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PERRY SQRT VISIT REPORT

T. L. Bridges
M. J. Russell
J. N. Singh

Idaho National Engineering Laboratory
Operated by the U.S. Department of Energy

Informal Report

Prepared for the
U.S. Nuclear Regulatory Commission
Under DOE Contract No. DE-AC07-76ID01570
FIN No. A6415

EG&G Idaho

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ABSTRACT

EG&G Idaho is assisting the Nuclear Regulatory Commission in evaluating Cleveland Electric Illuminating Company's program for the dynamic qualification of safety related electrical and mechanical equipment for the Perry Nuclear Power Generating Station. Applicants are required to use test or analysis or a combination of both to qualify equipment, such that its safety function will be ensured during and after the dynamic event, and provide documentation. The review, when completed, will indicate whether an appropriate qualification program has been defined and implemented for seismic Category I mechanical and electrical equipment which will provide reasonable assurance that such equipment will function properly during and after the excitation due to vibratory forces of the dynamic event.

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SUMMARY

A seismic qualification review team (SQRT) consisting of engineers from the Equipment Qualification Branch of the Nuclear Regulatory Commission and Idaho National Engineering Laboratory made a site visit to the Perry Nuclear Power Plant of Cleveland Electric Illuminating Company located at Perry, Ohio. They observed the field installation and reviewed the qualification reports for twenty-two selected pieces of seismic category I electrical and mechanical equipment and their supporting structures. Some equipment specific and certain general concerns were identified for which additional information is needed in order for the SQRT to complete the review. These are referred to as open items. The review indicated that the equipment was adequately qualified for the dynamic environment pending resolution of the open items.

1. INTRODUCTION

The Equipment Qualification Branch (EQB) of the Nuclear Regulatory Commission (NRC) has the lead responsibility in reviewing and evaluating the dynamic qualification of safety related mechanical and electrical equipment. This equipment may be subjected to vibration from earthquakes and/or hydrodynamic forces. Applicants are required to use test or analysis or a combination of both to qualify equipment essential to plant safety, such that its function will be ensured during and after the dynamic event. These pieces of equipment and how they meet the required criteria are described by applicants in a Final Safety Analysis Report (FSAR). On completion of the FSAR review, evaluation and approval, the applicant receives an Operating License (OL) for commercial plant operation.

A Seismic Qualification Review Team (SQRT) consisting of engineers from the EQB of NRC and Idaho National Engineering Laboratory (INEL), made a site visit to the Perry Nuclear Power Plant of Cleveland Electric Illuminating Company at Perry, Ohio, from August 14 through August 17, 1984. The purpose of the visit was to observe the field installation, review the equipment qualification methods, procedures (including modeling technique and adequacy), and documented results for a list of selected seismic Category I mechanical and electrical equipment and their supporting structures. This report, containing the review findings, indicates which of the items are qualified and require no additional documentation. It also identifies some equipment and certain general concerns for which additional information is needed in order for the SQRT to complete the review. These are referred to as open items. The applicant is to further investigate and provide additional documentation to resolve these issues.

Table 1 contains a list of personnel who attended the site visit. Subsequent sections of this report give a brief overview and identify the concerns, followed by the findings, for the selected seismic Category I equipment.

2.1 ELECTRICAL PROTECTION ASSEMBLIES (NSSS-1)

The electrical protection assemblies are wall mounted electrical boxes and associated devices. They measure 16 in. x 20 in. x 8 in. and weigh approximately 150 lb each. These assemblies were manufactured by General Electric Co. with model No. GE-DWG-914E175. All eight assemblies are located at the 620 ft elevation of the control complex. Each is attached to the wall with four 3/8 in. diameter bolts. Two inch diameter rigid conduits attach to the boxes at both the bottom and top. Each assembly must perform its 1E function during both hot standby and cold shutdown conditions.

The assemblies were purchased to GE purchase specification 21A3120. These items were qualified for dynamic loading by dynamic testing performed by GE, documented by test Report DRF C71-00044. The testing consisted of low level resonance search and biaxial, random, multifrequency dynamic testing. The assembly lowest natural frequencies were determined to be 54.5 Hz side/side (s/s), 61 Hz front/back (f/b), and 54.5 Hz vertical (v). The required test spectra zero period accelerations (ZPA) for the operating basis earthquake (OBE) are 0.213 g s/s and f/b, and 0.36 g v. The corresponding values for safe shutdown earthquake (SSE) are 0.33 g and 0.58 g. The test input ZPA values were as follows: OBE: s/s 5.4 g, f/b 8.0 g, v 7.0 g; SSE: s/s 11.0 g, f/b 10.07 g, v 8.9 g. The specimen was subjected to 10 OBE and 4 SSE tests. Half of each series was with the test motion in-phase and half out-of-phase. The specimen was test mounted flat rather than vertically. Acceptability of this mounting is justified because the test input levels are significantly higher than the required dynamic loading in combination with gravity loading. Operability of the assembly was verified during and after the dynamic testing.

Based on our observation of the field installation, review of the qualification reports and the responses by the applicant to our questions, the electrical protection assemblies are adequately qualified for the defined seismic and hydrodynamic loads.

2.2 ROD POSITION MULTIPLEXER CABINET (NSSS-2)

The rod position multiplexer cabinet (model No. H22-P071) was supplied by General Electric Company (GE). It measures 72 x 53 x 30 in. and weighs approximately 1500 lb. This cabinet is located at the 620 ft elevation of the containment building. The mounting consists of twelve 9/16 in. bolts to the floor.

This equipment is qualified by tests performed on a similar unit by General Electric Company. Seismic loads are considered in the qualification. The pertinent design specification for qualification requirements are in: GE Drwg 22A3746--Design Spec. Local Instrument Panel EDLPL865E133BAG001, Rev 6; Assy 865E133BA, Rev 2. The qualification details are in BWR 6 Rod Control and Information System Panels; GE DRF No. A00-794-8, dated March 18, 1980.

The rod position multiplexer cabinet is required to transmit correct rod position information or to fail safely during normal plant operation and after a seismic event. In any event, the multiplexer cabinet must not fail in a way that violates divisional separation of electrical systems.

