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January 5, 1984

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Byron Generating Station Units 1 and 2
Braidwood Generating Station Units 1 and 2
Environmental Qualification of Equipment
NRC Docket Nos. 50-454, 50-455, 50-456,
and 50-457

References (a): December 6, 1983 letter from T. R. Tramm to H. R. Denton.

(b): December 13, 1983 letter from T. R. Tramm to H. R. Denton.

Dear Mr. Denton:

This letter provides justification for interim operation (JIO) of several items of electrical equipment for which environmental testing will be incomplete at the time of fuel load for Byron Unit 1. All JIO's necessary for operation of Byron Unit 1 are contained in this letter except for two. JIO for inadequate core cooling instrumentation will be provided by January 9, 1984. The information on Barton 581A switches will also be provided by January 9, 1984. JIO information provided in references (a) and (b) is updated and repeated here. Review of these JIO's is necessary to close Outstanding Item 10 of the Byron SER.

Attachment A to this letter is a Westinghouse report titled "Response of Limitorque In-Containment Motors to the Byron/Braidwood HELB/LOCA Environment," MDQ-EQ-148, June 1, 1982. This report demonstrates that the Limitorque valve operators are adequately qualified to operate in the Byron/Braidwood containment until new motors can be installed during the first refueling outage. The valves covered by this report are:

1CC9416	1RY8000A
1CC9438	1RY8000B
1CV8112	1SI8808A
1RH8701A	1SI8808B
1RH8701B	1SI8808C
1RH8702A	1SI8808D
1RH8702B	

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Attachment B to this letter contains justification for interim operation of the Rockwell hydrogen recombiners. Available qualification tests and analysis are also summarized. Qualification of this equipment is expected to be complete by the end of 1985. Operation of a recombiner would be needed only for recovery from a major LOCA. There is an installed spare which can be valved in if necessary. There are also two other recombiners at Braidwood Station which also could be moved to Byron and installed within a matter of hours. Containment vent and purge equipment is also available for controlled release or dilution of containment atmosphere if all of the hydrogen recombiners should fail.

Attachment C to this letter contains the justification for interim operation of the containment purge valves. The Jamesbury butterfly valves are fully qualified but testing of the motor-operated Borg Warner actuators will not be completed before fuel load. These valves will only be opened to purge the containment during outages. Because of other concerns, these valves will always be closed during reactor operation. Inadvertant operation of these valves following a LOCA is precluded by electrically disabling the valve controls during reactor operation.

Attachment D contains justification for interim operation of six United Electric pressure switches used in various interlock circuits. Environmental qualification testing for these switches will not be completed by fuel load of Byron Unit 1 but the component materials appear to be resistant to harsh environments. They would only be expected to operate during fires in charcoal absorber units. Manual operator actions can compensate for switch failure and multiple fires would be necessary to compromise the overall effectiveness of redundant charcoal filters.

Attachment E contains justification for interim operation of the Borg Warner Model 85440 main steam atmospheric relief valves. Qualification testing of these valves is expected to be completed in the first quarter of 1984. A materials analysis indicates that the valve components should perform satisfactorily in the main steam line break environment. Depending upon the situation, various manual actions can be taken to compensate for valve failure in either the open or closed position.

Attachment F contains justification for interim operation of Barton Model 288A differential pressure switches which signal low level in the containment spray additive tank. These switches have no control function and a local level indicator is also available. These switches will be replaced with Barton Model 581 switches during the first fuel cycle.

Attachment G contains the justification for interim operation of the core exit thermocouples. The thermocouples, themselves, have been successfully tested but the testing of cable connectors and reference juction boxes is incomplete. Previous testing and materials analyses provide confidence of satisfactory operation of these thermocouples. Other plant instrumentation is available to verify the accuracy of these thermocouples in accident situations.

Please direct further questions regarding this matter to this office.

Very truly yours,

T. R. Tramm

T. R. Tramm
Nuclear Licensing Administrator

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Attachments

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ATTACHMENT B

Justification for Interim Operation

ROCKWELL HYDROGEN RECOMBINER

FUNCTION

The safety function of the hydrogen recombiner is to remove hydrogen from the containment atmosphere following a loss of coolant accident (LOCA). Performance of the safety function controls the hydrogen concentration to less than the lower flammability limit of hydrogen in air. If the safety function is not performed, containment integrity could be compromised.

Following a LOCA, the Rockwell International hydrogen recombiner is connected through suitable piping penetrations to form a closed loop with the containment atmosphere. A blower motor assembly on the recombiner circulates gas from containment through the recombiner, and returns the processed gas to containment. During the circuit through the recombiner, the hydrogen concentration is reduced to 0.1% by volume. The recombiner unit processes containment gas at the rate of 70 scfm (standard conditions: 14 psia and 68°F).

ENVIRONMENT

The hydrogen recombiners are located in Byron/Braidwood environmental zone A13E which has the following parameters*:

	Temperature °F	Relative Humidity	Pressure (Water Gauge)	Radiation (Rads)
Normal	104	0-70	-.25 to 0.0	10^3
Accident	104	0-70	-.25 to 0.0	10^6

These relatively mild environmental parameters are encountered by all the components on the skid assembly except the motor blower assembly. The motor blower assembly, enclosed in a carbon steel can, and its connective piping are exposed to the containment atmosphere having the following parameters*:

	Temperature °F	Relative Humidity	Pressure (Water Gauge)	Radiation (Rads)
Normal	165°	20-70%	-0.1 to 0.3 psig	3.5×10^6
Accident	320°/10-180 sec 270°/5-20 min 170°-155°/1-20 days 155°/120-365 days	100%	50 psig/0-20 min saturated 20 min-1 yr	2×10^8

* (Reference Byron/Braidwood FSAR Table 3.11-2)

The accident conditions represented by these parameters last a maximum of approximately 1 year. Thus, the skid components comprising the hydrogen recombiner are to endure a year of accident conditions.

MAJOR HYDROGEN RECOMBINER COMPONENTS

The 15 heating elements, which make up the heart of the system, are made to operate at 981°C with heat fluxes of 20 watts/in^2. These heat fluxes are about one-half of the heater design capability. Should 1/3 of the total heaters fail, the recombiner will continue to operate performing its safety function.

Chromel-Alumel Thermocouples are used as temperature monitors at several locations on the piping system. The Type K, Chromel-Alumel Thermocouples were picked for their accuracy and reliability at temperatures up to 1500°F. All thermocouples in the system are Type K, MgO packed, and inconel sheathed. The epoxy, which is used to isolate the transition from the sheath to the lead wire, is an organic material but can withstand temperatures in excess of 100°C with a radiation damage threshold of 2×10^8 rads.

The hydrogen recombiner also contains a 7-1/2 hp and 3 hp, 460v nuclear grade, random-wound induction motors furnished by Reliance Electric Company. The 7-1/2 hp motor is part of the motor blower assembly which draws in the containment atmosphere. The 3hp motor drives a centrifugal fan to cool the process gas before it is returned to the containment. Both motors use high temperature radiation resistant Class H, Type RN insulation system. This insulation system has been qualified to levels more severe than those postulated for operation of the equipment at Byron and Braidwood Stations.

