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KEISER, H. W. Pennsylvania Power & Light Co.
RECIP. NAME RECIPIENT AFFILIATION
ADENSAM, E. BWR Project Directorate 3

SUBJECT: Forwards supplemental info re application for Amends 80 & 33 to Licenses NPF-14 & NPF-22, respectively, per 860428 telcon request. SRP Sections re design of fifth diesel generator facility addressed. see Regs

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Harold W. Keiser
Vice President-Nuclear Operations
215/770-7502

MAY 19 1986

Director of Nuclear Reactor Regulation
Attention: Ms. E. Adensam, Project Director
BWR Project Directorate No. 3
Division of BWR Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

SUSQUEHANNA STEAM ELECTRIC STATION
REQUEST FOR ADDITIONAL INFORMATION
FOR PROPOSED AMENDMENT NO. 80 TO
NPF-14 AND PROPOSED AMENDMENT
NO. 33 TO NPF-22
PLA-2645 FILES R41-2/A17-2

Docket Nos. 50-387
and 50-388

Dear Ms. Adensam:

The attached document is being provided in response to a request made during an April 28, 1986 telecon between your staff and PP&L. The telecon was held to discuss our proposed technical specification changes which reflect installation of a fifth diesel generator into the Susquehanna design.

Specifically your Staff requested we address how the civil/structural/seismic design of the fifth diesel generator facility and supporting components conforms to the acceptance criteria of appropriate Standard Review Plan (SRP) sections. The specific sections addressed are 3.3.1, 3.3.2, 3.5.1.4, 3.5.1.5, 3.7.1, 3.7.2, 3.7.3, 3.8.4 and 3.8.5.

We have formatted the attached as follows:

- The first page of each of the above listed SRP sections has been copied followed by the pages containing the acceptance criteria.

- Our responses to each criteria is typed on back of the page preceding the page containing the acceptance criteria.

- Some responses contain numbered references - which are also provided in the enclosed document. Reference number 1 is a draft copy of the proposed changes to those FSAR sections on civil/structural/seismic design. Reference number 2 is a Design Description Report for the fifth diesel generator and Reference number 3 is a specification entitled "Design Criteria for Civil/Structural Work for New Emergency Diesel Generator Facility."

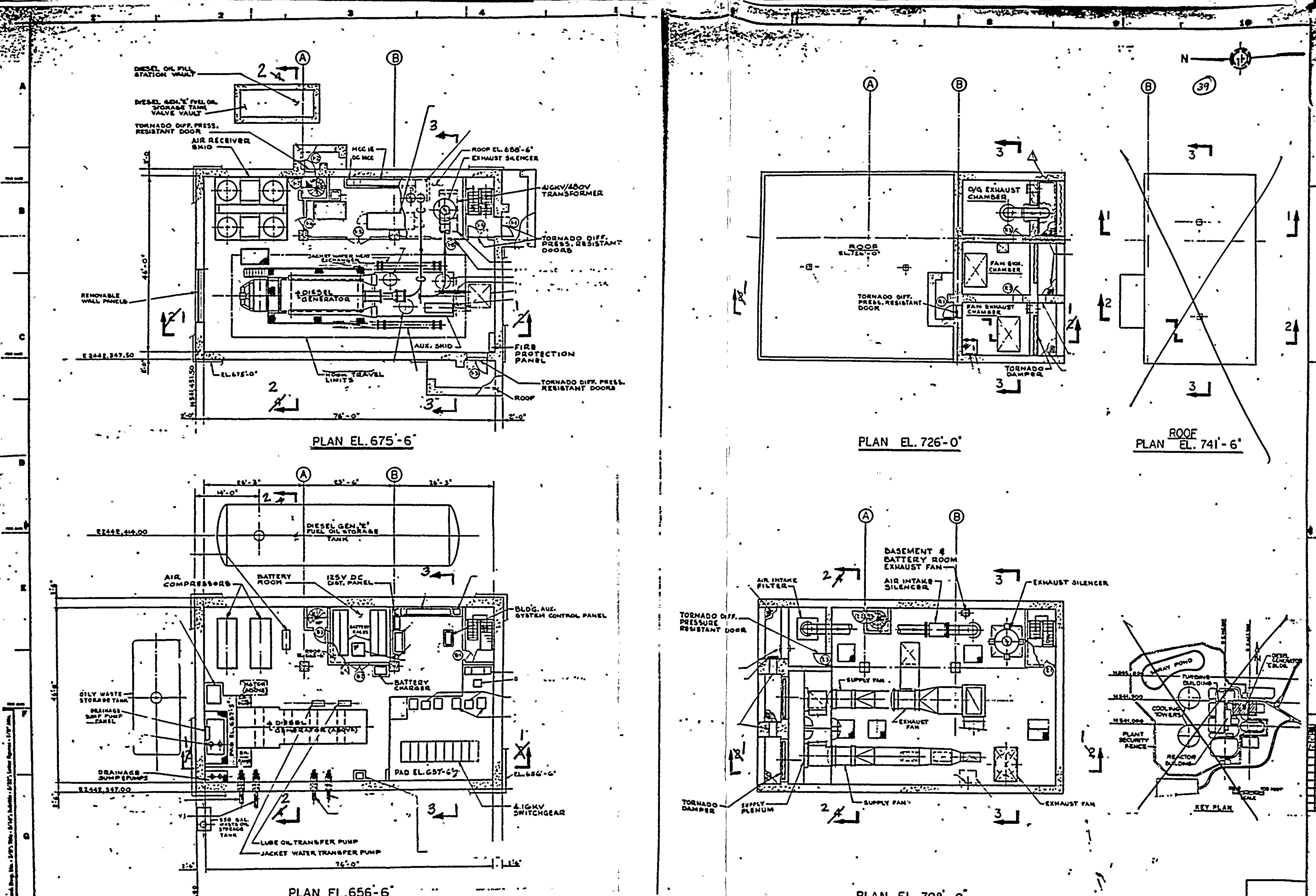
A001 1/1 Limited Dist

If you have further questions, please contact D. J. Walters.

Very truly yours,

H. W. Keiser
Vice President-Nuclear Operations

cc: M. J. Campagnone USNRC
R. H. Jacobs USNRC



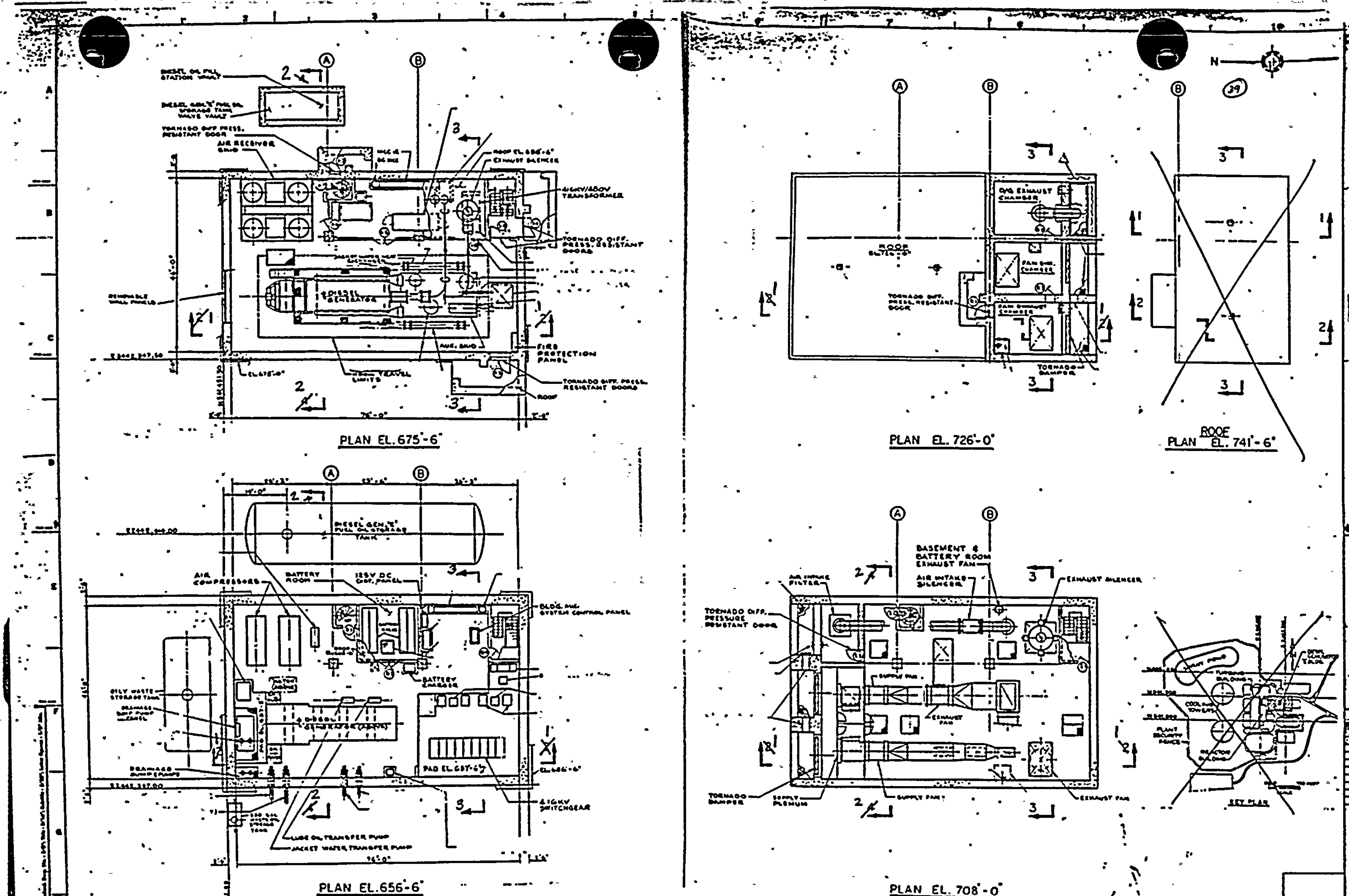
NOTE. THE EQUIPMENT DETAILS SHOWN IN VARIOUS PLANS AND SECTIONS HAVE BEEN PARTIALLY DELETED. IN PREPARING FINAL FIGURES 3.8-105 AND 3.8-106 MORE EQUIPMENT DETAILS MAY BE ELIMINATED SO AS TO CONFORM TO THE EQUIPMENT INFORMATION SHOWN ON EXISTING FIGURES 3.8-92 AND 3.8-93.

