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Department of Nuclear Energy

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May 5, 1980

Mr. Robert L. Ferguson
Chemical Engineering
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Bob:

Your letter of December 12, 1979 concerning penetration seal qualification tests requested that Brookhaven National Laboratory (BNL) prepare a matrix containing the relevant seal qualification information for each plant. Appendix 1 attached tabulates each plant and indicates for each whether (1) staff position "A" was applied, (2) what was required for cable penetration qualification, (3) was hose stream test required, and (4) was differential pressure required. Additionally, your letter requested a statement of the criteria which established the Δp that should be used during each test. The balance of this report addresses this concern.

There is so much ambiguity concerning fire stop penetration testing that at the outset it might be well to set down a definition of positive Δp testing. In the context of this letter then, positive Δp testing will be defined as the exposure of one side of a penetration wall to a fire environment with pressure on the hot or fire exposed side at some pressure greater than that of the unexposed or cold side maintained for the duration of the test.

Historically fire penetration tests have been performed with the pressure on the exposed fire side at a lesser pressure than that of the unexposed cold side, it provided air inflow at leak areas preventing smoke and fumes from escaping into the test facility. Any leakage, therefore, provided an inflow of cold air which was not representative of the actual fire situation, and which in fact negated the test parameters in some cases.

Furnace design to provide positive Δp testing has not been standardized and, in fact, the only fire testing performed with a pressure differential that we are aware of has been done by Southwest Research Institute.

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There appear to be three basic approaches to test furnace design. These are:

1. A floor outlet test furnace in which the flue outlet is at a lower level than the location at which positive pressure is desired. The value of the differential pressure obtained will be proportional to the vertical difference in elevation between the test specimen and the furnace flue outlet.

2. Another technique of developing a positive pressure in the furnace is to ensure that air is injected into the furnace at an appropriate rate and to install a restriction in the flue outlet. This restriction must be of the variable orifice type such as a damper to provide the necessary control.

3. To provide an enclosure over the unexposed side of the test specimen such that a negative pressure can be established and thereby provide a positive Δp from the exposed side.

Of these three types, the third was utilized in testing by the Southwest Research Institute for Duke Power Company. The report of the test for the Browns Ferry penetrations does not describe the test equipment.

Exclusive of the method of obtaining a positive Δp, there are no standardized furnace parameters as to size, volume, location of test specimen, orientation of test specimen method of ignition, method of maintaining combustion or instrumentation. One of the few standards adhered to is an attempt to provide instrumentation that will confirm testing to be in accordance with the time temperature curve of E-119.

The need to adhere to the requirements of E-119 provides another testing uncertainty. The time temperature curve is based on a fire in a fully ventilated building or compartment with an unlimited supply of highly flammable combustibles in the area. This may be much too severe for a fire in a non-ventilated compartment with a minimum of readily combustible material even allowing for poor housekeeping standards by the licensee. Some of the tests have evidenced difficulty in maintaining combustion for the expected duration of the test. The standard time temperature curve, by definition, actually represents a condition of high fire severity met in the early stages of actual fires only where combustible materials are such a character as to favor rapid development of high temperatures.

Another area of test uncertainty is the selection of the proper Δp. There is evidence which indicates that the higher the pressure on the fire side (a greater positve Δp) the more susceptable the fire stop is to failure. However, testing should provide a realistic assessment of the penetrations and high Δp testing may be completely unrealistic and failure might be the result of an overstress condition. Such a test appears to have been performed but no data is presently on hand at BNL.

In our investigation it was discovered that more work has been performed in this area which we have not had the opportunity of reviewing and which might add considerable support to the requirement for Δp testing. There has been some comparative testing in which penetration seals exposed to a constant positive pressure failed whereas the same seal exposed to intermittent positive pressures did not.

We have contacted Duke Power Company who had several tests performed at the Southwest Research Institute in San Antonio, Texas. It is our understanding that some of those tests were investigations for Duke Power's information only and, as such, are proprietary and were not reported as part of the staff's requirement for penetration testing. Δp testing ranging from 1/2" to 7" of water has been performed. We are presently attempting to arrange a meeting with Duke, Southwest Research and the cognizant engineer who was with Duke Power at that time.

An analytical approach to establish a meaningful Δp value was made in which the parameters of fire severity, compartment size, type of combustibles, ventilation (designed) and ventilation (leakage) were included. It was found that variations in fire intensity (watts) made such a large shift in the Δp value, either in a positive or negative direction as to negate any assessment of correct Δp.

In light of the foregoing, it is recommended that:

1. A standard test plan be written establishing methods and procedures for all fire stop testing and including guidance for determining the differential pressure or pressures to be used. The test plan should also define the test equipment and the method of establishing and maintaining Δp.

2. A review be instituted into the adequacy of E-119 for use as a standard for nuclear power station testing and that a new standard be written if E-119 is found to be inadequate or misleading. This would require testing which should be performed in accordance with the test plan.

3. Existing test data be collected and correlated on all penetration fire tests to obtain trend information or anomalies.

4. BNL continue this investigation. Several new areas of information have been uncovered but not pursued for schedule reasons and are not included in this interim report. It is estimated that a final report can be issued in three months depending on the cooperation of information sources.

