TOLEDO
EDISON

RICHARD P. CROUSE
Vice President
Nuclear
(419) 259-5221

Docket No. 50-346

License No. NPF-3

Serial No. 729

July 15, 1981

Director of Nuclear Reactor Regulation
Attention: Mr. Darrell G. Eisenhut, Director
Division of Licensing
United States Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Eisenhut:

NRC Generic Letter 81-14, dated February 10, 1981, requested that we review the seismic qualification of the Auxiliary Feedwater System for the Davis-Besse Nuclear Power Station, Unit No. 1. Attached is our response to Generic Letter 81-14.

The Davis-Besse Nuclear Power Station, Unit No. 1 Auxiliary Feedwater System was designed and constructed in accordance with Position 1.g of Safety Guide 1.29. Therefore, as our response indicates, this system as originally designed meets the intent of Generic Letter 81-14.

Yours very truly,

RPC:CLM

Attachment

pp c/5

cc:
NRC Davis-Besse Resident Inspector

A048
S
1/1

Docket No. 50-346
Licence No. NPF-3
Serial No. 729
July 15, 1981

Response to NRC Generic Letter 81-14
- Seismic Qualification of the Auxiliary Feedwater System

As requested by NRC Generic Letter 81-14, the Davis-Besse Unit 1 Auxiliary Feedwater (AFW) System has been evaluated to identify the extent to which it is seismically qualified. All components and structures required for the AFW system to perform its function have been found to be adequately designed and constructed to withstand the Maximum Possible Earthquake, also known as the Safe Shutdown Earthquake (SSE).

The AFW System is shown schematically in Appendix 1. The system consists of two (2) 100 percent capacity turbine driven auxiliary feedwater pumps (AFPs). Each of the pumps has the ability to provide AFW flow to either of the two (2) once-through steam generators (OTSGs). Steam supply to the auxiliary feedwater pump turbines (AFPTs) is provided from connections on the main steam lines located upstream of the main steam isolation valves (MSIVs). Cross connections provide the capability to provide the steam to either AFPT from either OTSG.

The AFPs normally take suction from the condensate storage tanks (CSTs), which are non-seismic Category I components. Where the normal suction line from the CST enters the auxiliary building, as shown in Appendix 1, the piping seismic classification changes from non-seismic Category I to seismic Category I. A seismic Category I source of water for the AFPs is provided from the service water system (SWS). The SWS is a nuclear safety-related system, and all components required to provide a source of water for the AFPs are seismic Category I. The switchover of pump suction from the CST to the SWS is accomplished automatically by low pressure switches located in the seismic Category I portion of the suction piping from the CSTs. Actuation of these low pressure switches opens the valves in the lines from the SWS and closes the valves in the lines from the CSTs. All of the equipment required to effect the switchover from the CST to the SWS is seismic Category I.

The large piping in the seismic Category I portions of the AFW System, with the exception of the AFPT exhaust piping, was included in the scope of NRC IE Bulletins 79-02, 79-04, 79-07 and 79-14. The AFPT exhaust piping was not included in the scope of the above NRC bulletins because it was being redesigned and rerouted in the auxiliary building to provide separate exhaust paths for the two AFPTs. It was therefore felt that inclusion of the existing AFPT exhaust piping in the responses to the bulletins was not appropriate, since the piping was being modified. The TED QA/QC program assures compliance with the design and installation specifications and tolerances for the AFPT piping and other new piping and support installations.

There is only one unresolved item related to NRC IE Bulletin 79-14. Reanalysis of the stress problems associated with the AFPT has indicated an increase in the loads transmitted to the AFPT nozzles. Recent correspondence with the AFPT supplier indicates that these loads are acceptable for continued short term operation. Design modifications to the AFPT pipe support are in progress, and when issued will bring the loads to within vendor specified allowable levels.

The AFW System has also been included in the scope of NRC IE Bulletin 80-11. Davis-Besse Unit 1 has twenty-nine (29) concrete masonry unit (CMU) block walls that support or are penetrated by AFW System piping and electrical circuits. Verification of CMU wall adequacy included consideration of local load transfer from attachment into the CMU wall and the transfer of CMU wall reactions to rigid supports. The walls have been reevaluated and presently either meet the acceptance criteria, or will be modified to comply with the stress acceptance criteria.

IE Information Notice 80-21 was reviewed. However, no response to the NRC was deemed necessary at that time.

Enclosure 1 of NRC Generic Letter 81-14 requested a description of methodologies and acceptance criteria used to support the conclusion of seismic qualification of the AFW System. The following provides that information.