8605280293-01

SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

DIESEL GENERATOR 'E' BUILDING PLANS
AT EL. 656'-6", 675'-6", 708'-0" AND 726'-0".

FIGURE 3.8-105



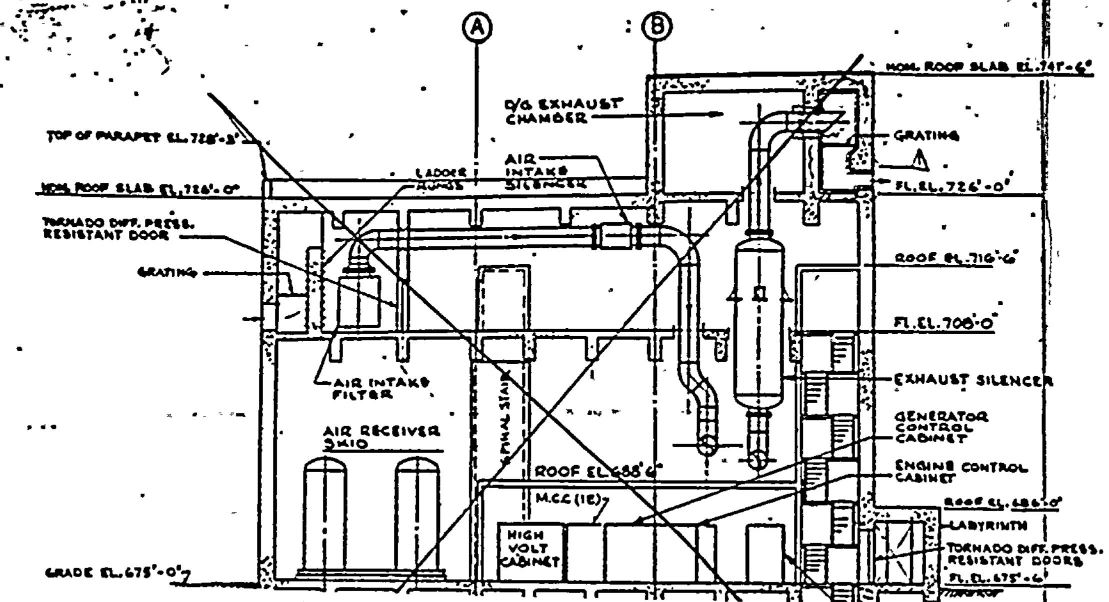
Note The equipment detaiLs shown in various plans and sections have been partially deleted. In preparing final figures 3.8-45 and 3.8-46 more equipment details may be eliminated so as to conform to the equipment information shown on existing figures 3.8-92 and 3.8-93.

8605280293-01

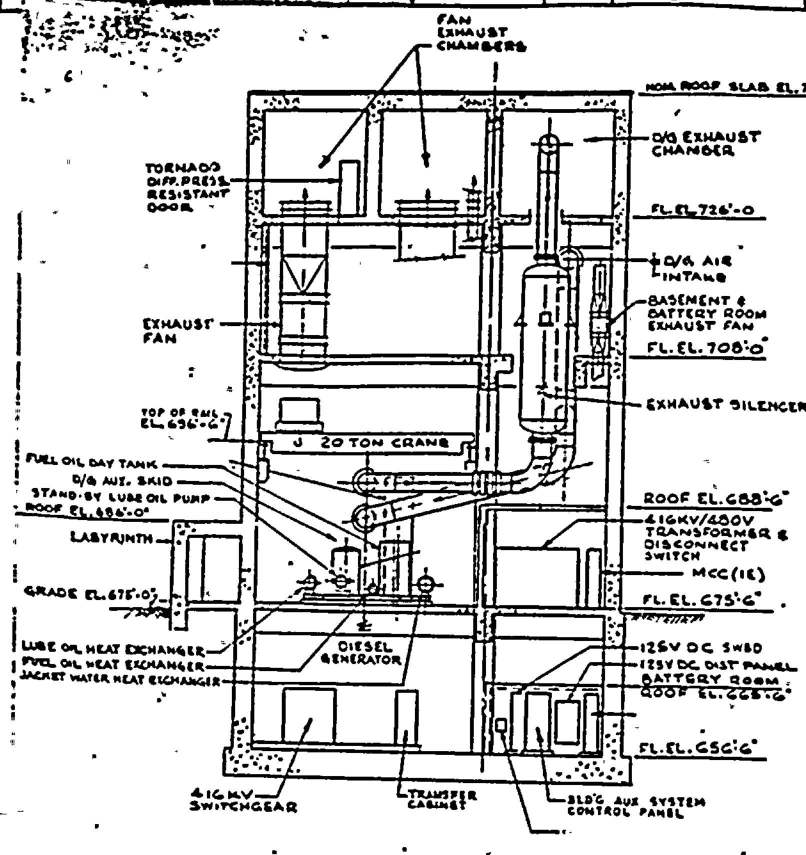
SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

DIESEL GENERATOR "E" BUILDING PLANS
AT EL. 656'-6", 675'-6",
708'-0" AND 726'-0".

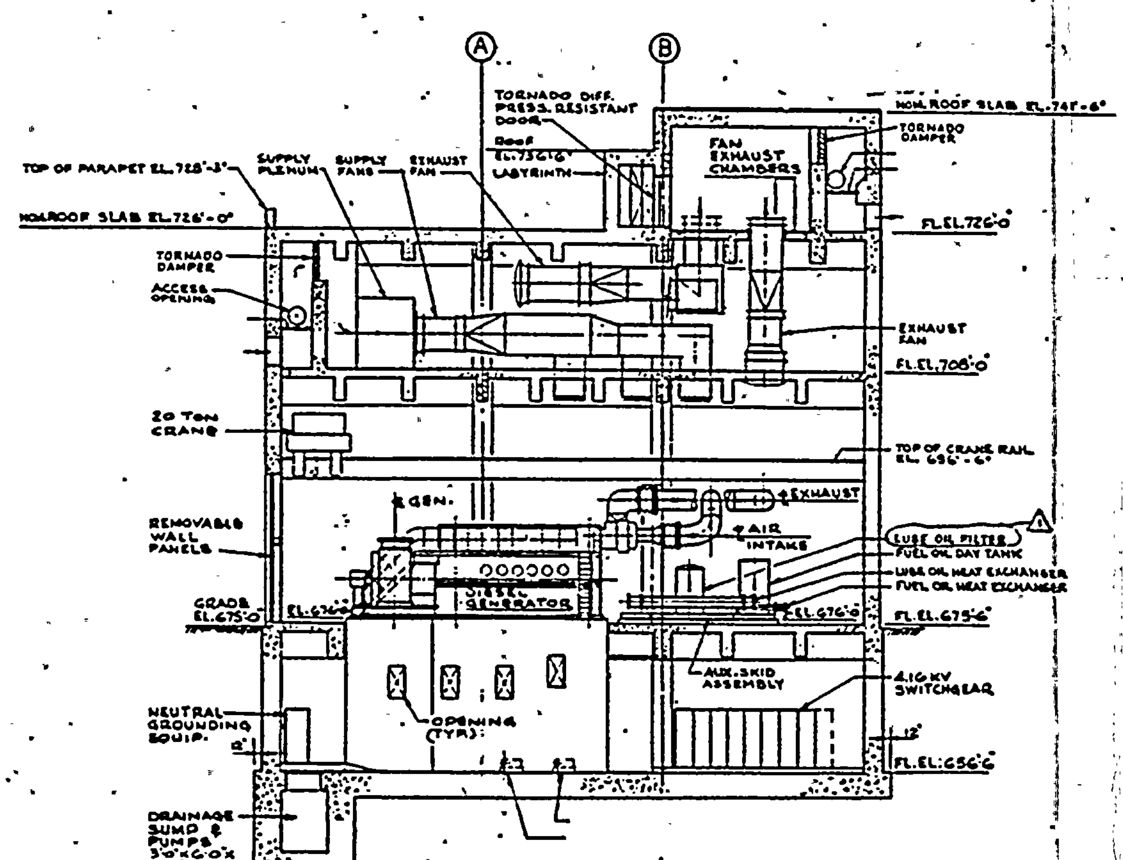
FIGURE 3.8-105



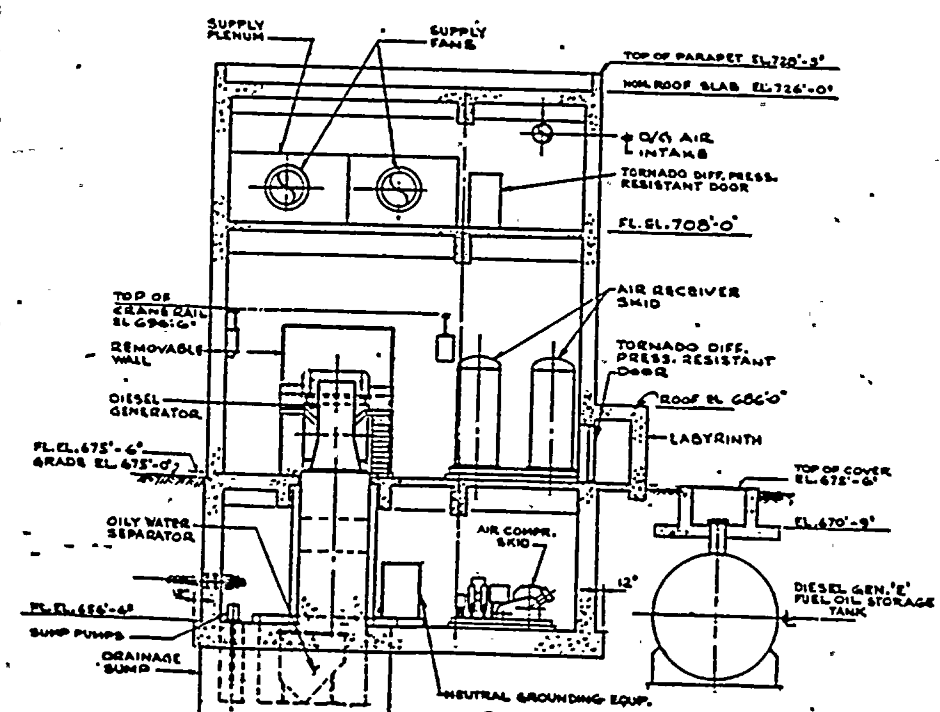
NOTE. THE EQUIPMENT DETAILS SHOWN IN VARIOUS PLANS AND SECTIONS HAVE BEEN PARTIALLY DELETED. IN PREPARING FINAL FIGURES 3.8-105 AND 3.8-106, MORE EQUIPMENT DETAILS MAY BE ELIMINATED SO AS TO CONFORM TO THE EQUIPMENT INFORMATION SHOWN ON EXISTING FIGURES 3.8-92 AND 3.8-93.