Reliance Electric has conducted environmental qualification tests for their motors. The results of those tests are reported in Reliance Electric Report NUC-9 (including Supplement 1). Rockwell has conducted environmental qualification tests on a 10-hp motor (a slightly larger motor and blower than is included in Byron), which demonstrated the motor's ability to operate for a period greater than 1 year in a post-LOCA environment.

The results of these tests are reported in ESG report N001TR700038. The motor tested is the same as the Byron motors except for the frame size and the shaft dimensions where the blower impeller attaches, to accommodate the slightly larger blower and impeller used in the test. Qualification reports documenting the test results and meeting the requirements of IEEE 323-1974 are in preparation for the motor and will be forwarded for review as soon as they are available.

OTHER COMPONENTS

Equipment mounted on the skid assembly can be certified by either:

a) Matching an existing qualification report to each component on the skid assembly, or

b) Replacing the questionable components with those of known qualification background.

The amount of qualification material gathered in the next few months will determine which course of action to take. The need for operation of the recombiner during the first few hours of a LOCA is also being reviewed to reduce the radiation qualification level.

HOT FUNCTIONAL TESTING

Hot functional testing has been performed on each of the 103 hydrogen recombiner systems built by Rockwell. Additionally, 49 of these system (PWR types) have been subjected to the 168 hour burn-in tests. These tests have all been performed in an uncontrolled temperature environment where the temperature typically is as low as 40°F in the winter and a high as 110°F in the summer.

HYDROGEN TESTING

Hydrogen testing has been performed on 4 PWR type and on 32 BWR type hydrogen recombiner systems in addition to the hydrogen testing performed on two development units. The hydrogen testing has typically consisted of testing with a hydrogen concentation over the range of 1 to 5%. These test were conducted by starting up the hydrogen recombiner system at rated flow rates, and when the reaction chamber reached the ignition temperature (typically from 1100°F to 1150°F for hydrogen concentrations below 6%), hydrogen was injected at the inlet to the recombiner unit at a controlled flow rate to achieve the desire hydrogen concentration. The hydrogen concentration in the recombiner unit exhaust gas was monitored during steady state operation and was well below the 0.1% maximum acceptance criteria (generally in the 0.2% to 0.05% range).

PERIODIC TESTING AT PLANT SITES

Rockwell hydrogen recombiners are installed in 50 operating nuclear power plants. Of these, 37 plants use the PWR-type hydrogen recombiner systems and the remainder use the BWR-type hydrogen recombiner systems. At each of these operating plants, the hydrogen recombiner systems have been subjected to the initial calibration and hot functional tests and additional testing at periodic intervals. These test intervals for the periodic test vary from plant to plant and are typically performed every 3 months.

REDUNDANCY

The Byron Plant contains two hydrogen recombiners. In the event of an accident, each recombiner can individually process the hydrogen gas from either of their respective containments. Should one recombiner fail, the second recombiner can be switched to the other containment by proper manual positioning of the interconnecting valves. This type of outside containment interconnective system assures a back-up should the primary system malfunction.

SUMMARY

On the basis of material selection, test and operational testing experience it is concluded that the recombiner's system design is capable of performing the intended safety function should the need arise.

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ATTACHMENT C

Justification for Interim Operation

CONTAINMENT PURGE ISOLATION VALVES

FUNCTION

The primary purpose of the containment purge isolation valves (1VQ001A&B and 1VQ002A&B) is to isolate the containment atmosphere from the outside environment in the unlikely event of an accident which releases radioactive material inside containment.

Although the containment purge system is non-safety-related these purge isolation valves are safety-related and require qualification. The purge supply to the containment is isolated by valves 1VQ001B (outside containment) and 1VQ001A (inside containment). The purge exhaust from containment is isolated by valves 1VQ002A (inside containment) and 1VQ002B (outside containment). Both outside containment valves are located in the auxiliary building in environmental Zone A13D adjacent to the containment penetrations.

The safety function of these valves is to close prior to any reactor startup and maintain closure during reactor operation and postulated accident.

VALVES

The valves are 48" wafer-sphere butterfly valves manufactured by Jamesbury Corporation. These valves have a high-performance one piece design with a resilient, positive sealing seat. One of the design features responsible for its superior performance is the valve's eccentric shaft design. The shaft is offset in two places: (1) away from the valve disc centerline and (2) behind the valve disc sealing plane. This design makes the rotating disc cam back away from the seat, eliminating the ususal wear points at the top and bottom of the seat. A positive stop is also incorporated into the design to prevent seat damage from over travel. The design and orientation of the valves provides and insures positive seating action by utilizing the differential pressure across the valve and the cam seating action.

These valves have been analyzed for environmental effects postulated for an accident inside containment, which is the most severe exposure that these valve pairs would be exposed to. Mechanical Equipment Binder CQD-009628 contains complete information on the qualification.

The metal components of the valves are not affected by the maximum normal (150^{o}F, 5 psig, 1×10^{7} Rads TID), or postulated (320^{o}F, 50 psig, 2×10^{8} Rads TID, 100% RH) environmental conditions. The non-metallic materials, valve seat, shaft bearing and seal have a 150#ANSI rating which is well above the required 50 psig maximum these valves will be exposed to. The packing and bearings have temperature ratings of 1000^{o}F and 400^{o}F respectively, the seat material is designed for 300^{o}F service but has been shown by the analysis to be suitable for the intended service.

Additionally the valve outside containment would be exposed to far less severe conditions and would provide the necessary backup should the inside containment valve be unable to perform its isolation function effectively. Similarly, the postulated radiation dose and humidity would have no degrading effect on the valve's safety function.

VALVE OPERATORS

The operators provided for these valves are manufactured by the Borg-Warner Corporation and are included in the Electrical Qualification Program. The present test schedule indicates that the qualification testing will not be complete until the first quarter of 1984 for these valve operators.

As stated above the actuators safety function is to close the valves prior to any reactor startup and maintain closure of the valves during reactor operation and any postulated accident. Even though these actuators do not have an active safety function, they must not fail during operation of the reactor or a postulated accident either by opening the valves or cause a failure of the Class 1E ac and/or dc distribution buses to which they are connected.

Once closed the valve is designed to remain closed unless mechanical force is applied to the operating shaft. Since the valve operator requires power to operate; the Class 1E ac power has been disconnected to meet Branch Technical Position EICSB-LE.

The Class 1E dc power connected to the operator for emergency closure of the valve will also be disconnected from the operator. This will preclude any adverse effect on the 1E dc supply system from its connection to the operator. Thus, with the valve closed and all sources of electric power to the actuator removed, the valve will remain in the closed position.

As stated in the Byron/Braidwood FSAR Subsection 8.1.10 the only time the actuator would be permitted to be connected to a power source would be after the reactor has been shut down. This would allow for containment purge operation prior to personnel access.

SUMMARY

With the valve designed and qualified to remain in the closed position and the operator disabled, the valves will remain in their closed position. Valve position is verified by safety-related, qualified limit switches on the valves and indicating lights are provided for the operator's verification at panel OPM02J.