In the interim, BNL recommends that the NRC position should be that all penetration testing be performed with a positive pressure on the fire side. Test data published in the Browns Ferry report of March 1976 indicates consistant damage to the unexposed side of the penetration with positive differential pressures of 0.5" and 5.0" of water. Four test runs at Southwest Research for Duke Power Co. with a 1" Δp successfully qualified the seal, however, the report states that the continuous pressure for the duration of the test imposed a more severe exposure factor on the penetration slab. Additionally, the Sandia Laboratory report of September 1979 prepared for the Engineering Methodology Standards Branch, Office of Standards Development, the IEEE Standard 634-1978 and the Underwriters Laboratories, Inc. procedure entitled "ASTM Designation E, Standard Method of Fire Tests of Electrical and Mechanical through Penetration Fire Stops, July 28, 1977" all recognize the desireability of positive Δp testing. We felt that this documentation is sufficient to support this interim requirement. It is also recommended that until we are more knowledgeable, the positive pressure be established as that which is equal to the maximum Δp measured in the safety related areas of the plant being considered plus a 25% factor of safety to cover variations that might be imposed by an actual fire.

The requirements of the NRC for penetration testing are shown in attachment 1. The reasons that these are not uniform for all plants are:

1. The plants all have some variations in penetration design and application.

2. The NRC staff position came out on February 14, 1978; some plant visits were completed prior to this date.

3. The state-of-the-art of testing penetrations (particularly with Δp) is evolving with most of the tests having been performed in the recent past.

We feel that when a satisfactory Δp fire test has been demonstrated by two or more testing companies, all of the licensee requirements should be reviewed by the staff.

Respectfully yours,

Robert E. Hall, Group Leader
Reactor Engineering Analysis

REH:ROS:EAM:sd
attachment
cc.: J. Boccio
E. MacDougall
R. Smith

APPENDIX 1

Plant	Elec. Cable Pen Qual. -Was Position A applied (All 8 Items)	ASTM E-119* What was Required on Cable Penetration Qual.	Was Hose Stream Req.	Was Δp Req.
ANO - Unit 2	Position A (7 items)	*	Item 8c	Item 5
Beaver Valley	Yes	*	Item 8c	Item 6
Big Rock	No	* 3 hours	No	No
Browns Ferry				
Brunswick 1-2	No	* 3 hours		
Calvert Cliffs	Yes Letter 1-18-79	* +7 conditions of "A"	Item 8c	Item 6
Cooper	Yes Letter 6-15-78	* +7 conditions of "A"	Item 8c	Item 6
Crystal River 3	No, upgrade to 3 hr. rating per 1-29-79 SER			
Dresden 1,2,3	Yes Letter 6-16-77	* +7 conditions of "A"	Item 8c	Item 6
Duane Arnold	No, upgrade to 3 hr. rating test			
FitzPatrick	No, upgrade to 3 hr. rating			
Fort Calhoun	No, upgrade to 3 hr. rating			
Ginna	Yes Letter 7-20-78	* +7 conditions of "A"	Item 8c	Item 6
Haddam Neck	Yes Letter 1-23-78	* +7 conditions of "A"	Item 8c	Item 6
Indian Point 2	No			

See page 3 for definition of terms.

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APPENDIX 1 (Cont'd)

Plant	Elec. Cable Pen Qual. -Was Position A applied (All 8 Items)	ASTM E-119* What was Required on Cable Penetration Qual.	Was Hose Stream Req.	Was Δp Req.
Indian Point 3	No			
Kewaunee	No			
LaCrosse	No			
Maine Yankee	No, upgrade to 3 hr. rating			
Millstone 1	No	3 hr. limit		
Millstone 2	No			
Monticello	Yes Letter 6-20-78	* +7 conditions of "A"	Item 8c	Item 6
Nine Mile Pt.	No			
Oconee 1-3	No			
Oyster Creek	No			
Palisades	No			
Peach Bottom 2,3	Yes Letter 11-14-78	* +7 conditions of "A"	Item 8c	Item 6
Pilgrim	No			
Point Beach 1,2	No			
Prairie Is. 1,2	No			
Quad Cities 1,2	No			
Rancho Seco	No			
H.B. Robinson 2	No			
St. Lucie 1	No	All req. of E-119 except hose stream		
San Onofre	No			

See page 3 for definition of terms.

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APPENDIX 1 (Cont'd)

Plant	Elec. Cable Pen Qual. -Was Position A applied (All 8 Items)	ASTM E-119* What was Required on Cable Penetration Qual.	Was Hose Stream Req.	Was Δp Req.
Surry 1,2	No			
Three Mile Is. 1	Yes Letter 6-13-78	* +7 conditions of "A"	Item 8c	Item 6
Trojan	No			
Vermont Yankee	Yes Letter undated	* +7 conditions of "A"	Item 8c	Item 6
Yankee Rowe	Yes Letter 6-12-78	* +7 conditions of "A"	Item 8c	Item 6
Zion 1,2	No			

Position A - Electrical Cable Penetration Qualification.

Item 5 - The fire barrier should be tested in both directions unless the fire barrier is symmetrical.

Item 6 - The fire barrier should be tested with a pressure differential across it that is equivalent to the maximum pressure differential a fire barrier in the plant is expected to experience.

Item 8c - The fire barrier remains intact and does not allow projection of water beyond the unexposed surface during the hose stream test.