SECTION 3-3



SECTION 1-1



SECTION 2-2

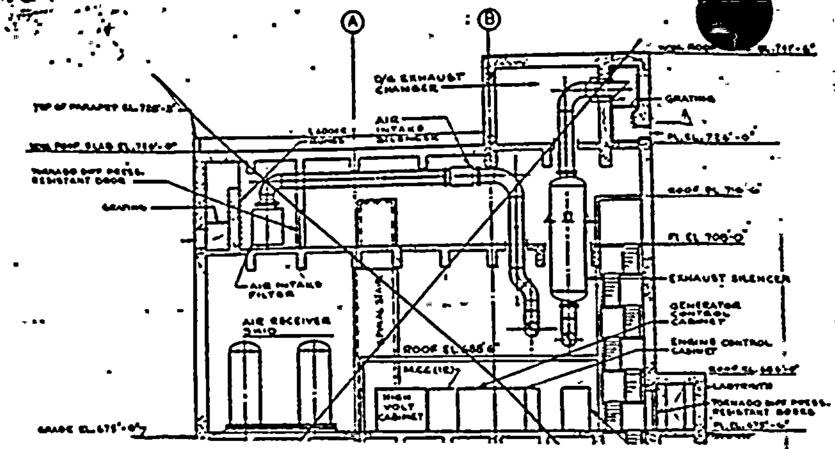
8605280293-02

SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

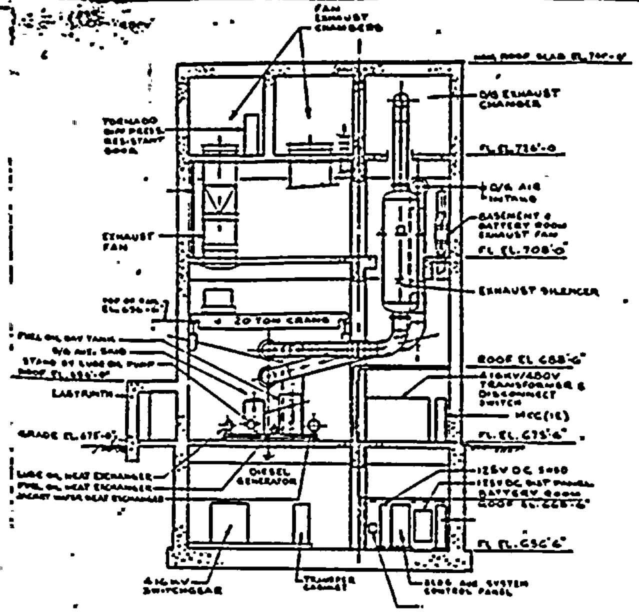
DIESEL GENERATOR 'E' BUILDING
SECTIONS
FIGURE 3.8-106

REFERENCE TITLE

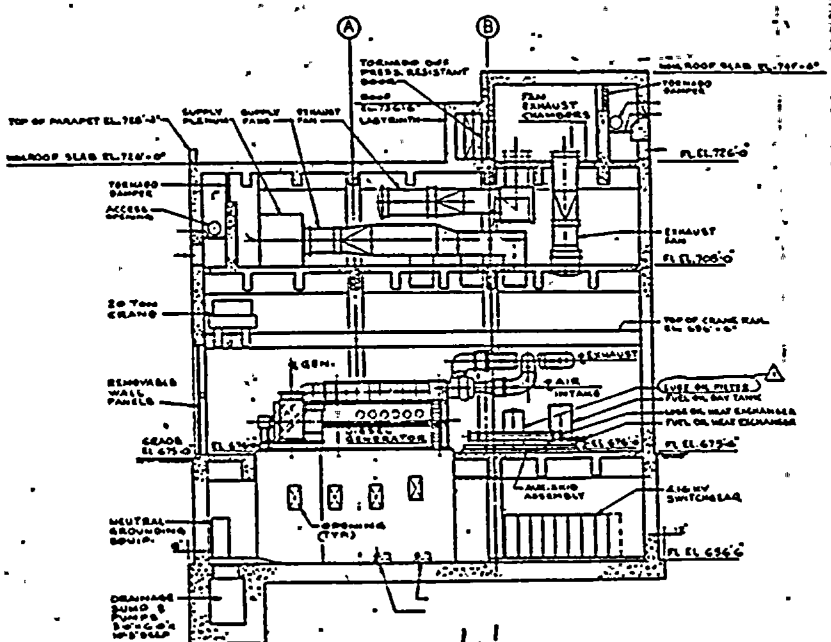
(40)



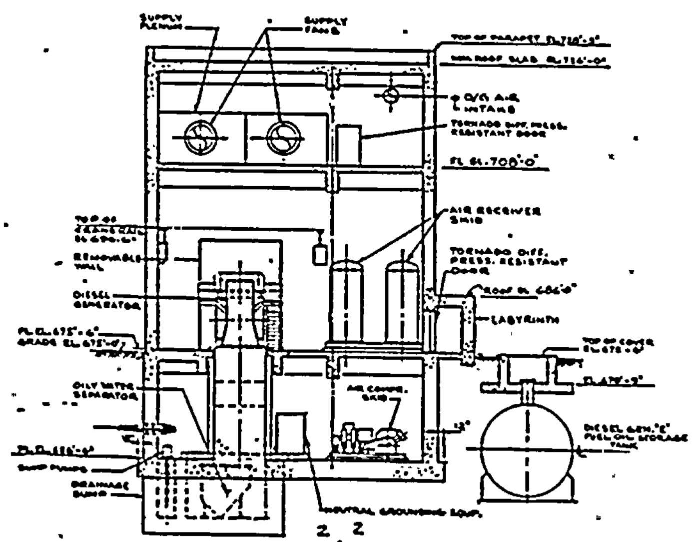
NOTE. THE EQUIPMENT DETAILS SHOWN IN VARIOUS PLANS AND SECTIONS HAVE BEEN PARTIALLY DELETED. IN PREPARING FINAL FIGURES 3.8-45 AND 3.8-46, MORE EQUIPMENT DETAILS MAY BE ELIMINATED SO AS TO CONFORM TO THE EQUIPMENT INFORMATION SHOWN ON EXISTING FIGURES 3.8-92 AND 3.8-93.



SECTION 3-3



SECTION ~~2-2~~ 1-1



SECTION ~~1-1~~ 2-2

8605280293-02

SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

DIESEL GENERATOR 'E' BUILDING

SECTIONS

FIGURE 3.8-106

TABLE 3.9-16

LIST OF COMPUTER PROGRAMS USED IN BOP MECHANICAL SYSTEMS AND COMPONENTS

COMPUTER PROGRAM No.	NAME	DOCUMENT TRACEABILITY	SYSTEM USED
ME101	Linear Elastic Analysis of Piping	Bechtel	Univac 1110
ME632	Piping System Analysis	Bechtel	Honeywell 6000 Univac 1110
ME912	Thermal Stress Programs	Bechtel	Univac 1110
ME913	Nuclear Class 1 Piping Stress Analysis	Bechtel	Univac 1110
-	MRI/STARDYNE 3	CDC or Mechanics Research, Inc Los Angeles	CDC 6600
CE798	ANSYS	Swanson Analysis Systems, Inc. Elizabeth, PA 15037	Univac 1110
ME351	PIPERUP	CDC or Quadrex Corp. Campbell, CA	CDC 175
J017	ADLPIPE	[redacted] Arthur D. Little, Inc. Cambridge, Mass.	IBM 4391

3.10b.1.2.1 Functional Criterion

Every instrumentation device shall be capable of performing its safety related function during plant operating conditions of startup, constant power operation, and normal or emergency shutdown without impairment of its safety related function while undergoing seismic and hydrodynamic excitation.

The safety related function of instrumentation devices can be either passive or active. Where one type of device is used in both types of applications, the device is qualified for the worst-case application.

3.10b.1.2.2 Qualification Levels

From the plant OBE, SSE, SRV, and LOCA conditions a family of acceleration required response spectra (RRS) were generated for each building elevation for north-south, east-west, vertical directions. The spectra for each elevation where instrumentation is located were examined to establish the worst-case response spectra.

Pipe-mounted devices are qualified for 6g vertical and 6g lateral along the weakest axis simultaneously applied. Hangers and snubbers are added, if required, to limit piping response. This value is checked against the piping analysis to insure that the piping reponse does not exceed the qualification level. Where equipment was not capable of meeting this standard value, the actual "g" values for that equipment ~~was used~~ for qualification.
were specified for each purchase order
For devices mounted in panels, the RRS used was derived from the panel analysis.

3.10b.1.2.3 Instrumentation Supports

Instrumentation devices, assemblies, and control panels shall be seismically qualified using the supports that will be used during in-plant installation. These items of equipment are required to maintain their functional capability while undergoing earthquake excitation at the equipment supports.