Reportedly, the equipment was tested up to high frequency, but the data was reduced only up to 23 Hz. Due to the loss of high frequency data, GE did a preliminary failure mode analysis. GE stated that this analysis indicates that none of the failure modes identified can prevent the position multiplexer from failing safely or can have a detrimental impact on the bus supplying power to this equipment. Thus, this unit is not a safety related item. The utility is not convinced of the argument and wants GE to justify their contention. GE is in the process of a detailed analysis of the failure modes. In case it turns out that this equipment is safety related, the item would be requalified according to Perry 1 requirements, including high frequency testing.

Based on the responses of the applicant to our questions, it is concluded that there is a mechanism in place (work is in progress) which

would assure the seismic qualification of the rod position multiplexer cabinet to a satisfactory level. The utility has agreed to inform the NRC when qualification is completed.

2.3 CONTROL ROD DRIVE VENT VALVE (NSSS-3)

The control rod drive vent valve is a one inch air operated globe valve. It was supplied by ITT Hammer Dahl with model No. 522FRR62HAZ9. The valve is line mounted in a one inch schedule 160 pipe line at elevation 642 ft inside the containment. The piping has vertical supports within 8 in. of either side of the valve. Horizontal support of the valve is provided near the vertical center of gravity of the valve-operator combination. This valve is normally open and is required to close during scram conditions. It is required for both hot standby and cold shutdown conditions. The valve closes upon the loss of operator air.

The valve was purchased to design specifications 22A6924, 22A6924AA, and 23A1331. It was qualified for seismic and hydrodynamic loading by testing performed by Wyle Laboratories, documented by test Report No. 58840 Rev. B, dated February 5, 1984. The test valve nozzles were welded to book-end shaped plates which were rigidly attached to the test table. The valve-operator combination natural frequencies were determined to be 20 Hz s/s, 60 Hz f/b, and rigid vertically. The specimen was tested using random, independent biaxial test motion. The testing consisted of 5 OBE and 1 SSE tests of 30 seconds duration each. Since the test mounting was more rigid than normal valve line mounting, the input test motion ZPA was set above the floor required response spectra peak. The valve and operator operated without any anomalies during and after the testing. Valve stroke times were within the allowable 30 seconds.

Based on our observation of the field installation, review of the qualification reports and the responses by the applicant to our questions, the control rod drive vent valve is adequately qualified for the defined seismic loads.

2.4 SQUIBB VALVE (NSSS-4)

The squibb valve (MPL No. 1C41F0004B, model No. 1832-159-01) was supplied to design specification Nos. 21A9370AB rev. 7 and 21A9370 rev. 6 by Conax. It is located in the reactor building at the 644 ft elevation. It was installed between flanges of the piping system with four 1 in. bolts. The valve weighs 40 lb and is 4.5 in. long by 7 in. diameter. The valve is part of the standby liquid control system. Its function is to provide leak tight isolation of the system until it is fired, at which time it allows injection of poison into the primary coolant.

The valve was qualified by test (General Electric report No. NEDC-30207, Environmental Qualification Report, SLCS Explosive Valve, October 1983). The fundamental natural frequency of greater than 100 Hz was calculated for the valve. It was subjected to a full test series. Vibration, thermal and radiation aging was applied before the seismic test. This included fifteen minutes of sine beat testing in each axis at an input acceleration value of 4.5 g, which would address aging due to hydrodynamic loads. Mounting for vibration testing was identical to the field mounting. Seismic qualification consisted of sine beat testing in three orthogonal axes. For each axis, five OBE tests were performed at an acceleration of 4.5 g and in the frequency ranges 5-20, 45-60 and 90-100 Hz. One SSE test was performed in each axis at an acceleration value of 6.75 g. These input acceleration values envelope the RRS ZPA values of 0.3 g horizontal and 0.2 g vertical for OBE, and 0.45 g horizontal and 2.0 g vertical for SSE.

Based on our observation of the field installation and review of the qualification documents, the squibb valve is adequately qualified for the prescribed loads.

2.5 REACTOR CORE ISOLATION COOLING STEAM TURBINE ASSEMBLY (NSSS-5)

The reactor core isolation cooling (RCIC) steam turbine assembly (model No. GS-2) was supplied by Terry Corporation. It is located in the auxiliary building at the 599 ft elevation and has a rated horsepower of 825 at 4550 revolutions per minute. The maximum inlet and outlet pressures are prescribed as 1250 psig at 575°F and 165 psig. The maximum governor valve travel is specified as 7/8 in. This base mounted, single wheel steam turbine measures about 7 ft long by 6 ft wide by 5 ft high and weighs approximately 5000 lb. The mounting consists of six 1 in. bolts. It drives the RCIC pump, providing cooling water to the reactor vessel over a pressure range of 1150 psig to 150 psig. The purchase specification from GE to Terry Turbine is in document No. 21A9526 rev. 2 dated July 5, 1973, (generic) and the Perry specification is: 21A9526AE of March 15, 1974.

The qualification of the turbine assembly is based on both analysis and test. The qualification documents are: Environmental Qualification Report E/L 20452, Rev. 1, dated April 21, 1980, prepared by Wyle Laboratories and Terry Corporation and reviewed by General Electric Company. Other supporting documents are:

S.N.	Document Identification	Revision or Date	Title or Subject
1	VPF 2757-74-1	7149	Turbine Stress Analysis
2	VPF 2757-34-2	7002	Stop Valve Stress Analysis
3	VPF 2757-35-1	7030	Seismic Analysis

The function of the pump driven by the turbine is to supply makeup water in three cases:

(i) loss of feed, loss of main condenser, etc.

(ii) control rod drop accident, and

(iii) anticipated transient without scram event.

Qualification Testing

The specimen was the same type of turbine assembly. The mounting consisted of the assembly base plate bolted to a rigid metal fixture which was in turn welded to the test table. This simulated the actual in-service mounting condition as closely as practical. Two RCIC turbine assemblies, Model GS-2, were subjected to dynamic qualification test programs. In the first program, the unit had a set of appendages, a particular support condition, and was not aged. This program showed some undesirable vibration characteristics and anomalies were detected. Subsequently, a second test program was commissioned which had the same model turbine assembly (GS-2), a slightly different set of appendages, modified support conditions, and was aged prior to dynamic testing. These appendages and support modifications were based on the lessons learned from the first test program. The following discussion pertains to the second test program.

