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June 25, 1981

Dr. Zoltan Rosztoczy, Chief
Equipment Qualification Branch
MS P-1030
Phillips Building
US Nuclear Regulatory Commission
Washington, DC 20555

Dear Dr. Rosztoczy

Enclosed please find our review reports relating to the twenty equipment items that were reviewed by BNL during the site visit to the Susquehanna Steam Generating Station in Pennsylvania during the week of March 16-20, 1981.

There are still six other pieces of equipment that were not reviewed during our visit. This is because it was found that the qualification reports for these items were not completed for hydrodynamic loadings. We originally expected to also review these and include them with our total review package.

We did receive on June 18, 1981, a package of information relating to the Susquehanna Steam Generating Station. This package contains responses to the questions that were asked during the BNL visit in March. These are presently being studied by us.

In any case, we are herewith enclosing the completed reviews for the twenty available equipment items in order not to delay our finding any further.

Sincerely yours,

Morris Reich, Head
Structural Analysis Group

Enc.
cc: A. Lee
T.Y. Chang

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Susquehanna Steam Electric Station

Plant Visit

Documentation Review

Introduction and Summary

This report deals with the evaluation of the dynamic qualification of particular equipment at the Susquehanna Steam Electric Station for seismic and hydrodynamic loads. A site visit was made during the period of March 16-20, 1981. At that time, 26 pieces of equipment were scheduled for review by SQRT. However, after arriving at the site it was found that 6 pieces of equipment from BOP were not yet qualified for hydrodynamic loads. Therefore, a total of 20 pieces of equipment were reviewed by BNL. The review team consisted of J. Curreri, M. Subudhi, A.J. Philippacopoulos and P. Bezler of BNL and A. Lee and T.Y. Chang of NRC.

The text that follows contains the BNL evaluations for the following 20 pieces of equipment:

NSSS

1. RHR Pump/Motor (E11-C002)
2. HPCI Pump (E41-C001)
3. GE Control Room Panel, Reactor Core Cooling (H12-P601)

**4. GE 48" Wide Panels, Core Spray Local Panel A (H23-P001)

**Note that the review reports for NSSS equipment numbers 4, 10, 11 have been combined into a single report.

5. GE Blower, MSIV Leakage Control System (E32-C001)

6. RCIC Pump (E51-C001)

7. Core Spray Pump/Motor (21-C001)

8. Ricirc. Gate Valve (B31-F023)

9. Safety Relief Valve (B21-F013)

**10. RV Level and Pressure Local Panel B-72" Wide (H23-P005)

**11. Jet Pump Local Panel B-72" Wide (H23-P010)

12. Term. Cabinets Assembly (H12-P700)

BOP*

1. 4 KV Switchgear (E109)

2. Automatic Transfer Switch (E152)

3. Field Mounted Electronic Pressure Transmitter (J3A)

5. Emergency Water Pumps (M-11)

6. Engine Driven Water (M30)

8. Diesel Generator Intake & Exhaust Expansion Joint (M30)

9. Prelube Pump (M30)

14. Gear Operated Butterfly Valves 150# ANSI (P16-II)

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*Note that the numbering sequence to define the equipment corresponds with the numbering system that was originally used for the plant site visit.

The other six pieces of equipment which were not reviewed during the visit include the following:

BOP

4. Control Panel, 2C-681 and 1C-681 (J05A)

7. Pilot Solenoid Valves (J69)

10. Containment Vacuum Relief Valve (M149)

11. Nuclear Safety and Relief Valve (M159)

12. Motor Operated Gate Valves 150# & 300# (P12B(1)

13. Motor Operated Globe Valves - 2" (P148)

These specific items will be reviewed at some future time, i.e., after qualification for the hydrodynamic loads are completed by the vendor and forwarded to us. A second visit to the plant site may also take place (depending on subsequent NRC decision).

In summarizing the results, it was found that the dynamic qualification reports satisfacatorily demonstate the design adequacy of the equipment listed, pending submission by the applicant of further documentation of several open issues as noted in the individual summary reports. In general, all of the SQRT forms need some modification and the pipe mounted valves need to be verified for design "g"-loads at the actuator, versus Bechtel's as-built piping analysis results. Specific details of the results for the particular reviews are given in the individual evaluations that follow. It should be noted that the recent responses submitted by the applicant during the week are not included in these review. These will be reviewed shortly.

E11-C002: Residual Heat Removal Pump/Motor

(Model No. 34-APKD-4 Stage-S/N 0573308/5K 6356XC10A)

A total of eight sets, two in each loop, were inspected at the plant site. The pumps (rating 10,000 gpm at 1180 RPM) manufactured by Ingersoll Rand Co. were coupled with G.E. motors. They are located on the basemat at an elevation of 649 ft. in the Reactor building. The pump flanges were rigidly mounted to the floor by 12 1-3/4" bolts. These pumps provide pressurized water for the ECCS and suppression pool cooling. The specifications used in the design are contained in Report No. 21A9243DN and Purchase Data Sheet Spec. No. 21A9369A2.

The performance of the pump/motor assembly was tested by the supplier. However, no performance report was reviewed in this regard. The dynamic qualification of this equipment was performed anlyatically by G.E. and is described in G.E. Report No. DRF-E12-43 (October 1980). The assembly unit was idealized by a detailed finite element model. The hydrodynamic masses were added to the actual masses, neglecting however the fluid-structure interaction effects because of a large gap between the outer barrel and the impeller casing. The input response spectrum includes both hydrodynamic and seismic responses combined by the absolute sum method. By using such combination, the equipment is conservatively designed to operate even at the time when both dynamic events would occur simultaneously.

Except for at two overstress conditions, the equipment was found to have adequate strength to withstand all of the possible loading conditions. These two conditions are at the upper motor bearing and at the foundation bolting (in tension only) where the stresses exceed the allowable. G.E. is going to resolve these issues by a more refined analysis as part of a new load program.

Based on our review of the reports, the field installation and the clarifications provided by the manufacturer, we conclude that this equipment is adequately qualified for all the dynamic loads pending clarification of the following two open issues:

(1) Reanalysis to show that the top motor bearing is not overstressed.

(2) Resolution for the overstressed foundation bolts.