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ATTACHMENT D

Justification for Interim Operation

UNITED ELECTRIC PRESSURE SWITCH

Model J302-S164

FUNCTION

The primary purpose of the pressure switches (OPS-FP162, OPS-FP163, OPS-FP164, OPS-FP165, 1PS-FP171, and 2PS-FP171) is to provide interlocks for valves and fans in the event of a fire protection deluge valve operation. Specifically, switches OPS-FP162 and OPS-FP163 are used to trip fan OVC03A, switches OPS-FP164 and OPS-FP165 are used to trip OVC03B, switch 1PS-FP171 is used to trip fan 1VQ03C and close valve 1VQ003, and switch 2PS-FP171 is used to trip fan 2VQ03C and close valve 2VQ003. The safety related interlock function of the pressure switches is to open the normally closed contacts at a set point of 15 psig on increasing pressure.

Switches OPS-FP162 thru 165 serve the main-control room emergency makeup filter units. Switches 1PS-FP171 and 2PS-FP171 serve the post-LOCA purge filter units. See B/B FSAR paragraph 9.4 for system description of these filter units. Upon a high temperature signal from the charcoal absorbers, an alarm sounds in the main control room and the deluge valves in the fire protection lines to the charcoal absorbers of the filter units are manually opened. When the water pressure to the charcoal absorbers reaches 15 psig, the associated fans of the filter units are tripped. The fans can also be controlled from the main control room. In the case of the post-LOCA purge filter unit, the associated containment isolation valve (1VQ003 or 2VQ003) is also closed in addition to tripping of the filter unit fan. These isolation valves can also be controlled from the main control room and are fail-closed valves. The only operation required is a one-time operation from the pressure switch during which the fan or valve is stopped or closed. The system will be visually inspected after the fire is controlled. Operability of the pressure switches can be verified during this inspection.

ENVIRONMENT

The switches OPS-FP162 thru 165 are located in zone A13e and 1PS-FP171, 2PS-FP171 are located in zone A13d. The accident conditions in these zones result from high radiation only; the dose being 10^6 Rads for zone A13d and 10^6 Rads for zone A13e. Temperature, humidity or pressure does not vary from normal during an accident scenario in the plant.

QUALIFICATION

A qualification program was conducted by Wyle Laboratories to qualify the Byron/Braidwood United Electric J302-5156 and J302-05164 pressure switches and is documented in their report 17612-1. Our review indicates that the type testing performed by Wyle qualifies the switches discussed here for a 40 years life to their service conditions except for the accident radiation dose requirements (10^6 Rads for zone A13e).

We are in the process of irradiation testing to 10^6 Rads on the tested specimens. However, in the interim, the use of switches discussed here is justified based upon the following:

1) The lowest radiation damage threshold for the materials used in the switches is that of sealing washer. The sealing washer is a nylon compound (zytel) which has a radiation damage threshold of 8.5×10^5 Rads. Remaining materials have radiation damage thresholds higher than 2×10^6 Rads. All wetted parts are of #316L S.S.

2) The radiation damage threshold of 8.5×10^5 Rads justify the use of the switches in zone A.13e where qualification dose requirement is 10^5 Rads.

3) The sealing washer is used for cover screws of the switches and, therefore, it maintains the sealing integrity of the switch housing. These washers can be considered safety related for areas where the switches will experience high humidity/steam conditions. However, for the switches discussed here, this is of no concern since they see only a maximum of 70% R.H and; therefore, any degradation of the sealing washer is considered not to be significant for the safety related function of the switches.

4) Realizing that the sealing washer is not important to the safety function of the switches and that the remaining component/materials have radiation damage thresholds higher than 2×10^6 Rads, it is considered that a maximum design basis radiation dose of 10^6 Rads will not affect the safety related components/materials of the switch.

In summary, type testing performed by Wyle supplemented by the above analysis substantiates that the swithces will perform their Class 1E function during a 40 years service life plus 2 years accident conditions. A schedule for irradiation testing is not finalized yet. However, we expect this to be completed by the end of February, 1984.

FINAL ANALYSIS

As discussed previously, there are no significant consequences on system performance or operator action due to the unlikely failure of the switches. The deluge valves are manually opened at the onset of a high temperature alarm signal from the associated filter units. The interlocking functions that are to be performed by the switches can be accomplished manually and are independent of the switch operation. Additionally, there are duplex or triplex filter units such that in the unlikely event of a switch failure, isolating one unit, the other(s) will be available and system performance should not be adversely affected. There are no adverse consequences of electrical failure upon other component or power supplies. Since the switches are only open/close contact mechanisms and are not load devices, malfunction of the switches would not demand any higher currents and will not result in any short circuits.

In addition to the redundancy provided by the capability of manual operation of the associated fan/valves, the following redundancy is built into the design of the system. Switches OPS-FP162 and 163 provide redundant control for fan OVC03CA and switches OPS-FP164 and 165 provide redundant control for fan OVC03CB.

SUMMARY

In conclusion, switches discussed here are justified for their intended use based on the following:

1) Their present qualification in conjunction with analysis for qualification to radiation substantiates that the switches will not fail during a 40 years service plus 1 year accident condition.

2) In the unlikely event of their failure, their functions can be accomplished through manual operations and their failure would not affect the integrity of the associated Class 1E circuits or the ability of the ventilation system.

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ATTACHMENT E

Justification for Interim Operation

BORG WARNER MODEL 85440

Main Steam Atmospheric Relief Valve

The present test schedule indicates that the qualification testing for main steam atmospheric relief IMS018A, B, C, and D will not be completed until the first quarter of 1984. We have reviewed the operability requirements of these valves as shown in the following pages for interim justification pending completion of the present test program.

FUNCTION

The main steam atmosphere relief valves are mainly used during the plant startup and for emergency dump of steam when the condenser is unavailable. They are also used to assist in depressurization of the system in the unlikely event of a steam generator tube rupture. The valves are always available either by remote operation from the main control board or the remote shutdown panel or locally by means of manually operated pump.

The hydraulic operator for the main steam atmosphere relief valve has a local manual override feature via a hand pump. The operator may be actuated to the (OPEN) or (CLOSE) position by positioning the handle of the selection valve to the desired position, and by pumping the handle of the hand pump.

No possible failure mode of power and control cables (open circuit, hot short, ground) can effect the local manual control capability of the main steam atmospheric relief valve. The only possible mode of failure would be the rupture of compression set seals (i.e., "O" ring seals) and degradation of seals, O-Rings, and gaskets which lead to the loss of hydraulic fluid. The operator system uses polyalphaolefin type hydraulic fluid, and Viton, and EPR for seals, gaskets and O-rings.

ENVIRONMENT

*Environmental Condition	Temp.(^{O}F)	Relative Humidity	Pressure	Radiation Rads (Carbon)
Abnormal	NA	NA	NA	NA
Normal	Max 122	20-70%	-0.25"-0.0"(H_2O)	10^3
Accident	Max 325	50-100%	Max 28 psi	10^4

* The source of data is Reference 3

QUALIFICATION OF MATERIALS

EPR

1) Chemical and Physical Properties

The chemical and physical properties of EPR are not affected by environmental parameters shown above (Ref. P-16, Ref. 1).

2) Radiation Properties

EPR compounds have been found to withstand radiation dose of up to 1×10^8 rads gamma (Ref. P-25, Ref. 1). Reference 2, P-3-24 has identified a radiation threshold of 1×10^6 rads in a compression set application for EPR, while the accident requirement for Byron/Braidwood is only 10^4 rads as shown in the above table.