3.10b.1.3 Device Qualification Test Criteria

Devices that were qualified by test were tested in accordance with IEEE Standard 344-1975. In general, test requirements and acceptance criteria are summarized as follows:

a) Devices under test are mounted in a manner that simulates intended use.

b) Devices are tested while in their normal operating condition (e.g., energized) to determine that vibratory conditions do not produce a malfunction or failure. Seismic Category I devices shall not malfunction during or after a safe shutdown earthquake.

c) Devices are tested in all three axes. Simultaneous excitation in all three axes is preferred; however, tests may be run one axis at a time and then be repeated for the other two axes as an acceptable alternative.

d) Where appropriate a frequency sweep (varying the frequency of excitation with time) is conducted at a low "g" value, e.g., 0.2g as noted in IEEE Std. 344. This test was performed to identify resonant frequencies in the range of interest.

e) Devices that are floor- or panel-mounted are subjected to five OBEs and one SSE in each axis tested. Each OBE and SSE consists of random input motion that envelop~~e~~s the RRS for that device.

f) Devices that are pipe-mounted are subjected to sine-beat tests over the frequency range of 1 to 100 Hz. Each sine-beat test is performed at a peak acceleration of 6g or to the peak acceleration for the specific mounting location.

g) The criteria for malfunction or failure include as many of the following characteristics as are applicable to the safety related function of the device during and after testing:

   1) Loss of output signal; e.g., open or short circuit

   2) Output variations greater than ±10 percent of full range

   3) Spurious or unwanted output; e.g., relay contact bounce

4) Major calibration shift; e.g., greater than ±10 percent of range

5) Structural failure; e.g., broken or loosened parts.

3.10b.2 SEISMIC CATEGORY I EQUIPMENT QUALIFICATION

Detailed information about seismic qualification of Non-NSSS Supplied Seismic Category I Instrumentation is maintained in a central file within PP&L. A synopsis of this information was by SQRT forms previously submitted to the NRC.

For The DG "E" facility, SQRT forms for various equipment have also been prepared.

3.10b.3 Methods and Procedures of Analysis or Testing of Supports of Instrumentation

Instrumentation equipment was qualified by test using the support designed for that particular equipment as one of the test elements.

3.10b.4 Operating License Review

Results of tests and analyses were provided in individual SQRT Forms.

For The DG "E" facility, SQRT forms for various equipment have also been prepared.

functions of electrical equipment or components, which are necessary for the functional requirements of the equipment, shall not be impaired when the equipment is subjected to the OBE or the SSE in conjunction with applicable electrical, mechanical, and thermal loads.

3.10c.1.4 Safe Shutdown Earthquake (SSE) Conditions

SSE is defined as an earthquake that produces the maximum vibratory ground motion for which certain structures, systems, and components are designed to remain functional. These structures, systems, and components are necessary to ensure the following:

a) Integrity of reactor coolant pressure boundary

b) Capability to shut down the reactor and maintain it in safe shutdown condition

c) Capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposures to the radioactive material released to the environment.

The load combinations include gravity loads and operating loads. Allowable stresses in the structural portions may be increased to 150 percent of allowable working stress limits. The resulting deflections, misalignment or binding of parts, or effects on electrical performance (microphonics, contact bounce, etc) do not prevent the operation of the equipment during or after the seismic disturbance.

3.10c.1.5 Operating Basis Earthquake (OBE) Conditions

The load combinations include gravity loads and operation loads.

Allowable stresses in the structural steel portions may be increased to 125 percent of the allowable working stress limits as set forth in the appropriate design standards, that is, AISC Manual of Steel Construction, ANSI and other applicable industrial codes. The customary increase in normal allowable working stress due to earthquake is used if, according to the appropriate code, it is less than 25 percent. The resulting deflections, misalignment or binding of parts, or effects on electrical performance (microphonics, contact bounce, etc); does not prevent continuous normal operation of the equipment during and after the seismic disturbance.

For The DG "E" facility, The above 25% increase in allowable working stress limit is not allowed.

3.10c.1.6 Prevention of Overturning and Sliding

Stationary electrical equipment is designed to prevent overturning or sliding by the use of anchor bolts, welding, or other suitable mechanical anchorage devices.

3.10c.2 METHODS AND PROCEDURES FOR QUALIFYING ELECTRICAL EQUIPMENT

3.10c.2.1 Seismic Analysis Method

For the purpose of analysis, the equipment has been idealized as a mathematical model consisting of lumped masses connected by massless elastic structural members. For dynamic analysis, the frequencies and mode shapes have been determined for vibration in the vertical and two orthogonal horizontal directions, termed global directions. The effects of coupling between vibrations in all three global directions have been considered. The spectral acceleration per mode has been obtained from the appropriate response spectrum curve, which has been provided for the appropriate damping value. For determining the spectral acceleration from the response spectrum curves, the value chosen is the largest value on the curve when the frequency in question varies by ±10 percent. Seismic response in terms of inertia forces, shears, moments, stresses, and deflections are determined for response to seismic excitation in each of the global directions for each mode. (See Subsection 3.7b.3.7)

For the consideration of stress or deflection at any point, the total seismic load consists of the most severe seismic load in one of the horizontal global directions combined by the sum of the absolute values method with the vertical seismic load. (See Subsection 3.7b.3.6)

For the DG "E" facility, responses at a point are obtained by taking the SRSS of corresponding responses due to three orthogonal components of earthquake acting simultaneously.

3.10c.2.2 Seismic Qualification for Electrical Equipment Operability

The seismic qualification of Category I electrical equipment, equipment supports, and material meets as a minimum the requirements of IEEE 344-1971 and project specification G-10, "General Project Requirements for Aseismic Design and Analysis of Class I Equipment and Equipment Supports" and complemented by Project Specification G-22, "Design Assessment and Qualification of Seismic Category I Equipment & Equipment Supports for Seismic & Hydrodynamic Loads." Project Specification G-10 is summarized in comparison to IEEE-344-1975 and Regulatory Guide 1.100 in Table 3.9-31.

8-

Electrical equipment is qualified for functional operability during and after an earthquake of magnitude up to and including the SSE according to at least one of the following input excitation tests:

a) Single frequency sinusoidal motion or sine beat motions ~~were~~ continuously inputed during the test at specified frequencies to cover the frequency range up to 33 Hz.

b) Random waveform, multifrequency tests.

For the DG "E" facility, qualification of the electrical equipment and supports meets the requirements of IEEE Std. 344-1975 and project specification C-1041.

3.10c.2.3 Seismic Test Report Analysis and Methods

The analysis and test reports furnished by the supplier demonstrate the ability of electrical equipment to perform its required function during and after the time it is subjected to the forces resulting from one SSE and a required number of OBE.

Four categories of reports are provided by the supplier of electrical equipment and material applicable to Seismic Category I qualification;

a) Electrical equipment qualified by testing method

b) Electrical equipment support and material qualified by analysis and calculation method

c) Electrical equipment qualified by supplier's certification of Seismic Category I requirements.

d) Combination of analysis and testing.

3.10c.2.3.1 Electrical Equipment Qualified by Testing and Combination of Testing and Analysis Method

Electrical equipment listed below was tested by the suppliers or test laboratories based on similarity in design and assembly, and representing representative equipment is shown in Tables 3.10c-4, ~~3.10c-5, 3.10c-6, 3.10c-8,~~ 3.10c-10 through 3.10c-16: 3.10c-5, 3.10c-6 3.10c-8,

a) Indoor secondary unit substation & Indoor power transformers (see Table 3.10c-1)

b) 480 V ac motor control centers (see Table 3.10c-2)

c) Battery monitors and fuse boxes (see Table 3.10c-3)

d) DC distribution panels (see Table 3.10c-4)

e) Battery charger racks and cabinets (see Table 3.10c-8)

TABLE 1.10c-1 SECONDARY UNIT SUBSTATIONS & POWER TRANSFORMER

ITEM NO.	EQUIPMENT IDENTIFICATION DESCRIPTION	EQUIPMENT NO.	LOCATION BLDG.	LOCATION ELEV.	UNIT NO.	SUPPLIER	TESTING FACILITIES	QUALIFICATION CRITERIA	QUALIFICATION "E1" SIGNED BY:
8856-E-117-5765A	Single Ended Secondary Unit Substation Consisting of: a. Terminal Chamber, b. 750 kVA Transformer, c. L.V. Switchgear	1B-210 1B-220 1B-230 1B-240 2B-210 2B-220 2B-230 2B-240	Reactor	749 749 719 719 749 749 719 719	1 1 1 1 2 2 2 2	I.T.E. Imperial Corporation	Wyle Laboratories Norco, California	Project Spec G-10* & IEEE-344-1975	Report # 26340-2 26340-3 26340-4 By: G. Shipway
	POWER TRANSFORMER CONSISTING OF: a. DISCONNECT SWITCH b. 750 KVA TRANSFORMER c. SECONDARY COMPARTMENT	OX-565	DG(E)	675'-6"	COMM.	BROWN-BOVERI CO.	~~(Wyle)~~ Wyle Labs Huntsville Alabama	PROJECT SPEC. C-1041△ & IEEE 344-1975.	BBC Report 37-55778-SSA By: J. Detwiler (similarity Analysis)

* NOTE: Specification G-10 is complemented by Specification G-22. For G-10 Specification Summary, See Table 1.9-11.

△ NOTE: SPEC. C-1041 IS COMPLEMENTED BY SPEC. E-1023.