E41-C001: HPCI Pump

(Model No. S/N 71150783 & S/N 71150782)

Two units of the HPCI pump, one for each reactor unit, were inspected at the plant site. Each pump(manufactured by Byron Jackson) was installed in line with a booster pump on one side and a turbine via a gear box on the other side. The pump is driven by the turbine which is operated by steam from the reactor. The assembly was installed on the basemat at the 645 ft. elevation in the Reactor building. The pump mat was secured to the floor via eight 1-1/4" bolts. The main function of this equipment is to inject cooling water into the reactor at high pressure for small breaks which do not result in depressurization of the pressure vessel.

The dynamic qualification of this equipment was done by the Byron Jackson Corp. (Report #DC-1528, Vol. I & II, "HPCI Pump Assembly Seismic Analysis", September 1980) and filed in G.E. under DRF No. E51-74. The main pump (10 x 12 x 15 2 Stage DVMX) and the Booster Pump (12 x 14 x 23 1 Stage DVS) were coupled by a gear box to accommodate different speeds. A finite element model using beam type elements to represent the assembly was employed for the analysis. The Response Spectrum Method was used for the analysis which was carried out using the SAP6 computer code. The input spectrum includes both seismic and hydrodynamic loads. The results were found to be well within the design limits for all components.

Another gear box between the turbine and the pump assembly was analyzed by the Western Gear Corp. (WGC S.O., 120-31011, "Seismic Analysis of Model 4110", May 19, 1980). since the frequency of the gearbox was found to be well above 60 Hz, a static analysis was made subject to ZPA level acceleration input. The results were found to be well within the allowable. The shaft coupling displacement limit were checked and found within the tolerance level.

Based on our review of all of the reports, field installations, and the responses from G.E., we conclude that this equipment is qualified for all dynamic loads anticipated at the Susquehanna Plant Site.

H12-P601-Control Room Panel, Reactor Core Cooling

The qualification document for this equipment is entitled, "Susquehanna Steam Electric Station Units 1 & 2, SA1-040-QA-81-PA-B, Seismic Qualification Reevaluation Class 1E Equipment, Control Room Panels". The report was prepared by E. S. Ramadas on January 15, 1981 for Science Applications, Inc., Almaden Blvd., San Jose, California. The report was approved by N. G. Luria of G.E. on 2/26/81.

The Control Room Panel MPL Ref: H12-P601 measures 192"x72"x36". It is located in the Reactor Core Building at the 729' level. Many components are mounted on the panel, including a power supply and approximately 128 switches. The panel is secured to the base with a 7" weld per foot of length.

The Control Panel is qualified by tests made on a similar panel. It is also qualified by identifying the components that are mounted on the panel and comparing the expected peak acceleration with the malfunction level of the various components as determined by previous tests.

The design of the Susquehanna control room panels is representative of a generic G.E. NSS control room panel design. The panels use similar angle iron bracing on top and bottom. The H12-P601 panel is compared to the third right section of the H13-P870 panel. The results of the third right section, which was tested, and which passed the test according to IEEE 344-1975, are extended to the whole panel since the panel is constructed of three similar panels. The maximum acceleration measured during the tests are transferred to the

Susquehanna control room panel in accordance with the tested transmissibilities. The applicable RRS at the 754' level is used for comparison since it envelops the RRS of the control room and the upper and lower relay rooms. The TRS conservatively envelops the hydrodynamic loads superimposed on the RRS for the Susquehanna Control Room Panel.

The qualificaton for the NSSS Class 1E Equipment which is mounted on the control panel is based upon the data provided from the GE seismic test summaries of control room panels and mounted equipment tested to IEEE 344-1975. This information is contained in "Control Room Panel Seismic Test Reports (IEEE334-1975), DRF A00-1138 (CO C61-P001, H13-P0601, H13-P§603, H13-P618, H13-P628 and H12 P870, L H12-P601, H12-P603). General Electric Co., Nuclear Energy Division and Nuclear Energy Business Group".

All of the equipment items that are mounted on the H12-P601 panels are listed on the GE sheets that relate to Susquehanna. The following table is illustrative of eight sheets of tables which show the items and compare their malfunction limits with the maximum expected peak acceleration at the location of each item. In all cases, the malfunction limits conservatively exceed the expected acceleration.

It is therefore concluded that the control room panel, H12-P001 and the mounted equipment, has sufficient structural integrity to withstand the specified environment and so are seismically qualified.

SEISMIC QUALIFICATION REEVALUATION

192" WIDE CONTROL ROOM PANEL CLASS 1E EQUIPMENT

Panel MPL Ref: H12-P601

System: Reactor Core Cooling BB

Panel Dimensions: 192" x 72" x 36"

Location: Control Room (729')

EQUIPMENT MPL NO	DESCRIPTION	PURCHASE PART DWG.	CURRENT SEISMIC CAPABILITY/ MALFUNCTION LIMIT			MAXIMUM EXPECTED PEAK ACCELERATION AT LOCATION			REMARKS
			f-b	s-s	v	f-b	s-s	v	
E11A-S09A,B	Switch	145C3040P008	7.5	4.0	10	6.8	1.18	0.42	
E11A-S10A,B	Switch	145C3040P013	7.5	4.0	10	6.8	1.18	0.42	
E11A-S11A,B	Switch	145C3040P017	7.5	4.0	10	6.8	1.18	0.42	
E11A-S12A,B, S13A,B	Switch	145C3040P013	7.5	4.0	10	6.8	1.18	0.42	
E11A-S14A,B	Switch	145C3040P017	7.5	4.0	10	6.8	1.18	0.42	
E11A-S15A,B	Switch	145C3040P003	7.5	4.0	10	6.8	1.18	0.42	
E11A-S16A,B, S17A,B	Switch	145C3040P017	7.5	4.0	10	6.8	1.18	0.42	
E11A-S18A,B	Switch	145C3040P006	7.5	4.0	10	6.8	1.18	0.42	
E11A-S19A,B, S20A,B	Switch	145C3040P004	7.5	4.0	10	6.8	1.18	0.42	
E11A-S32A,B,	Switch	145C3040P001	7.5	4.0	10	6.8	1.18	0.42	
E11A-S34A,B, S35A,B	Switch	145C3040P007	7.5	4.0	10	6.8	1.18	0.42	
E11A-S36A,B, S37A,B	Switch	145C3040P017	7.5	4.0	10	6.8	1.18	0.42	
E11A-S39A,B.	Switch	145C3040P013	7.5	4.0	10	6.8	1.18	0.42	
E11A-S41A,B.	Switch	145C3040P003	7.5	4.0	10	6.8	1.18	0.42	
E11A-S54A,B	Switch	145C3040P013	7.5	4.0	10	6.8	1.18	0.42	
E11A-S56A,B	Switch	145C3040P001	7.5	4.0	10	6.8	1.18	0.42	
E11A-S60A,B, S61A,B	Switch	145C3040P008	7.5	4.0	10	6.8	1.18	0.42	