3) Thermal Properties

The EPR compounds are good for continuous operation at 300°F (Ref. P-20, Ref. 1).

Viton

1) Chemical & Physical Properties

Viton is a flourine - containing hydrocarbon polymer. Viton compounds show good tensile strength and exceptionally good compression set. Viton remains elastically useful when exposed to temperatures up to 400°F. Viton shows excellent resistance to oils, fuels, lubricants and most mineral acid (Ref. P-17 of Ref. 1).

2) Thermal Properties

Viton is elastically useful at temperatures up to 400°F (see P-21 of Ref. 1) while our accident condition is only Max 325°F.

3) Radiation Property

Radiation exposure to Viton results in hardening and stiffening due to increased state of cure of the fluoroelastomers. Viton shows no radiation induced cracking. Viton has a radiation tolerance of 1.2×10^7 rads for dynamic applications (see P-25 of Ref. 1).

Reference 2 has identified a radiation threshold of 10^5 and 10^6 rads/compression set (see P-3-25 of Ref. 2).

Polyalphaoefin Hydraulic Fluid

1) Chemical and Physical Properties

PAO Hydraulic fluids demonstrate a better viscosity characteristic and high and low temperature compatability than conventional petroleum based oils. PAO fluids are compatible with Viton and EPR (Ref. P-17 of Ref. 1).

2) Thermal Properties

PAO type fluids have a maximum service temperature of 350°F (see P-21 of Ref. 1).

3) Radiation Property

PAO hydraulic fluids are not significantly affected by radiation exposure (Ref. P-25 of Ref. 1). Reference 2, P-3-37 states that there is no unusual problem from radiation noted for a dose of 10^6 rads or lower for lubricants, while the accident requirement for the valve is only 10^4 rads.

FAILURE ANALYSIS

On the loss of power, the actuators fail-as-is. (The valves are normally closed.) These valves can always be operated, either by remote control or by manual operation. There are two trains, train A and train B. Each train has two valves and two valves are required to depressurize the system.

In the event of an accident the valves in one of the trains should operate to cool down the system. In an unlikely event of single failure in the backup, the second valve would be available for depressurization and additional steam could be dumped to the condenser, except during DBE, when the MSIV would be closed. The time required to depressurize the sytem will be lengthened.

Qualified valve position limit switches will provide indication to the operator via lights both at the main control board and the remote shutdown panel.

References:

1) Analysis Report Number 528-1215, Nuclear Equipment Analysis Report on Electro-Hydraulic Modulating Operator Plant Number 85440, May 4, 1983, prepared for Borg-Warner by National Technical System.

2) Radiation Effect on Organic Materials in Nuclear Plants EPRI P-2129, Project 1707-3, Final Report November 1981.

3) Byron/Braidwood FSAR Table 3.11-2, Zone T_3.

ATTACHMENT F

Justification for Interim Operation

BARTON 288A DIFFERENTIAL PRESSURE SWITCHES

There are two Barton 581 differential pressure switches on order for use in the Byron Unit 1 spray additive tank. The instrument numbers are 1LS-CS046A and 1LS-CS046B. Testing on Barton Model 581 switches is completed and a qualification report is scheduled for issue December 15, 1983. Delivery of these switches to the plant is scheduled for March 30, 1984. The switches will be installed as soon as possible. Because of this delay in the delivery and qualification of the Model 581 switches, Barton Model 288A differential pressure switches are being used for interim use.

FUNCTION

The spray additive tank contains a 30% NaOH solution and the spray system is designed to deliver, with only one eductor delivering 30% NaOH solution, with both spray pumps operating, enough NaOH to the containment to form a 8.55 pH solution when combined with the refueling water and spilled reactor coolant water after the refueling water storage tank (RWST) has emptied. Containment spray injection and caustic eduction at the rate of 55 gpm per eductor of NaOH solution will continue until a total of 410,000 gallons have been pumped into the containment and low-low level alarm of the RWST is annunciated. The spray additive tank level is indicated locally and on the main control board, and alarms are provided for low level. Main control board flow indicators are provided for pump discharge, pump recirculation, and eductor NaOH suction, and an alarm is provided for NaOH injection flow failure. The containment spray system consists of two entirely independent subsystems such that the aforementioned requirements can be met in the event of a single active failure in either of the subsystems. All components of the containment spray system except the test/recirculating line are Safety Category I and Quality Group B.

QUALIFICATION

The flow indicators for NaOH eduction flow failure are qualified, Class 1E, Rosemont 1153 Series B pressure transmitters. The transmitter instrument numbers are FT-CS015 and FT-CS016, and are located in zone A13 at a level of 346' in location 16-V. (Rosemont Report 107025, Rev. A and Qualification Binder No. CQD-006044.)

The Barton Model 288A switches are located in zone A13c at a level of 346' in location 12-S (Byron/Braidwood FSAR). The Model 288A switches have been qualified seismically, (Wyle Test Report 17659-1 dated September 9, 1983). Radiation testing, up to 4.5×10^6 Rads total integrated dose was conducted (ITT Barton Report No. R3-288A-1).

REDUNDANCY

In zone A8 at a level of 346' in location 13-P on Panel PL92J, there is a local spray additive tank level indicator. This indicator is Non-Class 1E, but may aid in low level indication and serve as a check on the no flow detected by the above mentioned flow indicators. (Byron/Braidwood FSAR.)

FAILURE ANALYSIS

Component failure has no effect on system performance. However, the operator must assure that the proper amount of NaOH from the spray additive tank has reached containment. Containment spray injection and caustic addition may then be terminated, and the operating personnel may transfer the containment spray pumps from the injection to the recirculation mode by first closing the motor-operated valves in the suction line from the RWST, the water and caustic lines to the eductor, and then opening the motor-operated valves in the suction lines from the containment sumps.

If the Barton 288A switches fail to signal low level of NaOH and the Rosemont flow indicators demonstrate that the spray additive tank is in fact draining, operating personnel will get a NaOH injection flow failure alarm when the spray additive tank drains empty. This alarm can be checked on the second eductor line. Flow alarms from the eductor lines will cause the operator to close valves which will cease eduction from the spray additive tank, preventing air from being drawn into the lines. The spray additive tank would be empty and the proper amount of NaOH would reach containment.

SUMMARY

The Barton model 288A switches will be replaced with qualified model 581 switches before the Byron plant goes into full power operation. Its function is only required for one hour post-accident use in the unlikely event of a LOCA, therefore, it will not see the full one year accident radiation dose specified by Byron/Braidwood FSAR. If the Barton 288A low level indicating switch did fail, its failure would not inhibit the spray additive tank from operating properly to serve its safety function.

Attachment G

Byron

Interim Justification Position for the Seismic and Environmental Qualification of the Incore Thermocouples, Connectors, Adapters and Reference Junction Box (ESE-43 and ESE-44)

The Class 1E thermocouples, connectors, and reference junction boxes located inside containment form part of a core exit temperature monitoring system to be qualified for use during and after a design basis LOCA, SLB or seismic event. In addition to the HELB environment to which components inside containment might be subjected, the thermocouple junctions in the reactor vessel are to be qualified for operation in the event that a LOCA might lead to an inadequately cooled core (ICC). The DBE conditions to which the components are to be qualified, therefore, includes a 420°F peak temperature HELB simulation with caustic spray and, for the thermocouple junctions, a 2200°F peak temperature inadequately cooled core simulation.