The turbine assembly was subjected to the following test sequence:

Resonance search:	First horizontal axis and then vertical axis
Qualification tests:	Five OBE level and one SSE level tests performed
Rotate the specimen:	90 degrees about the vertical axis
Resonance search:	Second horizontal axis

Qualification tests: Five OBE level and one SSE level tests performed.

The resonance search tests were performed with a 0.2 g single axis sine sweep input between 1 Hz to 60 Hz, at a sweep rate of one octave per minute. The following natural frequencies were detected:

s/s	f/b	v
17, 24 Hz	16, 22 Hz	18, 33 Hz

The qualification tests consisted of two simultaneous, but independent random signals which produced phase-incoherent horizontal and vertical motion. The amplitude of each one-third octave bandwidth was independently adjusted in each axis until the TRS enveloped the generic RRS. The resulting motion was analyzed by a response spectrum analyzer at two percent damping and plotted at one-sixth octave interval over the frequency of 1 to 100 Hz. The generic RRS envelops the Limerick site required response spectrum for the floor where the unit is located. The dynamic simulation tests were each of 30 seconds duration. Operability of the turbine assembly (startup, steady state operation, and shutdown) was demonstrated during and after the tests. Two anomalies were detected during the test. Discussion of the anomalies and their disposition follows.

1. Turbine Trip: The turbine tripped during the SSE level run.

Discussion: The turbine trip was attributed to loose flange bolting at the interface of the governor valve and the turbine casing. This resulted in highly amplified vibration at the trip and throttle valve, causing the trip latching mechanism to separate. The bolting was retorqued and the test was repeated successfully. Six additional tests were performed with no further problems.

Disposition: The dynamic portion of the test specification defines the acceptability of tightening the hardware after each test. Furthermore, the maintenance portion of the turbine instruction manual defines the necessity for verifying bolt and stud-nut torque condition after every seismic event. The turbine trip occurred on the sixth test of the series. There had been no retorquing prior to this test, and none was required during the subsequent seven tests. It is, therefore, concluded that the design is adequate, and no corrective action is necessary.

2. Lube oil piping vibration: During the resonance search and the first OBE level testing, excessive displacement was observed in the oil piping to the coupling end bearing.

Discussion: The resonance search revealed a natural frequency of 15 to 20 Hz for the oil piping to the coupling end bearing. The first OBE level test revealed excessive displacement. This is critical piping. Its integrity is required for proper functioning of the turbine. A support bracket was added to stiffen the piping assembly. Subsequent tests were conducted without incident.

Disposition: The oil piping on all turbine assemblies will be inspected for support adequacy, with additional support added where necessary.

The lessons learned from the test program (on the unaged turbine assembly) included several areas where structural improvement was required. They are:

a. stiffness of the latching lever spring on the turbine trip and throttle valve,

b. dowel pin adequacy for the turbine coupling end pedestal,

c. positive locking of the turbine pedestal bolts, and

d. support adequacy for the turbine auxiliary piping.

These improvements were implemented on the second turbine assembly (the aged assembly test) prior to the start of its qualification tests, with the exception of the turbine auxiliary piping. This is because the piping supports are installation-unique to a degree. The results of this test program demonstrated the adequacy of the structural upgrade activity. The unit in Perry 1 has been upgraded.

Qualification Analysis

The original turbine analysis conservatively demonstrated the pressure integrity of the assembly. Using these calculations and the accelerometer data recorded during the qualification test program, detailed calculations were performed to define the nozzle load capabilities. A typical set of force/moment loads were applied to the turbine inlet and exhaust nozzle during the test. In brief, the structural adequacy of the assembly was ascertained as follows:

a. stresses due to pressure were calculated,

b. stresses due to dynamic loads were calculated from the acceleration data, and

c. the rest of the strength was available for nozzle loads.

Applicability of the Qualification Program

The test specimen and the installed product are both complete RCIC turbine assemblies. However, they were manufactured at substantially different times. A detailed similarity evaluation was performed by the applicant to identify the differences between the tested and installed unit. The upgrading and design differences to be implemented for the Perry unit to be fully qualified are as follows:

1. In the first qualification test program, #8 taper pins were used for coupling-end alignment. One of these pins failed after 31 tests (accumulated test time of approximately 15 minutes).

The turbine for the second test program (which was a success) used #9 taper pins. It also had lock plates for pedestal bolting. Therefore, the Perry turbine needed upgrading with #9 taper pins and lock plates for the pedestal bolting. This has been done in the field.

2. During the first seismic qualification test program, the initial test activity resulted in inadvertent, unacceptable closure of the trip and throttle valve. The original latching spring was replaced with one having a higher spring coefficient. The operability of the solenoid trip mechanism and the mechanical overspeed trip mechanism were verified after installation of the stiffer latch spring, and proved to be acceptable. The seismic qualification test program was then successfully completed.

   As a result the field installation required the following corrective action. The latch spring was to be removed from the trip and throttle valve assembly, and its spring constant measured, which should be 25 lb/in., ±10%. If the installed spring did not satisfy this value, it was to be replaced. The spring "load" in the valve latched position was to be 32.5 lb. This check has been done in the field, according to the applicant.

3. Each RCIC turbine installation has somewhat of a unique piping arrangement. For turbine oil piping adequacy, therefore, the Perry as-installed piping has been reviewed and adequate supports provided.

Aging evaluation of the nonmetallic mechanical components of the assembly has not been performed. However, there is a program in place (presented by the applicant) which, when completed, will alleviate this problem.

Based on observation of the field installation, review of the qualification documents and responses of the applicant, the RCIC turbine assembly will be seismically qualified when the program is completed.

2.6 TERMINATION CABINET (NSSS-6)

The termination cabinet (MPL No. 1H13P0702, no model No.) was supplied to the standard Perry NSSS design specification by General Electric. It is located in the control complex at the 654.5 ft elevation. The cabinet is attached to the floor with eighteen 5/8 in. bolts. It weighs approximately 2400 lb and measures 96 W x 102 H x 36 D in. The cabinet is a control room panel, where it serves as an interface between control room circuitry and electrical cables entering the control room.

Qualification of the cabinet was based on a similarity argument between this cabinet and a series of cabinets qualified by test (General Electric report No. GE DRF A00-794-5-1, Seismic Qualification Test Report, October 1, 1980). The tested cabinets were subjected to a series of multifrequency (random) tests on a biaxial test table. Test mounting was with sixteen 5/8 in. bolts. Testing was performed in two positions, with in-phase and out-of-phase inputs in each position. Five OBE tests followed by an SSE test were performed. TRS for all testing enveloped the Perry RRS. Since the spectra did not include hydrodynamic effects, there was a concern that a cabinet qualified to this methodology could be mounted in an area of the plant subject to hydrodynamic excitation. A check was made, and all the cabinets of interest were found to be located in the control complex, which is isolated from hydrodynamic loading.