H-23-P001, H23-P005, H23-P010-Local Panels, 30" and 72"

The qualification document is entitled, "Susquehanna Steam Electric Station Units 1 and 2, Seismic Qualification Reevaluation, Class 1E Equipment Local Panels". The report was prepared by E. S. Ramadas, dated January 15, 1981, for Science Application, Inc., San Jose, California. The report was approved by N.G. Luria of G.E. on 2/26/81.

The three local panels are similar in structure and differ only in size, and thus are discussed in the same qualifying document. The 30" panel measures 30"x84"x30" while the 72" panels measure 72"x84"x30". All thress panels are located in the Reactor Building but at different levels. The 30" panel is at the 645' level while the jet pump 72" local panel is at the 719' level and the 72" RV and pressure local panel is at the 749' level.

The panels are seismically qualified to the IEEE 344-1975 criteria by comparing these panels to similar panels that have been qualified by test. A multifrequency, multiaxis test was used to qualify the similar panels.

The 30" and 72" local racks are open framework steel structures that are structurally reinforced by lateral and longitudinal members. A comparison of the Susquehanna racks with the Cofrentes racks tested by the General Electric Nuclear Energy Business Group reveals that the dimensions are the same and the Cofrentes racks are of the same structural design as the Susquehanna racks. Although the frame structures are the same, a different natural frequency will result since the mass supported by the Cofrentes and Susquehanna racks are not the same. The Susquehanna frequency will be somewhat lower because the mass is slightly greater. The report discusses a "worst case analysis" which shows that the natural frequency changes no more than five percent while the transmissibility is not affected. In addition, the RRS for faulted conditions at the 779' level is used. This RRS envelops the faulted conditions RRS for all floor levels where local instrument racks are located, and so a conservative excitation is used. The TRS for the horizontal and vertical directions adequately envelops the RRS over the entire frequency range from 1 Hz to 60 Hz. The maximum peak acceleration of any Class 1E device location for the Cofrentes 72" frame was 6.0, 3.8 and 1.1g's in the three axes. This is the basis for establishing the peak acceleration for the corresponding Susquehanna panel. The report uses the results of the test plus analytical reasoning to conclude that the Cofrentes test results of the 72" panels can be used to qualify Susquehanna's 72" wide local racks. Similarily, the Cofrentes test results of the 30" side local panel can be used to qualify the 30" wide Susquehanna local panel. The Cofrentes panels that were used for comparison were all tested in their as-shipped condition. All Class 1E devices were mounted prior to testing.

Some mounted equipment items were previously evaluated by test to malfunction limits. However, the test to IEEE-1971 was only from 1 to 33 Hz. This applies to the Diaphram and Bellows type instruments and to Bourdon tube type instruments. The fundamental natural frequency of these instruments is then analytically determined in the qualifying document. The procedure is to evaluate the static deflection due to the weight loading of the instrument. The analysis shows that the fundamental natural frequency is in excess of 100 Hz. Hence, the malfunction limits tested to 33 Hz is applicable to 60 Hz.

The basis for qualification by similarity of dynamic response for similar structures is reasonable. The TRS that is used in the evaluation is conservatively taken at a level that envelops the RRS of all of the panels. The mounted eqiupment is shown to have a malfunction limit that adequately exceeds the maximum peak acceleration that is expected to occur.

It is concluded that the seismic qualification document shows that the local panels H23-P001, H23-P005 and H23-P010 are capable of carrying out their intended function during a seismic event. Therefore, these three local panels are seismically qualified.

E32-C001: MSIV LEAKAGE CONTROL SYSTEM BLOWER

Model No. 2CH6041-1U

The MSIV blowers take suction from the main steam lines and discharges into the standby gas treatment system. Each unit of the plant has three blowers located in the reactor building outside the primary containment. The vendor of the equipment is the GE Co. and it was designed according to the following spec.:

> "MSIV Leakage Control System Blower Purchase Specification", Document 21A3762, Rev. 2, GE.

The blower was qualified by test for both seismic and hydrodynamic loads. The test was performed by the Approved Engineering Test Laboratories and is documented in the report entitled, "Blower, MSIV-LCS. Seismic Loading Qualification, Test Report on Blower MSIV Leakage control", VPF 3830-14-1, 10-21-75.

Each blower is mounted on its own frame with a set of four 1/2" bolts. The frame is mounted on a wall of the secondary containment by six bolts. The natural frequencies of the blower were determined by test and they were found to be in the range of 1000 Hz 10%. A single frequency test was performed and ZPA values were employed. The ZPA values of the RRS were obtained by combining the seismic and the hydrodynamic loads. These values are 0.48g and 0.16g for the horizontal and vertical direction respectively and according to the report they were obtained by using the SRSS method. In response to our questions regarding the corresponding values if ABS method were used, we were told that they respectively are 0.56g and 0.31g, for the horizontal and vertical direction. During the test acceleration levels up to 3g were applied for all directions. These values are higher than the required acceleration levels for the blower. The blower was operating in its normal flow manner during the tests. Vacuum was maintained at the suction pipe and pressure at the discharge pipe. No anomalies were observed during test. A total of 8 tests were performed with a duration equal to 5 minutes for each test. The qualification tests demonstrated the operability of the equipment. No evidence of any structural damage or malfunction was observed.