The WRD qualification program is presently incomplete. Test sequence steps of accelerated thermal aging, normal radiation and seismic simulation have been completed on the connectors but a retest is currently being scheduled. The Reference Junction Box has completed all phases of testing but due to a miscalculation additional radiation testing will be required. The Thermocouple test sequence has been completed. The status of completed testing and the basis for justification of interim operation with the system is provided below.

Thermocouples

The thermocouples, including the junctions and portions of stainless steel sheathed cable located inside the vessel have been subjected to seismic and LOCA loading and demonstrated successful performance during and after the dynamic simulations. Accelerated thermal aging was not reqired because there are not organic materials in the thermocouple and effects of high (normal) irradiation were considered in developing dynamic test inputs.

The thermocouples have also been subjected to a 2200°F peak temperature inadequately cooled core simulation and demonstrated successful performance both during and after the tests.

Connectors

The thermocouple connector assemblies have been subjected to accelerated thermal aging and irradiation (gamma and beta) and seismic simulation. The test program is being repeated because the radiation test dose was not adequate to simulate a one year post accident dose.

The connector components are made of Ryton R-4, designed to tolerate high radiation expoure. Additionally, the metal outer sheath provides some shielding against exposure. Based on these facts, the additional radiation exposure is not anticipated to cause any changes in the previous successful test results.

A confidence test of the effects of a LOCA environment on a new LEMO connector has shown no effect on the accuracy of the thermocouple reading. These results are considered relevant to the question of performance of aged qualification units because the tendency for moisture to enter the unprotected connectos is the same for both new and aged samples. No evidence exists to suggest that the connectors will be more sensitive to HELB effects. Pending completion of the entire sequence of connector tests, the results of the HELB test of new connectors lend confidence of successful performance of the installed connectors.

Reference Junction Box

The Reference Junction Box (RJB) has been aged, irradiated and seismically tested successfully. However, a problem discovered prior to the LOCA test has altered the test program. During an external pressurization test it was discovered that the NEMA enclosure was not leak tight and would allow steam to enter the box during the LOCA test. Previous tests had revealed that RTD lead wires exposed to a steam environment would result in a substantial drop in the insulation resistance thus effecting the accuracy of the RTD. An attempt was made to seal the entire box with a silicone potting compound and perform a confidence test. If the potting method proved to be successful during the LOCA test a new box was to be modified with the potting and the test program repeated.

During the confidence test of the potted box the measured insulation resistance dropped substantially on all three RTD's indicating the potting had not sealed the box and that the RTD lead wires were being exposed to steam and caustic spray. However, a review of the data revealed little effect on he accuracy of the system (approximately 1%). WRD will continue the investigation of the apparent independence of insulation resistance and RTD performance. Present areas of investigation include the significance of data acquisition circuit variations and possible electro-chemical effects resulting from test measurement voltages in the presence of an electrolyte, such as the Boron/NaOH cuastic spray. Similar results are described by N. J. Selley in an "Experimental Approach to Electrochemistry". In conjunction with the investigation, the validity of existing IR measurement techniques used in establishing performance is being evaluated.

The confidence test performed in the potted box demonstrated that the probability of obtaining a true environmental seal on the box by ths method was low and was not required for successful system performance. After removal of the potting material from the qualification test unit, the HELB test was repeated and followed by a post accident simulation.

Upon completion of the test program it was realized that because of the inadequate seal it would not be possible to take credit for Beta-shielding. This lack of shielding increased the required TID for the 1 year post accident simulation. The test dose administered was adequate to simulate the 40 year normal operating dose prior to a seismic event. To address the increase in the required TID the Reference Junction Box will be exposed to additional radiation and the LOCA simulation repeated.

Because the components of the RJB were designed for a high radiation environment the additional exposure is not expected to effect its performance.

The results of sequential and confidence tests to date indicate that no changes are presently required in the installed thermocouple system and that adequate system performance is expected under all required conditions.

Attachment A

RESPONSE OF LIMITORQUE IN-CONTAINMENT MOTORS TO THE BYRON/BRAIDWOOD HELB/LOCA ENVIRONMENT

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I. PURPOSE

This report provides an evaluation, utilizing available test data, test results, and engineering analysis of the response of Limitorque/Reliance Class RH in-containment electric motors on site at Bryon/Braidwood to the specified HELB/LOCA environment at Byron/Braidwood and concludes that the motors will operate during and after the specified HELB/LOCA.

II. BACKGROUND

A. Previous Limitorque Testing

In 1975 Limitorque performed a type test sequence on an SMB-0-40 motor operator. The motor stator was thermally aged and the entire motor operator was mechanically aged, gamma radiation aged, vibration/seismic tested and DBE tested. The DBE profile involved two temperature/pressure transients from 120°F to 300°F (saturation conditions) in ten seconds, with the 300°F peak being held for approximately 24 minutes. After the second transient peak, the temperature was reduced to 250°F in one hour. The 250°F temperature was maintained for approximately three days with a cool down to approximately 192°F maintained for 26 days. The motor operator was operated during and after the test sequence and successfully completed all this testing. The entire second transient profile is shown in Figure 1. The details of this entire test sequence are discussed in Reference 1.

In 1978 Limitorque performed a "Super Heat" test on an SMB-00-15 actuator in order to determine the effect of short duration, high temperature transients on the motor operator. This test involved exposing the motor operator to three temperature/pressure transients of 385°F for 2-4.5 minutes. After the third transient peak the temperature was reduced to 365°F for 12 minutes and then 327°F for approximately 2 1/2 hours. The internal temperature of the motor was monitored during the entire test. The test results in terms of the motor temperature are shown in Figure 2. Limitorque concluded from the test results that short duration high temperature transients will not affect the results of the Reference 1 test since the motor and motor operator will not reach a temperature higher than the saturation temperature associated with the environmental pressure during the DBE profile. This is true as long as the "super heat" peak temperature is of short duration, i.e. on the order of several minutes. The details of this testing are discussed in Reference 2.

B. Westinghouse Generic Testing

In 1980 Westinghouse performed a type test sequence on an SMB-00-15 motor operator. This test sequence was similar to the Limitorque test sequence of Reference 1 except that in the Westinghouse test the entire motor/motor operator were thermally aged and the DBE profile for the Westinghouse test was more severe. The Westinghouse generic profile is depicted in Figure 1. Of particular importance is the higher peak temperature, the longer and higher saturation temperature plateau and slower cooldown in the Westinghouse generic DBE profile of Figure 1 compared to the Limitorque PWR test Figure 1 DBE profile.

Three motor operators all failed to complete the Westinghouse DBE profile. Subsequent testing and analysis by Westinghouse showed that the electric motor had failed in each case as a result of the caustic spray at high motor temperatures (340°F) reacting with the stator insulation over a period ot time to cause shorts in the stator. The operator itself (minus the motor) had not experienced any failure and in fact successfully completed the testing after a new motor was installed.