TABLE 3.10c-2 MOTOR CONTROL CENTERS

ITEM NO.	EQUIPMENT IDENTIFICATION DESCRIPTION	EQUIPMENT NO.	LOCATION BLDG.	ELEV.	UNIT NO.	SUPPLIER	TESTING FACILITIES	QUALIFICATION CRITERIA	QUALIFICATION "E1" SIGNED BY:
8856-P-118	Motor Control Center	0B-136	Control	783	Comm	Cutler-Hammer	Wyle Laboratories Huntsville, Alabama	Project Spec G-10* & IEEE-344-1975	Report #42966-1 By: J. Foreman
		0B-146	Control	783	Comm				
		0B-516	D.Gen.	677	Comm				Wyle Report #45590-1 45590-2 By: Vincent F. Kearns III
		0B-517		677					
		0B-526		677	Comm				
		0B-527		677	Comm				
		0B-536		677	Comm				
		0B-546		677	Comm				
		1B-216	Reactor	683	1				C. H. Eaton Report #DA57-3251 By: Vincent F. Kearns III
		1B-217		749	1				
		1B-219		670	1				
		1B-226		683	1				
		1B-227		749	1				
		1B-229		719	1				
		1B-236		719	1				
		1B-237		670	1				
		1B-246		719	1				
		1B-247		670	1				
		2B-216	Reactor	683	2				
		2B-217		749	2				
		2B-226		683	2				
		2B-227		749	2				
		2B-236		719	2				
		2B-237		670	2				
		2B-246		719	2				
		2B-247		670	2				
		1Y-216	Reactor	683	1				
		1Y-218		719	1				
		1Y-226		683	1				
		1Y-236		719	1				
		1Y-246		719	1				
		2Y-216		683	2				
		2Y-218		719	2				
		2Y-226		683	2				
		2Y-236		719	2				
		2Y-246		719	2				
		0B-565	D.GEN.(E)	675'-6"	COMM	GOULD/Telemecanique (TE)	~~[illegible]~~ Wyle Labs Huntsville, Alabama	PROJECT SPEC. C-1041 & IEEE 344-1975	~~[illegible]~~ TE Reports SC-655, Rev.1 SC-657, Rev.1 By: Paul Higgins (Similarity Analysis)
		0B-566		656'-6"	COMM				

* NOTE: Specification G-10, is complemented by Specification G-22

Δ NOTE: SPEC. C-1041 IS COMPLEMENTED BY SPEC. E-1024.

TABLE 3.11C-3 BATTERY MONITORS AND FUSE BOXES

ITEM NO.	EQUIPMENT IDENTIFICATION DESCRIPTION	EQUIPMENT NO.	LOCATION BLDG.	ELEV.	UNIT NO.	SUPPLIER	TESTING FACILITIES	QUALIFICATION CRITERIA	QUALIFICATION REPORT SIGNED BY:
8856-E-119AC	Battery Monitor 24V	1D-675	Control	771	1	Power Conversion Products Inc.	Wyle Laboratories Huntsville, Alabama	Project Spec G-10* & IEEE-344-1975	Vincent F. Kearns Test report #45463-1 Rev. A
		1D-676			1				
		1D-685			1				
		1D-686			1				
		2D-675			2				
		2D-676			2				
		2D-685			2				
		2D-686			2				
	Battery Monitor 125V	1D-691			1				
		1D-692			1				
		1D-693			1				
		1D-694			1				
		2D-691			2				
		2D-692			2				
		2D-693			2				
		2D-694			2				
	Battery Monitor 250V	1D-695			1				
		1D-696			1				
		2D-695			2				
		2D-696			2				
	125V Fuse Box 2-1000A	1D-611			1				
		1D-621			1				
		1D-631			1				
		1D-641			1				
		2D-611			2				
		2D-621			2				
		2D-611			2				
		2D-641			2				
	250V Fuse Box 2-1600A	1D-651			1				
		1D-661			1				
		2D-651			2				
		2D-661			2				
	Fuse Box, 24V, 2-100A	1D-671			1				
		1D-681			1				
		2D-671			2				
		2D-681			2				
	BATTERY MONITOR 125V	~~(Later)~~ 0D-601	DG (E)	656'-6"	CMMN	~~Vitro~~ C&D Power Systems	~~(Later)~~ Wyle Labs Huntsville Alabama	PROJECT SPEC. C-1041△ & IEEE 344-1975.	C&D Power Systems Report QR2-13201 by: G. Walker (Similarity [illegible])

* NOTE: Specification G-10 is complemented by Specification G-22.

△ NOTE: SPEC. C-1041 IS COMPLEMENTED BY SPEC. E-1025.

TABLE 3.10c-4 DC DISTRIBUTION PANELS

ITEM NO.	EQUIPMENT IDENTIFICATION DESCRIPTION	EQUIPMENT NO.	LOCATION BLDG.	LOCATION ELEV.	UNIT NO.	SUPPLIER	TESTING FACILITIES	QUALIFICATION CRITERIA	QUALIFICATION "EI" SIGNED BY:
8856-E-120	DC Distribution Panels 125V 225A Main Bus	1D-614	Control	771'	1	I.T.E. Imperial Corporation	Wyle Laboratories Norco, California	Project Spec G-10* & IEEE-344-1975	Report #26340-5 By: G. Shipway
		1D-615			1				Report #26340-3 26340-6 By: G. Shipway
		1D-624			1				
		1D-625			1				
		1D-634			1				
		1D-635			1				
		1D-644			1				
		1D-645			1				
	24V 100A Main Bus	1D-672			1				
		1D-682			1				
	125V 225A Main Bus	2D-614			2				
		2D-615			2				
		2D-624			2				
		2D-625			2				
		2D-634			2				
		2D-635			2				
		2D-644			2				
		2D-645			2				
	24V 100A Main Bus	2D-672			2				
		2D-682			2				
	125V. 600A. MAIN BUS	0D-597	DG "E"	656'-6"	COMMN	SQUARE D CO.	~~[illegible]~~ Farwell & Hendricks, Inc Testing Lab Milford, Ohio	PROJECT SPEC. C-1041 & IEEE 344-1975.	~~[illegible]~~ SDC/Farwell & Hendricks Report 8998-10.09-L74 by: P.J. Logan
	125V. 100A. MAIN BUS	0D-599		656'-6"	COMMN				

*NOTE: Specification G-10 is complemented by Specification G-22.

ΔNOTE: SPEC. C-1041 IS COMPLEMENTED BY SPEC. E-1027.

TABLE 3.10c-5 BATTERY RACKS

ITEM NO.	EQUIPMENT IDENTIFICATION DESCRIPTION	EQUIPMENT NO.	LOCATION BLDG.	ELEV.	UNIT NO.	SUPPLIER	TESTING FACILITIES	QUALIFICATION CRITERIA	QUALIFICATION "FI" SIGNED BY:
9956-P-1109	Stationary Batteries 24V 75AH	1D-670	Control	771	1	C&D Batteries Co.	Structural Dynamic Research Corporation, Milford, Ohio for Corporate Consulting Development Co.	Project Spec G-10* & IEEE-344-1975	Report #A379-41-31 Stephen A. Lehrain Dr. John Poland You
		1D-680			1				
		2D-670			2				
		2D-680			2				
	Stationary Batteries 125V 720AH	1D-610			1				
		1D-620			1				
		1D-630			1				
		1D-640			1				
		2D-610			2				
		2D-620			2				
		2D-630			2				
		2D-640			2				
	Stationary Batteries 250V 1800AH	1D-650			1				
		1D-660			1				
		2D-650			2				
		2D-650			2				
	STATIONARY BATTERIES 125V 660AH	~~(blank)~~ 0D-595	DG "E"	656'-6"	COMMON	C&D ~~BATTERIES~~ Power Systems	~~(blank)~~ Wyle Lab Huntsville Alabama	PROJECT SPEC. C-1241Δ & IEEE 344-1975.	~~(blank)~~ C&D Power Systems Report QR2-54035 by: G. Walker

* NOTE: Specification G-10 is complemented by Specification G-22.
Δ NOTE: SPEC C-1041 IS COMPLEMENTED BY SPEC. E-1025.

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TABLE 3.10c-7 CABLE TRAYS "SAFEGUARD"

ITEM NO.	EQUIPMENT IDENTIFICATION DESCRIPTION	EQUIPMENT NO.	LOCATION BLDG.	LOCATION ELEV.	UNIT NO.	SUPPLIER	TESTING FACILITIES	QUALIFICATION CRITERIA	QUALIFICATION "EI" SIGNED BY:
8856-E-132	Cable Trays: 3"D x 24"W	S9N1-24-144	Control Reactor	670' to 770'	1&2	Husky Product Inc.	Husky Products, Inc. 7405 Industrial Rd Florence, Kentucky	Project Spec G-10 & IEEE-344-1975	1-29-76 a. Test No. 977-978 Load Test-(Trays) By: T. O'Hara B. Heinz b. (Hold Down Test) 4/12/76 Test No. 1127-L,H,V, 5/14/76 1151& 1152 7/21/76 1188 8/10/76 1196-H,V c. Electric Test 12/12/72 Harper-Morrez B. Schuster d. Seismic Calculation 8/11/76 By: B. Schuster
	3"D x 18"W	S9N1-18-144							
	3"D x 12"W	S9N1-12-144							
	5"D x 24"W	S9N1-24-144							
	5"D x 18"W	S9N1-18-144							
	5"D x 12"W	S9N1-12-144							
	6¼"D x 12"W	KX-12SL-12	DG(E)	656'-6" to 726'-0"		TJ Cope	Franklin Inst. Philadelphia PA and TJ Cope, Inc. Collegeville, PA	Project Spec E-1032 and C-1041	Report No. PP&L JI-CMHR-102 by: M. Rose
	6¼"D x 18"W	KX-18SL-12							
	6¼"D x 24"W	KX-24SL-12							
	4"D x 12"W	KH-12SL-12							
	4"D x 18"W	KH-18SL-12							
	4"D x 24"W	KH-24SL-12							
	6¼"D x 12"W	KG-12SL-12							
	6¼"D x 24"W	KG-24SL-12							
	4"D x 12"W	KN-12SL-12							
	4"D x 24"W	KN-24SL-12							

TABLE 3.10c-3 BATTERY CHARGER RACKS AND CABINETS

ITEM NO.	EQUIPMENT IDENTIFICATION DESCRIPTION	EQUIPMENT NO.	LOCATION BLDG.	LOCATION ELEV.	UNIT NO.	SUPPLIER	TESTING FACILITIES	QUALIFICATION CRITERIA	QUALIFICATION "EI" SIGNED BY:
1350-P-119-SC	Battery Chargers 125V 100A	1D-613	Control 771'		1	Power Conversion Products Inc. 42 East Street, Crystal Lake, Illinois 66014	Wyle Laboratories Huntsville, Alabama	Project Spec G-10* & IEEE-344-1975	Test Report #45463-1 Rev. A Vincent F. Kearns
		1D-623			1				
		1D-633			1				
		1D-643			1				
		2D-613			2				
		2D-623			2				
		2D-633			2				
		2D-643			2				
		0D-673			Comm				
	Battery Chargers 250V 300A	1D-653A			1				
		1D-653B			1				
		1D-663			1				
		2D-653A			2				
		2D-653B			2				
		2D-663			2				
		0D-683			Comm				
	Battery Chargers 24V 25A	1D-673			1				
		1D-674			1				
		1D-683			1				
		1D-684			1				
		2D-673			2				
		2D-674			2				
		2D-683			2				
		2D-684			2				
		0D-685			Comm				
	BATTERY CHARGER 125V. 200A.	0D-596	DG(E)	656'-6"	COMMON	C&D ~~[illegible]~~ Power Systems	~~([illegible])~~ Wyle Labs Huntsville Alabama	PROJECT SPEC. C-1041$^{\Delta}$ & IEEE 344-1975	~~([illegible])~~ C&D Power Systems Report QR2-5v666 by: G. Walker

* NOTE: Specification G-10 is complemented by Specification G-22.