Based on our review of the reports, the field installation and the clarification provided by the manufacturer, we concluded that the equipment is adequately qualified for all the dynamic loads. The applicant, however still needs to;

a) Provide an explanation of how the steel support frame is analyzed, and,

b) Provide assurance that the hold down bolts are adequately designed.

E51-C001: Reactor Core Isolation Coolant Pump

(4 Stage 6 x 6 x 10-1/2 CP, Capacity - 625 gpm)

The equipment, manufactured by Cingham Willamette Pump Company, is located on the basemat at elevation 645 ft. in the Reactor building. Each reactor unit has one of the coolant pumps in its RCIC system. The pump is driven by a turbine which is operated by steam from the reactor. The pump injects cooling water into the reactor. The base plate was buried in the concrete and mounted by four 1-1/8" bolts.

The pump-turbine assembly was found to be rigid. However, these are quite a few small instrumentation pipe lines attached to it. All there small lines were found to be rigidly tied to the pump foundation slab and the surrounding structures. The dynamic qualification of this equipment was done by Handbook calculations using a static analysis approach.

The original calculations were done by the manufacturer. This is documented in the report in VPF# 3059-20-3 and is filed under G.E. DRF-E51-72 (dated October 1980). The calculations include nozzle loads, dead loads and dynamic loads consisting of SSE + SRV + LOCA combined by the absolute sum method. The static coefficient was established as 1.5 x maximum 'g'values obtained from the combined spectrum. The equivalent static analysis was made by using this coefficient multiplied by the weight of the complete assembly. The results were found to yield satisfactory values well within the upset condition allowable limits. Since the static analysis uses the 'g'-load corresponding to the faulted conditions and the stress conditions were compared against the upset allowable limits, no upset condition calculations were necessary. Our review and field installation inspection did not identify any concern with the dynamic qualification of this equipment and thus it is qualified for all dynamic loads anticipated at the plant site.

E21-C001: Reactor Core Spray Pump/Motor

(Model No. 25-APKD-6 Stage-S/N 10782/5K6338XC76A)

The equipment consists of a six stage pump (3175 gpm at 1780 RPM) manufactured by Ingersoll Rand Company and a G.E. motor. Two such pumps are installed for each loop in each unit making a total of eight sets. All of them are located on the basemat (649 ft. elevation) of the Reactor building. The pump/motor assembly is mounted to the floor by twelve 1-1/4" bolts. The primary function of this equipment is to supply pressurized water for the Emergency Core Cooling System from the Suppression Pool. The equipment is designed as per the design Specification No. 21A9243DM and Purchase Data Sheet Specification No. 21A9243.

The equipment was qualified by G.E. as per their Report No. DRF-E21-27 (Aug. 17, 1979). A detailed finite element analysis was employed using the Response Spectrum Method. Both seismic and hydrodynamic loads were considered in the analysis. In addition, nozzle loads supplied by Bechtel from their piping analysis, dead weight, internal pressure, design temperature and Shaft thrust to Motor were also included in the study. The hydrodynamic mass was calculated and added to the actual mass to take into account of the fluid in the downcomer. The input response spectrum used in the analysis was generated by combining all the possible dynamic spectra using absolute sum method. This method would yield the most conservative results and hence, the operability of the equipment at the time of dynamic occurrences will be maintained.

In addition to the analytical work, GE also stated that the pump/motor assembly was satisfactorily tested for performance at the suppliers shop.

The results obtained from the analysis were found to be within the allowables for each component in the equipment except for the maximum momentary thrust load that the pump shaft imposes on the motor shaft. This load exceeded the allowable value permitted, according to the motor vendor outline drawing. This problem is still to be resolved by G.E., after they perform a more refined analysis. According to GE this issue will be addressed in the "new Loads" program.

Based on our review of the reports, the field installation, and the clarifications provided by the applicant, we concluded that this equipment is adequately qualified for all the dynamic loads, pending a resolution of the overstressed top motor bearing imposed by the pump shaft mentioned above.

B-31-F023: Recirculation Gate Valve (Suction)

(Model No. S/N 71-GE-49497-30)

The plant has two gate valves. The suction valve which is located in the primary containment at elevation 708' was inspected at the plant site. It is a motor operated passive valve and it is required to operate for maintenance purposes. The bonnet flange contains twenty-eight 3/8" bolts. The vendor is the LUNKENHEIMER Co. and it was designed according to "Purchase Specification, Gate Valve", 21A1840, Rev. 2, GE.

Due to the fact that the recirculation suction valve is a passive one it is not required to maintain its factionality during a faulted condition. The basic qualification requirement of the valve is that it must maintain its structural integrity when subjected to the "worst" load combination. A static and a dynamic analysis was performed by GE in order to qualify this equipment. A static analysis was used for the valve itself whereas a dynamic analysis was performed for the evaluation of the recirculation lines. The documents relating to the qualification of this equipment are:

1. Seismic Valve Model Data Sheet, GE385HA699, Sept. 1976.
2. Engineering Calculation Sheet/Recirculation Suction Valve, from DRF# 206-B33-BLKV-KRO.
3. Piping Letter Report, Recirculation Piping (SRSS), GE Letter Report L.J. Tilly to B. Erbes, 10/13/80.

The latter of the above demonstrates in Table 22-A (Pipe Mounted Equipment-Suction Gate Valve-Highest Loading Summary-SRSS Susquehanna Recirculation Loop B) that the maximum accelerations obtained from the piping analysis are 6.4g and 1.18g in the horizontal and vertical directions respectively. The corresponding g levels for the other loop (Loop A) were found to be lower (horizontal = 3.87g, vertical 1.09g). These acceleration levels were found for faulted condition. In the piping analysis a total of 9 load combinations were considered by including both seismic and hydrodynamic loads. For these combinations the SRSS rule was employed. From the results of the static analysis (i.e., item 2 of the qualification reports mentioned above) it is concluded that the valve is capable of withstanding a horizontal acceleration equal to 10.64g and a vertical one equal to 4.0g. These values are higher than those obtained from the piping analysis.

Based on our review of the reports, the field installation, and the clarification provided by the manufacturer, we conclude that this equipment is adequately qualified for all dynamic loads pending the satisfactory resolution of the two items listed below:

a) Provide natural frequencies from the updated piping analysis being performed to reduce "g" loads at the valve.

b) Provide "G" value at the gate valve obtained from the updated analysis.