Westinghouse determined, utilizing actual supplemental test data, that the motor reached a temperature of approximately 340°F (corresponding to the saturation temperature at the specified DBE pressure) after the second peak transient and stayed at approximately this temperature for a period of hours while the Westinghouse DBE profile gradually cooled from 340°F after 20 minutes to 250°F after 24 hours. During the Limitorque test of reference 1 the motor could only have reached a temperature of 300°F, since this was the peak DBE temperature, and based on the much faster Limitorque test cooldown, the motor would have cooled to a 250°F range in the 1-3 hour range. The higher motor temperature attained during the Westinghouse test (340°F) compared to the Limitorque Reference 1 test (300°F) and the longer span time at this temperature (several hours at least for the Westinghouse test versus about 1 hour for the Limitorque Reference 1 test) accelerated and increased the deleterious effect of the caustic spray solution on the motor stator insulation causing stator failures in the Westinghouse test that were not experienced during the Limitorque Reference 1 test.

C. Conclusions From Previous Tests

Based on the previous testing by both Westinghouse and Limitorque, several conclusions can be reached regarding the ability of the Limitorque motor operator to successfully complete a typical HELB profile for PWR type plants. These are identified below:

1. The electric motor is the most critical part of the operator in this environment. This is based on the facts that the operator itself passed both the Westinghouse generic test and the Limitorque Reference 1 test.

2. The failure mechanism of the motor in these environments is the reaction of the caustic spray with the stator insulation at high temperatures over a period of time causing shorts in the stator. The higher the motor temperature, the faster and more potent is the reaction mechanism.

3. For HELB/LOCA profile,where a fairly short duration high temperature spike is followed by a longer cool down at progressively lower temperatures, the motor rapidly heats up to the saturation temperature corresponding to the HELB pressure. The motor stays at the temperature as the DBE environmental temperature is reduced and generally follows, albeit lagging somewhat, the cool down of the environment.

4. The motor can successfully withstand temperatures up to 300°F for twenty minutes or more without shorting out the stator windings. This is based on the Limitorque Reference 1 test where 300°F was maintained for 24 minutes and the motor successfully completed the test.

D. The Byron/Braidwood HELB/LOCA Environment

Figure 1 shows the Byron/Braidwood HELB/LOCA Envelope including 15°F margin as compared to both the Westinghouse Generic Envelope and the Limitorque PWR test of Reference 1. The Limitorque PWR Envelope encompasses the Byron/Braidwood Envelope everywhere except in the initial three minutes where the Byron/Braidwood temperature/pressure transient reaches 335°F and 55 psia for three minutes before cooling to 285°F in five minutes.

In order to demonstrate that the Limitorque inside containment motor operator will successfully pass the Byron/Braidwood Envelope, it is necessary to show that the electric motor will not reach a temperature in excess of 300°F during the exposure to the entire Byron/Braidwood Envelope. From the visual inspection of the Envelopes of Figure 1, it can be seen that the only time when the Byron/Braidwood Envelope exceeds 300°F (or for that matter the Limitorque PWR Envelope of Reference 1) is during the first three minutes of the Envelope where the temperature reaches 335°F and presssure is 55 psia.

This evaluation will show, using actual test data from the three tests discussed in part II of this report and modeling the heat transfer coefficient for heat-up of the motor, that the short duration (3 minutes) peak temperature (335°F) does not cause the motor to exceed 300°F (15°F higher than the saturation temperature of 285°F at 55 psia in the Byron/Braidwood Envelope). Thus the Limitorque PWR test of Reference 1, coupled with this analysis, verifies that the motor will successfully operate during and after the Byron/Braidwood Envelope.

III. THE HEAT TRANSFER MODEL

If the geometry of the sample is simple and the Biot number (ratio of the surface convective heat transfer coefficient to the materials thermal resistance times the thickness of the material) is low, i.e. $Bi = hc(L)/k < 0.1$, a reasonably simple heat transfer model can be developed for the motor in this environment. Fortunately the motor is cylindrical, a simple geometry, and $hc(L)/k$ (the Biot number) is less than 0.1. The fact that the Biot number is less than 0.1 means that the motor will not develop a significant temperature distribution and neglecting internal resistance of the motor's material will not effect the model's accuracy by more than 5%.[1]

The motor temperature is an important factor in determining the motor response to the environment because the temperature itself affects the surface heat transfer coefficient dramatically. When the temperature of the motor is below saturation temperature, the superheated steam condences on the motor. Large amounts of energy are released in the phase change, and the resulting condensate conducts this thermal energy rapidly to the motor. During this time the motor temperature rises rapidly until the motor reaches saturation temperature. In Frank Kreith's third edition of "Principals of Heat Transfer" there is a table which gives ranges of various types of average convective heat transfer coefficients. ($\overline{hc}$). For steam condensing, the table gives this range 1,000 - 20,000 BTU/hr ft^2°F. For steam or air in forced convection, the range is 5 to 50 BTU/hr ft^2°F. Thus the heat transferred from the steam to the motor will be large, accompanied by rapid temperature rise in the motor, until the temperature of the motor reaches saturation temperature. At this time the heat transfer coefficient will decrease greatly and the heat transferred to the motor will be by forced convection with a subsequent slow rise in motor temperature.

In order to determine the actual heat transfer coefficient of the motor under these conditions, the Limitorque Superheat Test of Reference 2 was chosen as a source of data for three reasons. First, of the test data available, it is the closest to the Byron/Braidwood D.B.E. The Limitorque Superheat Test was conducted at a saturation temp. of 310°F while the Byron and Braidwood conditions call for a saturation temperature of 285°F. Second, it contained a third Superheat transient conducted when the operator was at saturation temperatures. This third transient produced sufficient data to conservatively correlate the model. Third, the motor in the test is identical to the smallest motor in containment at the Byron/Braidwood plants, even though the superheat test motor delivers 5 ft lbs more torque than the smallest motor at Byron/Braidwood.

The smallest motor was modeled because the surface area of the motor is roughly a function of the square of its radius, while the mass is roughly a function of the cube. Thus a larger motor will have less surface area to convect thermal energy and more metal to heat; a larger motor will rise in temperature more slowly.

[1]Frank Kreith, "Principles of Heat Transfer," 3rd Edition, Harper & Row New York, 1973.

The model was developed for the super heat region, when the motor is at saturation temperature or above (TM ≥ TSAT), since the only time the Byron/ Braidwood conditions excede the Limitorque P.W.R. qualification test is during the first three minutes of the test when the Byron/Braidwood curve goes above 300°F.

The first step required to develop the model was to define the test chamber conditions during the Limitorque superheat test, since exact data on mass flow rate of steam is not available from Limitorque. The environmental state properties were taken straight from test data. The mass flow rate of steam which is required to determine the velocity of the steam was calculated based on conservative assumptions. It was assumed that when the motor was well below saturation temperatures, during the initial temperature rise of the first transient, all the steam that struck the motor condensed and as a result, the following equation describes the heat or energy transferred from the steam to the motor.

$$C(Mm)\ (\Delta T) = \Delta H\ m_s \Delta t$$

Where: C = The heat capacity of steel (the motor material)

Mm = Mass of motor

ΔT = 200 - 120 (chosen)

ΔH = Change in internal energy of the steam (superheat condition to saturated liquid)

ms = Mass flow rate of steam impinging on the motor

Δt = Change in time (0.5 min)

The resulting mass flow rate was multiplied by the ratio of the cross sectional area of the chamber over the crossectional area of the motor to determine the mass flow rate into the chamber. This calculated chamber flow rate was then verified by matching the mass flow rate to typical values needed for this size chamber for these temperatures and motor/operator sizes in similar tests done by Westinghouse and Limitorque.