GE analyzed the test results. Variations in cabinet response as a function of cabinet size, aspect ratios, mass, and mass distribution were established. All cabinets were of similar construction. Results of the study were used to demonstrate similarity of the termination cabinet with those tested.

Based on inspection of the field installation, review of the qualification documents, and the applicant's response to questions, the termination cabinet is adequately qualified for the prescribed loads.

2.7 CONTROL ROOM PANEL (NSSS-7)

The control room panel (model No. H13-P680) was supplied by General Electric Company (GE). It measures 240 x 33 x 63.5 in. and weighs about 7200 lb. It is located in the control room at the 654 ft 6 in. elevation. The mounting consisted of welding at the corners to the floor channel. Seismic loads are considered in the qualification. The qualification details are contained in report: Test Report H13-P680 Prototype Center Enclosure Compact Principal Plant Control Console, GE DRF A00-1138.

The qualification is based on the tests performed on a dynamically similar panel (minute dimensional difference). Test mounting consisted of clamps at angle supports where welding in the field was specified. The required ZPA for the location were:

	s/s	f/b	v
OBE:	0.43 g	0.43 g	0.40 g
SSE:	0.64 g	0.64 g	0.60 g

A low level resonance search indicated the following natural frequencies:

s/s	f/b	v
24 Hz	19.5 Hz	28 Hz

The qualification test consisted of biaxial (independent) random input. The test was done with in-phase and out-of-phase inputs and then repeated after the equipment was rotated 90 degrees about the vertical axis. TRS were generated. The TRS envelope the RRS satisfactorily. Four percent damping was used for both RRS and TRS.

Panel structural integrity was maintained and the class 1E devices functioned as required during and after the test. There were five OBE and one SSE level tests performed.

There was a difference between the field and the laboratory supports. In the laboratory mounting, welding at each angle support was specified (where it was clamped), but in the field it is only welded at the corner. The applicant has committed to provide a justification for the discrepancy.

During the review of the documentation it was discovered that there were unqualified items on panels H13-P883, P884, P885 but not on H13-P680. This was pointed out to the applicant. The applicant is required to address these items.

Based on observation of the field installation, review of the qualification reports and the responses of the applicant, the control room panel is adequately qualified for seismic loads pending resolution of the mounting difference and the unqualified items..

2.8 BENCHBOARD (NSSS-8)

The benchboard (control room panel, MPL No. 1H13P0870, model No. H13-P870) was supplied to the standard Perry NSSS design specification by General Electric Co. It is located in the control room, at the 654.5 ft elevation. The benchboard was attached to the floor with eighty-four 1/2 in. bolts. It weighs approximately 2400 lb and measures 252 W x 36 D x 90 H in. The benchboard is a control room panel, where it serves as a support for electrical instruments such as displays, indicators and switches.

The benchboard was qualified by test (General Electric report No. GE DRF A00-1138, H13-P870 Seismic Test, Index I). It was mounted to the test table in a fashion identical to the field mounting. A series of multi-frequency (random) biaxial tests were performed. Testing was performed in two positions, with in-phase and out-of-phase inputs in each position. Five OBE tests were performed, followed by one SSE test. All TRS enveloped the appropriate Perry RRS. Panel structural integrity was demonstrated and all mounted class 1E devices functioned as required.

Although not required for qualification in this case, fundamental natural frequencies of 14.0 Hz (s/s) and 17.5 Hz (f/b) were established during testing. These compared to frequencies of 17.5 Hz (s/s) and 16.8 Hz (f/b) obtained from in-situ testing.

Generally, not all cabinet mounted instruments at Perry were qualified simultaneously with their cabinets, as was done with this benchboard. Therefore a check was made on a cabinet mounted relay which was qualified separately from its cabinet. The device chosen was a relay (MPL No. D17-74-E) mounted in cabinet H13-P872. The G.E. qualification document number for this device is DRF A00-1084, Index 212. The document was found to be incomplete, with test procedure QTP-GP-1 missing. The test procedure was located in the San Jose Office of GE, but a copy of it should have been included with the qualification document. This was classified as an isolated incident, since all other qualification files reviewed were complete. Test results found in the document indicated that single

frequency fragility testing was performed. This included a determination of fundamental natural frequency (rigid). The failure mode of the relay was determined to be failure of the attachment to the table, and not a malfunction of the relay. This occurred at 17 g horizontally and 7.4 g vertically. A series of single frequency tests were performed in the two horizontal and one vertical direction at closely spaced frequencies (2 Hz) in the seismic range. Input acceleration was at the table limit for the lower frequencies and the malfunction limit for the higher frequencies. The accelerations required for the mounting location were 5.6 g (f/b), 5.1 g (s/s), and 1.6 g (v), which were enveloped by the test accelerations. Seismic qualification with substantial margin was demonstrated.

Based on inspection of the field installation, review of the qualification documents, and the applicant's response to questions, the benchboard is adequately qualified for the prescribed loads.

2.9 FUEL POOL RETURN LINE FLOW CONTROL VALVE (NSSS-9)

The fuel pool return line flow control valve is a 10 in. 150 lb class butterfly valve. It was supplied by Contromatics Corp. with model No. C-W2566-CC. Its actuator was supplied by Limitorque with model No. SMB/4BC. The valve and actuator are line mounted in the fuel pool return line at elevation 599 ft of the intermediate building.

The control valve and actuator were purchased to design specification SP-524-4549-00. Qualification of the valve and actuator for dynamic loading was accomplished by testing performed by Acton Environmental Testing Co., documented in report No. 12875-1, dated April 27, 1977. The valve and actuator assembly were rigidly attached to the test table at 45 degrees to the table input motion. The side to side natural frequency was determined to be 22.8 Hz. The vertical and front to back natural frequencies were determined to be above 33 Hz. The test specimen was subjected to sine beat testing with peak input acceleration levels of 3.0 g. Each test had 5 beats with 10 cycles per beat.