B21-F013 Main Steam Safety Relief Valves

Model No. 6R10 HB-65-BP

Each unit of the plant is equiped with 16 safety/relief valves. These are mounted in the steam lines and located inside the drywell structure. They have an electro-pneumatic actuactor and are spring loaded safety valves. Their function is to control possible pressure transients in the primary system and are actuated either when the inlet pressure reaches a preset value or by an electrical signal. The vendor is the Crosby Valve & Gauge Co. The valves were qualified by a test carried out at the Wyle Labs. Details about the qualification of the valves are documented mainly in the following reports:

1. Seismic Simulation Test Program on 6-R-10 HB-65-BP valve. Document: VPF 3379-260-1, Wyle Lab., 1-12-77.
2. Seismic Simulation Test Program On An 8-R-10 HB-65-DF Valve. Document: VPF-5485-25-1, 8-20-79, by Wyle Lab.

The SRV's employed at the Susquehanna plant are 6-R-10 type (6" inlet - 10" outlet). These valves are qualified with test performed according to IEEE 344-1975. A total of seven anomalies were revealed during the tests performed originally for the 6-R-10 valve. These anomalies appeared mainly in the actuator portion of the valve. After this test, the electro-pneumatic actuator design of the 6-R-10 valve was modified to be the same as the actuator of the 8-R-10 valves which had been tested successfully according to IEEE 344-1975. The SRV's which are installed in the plant have the body of the 6-R-10 Crosby valve and also contain the improved electro-pneumatic actuator of the 8-R-10 valve. Both parts of this equipment were qualified successfully.

The qualification of the SRV's was done for both seismic and hydro-dynamic loads. Their operability and structural integrity was demonstrated by tests. The acceleration levels at the flange were obtained from the piping analysis of the main steam lines. When modeling the piping system the SRV's were included by assuming lumped-mass models. The latter also incorporates the actuator of the valve. The required acceleration levels were selected from the results of the piping analysis considering the worst case. The worst case was evaluated by comparing different locations of the the valve along the main steam lines (including all loops) and different load combinations. Thus the final RRS values were selected by considering the worst case in terms of valve location and load combination. These values were 4.79g in horizontal direction and 2.94g in vertical direction. The corresponding values used for the qualification test were 5.2g and 4.4g in the horizontal and vertical directions respectively. A number of multi-frequency, multi-axis random tests were performed. Each test had a duration time of 30 seconds. The TRS enveloped the RRS for the range of 1 to 260 Hz. The laboratory mounting was consistent with the field installation. The discharge pipe and the nozzle loads obtained from piping analysis of the main steam lines were simulated during these tests.

The 6" inlet of the valves is formed from the main steam lines through a sweepolet which is welded to the body of the lines. GE was requested to provide assurance that the structural integrity of the pipe welding area will be maintained under the loadings considered. Further clarifications provided by GE indicated that the total stress levels in question are below the allowable.

Based on our review of the reports, the field installation, the clarifications provided by the manufacturer, and the clarifications provided by GE for the sweepolets, we conclude that the main steam safety relief valves of the plant are adequately qualified for both seismic and hydrodynamic loads.

H12-P700-Termination Cabinet Assembly

The Termination Cabinet is used to house the terminal and connection modules. Physically, it measures 96"x102"x36" deep and is located in the relay room at the 754' elevation level. It is welded to the floor with a 1" weld every 12".

The termination cabinet is qualified by test as described in the report entitled, "Seismic Qualification Test Report to the IEEE Standard 344-1975 Requirements of BWR/6 Termination Cabinet Assemblies Manufactured by ACL-FILCO Corporation under G.E. Drawing M169C8857G003 to G011", prepared by David M. Rheuble & Associates, Campbell, California. The report was approved by N.G. Luria, Manager Qualification and Standards, G.E., Co.

The test was done by the General Electric Company and is documented in a report G.E. Doc. A00-794-5-1. The description of the TRS shows that it envelops the seismic RRS plus hydrodynamic RRS over the frequency range. The test consisted of a low level resonance search up to 60 Hz. Natural frequencies of 6, 20, 22.5, and 27.5 Hz. were detected during the test. The test cabinet, which is structurally representative of termination cabinet designs, was exposed to 5 simulated OBE's, as required by the IEEE Standard 344-1975. These seismic exposures were performed by using biaxial, phase coherent motion input for 20 seconds with random multifrequency time histories. Five exposures were made with input motions simultaneously applied in phase along the front to back and vertical axes. Five additional exposures were made with the input motions simultaneously applied 180 out of phase along the front to back and vertical axes. The same procedure was used in the biaxial directions involving side to side and vertical. The SSE excitation procedure was also simarily applied but with one exposure in phase and one exposure 180° out of phase, instead of the five exposures.

The functional monitoring of the test termination cabinet, during seismic vibration exposure, disclosed no anomialies of continuity nor shorting.

Post seismic inspection revealed that the doors of the cabinet were distorted due to the input motion. Some of the welds were cracked. However, neither of the structural deformations caused any anomalies to the function of the cabinet during or after the seismic exposure.

The test results of the seismic exposure of the Termination Cabinet and its devices leads to the conclusion that the design of the cabinets, as defined by G.E. Drawings No. 169C8857G003 through 169C8857G011, is adequate to qualify them for Seismic Category I Equipment.

E-109-4.16 KV Switchgear

The PP&L Plant at Susquehanna contains 12 4.16KV switchgear units which are used in the power distribution system. They are used for both a hot standby as well as for a cold shutdown condition. The switchgear is contained in a cabinet which measures 2'x6.5'x7' high. They are located in the reactor building at elevations 719'-1" and 749'-1". Each cubicle weighs 2000 lbs. Each unit contains many components, including relays, switches, meters, resistors, fuses, thermostats and transducers.