The average heat transfer coefficient $\overline{hc}$ was then calculated by using the following formula which is based on emperical data gathered by S. Whitaker, "Forced Convection Heat Transfer Correlations for Flow in Pipes, Past Flat Plates, Single Cylinders, Single Spheres, and for Flow in Packed Beds and Tube Bundles," AI.Ch.E. Journal, Vol. 18 (1972), pp. 361-371.

$$\frac{\overline{hc}\ D}{k} = (0.4\ Re_D^{0.5} + 0.06\ Re_D^{0.67})\ Pr^{0.4} (\mu_s/\mu_o)^{0.25}$$

Where Re = Reynolds number; Pr = Prantl number

D = Diameter of cylinder (motor)

k = Thermal conductivity of steam $\left(\frac{BTU}{hr\ ft\ °F}\right)$

μ_o = Absolute viscosity of steam in chamber

All variables are determined from free stream conditions, except μ_o which is the absolute viscosity at the average surface temperature at the motor. This $\overline{hc}$ was then used to calculate the Biot number. This was found to be 0.004, which i

less than 0.10, thus verifying the assumption of low internal heat transfer resistance of the motor in relation to the heat being transferred to the motor.

The second transient in the Limitorque super heat test was then modeled by using the following equation:

$$(t)\ \frac{\overline{hc}(Am)}{Cm(Mm)} = Ln\ \left(\frac{Tm2 - Too}{Tm1 - Too}\right)$$

Where: Am = The exposed surface area of the motor
Tm2 = The temperature to be obtained by the motor
Tm1 = The original temperature of the motor
Too = Free stream temp of the steam

Mm = Mass of the motor
t = Time at super heat temp.
Cm = Specific heat of the motor

The model was verified by allowing the time "t" to be 3 minutes (The length of the third transient in the Limitorque Super Heat Test) and Tm1 was assigned Tsat or the saturation temperature (312°F). The model then predicted the temperature rise of 0.328°F per minute or .974°F at the end of the transient.

The model results were next compared to actual test data from the Limitorque Super Heat test. The data indicates an approximately 1°F change in temperature during the actual three minute transient. There is a good correlation between the predicted results of the model and the actual test results.

This same technique was next used to evaluate the motor's response to the Byron/Braidwood environment. The evaluation involved first reformulating $\overline{hc}$ for the Byron/Braidwood super heat conditions. Then the transient equation was solved to determine the length of time that the motor would be required to be in super heat conditions to reach a temperature of 300°F, assuming the motor at the initiation of the superheat time span was at 285°F (saturation temperature). This required time was 1 hr. 51 minutes. Thus the motor in the Byron/Braidwood super heat transient (335°F for 3 minutes) would not reach 300°F. Utilizing the $\overline{hc}$ calculated by the model and the Byron/Braidwood transient conditions of 335°F and three minutes, the calculated temperature rise of the motor 0.48°F. Thus the motor temperature would be 285.48°F and the motor temperature would always be below that of the Limitorque PWR test of Reference 1.

IV. ACTUAL CALCULATIONS

The actual calculations are on file at Westinghouse.

V. CONCLUSIONS

A. Based on actual test data and the analysis described herein, the Limitorque Class RH Inside-containment motor will not rise above 300°F at any time during the Byron/Braidwood HELB/LOCA temperature peak of 335°F in three minutes.

B. Only the 335°F, three minute temperature peak portion of the Byron/Braidwood profile is not enveloped by the Limitorque PWR test profile. The motor during the portions of the Byron/Braidwood profile enveloped by the Limitorque PWR test profile will be at a lower temperature than the motor in the Limitorque PWR test.

C. Based on A and B above, the motor will operate successfully during all phases of and after the Byron/Braidwood HELB/LOCA profile identified herein.

D. Since a fully aged (40 year qualified life) in-containment design Limitorque operator successfully completed the Westinghouse Generic HELB/LOCA test profile identified herein. The Limitorque in-containment operator at Byron/Braidwood will successfully operate during all phases of and after the Byron/Braidwood HELB/LOCA profile.

E. The Limitorque motor utilized in the Limitorque PWR test Reference 1 was not thermally aged as a complete assembly. Rather the motor stator was aged separately by Reliance (manufacturer of the motor) for a 40 year period. This aging was in accordance with standard practice at the time, but is not in complete compliance with the Westinghouse interpretation of in-containment aging requirements in WCAP 8587. In particular the motor bearings were not thermally aged. Westinghouse notes that testing performed on these type design motor bearings by Westinghouse showed that at the maximum temperatures reached by the motor during the Byron/Braidwood HELB/LOCA profile, i.e. 285-290°F, no loss of bearing functions is evident even after extended exposure (up to 4 days at 300°F) to these conditions.

F. Based on C and E above the Limitorque electric motors used on in-containment Class 1E valves are acceptable for interim usage until new design Limitorque motors can be installed. These new design Limitorque motors will have passed the Westinghouse Generic HELB/LOCA profile in the fully aged condition.

VI. MARGINS

A. The Byron/Braidwood HELB/LOCA profile identified herein contains a 15°F margin over the actual calculated values of these environmental conditions. Thus the 335°F peak temperature would be only 320°F and the ΔT driving force during the short duration transient would be 20°F rather than 35°F.

B. The short term, peak temperature transient in the Byron/Braidwood HELB/LOCA profile occurs at the beginning of the profile. Actual test data from the tests referenced herein show that it takes approximately 1.5-2 minutes for the motor to heat up from ambient to the saturation temperature. This heat up time would reduce the three minute peak transient for Byron/Braidwood to actually about 1.5 to 1 minute. The analysis performed assumed the motor for Byron/Braidwood was already at 285°F when the 3 minute transient started. This adds significant conservatism to the calculated temperature rise.

VII. REFERENCES

1. Limitorque Report, "Nuclear Power Station Qualification Type Test Report, Limitorque Valve Actuators for PWR Service," Project #600456, dated 12/9/75.

2. Limitorque Report, "Limitorque Valve Actuator Temperature Related to High Superheat Ambient Temperatures," Project #600508, Report *B-0027, dated 8/31/78.