Pumps/Motors

1. Auxiliary Feedwater Pumps

   The auxiliary feedwater pumps were seismically qualified by analysis using the Byron Jackson computer program CRTSPD. Since all natural frequencies were greater than 33 Hz, a static 3-dimensional analysis was performed. The seismic input was the ZPA values from the SSE floor response spectra of the Auxiliary Building, Area 7, Elevation 565 feet. These floor response spectra were based on an SSE ground acceleration of 0.15g. The ZPA values were applied to the pump weights for the static analysis. All calculated stresses were less than the material allowable stress values. Qualification testing was not performed. Bechtel Power Corporation reviewed the seismic analysis report and approved the vendor's method of analysis.

2. Auxiliary Feedwater Pump Turbines

   The auxiliary feedwater pump turbines were seismically qualified by an analysis done by Keith, Feibusch Associates. Since all natural frequencies were greater than 33 Hz, a static analysis was performed. The seismic input used in the analysis was greater than the ZPA values from the SSE floor response spectra of the Auxiliary Building, Area 7, Elevation 565 feet. These floor response spectra were based on an SSE ground acceleration of 0.15g. The seismic accelerations were applied to the turbine weights for the static analysis. All calculated stresses were less than the material allowable stress values. Qualification testing was not performed. Bechtel Power Corporation reviewed the seismic analysis report and approved the vendor's method of analysis.

Piping

All piping and its supporting system within the limits of the seismic Category I portion of the AFW System was originally designed and constructed in accordance with Position 1.g of Safety Guide 1.29. This includes all of the AFP suction piping, including the SWS piping and all of the AFP discharge piping to the nozzles on the OTSGs. It also includes all steam piping to the AFPTs, as well as the AFPT exhaust piping to the atmosphere. All branch piping connected to the seismic Category I portions of the AFW System have been seismically qualified and the seismic Category I portion of the branch piping terminate in a seismic boundary anchor. With one exception, all of these seismically qualified

branch lines include two normally closed valves or two valves capable of automatic closure when the safety function is required. The single exception is the alternate supply to the startup feed pump, which has only one normally closed manual valve.

Pipe greater than two (2) inches in diameter was subjected to a rigorous linear elastic static and dynamic analysis. The Bechtel computer program, ME 101, performs a thermal, deadweight, and dynamic analysis. This analysis is based on standard normal mode techniques utilizing response spectrum input. Pipe two (2) inches or less in diameter is supported in a manner that keeps the fundamental frequency of the system greater than or equal to twenty (20) Hz.

Loading combinations and their corresponding allowable stresses for all piping and supports located in the seismic Category I portion of the AFW system are as follows:

Loading Combination	Piping Allowable Stress	Pipe Support Structural Member Allowable Stress
D + P + OBE	1.2 S_h	
D + P + SSE	1.0 S_y	
D + T + OBE		0.6 S_y (Bending) 0.4 S_y (Shear)
D + T + SSE		0.9 S_y (Bending) 0.6 S_y (Shear)

Where
D = Deadweight
P = Pressure
T = Thermal

OBE = Operating Basis Earthquake (0.08g)

SSE = Safe Shutdown Earthquake (0.15g)

S_h = Allowable Hot Stress*

S_y = Minimum Yield Stress*

*Values for S_h and S_y are taken from the 1971 Edition of ASME Code Section III

Piping loads imposed on structures housing or supporting the AFW System have been checked using the allowable stresses described in Appendix 2.

Valves/Actuators

All valve and actuator assemblies were analyzed by the valve suppliers to withstand an acceleration of at least 3.0g in any direction, in addition to the normal operating load. These analyses show that all stresses were within allowable limits. The maximum acceleration to which the valve and actuator will be subjected in the installed piping system is less than 3.0g in any direction. Bechtel Power Corporation has reviewed the seismic analyses and approved the vendor's methods of analysis.

Electrical Equipment

The electrical equipment necessary for the operation of the AFW System is listed below. A description of how each was seismically qualified follows each component. All equipment is Class IE.

1. Motor Control Centers (AC and DC)

   The Motor Control Centers were seismically tested by Wyle Laboratories. The resonance frequency survey tests, in the range of 0.5 Hz to 35 Hz, revealed natural frequencies in all directions to be 3, 6, 8, 11, 17, and 20 Hz. Single frequency, single axis, sine beat dwell tests were conducted with input acceleration levels of 0.433g side to side (S/S) at 2% damping and 0.58g S/S at 5% damping. Applicable floor required response spectra (RRS) for the Auxiliary Building were used.