The tests were performed at the valve natural frequency and at the following frequencies: 1, 5, 10, 15, 20, 25, 30, 33 Hz. The tests were performed in four orientations to provide both in-phase and out-of-phase motion for each biaxial combination. The valve was actuated during each test and was observed to operate without malfunction. No valve leakage was observed during or after tests with the valve pressurized to 165 psi. The valve acceleration levels determined from the piping seismic analysis are s/s 1.014 g, f/b 0.522 g, and v 0.307 g.

Based on our observation of the field installation, review of the qualification reports and the responses by the applicant to our questions, the flow control valve is adequately qualified for the prescribed loads.

2.10 DIFFERENTIAL PRESSURE TRANSMITTER (NSSS-10)

The differential pressure transmitter (model No. 1151) was supplied by Rosemount to purchase part drawing No. 163C1563. This locally mounted item is in the auxiliary building at the 568 ft 4 in. elevation. It weighs 11.9 lb. The mounting consists of horizontal and vertical plates, with the equipment bolted with four 1/4 in. bolts. Seismic loads were considered in the qualification. Details of the qualification were in the report: H22 Local Panels Qualification Report, GE DRF No. A00-794-10, dated March 18, 1980.

This pressure transmitter measures water pressure in the residual heat removal shutdown cooling suction piping. It provides an electrical output signal that is proportional to the measured pressure. If the pressure rises to a predetermined high value, it provides a trip signal which will sound a control room annunciator alarm and illuminate an associated window message. During normal operation, this alarm is an indication of leakage (through closed isolation valves) from the reactor into the RHR shutdown cooling suction piping.

Qualification is based on tests performed on a similar unit. The test consisted of independent biaxial random input. In-phase and out-of-phase inputs were provided. The same set of tests were repeated after rotating the specimen 90 degrees about its vertical axis. There were five OBE and one SSE level tests performed. TRS were generated for each case. TRS, having a five percent damping, envelope the RRS with four percent damping satisfactorily. The ZPA for the TRS is higher than that required in each case. GE also stated the equipment has only a passive safety function and it did demonstrate pressure integrity.

Based on observation of the field installation, review of the qualification document and the answers provided by the applicant to our questions, this pressure transmitter is adequately qualified for the Perry site.

3.1 CONTROL COMPLEX CHILLED WATER PUMP (BOP-1)

The control complex chilled water pump is located at elevation 574 ft of the control complex building. It is a horizontal pump rated for 1600 gpm at 1750 rpm. The pump was supplied by the Ingersoll-Rand Co. The pump has serial No. 0378140. The pump motor is a 100 horsepower Westinghouse motor, catalog No. 7901-01-001. The pump and motor are both bolted to a common skid with four 1 in. diameter bolts. The skid is in turn bolted to the floor with six 7/8 in. diameter embedded bolts.

Qualification of the pump and motor for seismic loading was performed by analysis. Both were purchased to design specification SP-750-4549-00. The structural integrity and operability analysis of the pump was performed by the Ingersoll-Rand Company, documented in report No. 94Q-211-2, dated November 23, 1982. The motor analysis was performed by Westinghouse, documented in report No. AL50037, dated June 16, 1983. The pump analysis was performed considering static seismic loading in combination with normal operating loads per the requirements of ASME Boiler and Pressure Vessel Code Section III, Subsection ND. Natural frequencies of the pump were determined to be greater 33 Hz in all three directions. Static loading coefficients equal to the seismic ZPA were used for the seismic loading portions of the analysis. These values were 0.09 g in all three directions for OBE and 0.18 g for SSE loading. All stresses for combined seismic and normal operating loads were within the ASME Section III, Subsection ND allowables. The pump motor analysis was also performed using ZPA static coefficient loading. The stresses from this analysis were also within allowable stresses and the motor rotor deflections were less than the provided clearance, assuring operability of the motor.

Based on our observation of the field installation, review of the qualification reports and the responses by the applicant to our questions, the chilled water pump and motor is adequately qualified for the defined seismic loads.

3.2 LEAD-ACID ELECTRICAL STORAGE BATTERIES AND RACKS (BOP-2)

The batteries (model No. 2GN-15) and battery racks were supplied by Exide Power Systems Division of ESB Corporation. This 125 Vdc system, measuring 108 W x 38.25 H x 48.75 D in., is located in the control complex at the 638.5 ft elevation. The battery cells are clear plastic, mounted on an open steel lattice rack. The rack is a three bay, two step type which is welded to the floor. There are sixteen 2.5 in. long welds per rack. The purchase specification is contained in the report: Design, Fabrication, and Delivery of Class 1E Station Batteries and Racks, SP-554-4549-00, Rev. 1, dated January 17, 1978. The qualification of the batteries is documented in the report: Nuclear Environmental Qualification Program on Type GN Lead Acid Electrical Storage Batteries, No. 45001-1, rev. A, dated November 30, 1981, done by Wyle Laboratories. The test was performed on a 12 battery configuration rack. Through analysis the 15 battery configuration was found to be adequate. This rack analysis is contained in the report titled: Comparison Test and Analysis of Two Step "G" Size, 3 Bay High Seismic Battery Rack, No. A-3-82 dated February 10, 1982. These reports were reviewed by Gilbert/Commonwealth.

The qualification of the batteries and racks was done through test. Required peak acceleration for the location were:

	s/s	f/b	v
OBE	2.53 g	2.53 g	2.53 g
SSE	3.2 g	3.2 g	3.2 g

In the laboratory configuration, a three bay, two step 12 battery arrangement was welded to the test table. There were two types of tests performed, resonance search and qualification tests. Resonance searches were performed in the range of 1 to 200 Hz. The following fundamental frequencies were detected (for the racks):

s/s = 11.5 Hz, f/b = 15.2 Hz, and v = 35 Hz.

Qualification tests were independent, biaxial and random. In-phase and out-of-phase inputs were provided. The specimen was subjected to the same set of tests after a 90 degree rotation about the vertical axis. The peak acceleration for the tests were:

	s/s	f/b	v
OBE	6.25 g	6.25 g	6.25 g
SSE	10.0 g	9.8 g	7.4 g

Ten OBE and two SSE level tests were performed. These tests were performed after thermal and radiation aging equivalent to 20 years of normal operation. TRS were generated for each test. TRS enveloped the RRS for each case for 2% damping.