Δ NOTE: SPEC. C-1041 IS COMPLEMENTED BY SPEC. E-1025.

TABLE 3.10c-10 PANELS AND TERMINATION CABINETS ~~TRANSFER SWITCH PANELS~~

~~This Table Intentionally Left Blank~~

ITEM NO.	EQUIPMENT IDENTIFICATION DESCRIPTION	EQUIPMENT NO.	LOCATION BLDG	LOCATION ELEV.	UNIT NO.	SUPPLIER	TESTING FACILITIES	QUALIFICATION CRITERIA	QUALIFICATION "EI" SIGNED BY:
	TRANSFER ~~SWITCH~~ PANELS	0C512E-A 0C512E-B 0C512E-C 0C512E-D	DG(E)	656'-6"	1 2 1 2	YORK ELECTRO-PANEL	~~(Later)~~ None	PROJECT SPEC. C-1041* & IEEE 344-1975	~~(Later)~~ NAS Reports 1290-1 and 1290-2 by: M. Randall
	TERMINATION CABINETS	0TC512-A/C 0T512-B/D			1 2				
	TRANSFER PANELS	0C512-A 0C512-B 0C512-C 0C512-D	DG(A) DG(B) DG(C) DG(D)	719'-9" ~~675'-6"~~	1 2 1 2				
	Synchronizing Panel	0C619	DG(E)	675'-6"	CMMN	GOLDEN GATE SWITCHBOARD CO.	Wyle Labs Norco California	PROJECT SPEC. C-1041Δ & IEEE 344-1975	~~(Later)~~ Wyle Labs Report 53444, by: C.F. Lee

* NOTE: SPEC. C-1041 IS COMPLEMENTED BY SPEC. E-1026.

Δ NOTE: SPEC. C-1041 IS COMPLEMENTED BY SPEC. E-1022.

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TABLE 3.10-11 BATTERY CHARGERS

ITEM NO.	EQUIPMENT IDENTIFICATION DESCRIPTION	EQUIPMENT NO.	LOCATION BLDG.	LOCATION ELEV.	UNIT NO.	SUPPLIER	TESTING FACILITIES	QUALIFICATION CRITERIA	QUALIFICATION REPORT SIGNED BY:
4356-E-110-1C	Battery Chargers 125V 100A	1D-613	Control 771		1	Power Conversion Products, Inc.	Wyle Laboratories Huntsville, Alabama	Project Spec G-10* & IEEE-344-1975	Test Report #45463-1 Rev. A Vincent F. Kearns III
		1D-623			1				
		1D-633			1				
		1D-643			1				
		2D-613			2				
		2D-623			2				
		2D-633			2				
		2D-643			2				
		0D-673			Comm				
	Battery Chargers 250V 300A	1D-653A			1				
		1D-653B			1				
		1D-663			1				
		2D-653A			2				
		2D-653B			2				
		2D-663			2				
		0D-683			Comm				
	Battery Chargers 24V 25A	1D-673			1				
		1D-674			1				
		1D-683			1				
		1D-684			1				
		2D-673			2				
		2D-674			2				
		2D-683			2				
		2D-684			2				
		0D-685			Comm				
	BATTERY CHARGER 125V 200A	0D-595	DG (E)	656'-6"	COMMON	C&D ~~BATTERIES~~ Power Systems	~~(Later)~~ Wyle Labs Huntsville Alabama	PROJECT SPEC. C-1041[Δ] & IEEE 344-1975.	~~(Later)~~ C&D Power System Report QR2-5V666 by: G. Walker

* NOTE: Specification G-10 is supplemented by Specification G-22.

Δ NOTE: SPEC. C-1041 IS COMPLEMENTED BY SPEC. E-1025.

TABLE 3.10a-12 4.16 KV SWITCHGEAR

ITEM NO.	EQUIPMENT I.D. DESCRIPTION	APPLICATION EQUIPMENT NO.	LOCATION BLDG.	LOCATION ELEV.	UNIT NO.	SUPPLIER	TESTING FACILITIES	QUALIFICATION CRITERIA	QUALIFICATION "EIR" SIGNED BY:
3054-E-103-14	4.16 KV Switchgear	1A-201	Reactor	719	1	Westinghouse	Wyle Laboratory, Huntsville, Alabama and Wyle Laboratory Norco, CA	Project Spec G-10* & IEEE-344-1975	Report #-- 57577-1 57588
		1A-202		719	1				
		1A-203		719	1				
		1A-204		719	1				
		2A-201		719	2				58642
		2A-202		749	2				58664
		2A-203		719	2				
		2A-204		719	2				G. Shipway
		OA-510	DG(E)	656'-6"	CMMN	BROWN-BOVERI CO. (BBC)	~~[illegible]~~ Wyle Labs Huntsville Alabama	PROJECT SPEC. C-1041Δ & IEEE 344-1975.	~~[illegible]~~ BBC Report 37-55736-SSA Rev 2 by: J. Detwiler
		OA-510A	DG(A)	710'-9"	1	BROWN-BOVERI CO. (BBC)	Wyle Labs Huntsville Alabama	Project Spec. C-1041Δ & IEEE 344-1975	BBC Report 37-55736-SSA, Rev. 2 by: J. Detwiler
		OA-510B	DG(B)		2				
		OA-510C	DG(C)		1				
		OA-510D	DG(D)		2				

* NOTE: Specification G-10 is complemented by Specification E-22.
Δ NOTE: SPEC. C-1041 IS COMPLEMENTED BY SPEC. E-1022.

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TABLE 1.10E-13 DC CONTROL AND LOAD CENTERS

ITEM NO.	EQUIPMENT IDENTIFICATION DESCRIPTION	EQUIPMENT NO.	LOCATION BLDG.	ELEV.	UNIT NO.	SUPPLIER	TESTING FACILITIES	QUALIFICATION CRITERIA	QUALIFICATION DESIGNED BY:
8856-E-121-22-1	DC Control Centers 250V	1D-254	Reactor	573	1	General Electric Co.	Wyle Laboratory, Norco, CA	Project Spec G-10* & IEEE-344-1971	Report # 26340-8 By: G. Shipway
		1D-264	Reactor	633	1				
		1D-274	Reactor	633	1				
		2D-254	Reactor	570	2				
		2D-264	Reactor	633	1				
		2D-274	Turbine	729	2				
8856-E-121-22-3	DC Load Centers 250V	1D-652	Control	771	1			Project Spec G-22 & IEEE-344-1975	Report #'s 26340-2 26340-3 26340-7 By: G. Shipway
		1D-662	Control	771	1				
		2D-652	Control	771	2				
		2D-662	Control	771	2				
	DC Load Centers 125V	1D-612	Control	771	1				
		1D-622	Control	771	1				
		1D-632	Control	771	1				
		1D-642	Control	771	1				
		2D-612	Control	771	2				
		2D-622	Control	771	2				
		2D-632	Control	771	2				
		2D-642	Control	771	2				
	DC MOTOR CONTROL CENTER 125V	OD-593	D.G.(E)	~~675'-6"~~ 656'-6"	CMMN	GOULD/ Teleme-Canique (TE)	~~(Later)~~ Wyle Lab. Huntsville Alabama	PROJECT SPEC. C-1041 Δ & IEEE 344-1975.	~~(Later)~~ TE Report SC-655, Rev 1. by: P. Higgins

* NOTE: Specification G-10 is complemented by Specification G-22.

Δ NOTE: SPEC. C-1041 IS COMPLEMENTED BY SPEC. E-1024.

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TABLE 3.10c-15 AUTOMATIC TRANSFER SWITCHES

ITEM NO.	EQUIPMENT IDENTIFICATION DESCRIPTION	EQUIPMENT NO.	LOCATION BLDG.	LOCATION ELEV.	UNIT NO.	SUPPLIER	TESTING FACILITIES	QUALIFICATION CRITERIA	QUALIFICATION "EI" SIGNED BY:
8856-E-152	Automatic Transfer Switch	0ATS-516	Diesel-Gen.	677'	Comn	Russelectric, Inc.	Wyle Laboratory, Alabama for C.C & D Company Ltd.	Project Spec G-10* & IEEE-344-1975	Report # 44934-1 By: James R. Foreman
		0ATS-526		677'	Comn				
		0ATS-536		677'	Comn				
		0ATS-546		677'	Comn				
		1ATS-219	Reactor	670'	1				
		1ATS-229		719'	1				
		2ATS-219	Reactor	670'	2				
		2ATS-229		719'	2				
		0ATS-556	DG(E)	656'-6"	Comn.	Gould/Telemecanique (TE)	~~(Same)~~ Wyle Labs Huntsville Alabama	Project Spec. E-1041Δ & IEEE 344-1975.	~~(Same)~~ TE Report SC-657 Rev-1 by: P. Higgins

* NOTE: Specification G-10 is complemented by Specification G-22.

