VLV	I-202
HV E11 1F023	RHR REAC HEAD SPR OB ISO VLV	I-204
HV E11 1F049	RHR DISCH TO RADW IB ISO VLV	I-202
HV B21 1F019	MAIN STEAM LINE DRAIN VALVE	I-411
HV E41 1F001	HPCI STM SUP TO TURB VLV	I-11
HV E41 1F004	HPCI PP SUCT FRM COND STOR TNK VLV	I-11
HV E41 1F006	HPCI PP DISCH VLV	I-550
HV E41 1F007	HPCI PP DISCH VLV	I-102
HV E41 1F008	HPCI TEST BYPS TO COND STOR TNK VLV	I-102
HV E41 1F011	HPCI TEST BYPS TO COND STOR TNK VLV	I-10
HV E41 1F012	HPCI MIN FLOW BYPASS VLV	I-106
HV E41 1F042	HPCI PP SUCT FRM SUPP POOL VLV	I-11
HV E41 1F059	HPCI LUBE OIL CLG WTR SUP VLV	I-11
HV E41 1F066	HPCI TURB EXH TO SUPP POOL VLV	I-106
HV E41 1F075	HPCI TUB EXH VAC BKR OB VLV	I-106
HV E41 1F079	HPCI TUB EXH VAC BKR IB VLV	I-106
HV E51 1F010	RCIC PP SUCT FROM CNDS STOR TNK VLV	I-12
HV E51 1F012	RCIC PP DISCH VLV	I-102
HV E51 1F022	RCIC TEST BYPS TO CONDS STOR VLV	I-102
HV E51 1F031	RCIC PP SUCT FROM SUPP POOL VLV	I-12
HV E51 1F013	RCIC INJ SHTOFF VLV	I-520
HV E51 1F045	RCIC TURB EXH VAC BKR OB VLV	I-12
HV E51 1F046	RCIC TURB CLG WS VLV	I-12
HV E51 1F059	RCIC TURB EXH TO SUPP POOL VLV	I-107
HV E51 1F060	RCIC VAC PP DISCH VLV	I-107
HV E51 1F062	RCIC TURB EXH VAC BKR OB VLV	I-107
HV E51 1F084	RCIC TURB EXH VAC BKR OB VLV	I-107

TABLE 5. VALVES WITH HELB FUNCTIONS

The following valves have safety-related functions during HELBs and have safety-functions when subjected to the secondary effects radiation from a LOCA.

Device Identity No.	Description	Room	Duration of HELB Func.
HV E41 1F003	HPCI STM SUP LINE ISO VLV	I-202	2 minutes
HV E41 2F003	HPCI STM SUP LINE ISO VLV	II-202	2 minutes
HV E51 1F008	RCIC OB STM LINE ISO VLV	I-202	2 minutes
HV E51 2F008	RCIC OB STM LINE ISO VLV	II-202	2 minutes
HV G33 1F004	RWCU OB ISO VLV	I-501	2 minutes
HV G33 2F004	RWCU OB ISO VLV	II-501	2 minutes