2. Disconnect Switch Cabinets

   The Disconnect Switch Cabinets were seismically tested by Acton Environmental Testing Laboratories. A resonance frequency survey test in the range of 1 Hz to 33 Hz was conducted. At the resonant frequencies, single axis dwell tests were conducted at input acceleration levels of 0.41g side to side (S/S), front to back (F/B), and vertical (V). Applicable floor RRS for the Auxiliary Building were used.

3. Batteries

   The Batteries were seismically tested by ITT Testing Laboratories. A resonance frequency survey test, in the range of 4 Hz to 35 Hz was conducted. At the resonant frequencies, multi-axis sine dwell tests were conducted at input acceleration levels of 0.38g S/S. Floor RRS for the Auxiliary Building, Area 6, Elevation 603 feet were used.

4. Battery Racks

   The Battery Racks were seismically analyzed by Gould using the static method of analysis. The absolute sum method for combining of dynamic responses and 2% damping were used for the calculations. All calculated stresses were less than the material allowable stress values. The floor RRS for the Auxiliary Building, Area 6, Elevation 603 feet were used.

5. AC and DC Distribution Panels, Battery Chargers, Inverters, Rectifiers

   The AC and DC Distribution Panels, Battery Chargers, Inverters, and Rectifiers were seismically tested by Westinghouse. The resonance frequency survey test, in the range of 1 Hz to 35 Hz, revealed natural frequencies in all directions to be 8, 18, 22, and 28 Hz. Single frequency, multi-axis sine beat tests were conducted with input acceleration levels of 0.332g S/S and 0.22g V. Floor RRS for the Auxiliary Building, Area 6, Elevation 603 feet were used.

6. Local Control Stations

   Various configurations of Local Control Stations were seismically tested by American Environments Company. A resonance frequency survey test in the range of 1 Hz to 35 Hz was conducted. At the equipment's resonant frequencies and at the floor critical frequencies, multi-axis dwell tests were conducted at input acceleration levels of

0.74g S/S, 0.74g F/B and 0.21g V. Applicable floor RRS for the Auxiliary Building were used.

7. Penetrations

The Electrical Penetrations were seismically tested by Applied Nucleonics Company. The resonance frequency survey test, in the range of 1 Hz to 33 Hz, did not reveal any natural frequencies. It was determined that the equipment's natural frequencies are much higher than 33 Hz. Proof tests were conducted at 5 Hz and 17 Hz, where maximum responses due to the building floor response might occur. The test input accelerations were as listed below.

Frequency	Acceleration
1. 5 Hz and 17 Hz	0.60g S/S, 0.25g V
2. 5 Hz	0.75g F/B, 0.30g V
3. 17 Hz	1.00g F/B, 0.25g V

Applicable floor RRS for the Containment were used.

8. Steam and Feedwater Rupture Control System (SFRCS) Cabinets

The SFRCS Cabinets were seismically tested by American Environments Company. The resonance frequency survey test, in the range of 1 Hz to 33 Hz, revealed the natural frequencies in the S/S direction to be 6, 7, 11, 18.5, 23.5, 30 and 33 Hz. Single frequency, single-axis sine dwell tests were conducted with input acceleration levels of 0.5g S/S and 0.33g V. Floor RRS for the Auxiliary Building, Area 7, Elevation 623 feet were used.

9. Conduit

The allowable spans of the various sizes of conduit were determined using the approximate zero period acceleration (30 cps) of the conduit. The stresses in the conduit were then checked to verify that these stresses did not exceed the allowable values. The conduit supports were designed for the resulting allowable conduit spans and the accelerations associated with 30 cps.

In the analysis of the conduit and supports, the effect of horizontal and vertical spans, bending and axial stresses, and the effect of conduit coupling deflections were all considered. The conductors within the conduit were considered as dead loads in the analysis.

The load combinations and allowable stresses in the conduit seismic analysis are listed below.

Load Combinations	Allowable Stresses
1. Dead Load (D)	Working Stress
2. D + OBE	Working Stress
3. D + SSE	Working Stress

10. Cable Trays

The natural frequency of the cable tray plus cable fill was calculated for the maximum permissible spans. Using these values, accelerations were obtained from the floor response curves. The stresses in the cable trays, supports, and connections were calculated and shown to be less than the allowable stresses. The live load in the load combinations was assumed to be the weight of a man and was not included in the frequency calculations.