Δ NOTE: SPEC. E 1041 IS COMPLEMENTED BY SPEC. E-1024.

3.11.2b.3 Compliance with IEEE 323-1971 for Non-NSSS Class IE Equipment

3.11.2b.3.1 Non-NSSS Equipment Located Inside Containment

All non-NSSS Class 1E equipment located inside containment has been qualified to IEEE 323-1971.

3.11.2b.3.2 Non-NSSS Equipment Located Outside Containment

All non-NSSS Class 1E equipment located outside containment, except that listed in Table 3.11-5, has been qualified to IEEE 323-1971. ADDITIONALLY, THE CLASS 1E EQUIPMENT ASSOCIATED WITH THE FIFTH STANDBY DIESEL GEN. "E" HAS BEEN QUALIFIED TO IEEE 323-1974 EXCEPT THE ~~[illegible]~~ EQUIPMENT IS LOCATED IN A MILD ENVIRONMENT WAS NOT REQUIRED TO BE PRE-CONDITIONED (AGED). ~~The~~ SINCE equipment listed in Table 3.11-5 is qualified to perform its safety function in the environment in which it is located. However, the vendors for the equipment were not required to certify compliance with IEEE 323. In lieu of IEEE 323 certification the equipment listed in Table 3.11-5 is qualified by a combination of analysis, similarity, and previous operating experience. The qualification documents are available for NRC audit as stated in Subsection 3.11.3.4. This qualification method is justified because the selected equipment meets a combination of the following conditions:

1. Mean normal operating temperature is less than 40°C.

2. Accident environment is not substantially more severe than the normal environment. By this it is meant, the equipment will continue to satisfactorally perform its safety function in the accident environment, however, its length of qualified life is reduced.

3. Equipment is similar to equipment previously used in other nuclear plants and other industrial applications.

4. Design and fabrication is in accordance with an approved and auditable nuclear quality assurance program.

5. The equipment is tested (either in the shop or at the site) prior to plant start-up.

6. The equipment is used, or frequently tested, during normal operation.

3.11.3 QUALIFICATION TEST RESULTS

3.11.3.a.1 NSSS Instrumentation and Electrical Equipment

This paragraph discusses the test results for safety-related instrumentation and electrical equipment in the NSSS, except that which is supplied with NSSS pumps and valves. The test results for GE safety related equipment are maintained in a permanent file by GE and can be readily audited. In all cases, the equipment used in Class 1E applications passed the prescribed tests. Table 3.11-1 shows the plant environmental areas in which NSSS Class 1E components are located. Tables 3.11-2 and 3.11-3 show the temperature, pressure and humidity environments and Table 3.11-4 shows the radiation environments to which the components are tested.

3.11.3.a.2 NSSS Valve Mounted Electrical Equipment

The electrical equipment mounted on the safety/relief, SLC and recirculation gate valves is tested to conditions which are at least as severe as the temperature, pressure and humidity conditions shown in Tables 3.11-1, 3.11-2 and 3.11-3. They are also tested to the radiation environment applicable to their plant location as shown in Table 3.11-4. The equipment performed its required safety function under the extreme environmental conditions specified.

3.11.3.a.3 NSSS Motors

The ECCS pump motors listed in Table 3.11-3 are tested to the temperature, pressure and humidity conditions shown in the table. They are also tested to the radiation environment applicable to their location as shown in Table 3.11-4. The equipment tested performed its required safety function under the extreme environmental conditions specified.

3.11.3.b Non-NSSS Class 1E Electrical Equipment

Environmental qualification documentation for non-NSSS Class 1E electrical equipment is presently located at the Bechtel home office in San Francisco and is available for NRC audit, WITH THE EXCEPTION OF THE CLASS 1E EQUIPMENT ASSOCIATED WITH THE FIFTH STANDBY DIESEL GEN. "E". THE DOCUMENTATION ASSOCIATED WITH THIS UNIT IS LOCATED AT THE PENNSYLVANIA POWER & LIGHT COMPANY OFFICES IN ALLENTOWN, PA., AND AT THE SUSQUEHANNA STEAM ELECTRIC STATION SITE.

2. If Equation 10 results in $2.4 < S < 3,0\ S$ for ferritic or austenitic steels, the cumulative usage factor, U, calculated on the basis of Equation 14 of NB-3653.6, must be <0.1.

3. If Equation 10 results in $S > 3.0\ S$ for ferritic or austenitic steels, then the stress value in Equations 12 and 13 of NB-3653.6 must not be $<2.4\ S$.

Regulatory Guide 1.47 - BYPASSED AND INOPERATIONAL STATUS INDICATION FOR NUCLEAR POWER PLANT SAFETY SYSTEMS (May 1973)

The design, as discussed in Subsections 7.1.2, 7.2.2.1.2.1.5, 7.3.2a.1.2.1.7, 7.3.2a.2.2.1.5, 7.4.2.1.2.1.7, 7.4.2.2.2.1.7, 7.4.2.3 and 7.6.2.8, complies with the provisions set forth in this regulatory guide.

Regulatory Guide 1.48 - DESIGN LIMITS AND LOADING COMBINATIONS FOR SEISMIC CATEGORY I FLUID SYSTEM COMPONENTS (May 1973)

The design loading combinations for non-NSSS systems for Positions C.1 to C.12 are described in Tables 3.9-1 to 3.9-8.
The design loading combinations for the DG facility are in compliance with this regulatory guide.
Operability of active pumps and valves is assured as described in Subsection 3.9.3.2.

GE practice is representative of industry practice and is in general agreement with the requirements of Regulatory Guide 1.48 with the following clarifications:

a. The probability of an OBE of the magnitude postulated for the Susquehanna SES is consistent with its classification as an Emergency Event. However, for design conservatism, loads due to the OBE vibratory motion have been included under upset conditions. Loads due to the OBE vibratory motion plus associated transients, such as turbine trip, have been considered in the equipment design under emergency conditions consistent with the probability of the OBE occurrence.

b. The use of increased stress levels for Class 2 components is consistent with industry practice as specified in ASME B&PV Code Section III.

For a comparison of NSSS compliance with Regulatory Guide 1.48 see Table 3.13-1. This comparison reflects a GE practice on BWR 4's and 5's and therefore, is applicable to the Susquehanna SES (see Subsections 3.9.2 and 3.9.3).

Regulatory Guide 1.60 - DESIGN RESPONSE SPECTRA FOR SEISMIC DESIGN OF NUCLEAR POWER PLANTS (Revision 1, December 1973)

The design response spectra used in the analysis of Susquehanna SES are different from those of the regulatory guide. A detailed discussion of the design response spectra is presented in Subsection 3.7b.1.
The DG "E" facility follows the guidelines in this regulatory guide.

Regulatory Guide 1.61 - DAMPING VALUES FOR SEISMIC DESIGN OF NUCLEAR POWER PLANTS, REV. 0 (October 1973)

The damping values used in the seismic design of Susquehanna SES are different from the regulatory guide. A detailed discussion of the damping values is presented in Subsection 3.7b.1.

The DG "E" facility meets the guidelines in this regulatory guide. See Table 3.7b-7.

Regulatory Guide 1.62 - MANUAL INITIATION OF PROTECTIVE ACTIONS (October 1973)

The provisions for manual initiation of protective actions are described in Subsections 7.2.2.1.2.1.7, 7.3.2a.1.2.1.9, 7.3.2a.2.2.1.7, 7.3.2a.3.2.1.3, 7.4.2.1.2.1.9 and 7.4.2.2.2.1.9.

Regulatory Guide 1.63 - ELECTRIC PENETRATION ASSEMBLIES IN CONTAINMENT STRUCTURES FOR WATER COOLED NUCLEAR POWER PLANTS (Revision 1, May 1977)

Since the construction permit for Susquehanna SES was issued in November 1973, the provisions of Revision 1 to this regulatory guide (which supplements IEEE 317-1976) were not specifically considered in the design of Susquehanna SES. The design of the electric penetration assemblies is therefore in compliance with Regulatory Guide 1.63 dated October 1973 (which supplements IEEE 317-1972). Specifically, Sections 4.2.3, 4.2.4, 5.1.6, 5.2.2, 6.2, 6.3.3, and 6.4 of IEEE 317-1976 have not been incorporated.

The penetration cable protection limitation curves are shown together with their respective protective device coordination curves on Figures 3.13-1 to 3.13-7. The short circuit curves apply for the condition when the electrical and mechanical seal integrity is maintained. The seal limitation curves apply when the mechanical seal integrity is maintained and the electrical integrity is sacrificed.

The penetration assemblies are type tested. There are no provisions for periodic testing under simulated fault conditions.

Electrical penetration circuits are summarized as follows:

<u>Regulatory Guide 1.60</u> - <u>DESIGN RESPONSE SPECTRA FOR SEISMIC DESIGN OF NUCLEAR POWER PLANTS (Revision 1, December 1973)</u>

The design response spectra used in the analysis of Susquehanna SES are different from those of the regulatory guide. A detailed discussion of the design response spectra is presented in Subsection 3.7b.1.

<u>Regulatory Guide 1.61</u> - <u>DAMPING VALUES FOR SEISMIC DESIGN OF NUCLEAR POWER PLANTS (October 1973)</u>

The damping values used in the seismic design of Susquehanna SES are different from the regulatory guide (with the exception of the DG "E" facility). A detailed discussion of the damping values is presented in Subsection 3.7b.1.

<u>Regulatory Guide 1.62</u> - <u>MANUAL INITIATION OF PROTECTIVE ACTIONS (October 1973)</u>

The provisions for manual initiation of protective actions are described in Subsections 7.2.2.1.2.1.7, 7.3.2a.1.2.1.9, 7.3.2a.2.2.1.7, 7.3.2a.3.2.1.3, 7.4.2.1.2.1.9 and 7.4.2.2.2.1.9.