The qualification report was prepared by Wyle Laboratories, Huntsville, Alabama. It is identified as Wyle Lab Report No. 57577-1, dated 2/6/81 and is marked "Preliminary". The report discusses the results of the seismic qualification tests of the 4.16KV switchgear. The report intends to demonstrate the qualification of the switchgear by laboratory tests on single cubicle in two configurations. One configuration was set up to represent the single cubicle installation of A 205 & A 206 unit. The second configuration was set up to represent the multiple cubicle installation of the other assemblies. The design and tuning of the setups was based on the results of in-situ tests.

In-situ tests were performed to determine the predominant dynamic characteristics that were dependent on the number of cubicles in an assembly, and on the dynamic nature of the top entry conduits. This provided the dynamic data to account for mutual support between cubicles, top entry conduits, and bus ducts, and the torsional or wave motion of the multi-cubicle assemblies. The dynamic characteristics were used to design and tune the auxiliary support fixturing which was used to make the test of the single cubicle representative of all configurations. This is an accurate and sophisticated approach that assures that reliable results will be obtained from the test if enough response points are used.

The operational components within the cubicle were subjected to detailed functional tests before, during, and after the dynamic tests, to demonstrate operational capabilities.

The Wyle report concludes that the Switchgear possessed sufficient integrity to withstand the prescribed seismic tests without compromise of function. However, some anomalies were indicated.

The Bechtel review of the Wyle report raised some questions regarding the details of the test and some of the results and asked for certain clarifications. At our meeting at Susquehanna, additional requests were made. These include:

a) Provide a list of anamolies observed during the test and provide the resolution action plan.

b) Confirm that the HP analyzer had been calibrated for damping measurements prior to test and the method of calibration.

c) Provide a natural frequency and the associated damping value table for review.

d) Provide an updated qualification report for review, which incorporates specific new paragraphs identified during the audit.

A reply to these questions as well as to the Bechtel questions is required before a final resolution of the qualification report for this equipment can be made.

E-152 Automatic Transfer Switch

The automatic transfer switch is housed in a rectangular cabinet which measures 37"x20"x92" high. It wieght 950 lbs. There are eight such transfer switches. During the site visit, the Diesel Generator Automatic Transfer Switch No. OAT5536 located at the 667'0" level was inspected.

The Russelectric Automatic Transfer Switch is qualified by test. The test was carried out at the Wyle Labs. The test results are contained in a report entitled, "Seismic Test Report of Automatic Transfer Switch for Susquehanna Steam Electric Station - Units 1 & 2, Pennsylvania Power and Light.". Wyle Report No. 44434-1.

The seismic test consisted of a random, multi-frequency, phase-incoherent input which enveloped the RRS. The transfer switch was mounted on the Wyle Multiaxis Seismic Simulator Table which imparted simultaneous side-to-side plus vertical excitation. The speciment was rotated 90° so that front-to-back plus vertical excitation was then applied.

The specimen was subjected to a low level (about 0.2g) resonant search covering the frequency range of 1 Hz to 40 Hz. Natural frequencies in the side-to-side direction were identified at 14 and 24 Hz, in the front-to-back direction at 22 Hz, and in the vertical direction at 22 and 34 Hz. These were determined from the transmissibility plots. Multi-frequency multi-axis tests of 40 second duration were also imposed on the test specimen. The amplitudes at frequency bandwidths spaced one-third octave apart were independently adjusted until the TRS enveloped the RRS. Five OBE tests were followed by 1 SSE test in both F/B plus vertical as well as SS plus vertical.

No anomalies were reported as a result of the tests. The equipment functioned, as required.

Two issues were raised at our meeting at Susquehanna:

1. The test report document showed that the front-to-back natural frequency was 22 Hz, and not the 25 Hz, as listed in the SQRT forms.
2. It appeared that a heavy cable entered the top one of the automatic transfer switch cabinets. Since this weight was not simulated in the tests, is the actual weight significant enough to affect the test results?

It was agreed that the SQRT form would be changed, in accordance with (1). For the second question, a section of cable was weighed during our visit and was reported to be 30 lbs. Since this weight is at the top, all of it is effective as end mass. The cabinet itself weighs 950 lbs. For a cantilever beam type of first mode, which represent a worst case evaluation, 23 percent of its mass is effective as end mass. Therefore, the test neglected $\frac{30}{(.23)(950)}$, or $\frac{30}{219} = 13\%$ of the mass. This implies only about a 6% change in lateral natural frequency, which in this case should be acceptable for the results shown by the test.

It is concluded that the automatic transfer switch meets all the seismic requirements and will function during a seismic event plus SRV.

J-03A Field Mounted Electronic Pressure Transmitters

(Model No. 1151, AP, GP, DP)

Fifty-two of these pressure transmitters are used in units one and two of the plant, 32' of these are in unit one, and 20' in unit two. These serve to monitor absolute, gauge and differential pressures. The units were manufactured by Rosemont Inc. and are a standard product line modified to have either a five valve or a three valve block valve manifold attached directly to them. The units are located throughout the reactor and control buildings from elevations 645' to 783'. The units inspected were bolted to rigid, floor mounted 6" square tube columns, with four 3/8" bolts fixing each valve. An alternate mounting arrangement used is to bolt the valve directly to a wall mounted channel. The units have a rectangular body and a cylindrical operator and weigh 14 lbs. The block valve manifold attachment bolts to the rectangular body and is estimated to weigh 1 lb. The pertinent design specifications are 8856-J03A, Rev. 4 & 5, 8856-J800, Rev. 3, 8856-6-24 and 8856-622.

The basic valves were qualified by tests conducted by Rosemont Inc. and Wyle Lab. The qualification reports are Rosemont Inc. Report No. 9276C, Rev. A (Dec. 1975) and Wyle Report No. 43082-1 Rev. A (Nov. 1975). The tests conducted by Rosemont were single axis frequency sweep tests to establish natural frequencies while those conducted by Wyle were biaxial axis, multi-frequency tests. The measured natural frequencies were 7, 50 and 68 Hz in one lateral direction and 62 and 72 Hz in the other two directions respectively. The multi-frequency, biaxial axis testing consisted of 36 tests at 1/2 the TRS level 3% damping for each of two mounting configurations. These were followed by single axis, random motion tests of 30 sec. duration, for four orientations at 3/4 and full TRS levels and 5% damping. The valves were calibrated before and tested after each test sequence and found to exhibit no loss of function.