The load combinations and allowable stresses in the cable tray seismic analysis are listed below.

Load Combinations	Allowable Stresses
1. Dead Load (D) + Live Load (L)	Working Stress
2. D + L + OBE	Working Stress
3. D + L + SSE	Working Stress

The test and analysis acceleration input levels utilized in items 1 through 8 above were highly conservative and exceeded the SSE required response spectra. The floor RRS was based on a SSE acceleration of 0.15g horizontal and 0.10g vertical. Based on the test or analysis results it was concluded that equipment functionality during an SSE was demonstrated. Bechtel Power Corporation reviewed the vendor reports and approved the test and analysis methods.

Instrumentation

All field mounted instrumentation essential to the operation of the AFW System has been seismically tested. A description of the seismic qualification tests performed on the essential pressure transmitters and switches is given below. All other field mounted instrumentation associated with the AFW System is seismically qualified for structural integrity only as their functions are not essential to operation of the system.

1. Rosemount Differential Pressure Transmitters

Rosemount Differential Pressure Transmitters used for measuring steam generator water level were tested by Wyle Laboratories. The transmitters were subjected to a biaxial test series and a pseudo-biaxial fragility test.

During the biaxial testing, the test specimens were subjected to horizontal/vertical and lateral/vertical phase incoherent inputs of random motion; consisting of frequencies spaced one-third octave apart over the frequency range of 1 Hz to 31.6 Hz. A minimum of five biaxial tests at one-half level followed by a full level test, each of 30 seconds duration, was performed in both the horizontal/vertical and lateral/vertical orientations. The full level test exceeded a response spectrum defined by the following, at three percent damping: 1 Hz, 0.5g; 3 Hz, 1.5g; 3.5 to 6 Hz, 2.7g; 10 Hz, 1g; 30 Hz, 0.5g. Both transmitters were mounted with the Rosemount panel bracket (PB option).

Fragility testing was done on a long stroke single axis machine inclined 45° to the horizontal. One transmitter, the model 1151, was mounted using the panel bracket (PB); the other, model 1152, was rigidly mounted. The specimens were mounted with their longitudinal axis parallel to the horizontal and the input motion was inclined at 45° to the horizontal. The specimens were tested in the vertical and first horizontal axis simultaneously, and then the fixturing was rotated 90° and the test repeated for the vertical and second horizontal axis. This was repeated until all four principle horizontal directions were tested. Input motion along the 45° inclined axis was analyzed at a 5% damping value The response spectrum for this table motion exceeds a curve defined by the following: 3g, 1 Hz; 15g, 3 Hz to 40 Hz. Horizontal and vertical components can be determined by dividing by the square root of 2.

It was demonstrated that models 1151 and 1152 possessed sufficient integrity to withstand, without compromise of structures or electrical functions, the described simulated seismic environment. And, although a slight amplification did occur at three Hertz during the biaxial testing, no significant resonance was found below 5 Hertz. This is additionally demonstrated by the fragility test data.

2. Static-O-Ring Pressure Switches

Static-O-Ring Pressure Switches used for measuring both steam line pressure and AFP suction pressure were seismically tested by Viking Laboratories. Testing consisted of a resonance search test, a vibration endurance test, and a malfunction limit test. The resonance search test revealed no resonances between 5 Hz and 1000 Hz at a double amplitude acceleration of 0.1g in each of three mutually rectilinear axes.

No malfunction occurred during, nor damage resulted from, the vibration endurance test under the following conditions:

Axis	Frequency (Hz)	Acceleration (g's)
Horizontal	30.0 to 10.8	3
	10.8 to 8.9	3 to 2
	8.9 to 6.3	2 to 1
	6.3 to 5.0	1 to 0.6
Vertical	30.0 to 6.3	1
	6.3 to 5.0	1 to 0.6

No malfunction occurred during, nor damage resulted from, the malfunction limit test.

3. ITT Barton Differential Pressure Switches

ITT Barton Differential Pressure Switches for measuring steam generator/feedwater differential pressure were seismically tested by Wyle Laboratories. Testing consisted of a resonance search test between 1 Hz and 60 Hz at a double amplitude acceleration of 0.5g in each of three mutually rectilinear axes. This was followed by a one (1) minute vibration endurance test at each resonant frequency with a test acceleration of 3.0g horizontal and 2.0g vertical. All tests were performed twice. Resonance was observed at 38 Hz and 3.0g in one test specimen containing the manufacturer's standard relays. Contact chatter was observed at this frequency and

acceleration in one relay. This frequency is higher than the maximum frequency (33 Hz) where significant resonances occur during an SSE. Relay contact chatter of these switches was therefore not considered a plausible problem under SSE conditions. No other resonances were observed in any test specimens.