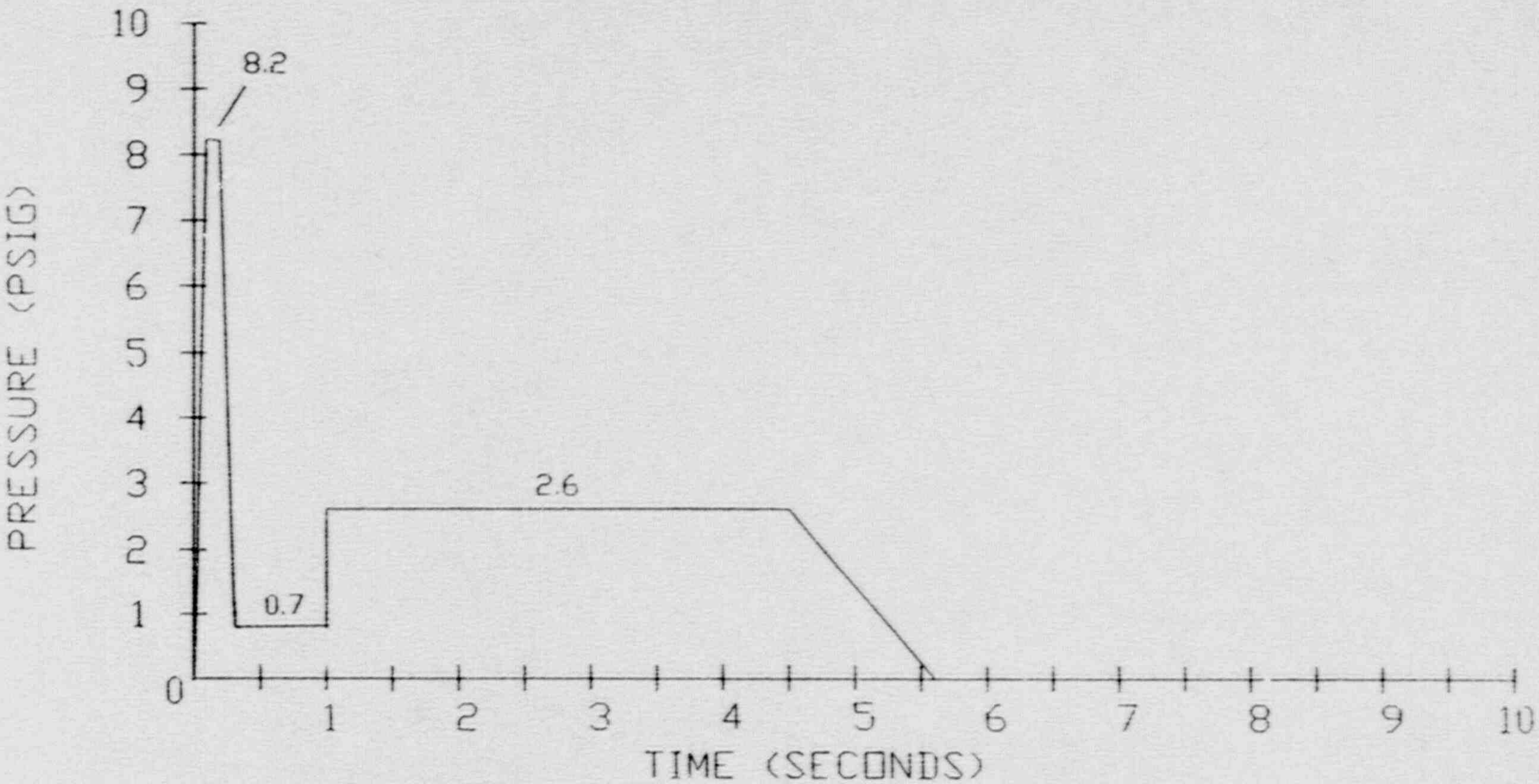

Figure 1. HELB Profile for Group A Rooms

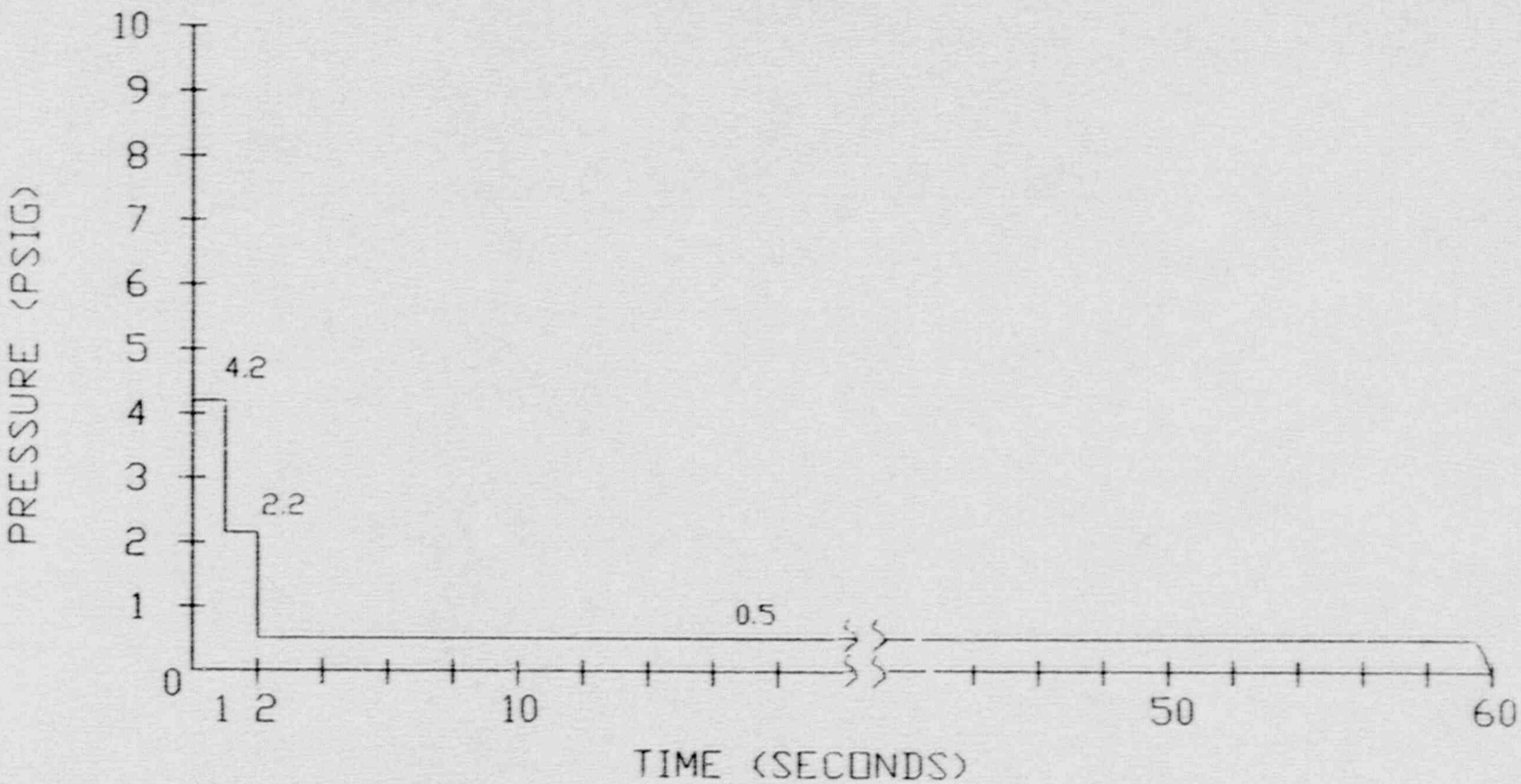

Figure 2. HELB Enveloping Profile for Group B Rooms