The qualification testing demonstrated the integrity of the basic valve when tested to the TRS levels. However, two open issues exist. Firstly, in none of the tests was the block valve manifold attached to the valve. Secondly, the data reviewed did not support the contention that the TRS exceeded the OBE at 1/2% damping or the SSE at 1% damping or the SSE+SRV+LOCA at 2% damping. If it can be shown that the attached valve manifold does not greatly alter the vibrational characteristic of the unit, and if the TRS is shown to exceed the mentioned spectra, then the valve seismic design is adequate.

In summary, it is required that the vendor:

Provide information regarding the effect on qualification of the manifold attached at the bottom of the support, and the effect of small tubes connecting the transmitter and the manifold. Assess every transmitter throughout the plant for the similar effects.

M-11: Emergency Service Water Pumps

(Byron Jackson 24 BXF 1 Stage VCT)

Four such pieces of equipment manufactured by Byron Jackson with G.E. motor are located in the ESSW Pump House at an elevation of 686'-10". The pump is mounted to a base plate via twelve-1" bolts at the outer skirt. The motor is attached to the top of the pump. The suction inlet extends down to the spray pond at an elevation of 661'-0". The main function of this equipment is to provide cooling water to safety related equipment and the equipment room.

The equipment was qualified by analysis using a finite element model of the entire structure. The design is based on Purchase Order No. 8856-M11-AC and is required to be qualified for seismic load only (since the equipment is not located in the Reactor Building). The manufacturer Byron Jackson Pump Division conducted the original qualification, which was reviewed by Bechtel Power Corp. The qualification report is documented as "Seismic Analysis for ESW Pumps", dated January 10, 1978 (TCF-1036 SEI Rev. B, Bechtel V.P. #8856-M11-13). A starting unit found to be attached to the motor on one side was not included in the analysis. It was later clarified that the weight of this unit is one-seventh of the motor unit alone and hence should not significantly affect the conclusions of the analysis.
The analysis procedure was broken into two separate parts: a stick model, of the complete model, subjected to horizontal ground response spectrum only, and a more simplified model using static analysis for vertical excitation

alone. The equipment does not have any eccentric masses to introduce significant coupling between the spatial directional responses. Moreover, the vertical frequencies were much higher than the horizontal ones. This approach of decoupling the total effect was questioned for its validity. It was later established that the results would be conservative. Additional (nand) calculations were submitted after questioning relating to bearing load and foundation bolt stress which were not included in the analysis. All finite element calculations were carried out by using the SAP IV computer code.

Based on our review, inspection of the field installations, and the responses from Bechtel, we conclude that this equipment is qualified for seismic loads for the Susquehanna Plant Site.

M30-358: Engine Driven Water Pump

Model No. 6x5x11 NR C16

This equipment is a centifugal pump attached to the diesel engine and is thus located in the diesel generator building. Each diesel employs one engine driven water pump and there are a total of four such pumps in the plant attached to the four diesel engines. The vendor of the equipment is Allis-Chalmers. The equipment was designed according to the design specification: SD-140 8856-G-10. Each pump is bolted to the diesel engine with ten 5/8" bolts at elevation 677'. The role of this equipment is to circulate water between the engine and the standpipe.

The dynamic qualification of this equipment was done by Hissong Consultants, (Mt. Vernon, Ohio, 43050) The pertinent qualification report is:

"Seismic Analysis of Allis-Chalmers 6x5x11 NR C16 Wet and Kit Pump", by Hissong Consultants, HC5-1008-3, Oct. 8, 1975.

Frequency calculations were performed and it was concluded that the frequency values in all directions were well above 40 Hz. Due to this, a static analysis was done for the seismic resistance evaluation of the equipment. The total required acceleration levels were found by the absolute summation of values obtained from the response spectrum provided in the SD-140 standard and the peak values for the pump mounting point. The latter were supplied by Cooper Bessemer. The acceleration values obtained from the SD-140 spectra are 0.8, 0.54 and 0.8g, whereas the corresponding values supplied by Cooper Bessemer are 0.91, 0.17 and 0.46g respectively in three directions x, y and z (y is vertical). Therefore the total acceleration values used for the seismic evaluation of the equipment were 1.71, 0.71 and 1.26 in x, y and z directions. Considering the fact that the diesel engine is a rigid equipment and that the spectra specified in the SD-140 standard are much higher than the spectra calculated for the diesel generator building it can be concluded that the total acceleration values of 1.71, 0.71 and 1.26g used for the analysis of the equipment seem to be conservative. A set of delflection and stress calculations were done for the equipment. It was found that the maximum deflection of the impeller is less than the allowable for both gravity and seismic loads. The total combined streses at pump mounting bolts and pump shaft where found to be below the allowable.

Based on our review of the reports, the field installation, and the clarifications provided by the manufacturer, we conclude that this equipment is adequately qualified for seismic loads. Hydrodynamic loads are not applicable for this particular equipment and thus they were not considered.

M-30-372: Intake & Exhaust Expansion Joints

(30"-V FGV-L, 30"-U-F4V Tube Turns)

A total of 16 pieces of this equipment, 4 for each diesel generator, are mounted to the intake and exhaust pipe lines. There are three joints in the exhaust line and one in the intake turbocharger line. All units are flange mounted to the piping system and are located in the diesel generator building at elevation 677 ft. These fittings are designed to reduce pipe loads.

The expansion joints manufactured by Tube Turns were qualified by standard handbook type of calculations. Since this kind of equipment has smaller mass as compared to the pipe mass, hand calculations using static g-loads are justified. The calculations were done as per the instructions given in "Standards of Expansion Joint Manufacturer's Association Inc., 4th ed., 1975". The sepcification used in the design were SD-140 and 8856-G-10. The entire documentation of the analysis is described in the Chemetron Tube Turns Report No. 78465, entitled "Seismic Calculations for Cooper Bessmer Co." prepared by Tube Turn dated June 6, 1975. Additional calculations were further documented to higher g'values to include the hydrodynamic loads. Since the fundamental frequencies for this equipment were found to be high, the pipe frequencies would not be altered and its response under dynamic loadings for the Susquehanna Site should not be affected.