There was no anomaly detected during the tests. Subsequently, an analysis was performed to extend the adequacy of the rack to a 15 battery configuration. The fundamental frequencies of the model were:

s/s = 11.17 Hz, f/b = 15.98 Hz and v = 34.51 Hz.

The critical stresses were:

Element	Total Stress (psi)	Allowable Stress (psi)
support angle	950	28,000
lower left frame support	27,795	31,110

Allowable stresses were taken from AISC Sections 1.5 and 1.6.

Based on the observation of the field installation (with spacer), review of the qualification documents and the answers provided by the applicant to our questions the batteries and racks are adequately qualified for 20 years service in the seismic site environment.

3.3 FOUR INCH GLOBE VALVE (BOP-3)

The globe valve (MPL No. 11M51F0010B, model No. 81300) was supplied to design specification No. SP-521-02 by Borg Warner. It is located in the reactor building at an elevation of 670 ft. The valve weighs 423 lb (with actuator), and has dimensions of 15 x 22 x 40 in. It is supported by the piping to which it is welded. The valve is part of the combustible gas control system, where it provides isolation when shut and throttling when open.

The valve was qualified by analysis to the ASME Code (Borg Warner report No. NSR 81300, revision C, Seismic Analysis of 4 in.-300 lb Carbon Steel, Motor Operated Globe Valve, April 7, 1982). The fundamental natural frequency of the valve was established at 40.57 Hz by finite element analysis. The valve was then qualified using an equivalent static analysis. A conservative, simply supported boundary condition was used. Accelerations taken from the associated piping analysis were applied. All stresses were below the allowables. The maximum critical deflection (0.0142 in.) was less than the machining tolerances.

Based on our observation of the field installation and review of the qualification documents, the 4 in. globe valve is adequately qualified for the prescribed loads.

3.4 SOLENOID VALVE (BOP-4)

The solenoid valve (MPL No. 1D17F0079A, model No. 77JJ-004) was supplied to design specification No. SP-597-4549-00 by Target Rock Corp. It is located in the intermediate building at an elevation of 635 ft. The valve weighs 30 lb and is 15 in. long by 6 in. diameter. It is supported at the base by an integral attachment plate welded to a beam cantilevered from the wall. The valve is part of the plant radiation monitoring system, where it serves a containment isolation function.

The valve was qualified by analysis (Target Rock report No. 3215, Seismic Analysis of TRC Models 77JJ-001 through -004, February 18, 1982). The fundamental natural frequency was established at 117 Hz by a beam type calculation. The valve was qualified with a static analysis of an equivalent cantilevered beam. A 3 g acceleration was applied in all three orthogonal directions. This is well above the ZPA value for the mounting location. The maximum stress was calculated to be 7756 psi, vs. an allowable of 18750 psi. Operability was assured by a calculated maximum critical deflection of 0.0007 in. vs. a 0.005 in. allowable.

The design specification made reference to IEEE 344-1975 without reference to Regulatory Guide (R.G.) 1.100. Although a check of the analysis showed no concern for this particular item, there was a concern that the modifications of IEEE 344-1975 stated in R.G. 1.100 were not generically applied. However, the commitments made by the applicant in the FSAR (in tables 1.8-1, 8.1-2, and in Section 3.10.1.1.3.4) indicate that the R.G. 1.100 modification to IEEE 344-1975 are part of the generic requirements. This was supported by the fact that this problem was not encountered with any other SQRT item.

During field inspection of this valve, a nearby valve (No. 1D17F071A) was observed to be questionably supported. Lateral motion of the valve actuator was restrained by a cantilevered support (No. 1H51P071) which was not positively attached to the actuator. Contact between actuator and valve was through nonparallel surfaces. This could have resulted in an interaction where the contact load would force the support to slip up,

allowing the valve to move laterally. However, hand calculations showed that the support was sufficiently stiff in the vertical direction to prevent such motion.

Based on our observation of the field installation, review of the qualification documents, and the applicant's answers to our questions, the solenoid valve is adequately qualified for the prescribed loads.

3.5 EMERGENCY SERVICE WATER TRAVELING WATER SCREEN CONTROL PANEL (BOP-5)

The emergency service water traveling water screen control panel, supplied by Rexnard Control Products, is located in the emergency service water pumphouse at elevation 586 ft 6 in. This control box is custom made. It supports electrical devices required to provide control functions to the emergency service water traveling water screen. These functions must be provided for both hot standby and cold shutdown conditions in addition to post-accident and after normal shutdown conditions. The control box is pedestal mounted. The base of the pedestal is bolted to the pumphouse floor with four 1/2 in. diameter embedded bolts.

The qualification of the control box and associated electrical devices was performed by a combination of analysis and testing. A response spectra analysis of the pedestal and box was performed by LeRoy A. Lutz Computerized Structural Design, Inc. Documentation of this analysis is contained in Lutz report No. 78321, dated May 31, 1979. The pedestal natural frequencies were determined to be 9.73 Hz s/s, 11.91 Hz f/b, and 20.44 Hz vertical. The results of the analysis demonstrate that structural integrity of the control box will be maintained for postulated seismic loading. An additional analysis was performed by Gilbert/Commonwealth to determine the in cabinet response spectra for the associated electrical devices. This analysis is documented by Gilbert report No. 940-364-1-0, dated October 5, 1983. Since the associated electrical devices are used in several applications throughout the Perry plant, they were qualified separately by seismic qualification tests with test response spectra which sufficiently envelopes the control box in-cabinet required response spectra.

Based on our observation of the field installation, review of the qualification reports and the responses by the applicant to our questions, the control panel is adequately qualified for the defined seismic loads.

3.6 MOTOR CONTROL CENTER (BOP-6)

The motor control centers, supplied by Eaton/Cutler-Hammer (model No. F245), are located at elevation 586 ft 6 in. of the emergency service water pumphouse. This equipment consists of electrical switchgear mounted in cabinets which are 96 in. long, 24 in. wide, 90 in. high with a total weight of 2240 lb. The cabinet base is welded (front and back) to embedded angle iron with intermittent 1/4 in. fillet welds 3 in. long, spaced at six inches.