Structures Supporting or Housing AFW System

Davis-Besse Unit 1 was designed to withstand the seismic acceleration associated with a Modified Mercalli VII-VIII Earthquake. Based upon geotechnical conditions and site geology, a maximum horizontal vibratory ground acceleration of 0.15g was established for the Maximum Possible Earthquake (SSE), and an acceleration of 0.08g was established for the Maximum Probable Earthquake (OBE).

In order to evaluate the loads induced in the structures by the earthquake motion, mathematical models representing the structural characteristics of the buildings were developed. Each of the models represented the mass, stiffness, and damping characteristics of the building as a lumped parameter system. Fixed based idealized models were developed since the structures were founded on rock, and the seismic input was applied at the foundation-bedrock interface. The applicability of using the lumped parameter techniques for structural analysis was predicated on the fact that seismic deflections would be small and within the elastic range.

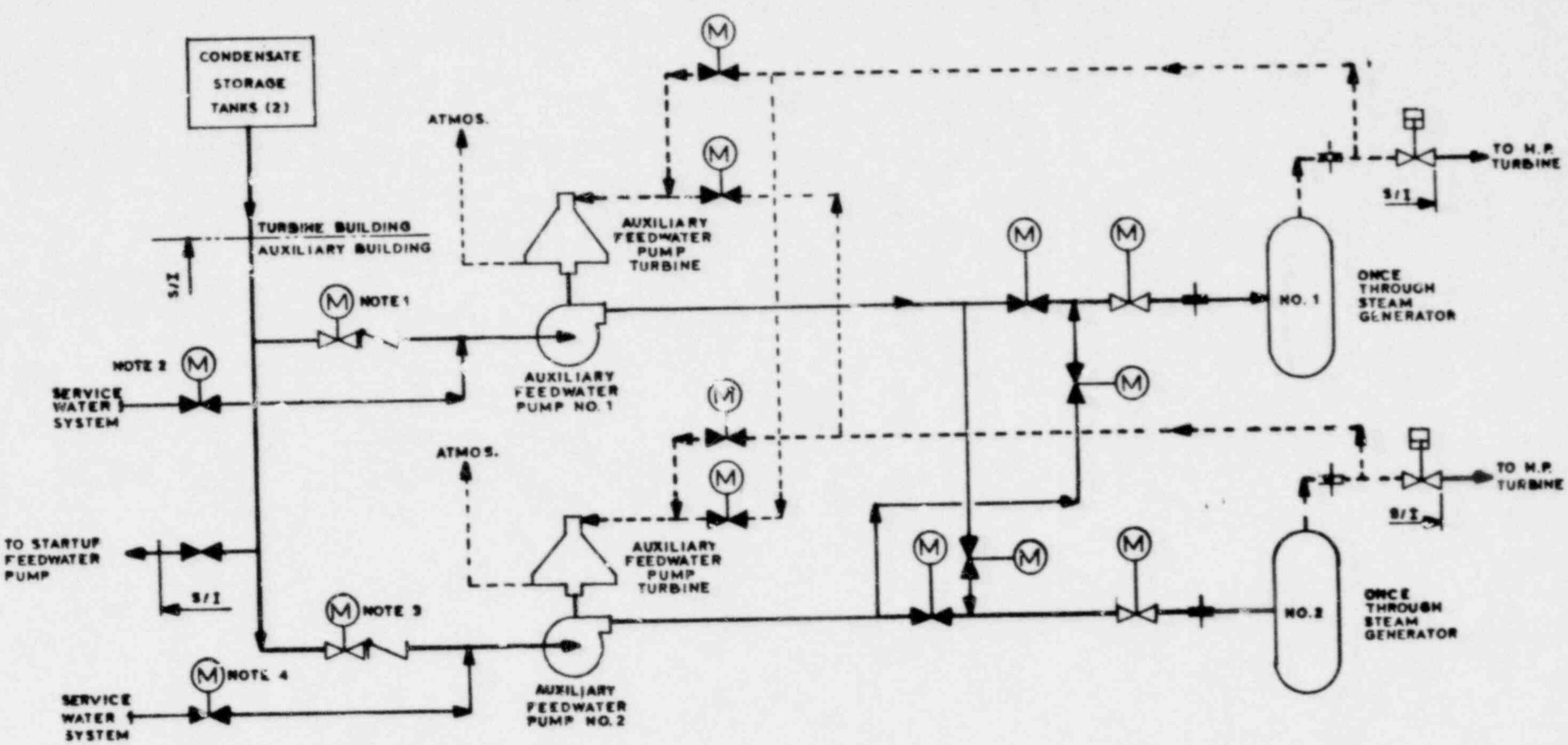
The modal synthesis technique was used to determine the spectrum and time-history responses for each structure when subjected to an OBE of 0.08g and a SSE of 0.15g.