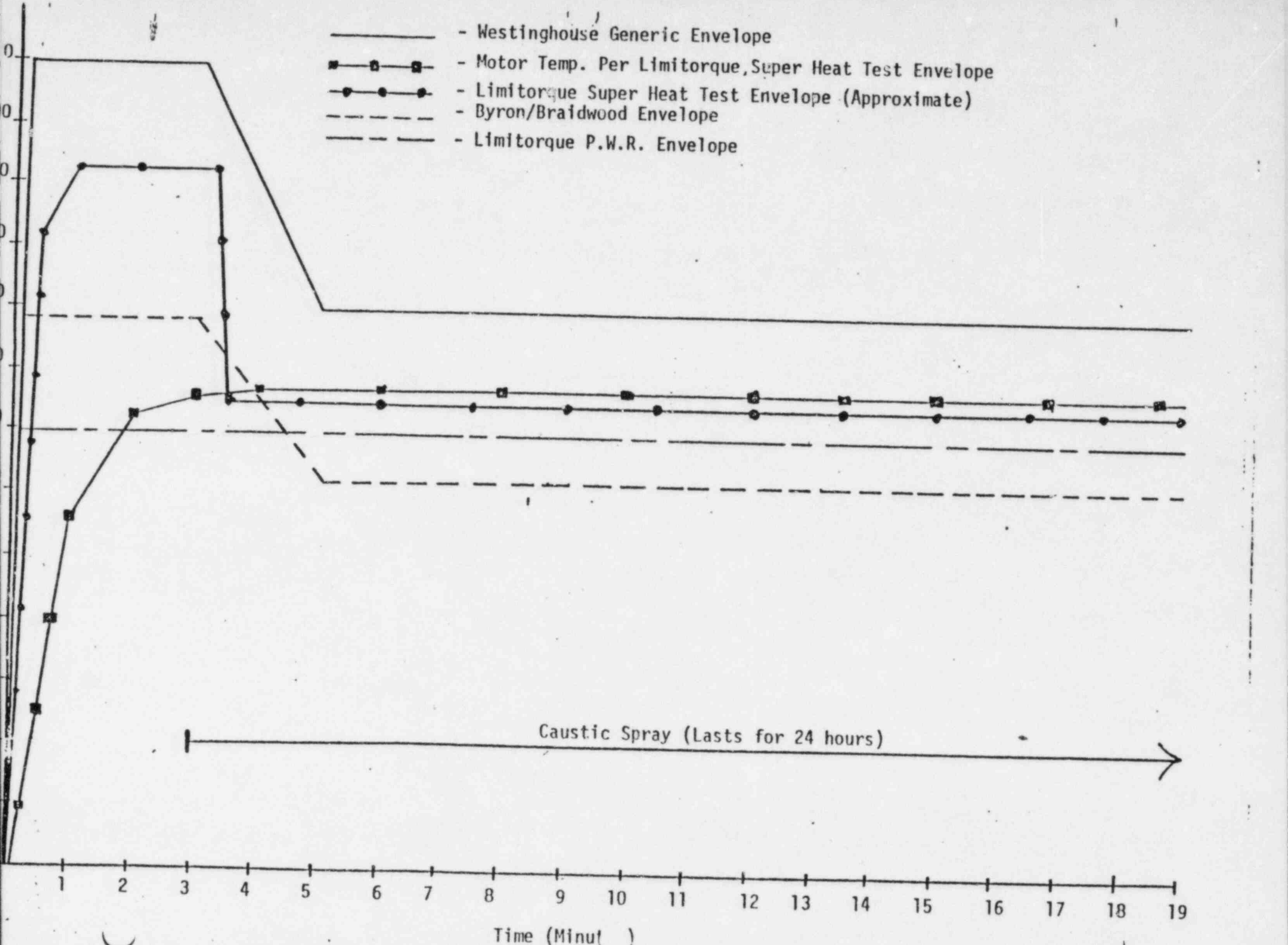
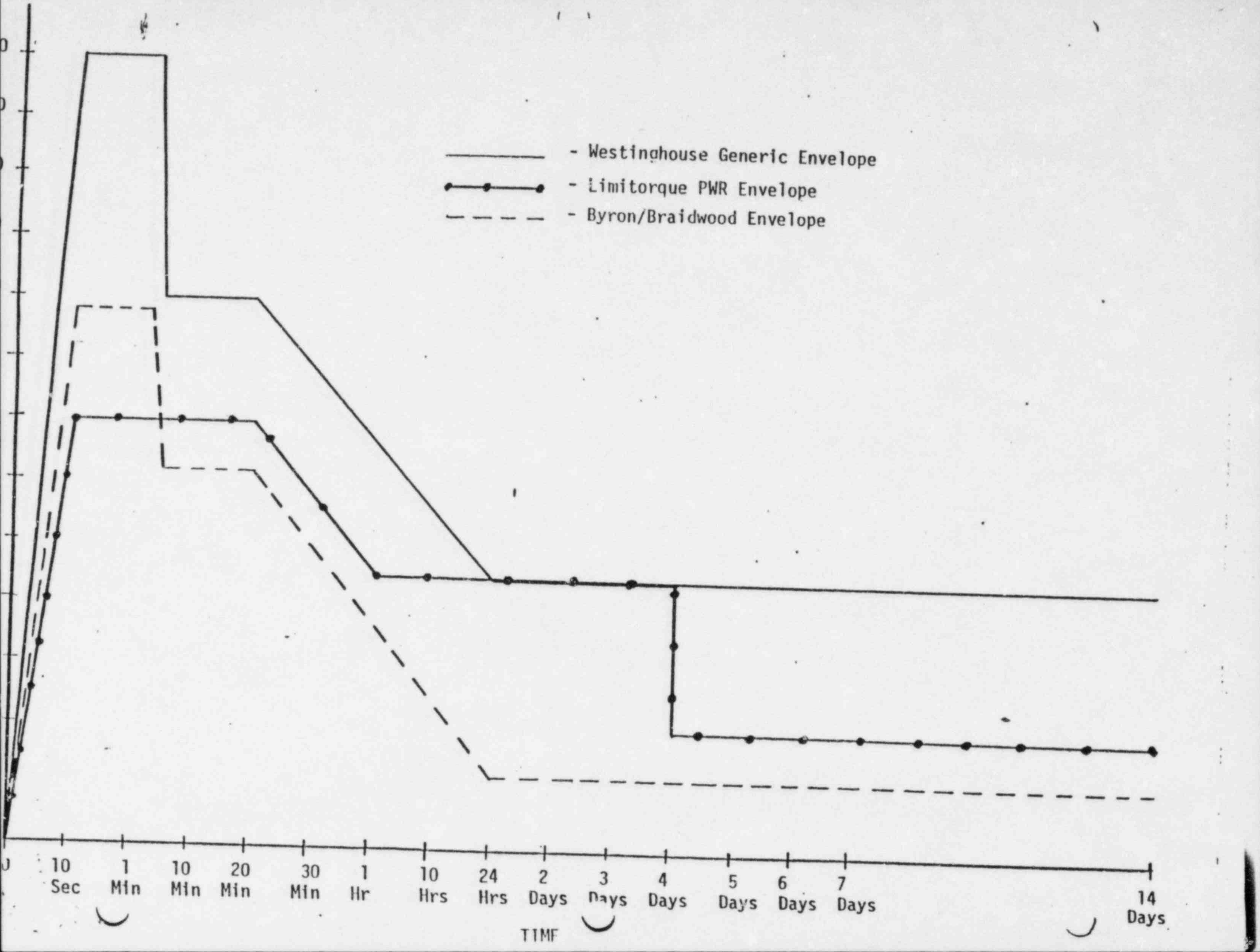


Figure 2 Comparison of Short Term Thermal Transi


- Westinghouse Generic Envelope
- Limitorque PWR Envelope
- Byron/Braidwood Envelope
10 Sec
1 Min
10 Min
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3 Days
4 Days
5 Days
6 Days
7 Days
14 Days
TIME