This item was purchased to design specification SP-750-4549-00. The cabinet and its contents were qualified for seismic loads by testing. The report documenting the seismic qualification of this item was prepared by Patel Engineering, report No. PEI-TR-83-9, dated March 24, 1983. The testing was performed by Farwell and Hendricks, documented by report No. 10049, dated March 18, 1983. The cabinet was welded to a test fixture and subjected to low level resonance search and biaxial random motion seismic tests. The cabinets natural frequencies were determined to be 17.8 hz side to side, 18.9 hz front to back, and greater than 33 hz vertically. The seismic tests consisted of five OBE and one SSE biaxial tests in each test direction; front to back/vertical and side to side/vertical. The test response spectra enveloped the required response spectra for both OBE and SSE tests. Functional operability of the electrical devices contained in the cabinet was verified during and after the tests. A seperate analysis was performed to account for the effects of a top entry cable. This analysis is documented by GAI calculation No. 40.01 dated June 8, 1983. It demonstrated that stresses for a malleable iron connector would be within the allowable stress.

Based on our observation of the field installation, review of the qualification reports and the responses by the applicant to our questions, the motor control center is adequately qualified for the defined seismic loads.

3.7 VERTICAL PUMP (BOP-7)

The vertical pump (MPL No. 1P45C0002, model No. VIT) was supplied by Gould Pumps to design specification Nos. SP-750-4549-00, Revision 1, and SP-501-4549-00, Revision 2. It is located in the emergency service water pumphouse at an elevation of 586.5 ft. The pump weighs 3730 lb (flooded) and is 41.75 ft long by 11-3/8 in. diameter. The pump is attached to the floor with four 1-3/8 in. bolts. Seismic lateral supports are provided for the unit. The pump is part of the emergency service water system, where it supplies water for component cooling.

The pump was qualified by analysis. (McDonald Engineering Analysis Company report No. ME-453, Seismic Analysis of Vertical Pump, September 16, 1977). The fundamental frequency of the pump was established at 13.6 Hz by a 2-D finite element analysis. The computer code used, ICES-STRUDL, is a well known and widely used code. Response spectrum analysis indicated that the most strongly challenged area of the pump was the discharge head base plate. The calculated stress there was 26,155 psi, vs. an allowable of 26,250 psi. Operability was ensured by a maximum critical deflection of 0.0010 between rotor and starter. The maximum allowable deflection in this area is 0.0040 in.

Based on our observation of the field installation and review of the qualification documents, the vertical pump is adequately qualified for the prescribed loads.

3.8 AIR HANDLING UNIT (BOP-8)

The air handling unit is located at elevation 574 ft of the auxiliary building. It is a floor mounted, box shaped housing with an 11 in. diameter fan. The fan motor is mounted external to the fan housing. The total weight of this unit is approximately 700 lb. The unit was supplied by Carrier Air-Conditioning Company with model No. 3913A050. The fan motor was supplied by Reliance Electric Company. The unit is floor mounted with four 1/2 in. diameter bolts. This unit supplies ventilation and cooling air to the AB-3 area of the auxiliary building, and is required during both hot standby and cold shutdown conditions.

This unit was purchased to design specification SP-750-4549-00. Seismic qualification of the air handling unit was performed by John Henry Associates, Inc. documented by Report No. JHA-76-73A, dated December 29, 1978. This item was qualified by response spectrum analysis. A three dimensional computer model comprised of beam and plate elements was used in the analysis of the air handling unit. The computer code STARDYNE was used to perform this analysis. Stresses from combined seismic and normal loading, including a pressure loading of 5 in. of water, were evaluated. They were compared to the requirements of the ASME Boiler and Pressure Vessel Code Section III Subsection NF. All stresses were determined to be within the specified allowables. The seismic loading was derived from the auxiliary building floor response spectra for the 599 ft elevation with 4% OBE and 7% SSE damping. The unit natural frequencies were determined to be 28.8 Hz (s/s), 14.6 Hz (f/b), and 6.1 Hz (v). The relative displacement between the fan and housing was determined to be 0.0039 in. compared to a clearance of 0.25 in., which assures operability of the unit during a postulated seismic event.

The fan motor was qualified by Reliance Electric, documented by report No. 77-A-34, dated June 29, 1977. The motor was analyzed for seismic loading which accounted for the flexibility of its mounting location on the fan housing. The motor stresses were determined to be below allowable values and the motor rotor to stator relative displacements were one third the provided clearance.

Based on our observation of the field installation, review of the qualification reports and the responses by the applicant to our questions, the air handling unit is adequately qualified for the defined seismic loads.

3.9 POWER SUPPLY PANEL (BOP-9)

The power supply panel (MPL No. 1M51S0002, no model No.) was supplied by Westinghouse Corp to design specification Nos. SP-750-4549-00, and SP-628-4549-00. It is located in the control building at an elevation of 620.5 ft. It is attached to the floor with eight 3/4 in. bolts. The panel weighs 950 lb and has dimensions of 61 L x 34.2 W x 23.5 h in. It is part of the combustible gas control system, where it supplies power to a hydrogen recombiner.

The panel was qualified by test (Westinghouse report Nos. WCAP-7709L supplements 1 through 7, Electric Hydrogen Recombiner for Water Reactor Containment). Two series of tests were performed. Attachment to the test table for both was with eight 1/2 in. cap screws. The first test was a resonance search (fundamental natural frequency of 3.5 Hz). This was followed by eleven sine beat tests distributed in the 1.25 to 33.5 Hz range. Testing was to 8 g input accelerations in two horizontal directions in combination with a 5.3 g vertical. It was performed in four orientations on the table. A later test series on the cabinet consisted of five multifrequency tests to a generic OBE RRS that enveloped the Perry RRS. Each test showed the equipment to be in operating condition.

A wiring harness strap was added and a temperature indicator mounting bracket was modified early in the sine beat testing. Four consecutive sine beat tests were successfully run following the modification. The panel installed in the field reflected the modifications.

During the field inspection, the panel was observed to be located next to a sheetrock wall. There was a concern about the seismic integrity of the wall. Followup indicated that seismic loads were considered in the design of the wall.

Based on our inspection of the field installation, review of the qualification documents, and the applicant's responses to questions, the power supply panel is adequately qualified for the prescribed loads.

3.10 LEVEL SWITCH (BOP-10)

The level switch (model No. 580A-1) was supplied by ITT Barton according to the purchase Specification No. SP-598. It has a range of 0-30 in. of water. This equipment, weighing about 17 lb, was located in the intermediate building at the 620 ft elevation. It was mounted on a post attached to the floor with four 5/16 in. bolts. Seismic loads were considered in the qualification. Details of the qualification are in the document: ITT Barton Qualification Report, Nos. R3-580A-9 and 94Q-689-2-0 (TABC) as supplemental volumes 1, 2, 3, and 4 dated December 23, 1983. They were reviewed by Gilbert/Commonwealth.