For each building, a set of uncoupled modal equations, representing the idealized system, was solved using the Runge-Kutta Fourth Order Method. Analytical results obtained were in the form of acceleration time-histories at the various floor levels. Horizontal and vertical response components were generated. Accelerograms digitized at equal time intervals, were used to generate the floor response spectra. These spectra were then used for the seismic design of the buildings and the seismic qualification of equipment.

During the construction phase, various modifications to the buildings were incorporated to accommodate design changes. Seismic re-evaluations were made using these revised structural characteristics, which reflected the "as-built" structural properties and mass distributions. These studies indicated that the design response spectra enveloped the "as-built" spectra at the peaks, which had been broadened ±10% to account for uncertainties in the physical characteristics of the structures. The studies also showed that any variations from the original design values were below or well within the range which could be anticipated due to the analytical and modeling techniques.

Further details of the structures housing or supporting the AFW System are contained in Appendix 2.

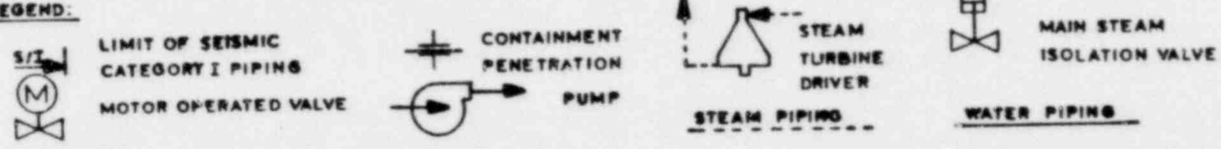
APPENDIX 1



NOTES:

1. VALVE CLOSES ON AUX. FEEDWATER PUMP NO. 1 LOW SUCTION PRESSURE.
2. VALVE OPENS ON AUX. FEEDWATER PUMP NO. 1 LOW SUCTION PRESSURE.
3. VALVE CLOSES ON AUX. FEEDWATER PUMP NO. 2 LOW SUCTION PRESSURE.
4. VALVE OPENS ON AUX. FEEDWATER PUMP NO. 2 LOW SUCTION PRESSURE.

LEGEND:



THE TOLEDO EDISON COMPANY
DAVIS-BESSE NUCLEAR POWER STATION
UNIT NO. 1
AUXILIARY FEEDWATER SYSTEM

AFW SYSTEM SEISMIC CATEGORY I STRUCTURES

The seismic Category I structures are designed such that elastic behavior is maintained when the structure is subjected to various combinations of seismic, dead, thermal, and accident loads. The upper limit of elastic behavior is considered to be the yield strength of the effective load-carrying structural members. The yield strength (F_y) for steel (including reinforcing steel) is considered to be the guaranteed minimum given in appropriate ASTM specifications. The maximum allowable stress for structural steel in bending and tension under SSE conditions is 0.9 F_y. Also, maximum allowable stresses in shear for structural steel is 0.6 F_y. The yield strength for reinforced concrete structures is considered to be the ultimate resisting capacity as calculated from the "Ultimate Strength Design" portion of the ACI-318-63 Code.

The FSAR provides a description of the methodologies and acceptance criteria used to support the conclusion that all structures housing or supporting the AFW System are seismically qualified. This description includes seismic analyses, methods employed, seismic input load combinations which include the SSE, and allowable stresses. The table below lists the affected structures and appropriate sections of the FSAR.

Structure	FSAR Section(s)
1. Containment Vessel	3.8.2.1
2. Shield Building	3.8.2.2
3. Containment Internal Structures	3.8.2.3
4. Auxiliary Building	3.8.1
5. Intake Structure	3.8.1
6. Service Water Pipe Tunnel and Valve Rooms	3.8.1
7. Intake Canal Forebay	2.4.8.2 2.5.1.9.1 2.5.1.9.2 2.5.1.10.1