Based on our review of the report and the inspection of the installation it is concluded that this equipment possesses adequate flexibility to withstand the specified dynamic loadings.

M30-376: Prelude Pump & Motor

Model No. D1 Gearex

This equipment is attached to the diesel engine and it is located in the diesel generator building at elevation 677'. The plant has four diesel engines and thus there is a total of four identical prelube pumps in the plant. This equipment is required to operate during the start-up of the diesel engine and it circulates oil required for engine start-up. When the oil pressure builds up in the diesel engine the pump stops operating. The pump and motor system is mounted though a sub-base plate to a frame. The pump is mounted to the sub-base plate with two 5/8" bolts, whereas, the motor is mounted to the same plate with four 3/8" bolts. The sub-base plate is mounted to the frame with four 3/4" bolts. Finally the mounting of the frame to skid is accomplished differently for the A & B and C & D engines. In particular, for A & B engines twelve 5/8" bolts are used while for the C & D engines twelve 1/2" bolts are used respectively for the frame to skid mounting. The total of 12 bolts for each of the above mountings corresponds to 3 bolts per leg of the sub-frame. The reason that two different types of frame to skid mounting are used, is that the A & B engines were completed before the C & D engines were built. At a later date, CES requested that 1/2"bolts be used for this mounting. Thus the remaining two diesel engines were built by using 1/2" bolts for the frame to skid mounting for the prelube pumps.

The vendor for this equipment is the Sieer-Bath Div. and the equipment was designed according to the design specification: SD-140 88546-G-10. In order to qualifiy the equipment an analysis was performed. The pertinent qualification report is:

"Seismic Analysis, Cooper Bessemer P.O. 3621N4770", by Sier-Bath, Job P-22314, March 11, 1976.

In this analysis the system including the pump, motor and the base was modeled and analysed by the STRUDL-DYNAL code. A total of 15 modes were considered in this analysis. The lowest natural frequency was found to be found to 56.4 Hz. The 15th Hz mode has a frequency equal to 834.5 Hz. The seismic analysis is based on the SD-140 spectra which are conservative. These spectra envelope the floor response spectra computed for the diesel generator building at elevation 677'-0". A static analysis was performed for the pump shaft deflection evaluation. The loads considered were design loads with and without the earthquake contribution. The shaft deflection without the earthquake considered was found to be -0.0003371." This deflection is equal to 0.00041" when earthquake loads are considered. The latter value for the deflection was obtained by considering the worst loading case which corresponds to horizontal earthquake plus pump pressure load. From these values it is concluded that the contribution of the seismic load is very small. This is due to the fact that the lowest frequency of the system is above 33 Hz. In addition, the pump radial clearance is equal to 0.0035" and therefore can accomodate the above computed shaft deflection. The shaft bending stress was also computed with and without seismic loads. In both cases this stress was found to be below the yield strength.

An analysis was performed to evaluate the pump bearings and pump housing. It was concluded that there will be no peening of the rollers and no stresses will be developed above the allowable ones. The frequency of the rotor and shaft system was computed. This frequency was found equal to 942 Hz which is much higher than 33 Hz or the pump rotational frequency which is equal to 20 Hz. The loads at each bolt of the pump base were computed for both external and seismic loads. The bolts were evaluated for tensile and shearing stresses. As failure criterion the Mises or the maximum distortion energy theory was employed.

Based on our review of the reports, the field installation, and the clarifications provided by the manufacturer we concluded that this equipment is adequately qualified.

P-16A3: Gear Operated Butterfly Valves

(Jamesbury valves with MA 050 Z/MA 060 Z actuators)

Twelve such pieces of equipment (2-14 inch, 4-18 inch, 4-20 inch and 2-36 inch) are located at various buildings in the plant. They are all flange mounted to different size pipelines. They are equipped with gear operated actuators which are rigidly connected to the valve body by bolts. Only the two 14" valves are require requalification for hydrodynamic loads since these are located in the Reactor building. The other ten valves were qualified for Seismic loadings only.

The reports reviewed for dynamic qualification of these twelve valves were prepared by John Henry Associates Inc. for Jamesbury Corp. They are:

(1) "Seismic Qualification of Wafer-Sphere Valves for the W. H. Zimmer Nuclear Power Station", Report # JHA-74-2, 11 July 1975.

(2) "Seismic Qualification of 36-822 6 PX WSV with Limitorque SMB000/25 - H3 BC activator", Report # JHA-75-11, Dec. 75.

(3) "Seismic Qualification of Wafer-Sphere Butterfly Valve covered by Jamesbury Order No. JPB-45525", Report #JHA-76-68, April 15, 1977.

Since similar equipment were installed in Zimmer Plant, the same reports were used to qualify the valves in this plant. The first report includes a 18" valve since it was selected to be the most representative of all the valves up to 36 inch size. The second report refers to a 36 inch valve with a motor operator. Since the gear operated actuators are more rigid as compared to motor operated actuators, this report encompasses the qualification of all valves which are both gear as well as motor operated.

The last report (i.e., item 3) was submitted to us at the exit meeting and qualified the 14" valve which needs to be requalified for hydrodynamic loads. There is no mention of the hydrodynamic loads in the report. ' 12" valve was selected in the report to represent the 14" valve. The first fundamental frequency of the selected valve was found to be 60 Hz. The g-level used in the report in each direction is 3g. According to the report the 14" valve will have frequency higher than 60 Hz.

In all of the reports, a finite element model was used for the analysis. The frequency calculations were obtained using the computer code STARDYN. Once the rigidity frequency level (33 Hz) was established from the above analysis, the same model was used to perform a static analysis with a load of 3g in each direction. The first report also includes results for SSE condition with a load of 5g in each direction. In all cases, the results were found to be well within the allowables.

Since all valves are pipe mounted, the final qualification of this equipment depends on the g-value results obtained at the valve c.g. from the as-built piping analysis. As mentioned in the introductory remarks this is a generic open item that needs to be confirmed by Bechtel after they complete their piping analysis.

In conclusion based on our review, inspection of the field installation and the response from the responsible engineers, we conclude that these valves have adequate dynamic resistance and hence they are qualified pending to the final g-level verification from the as-built piping analysis.