This auxiliary mixing tank level indicator, part of the standby liquid control system, was qualified based on tests performed on a structurally similar unit (Model No. 580A-0). The mounting for the test specimen was similar to the field mounting. Input to the table for the tests was independent, biaxial and random. The inputs were in-phase and out-of-phase. The same set of tests was repeated for another orientation (rotated 90 degrees about the vertical axis from the first orientation). There were five OBE and one SSE level tests performed. The input duration in each case was 30 seconds. TRS were generated for each test and compared to the RRS for 2% damping. Envelopment in every case (including the ZPA) is satisfactory.

Two anomalies were observed during the qualification process. Their resolution follows:

1. The acceptance criteria according to the purchase specification SP-598 was ±4.0%. The test indicated an accuracy of ±9%. The applicant stated the following in response to our question:

   "The SP-598 ±4% accuracy requirement is the catalog accuracy. System analysis in Section 6 of the qualification package demonstrates that ±9% is adequate for the switch application/function."

2. There was contact chatter detected during the seismic tests. In response to our question, the applicant submitted the following:

> "Section 8 of the lab report states that the switch was functional before, during and after each seismic test and the contact chatter did not effect the switch operation at its set point. Therefore, it does not constitute a failure."

Based upon the observation of the field installation, review of the qualification report and especially the applicant's responses to questions, the level switch is adequately qualified for the seismic environment of the Perry site.

3.11 MEDIUM VOLTAGE MODULAR ELECTRICAL PENETRATION (BOP-11)

The medium voltage modular electrical penetration is located at elevation 659 ft of the containment. This component penetrates through the containment wall. It must provide electrical service while maintaining the containment pressure boundary during both hot standby and cold shutdown conditions. The penetration is 18 in. in diameter by 128 in. long and weighs approximately 1200 lb. It was supplied by Westinghouse with model No. WX 33328.

This item was qualified for combined seismic and hydrodynamic loading through testing performed by Westinghouse. This testing is documented by report No. PEN-TR-82-52, dated December 1, 1982. The design specification for seismic qualification to which the medium voltage penetrations were purchased is SP-750-4549-000. A prototype penetration was welded to a rigid test table nozzle for low level resonance search and biaxial dynamic testing. Its natural frequencies were determined to be 11 Hz, 15 Hz, and 22 Hz. The dynamic tests were pseudo-biaxial.

The test specimen was mounted at 45 degrees to the test motion. The specimen was rotated 90 degrees between tests to account for in-phase and out-of-phase effects. The specimen was subjected to 20 OBE level and 4 SSE level tests. The test motion was random, multifrequency. The required response spectra peaks for elevation 688 ft. 6 in. of the containment are as follows:

	s/s	f/b	v
OBE	3.23 g	3.23 g	2.75 g
SSE	4.5 g	4.5 g	3.35 g

The TRS fully enveloped the RRS with spectral peaks as follows:

	s/s	f/b	v
OBE	8.2 g	8.2 g	8.2 g
SSE	10.5 g	10.5 g	10.5 g

The penetration performed its electrical function and maintained its leak tight function during and after the dynamic tests.

Based on our observation of the field installation, review of the qualification reports and the responses by the applicant to our questions, the medium voltage modular electrical penetration is adequately qualified for the defined seismic loads.

3.12 CONTROL ROOM CEILING

The control room ceiling was chosen for review, for seismic loads adequacy, during the course of the audit. This allowed the applicant insufficient time to locate and provide the documentation during the audit. The documentation was subsequently provided. It demonstrated that the seismic loads were adequately considered in the design and installation of the control room ceiling.

4. FINDINGS AND CONCLUSION

The review of the Perry plant will be completed when the following open items are closed:

1. The applicant must supply confirmation that all safety related equipment has been fully qualified. This requirement may be waived for a limited number of items, provided that justifications for interim operation have been submitted and approved for all unqualified safety related equipment prior to the fuel load.

2. New hydrodynamic loads (related to LOCA) have been calculated and approved by the NRC. The impact of the new loads on the qualification of equipment must be assessed. A schedule for the assessment and confirmation that the affected equipment, if any, has been requalified under the new loads, is needed.

3. The applicant must report whether or not the rod position multiplexer cabinet (NSSS-2) is safety-related.

Based on our review, we conclude that, pending resolution of all open items, an appropriate qualification program has been defined and implemented for the seismic Category I mechanical and electrical equipment which will provide reasonable assurance that such equipment will function properly during and after the excitation due to the vibratory forces imposed by a safe shutdown earthquake in combination with hydrodynamic and normal operating loads.

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TABLE 1. LIST OF ATTENDEES

Name	Company
N. Anderson	GE
G. Bagchi	NRC/DE
J. Boseman	GE
B. S. Ferrell	CEI
B. Fleming	GE
M. Gaballa	GAI
D. R. Green	CEI
D. Hardy	GE
J. Ionnidi	GAI
J. Kelso	GE
C. Kido	EG&G Idaho
G. Koenig	GAI
R. Kowicki	CEI
M. R. Kritzer	CEI
S. Litchfield	CEI
D. P. Lohisey	CEI
S. R. Mannon	GAI
C. F. Miller	EG&G Idaho
H. Patel	Bechtel
H. A. Putre	CEI
T. Rockwell	GAI
N. Romney	DE/EQB
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J. Smith	CEI
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J. J. Stefano	NRC/DL
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E. B. Thomas	CEI
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L. E. Wise	GAI

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13 ABSTRACT (200 words or less)

EG&G Idaho is assisting the Nuclear Regulatory Commission in evaluating Cleveland Electric Illuminating Company's program for the dynamic qualification of safety related electrical and mechanical equipment for Perry 1 Nuclear Power Plant. Applicants are required to use test or analysis or a combination of both to qualify equipment, such that its safety function will be insured during and after the dynamic event, and provide documentation. The review when completed will indicate whether an appropriate qualification program has been defined and implemented for seismic Category I mechanical and electrical equipment which will provide reasonable assurance that such equipment will function properly during and after the excitation due to vibratory forces of the dynamic event.

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