<u>Regulatory Guide 1.63</u> - <u>ELECTRIC PENETRATION ASSEMBLIES IN CONTAINMENT STRUCTURES FOR WATER COOLED NUCLEAR POWER PLANTS (Revision 1, May 1977)</u>

Since the construction permit for Susquehanna SES was issued in November 1973, the provisions of Revision 1 to this regulatory guide (which supplements IEEE 317-1976) were not specifically considered in the design of Susquehanna SES. The design of the electric penetration assemblies is therefore in compliance with Regulatory Guide 1.63 dated October 1973 (which supplements IEEE 317-1972). Specifically, Sections 4.2.3, 4.2.4, 5.1.6, 5.2.2, 6.2, 6.3.3, and 6.4 of IEEE 317-1976 have not been incorporated.

The penetration cable protection limitation curves are shown together with their respective protective device coordination curves on Figures 3.13-1 to 3.13-7. The short circuit curves apply for the condition when the electrical and mechanical seal integrity is maintained. The seal limitation curves apply when the mechanical seal integrity is maintained and the electrical integrity is sacrificed.

The penetration assemblies are type tested. There are no provisions for periodic testing under simulated fault conditions.

Electrical penetration circuits are summarized as follows:

Regulatory Guide 1.92 - COMBINING MODAL RESPONSES AND SPATIAL COMPONENTS IN SEISMIC RESPONSE ANALYSIS (Revision 1, February 1976)

Since the construction permit for the Susquehanna SES was issued in November 1973, the methods of combining modal responses and spatial components in seismic response analysis, as described in this regulatory guide, were not specifically considered in the design. The methods of design and analysis for structures, components, and piping systems that have been employed are described in Sections 3.7a, 3.7b and 3.9.

Regulatory Guide 1.93 - AVAILABILITY OF ELECTRIC POWER SOURCES (December 1974)

The DG "E" facility meets the guidelines in this regulatory guide.

Compliance with this guide is discussed in Subsection 8.1.6.2.

Regulatory Guide 1.94 - QUALITY ASSURANCE REQUIREMENTS FOR INSTALLATION, INSPECTION, AND TESTING OF STRUCTURAL CONCRETE AND STRUCTURAL STEEL DURING THE CONSTRUCTION PHASE OF NUCLEAR POWER PLANTS (Revision 1, April 1976)

The quality assurance program for the construction of Susquehanna SES is described in the PSAR, Appendix D and amendments. Compliance of the Operational Quality Assurance Program with this guide is described in Section 17.2.

Regulatory Guide 1.95 - PROTECTION OF NUCLEAR POWER PLANT CONTROL ROOM OPERATORS AGAINST AN ACCIDENTAL CHLORINE RELEASE (February 1975)

The present design of the Susquehanna SES complies with the position statements of this regulatory guide.

Regulatory Guide 1.96 - DESIGN OF MAIN STEAM ISOLATION VALVE LEAKAGE CONTROL SYSTEMS FOR BOILING WATER REACTOR NUCLEAR POWER PLANTS (Revision 1, June 1976)

Subject to the clarification indicated below, the provisions of this regulatory guide are met by the current plant design.

(1) Reference: Appendix A, Paragraph 6. The design and inspection of this portion of the leakage control system is in accordance with the provisions of Section XI of the ASME Boiler and Pressure Vessel Code. The 100 percent volumetric inspection

Regulatory Guide 1.92 - COMBINING MODAL RESPONSES AND SPATIAL COMPONENTS IN SEISMIC RESPONSE ANALYSIS (Revision 1, February 1976)

Since the construction permit for the Susquehanna SES was issued in November 1973, the methods of combining modal responses and spatial components in seismic response analysis, as described in this regulatory guide, were not specifically considered in the design. The methods of design and analysis for structures, components, and piping systems that have been employed are described in Sections 3.7a, 3.7b and 3.9.

Regulatory Guide 1.93 - AVAILABILITY OF ELECTRIC POWER SOURCES (December 1974)

Compliance with this guide is discussed in Subsection 8.1.6.2.

Regulatory Guide 1.94 - QUALITY ASSURANCE REQUIREMENTS FOR INSTALLATION, INSPECTION, AND TESTING OF STRUCTURAL CONCRETE AND STRUCTURAL STEEL DURING THE CONSTRUCTION PHASE OF NUCLEAR POWER PLANTS (Revision 1, April 1976)

The quality assurance program for the construction of Susquehanna SES is described in the PSAR, Appendix D and amendments. Compliance of the Operational Quality Assurance Program with this guide is described in Section 17.2.

Regulatory Guide 1.95 - PROTECTION OF NUCLEAR POWER PLANT CONTROL ROOM OPERATORS AGAINST AN ACCIDENTAL CHLORINE RELEASE (February 1975)

The present design of the Susquehanna SES complies with the position statements of this regulatory guide.

Regulatory Guide 1.96 - DESIGN OF MAIN STEAM ISOLATION VALVE LEAKAGE CONTROL SYSTEMS FOR BOILING WATER REACTOR NUCLEAR POWER PLANTS (Revision 1, June 1976)

Subject to the clarification indicated below, the provisions of this regulatory guide are met by the current plant design.

(1) Reference: Appendix A, Paragraph 6. The design and inspection of this portion of the leakage control system is in accordance with the provisions of Section XI of the ASME Boiler and Pressure Vessel Code. The 100 percent volumetric inspection

Regulatory Guide 1.100 - SEISMIC QUALIFICATI..N OF ELECTRIC EQUIPMENT FOR NUCLEAR POWER PLANTS (March 1976)

The implementation paragraph of this regulatory guide states that the requirements of the position statements will only be applied to plants that received construction permits after November 16, 1976. The Construction Permit for Susquehanna SES was issued in November 1973 and therefore the guidelines of this regulatory guide have not been utilized in the design of this nuclear power station.

Seismic qualification of the safety related electric equipment (non-NSSS scope of supply) has been conducted in accordance with the IEEE Standard 344-1971. Section 3.10 describes the complete qualification methods and procedures that have been utilized.

The safety-related electric equipment (NSSS scope of supply) meets IEEE 323-1971 and IEEE 344-1971.

The DG "E" facility equipment meets the guidelines in regulatory guide 1.100, Rev. 1 (8/77) and IEEE Std. 344-1975.

Regulatory Guide 1.101 - EMERGENCY PLANNING FOR NUCLEAR POWER PLANTS

Withdrawn September 24, 1980.

Regulatory Guide 1.102 - FLOOD PROTECTION FOR NUCLEAR POWER PLANTS (Revision 1, September 1976)

The present design of the Susquehanna SES complies with the provisions of this regulatory guide.

Regulatory Guide 1.103 - POSTTENSIONED PRESTRESSING SYSTEMS FOR CONCRETE REACTOR VESSELS AND CONTAINMENTS (Revision 1, October 1976)

Not Applicable.

Regulatory Guide 1.104 - OVERHEAD CRANE HANDLING SYSTEMS FOR NUCLEAR POWER PLANTS (February 1976)

Subject to the clarifications and exceptions indicated below, the safety related overhead crane handling systems of this station comply with the provisions of this regulatory guide.

(1) Reference: Position C.1.b(2). The nil-ductility transition temperature for the structural steel associated with the cranes was not determined as suggested by this position. Position

<u>Regulatory Guide 1.122</u> - DEVELOPMENT OF FLOOR DESIGN RESPONSE SPECTRA FOR SEISMIC DESIGN OF FLOOR-SUPPORTED EQUIPMENT OR COMPONENTS (September 1976)

The methods used for developing the floor design response spectra for Susquehanna SES are in compliance with the positions of this regulatory guide except as follows:

1. The frequencies used for the calculation of the response spectra are different and are described in Subsection 3.7b.2.5.

2. The procedure for smoothing the spectra (broadening of peaks) is different and is discussed in Subsection 3.7b.2.9.

The DG "E" facility meets the guidelines in Regulatory Guide 1.122, Rev. 1 (2/78).

<u>Regulatory Guide 1.123</u> - QUALITY ASSURANCE REQUIREMENTS FOR CONTROL OF PROCUREMENT OF ITEMS AND SERVICES FOR NUCLEAR PLANTS (Revision 1, July 1977)

The Susquehanna SES quality assurance program for the construction phase is detailed in PSAR Appendix D and amendments. Compliance of the Operational Quality Assurance Program with this regulatory guide is discussed in Section 17.2.

<u>Regulatory Guide 1.124</u> - DESIGN LIMITS AND LOADING COMBINATIONS FOR CLASS 1 LINEAR-TYPE COMPONENT SUPPORTS (November 1976)

Since the construction permit for Susquehanna SES was issued in November 1973, this regulatory guide was not specifically considered in the design. The methods used to determine design loading combinations for Susquehanna SES are described in Section 3.9.

<u>Regulatory Guide 1.125</u> - PHYSICAL MODELS FOR DESIGN AND OPERATION OF HYDRAULIC STRUCTURES AND SYSTEMS FOR NUCLEAR POWER PLANTS (March 1977)

No physical models were used during the design of Susquehanna SES.

(1) Paragraph C.2 - The design basis event condi''ons meet the most severe postulated conditions for Susquehanna SES. Factors or margin given in Section 6.3.1.5 of IEEE 323-1974 were not used, EXCEPT FOR THE CABLES ASSOCIATED WITH THE FIFTH DIESEL GEN. "E" ADDITION, WHERE MULTIPLE LOCA TRANSIENTS WERE USED TO DEMONSTRATE MARGIN.
(2) Paragraph C.4 - Only one aging data point (121 C) has been applied to the cables used on Susquehanna SES, EXCEPT FOR THE CABLES ASSOCIATED WITH THE FIFTH DIESEL GEN. "E" ADDITION, WHERE AT LEAST TWO AGING DATA POINTS WERE USED INCLUDING 136 C.
(3) Paragraph C.6 - Flame tests were done in accordance with IEEE 383-1974. No tests were performed on aged specimens, EXCEPT FOR THE CABLES ASSOCIATED WITH THE FIFTH DIESEL GEN. "E" ADDITION, WHERE BOTH AGED AND UN-AGED SPECIMENS WERE SUBJECTED TO FLAME TESTS.
(4) Paragraph C.10 - Gas burner position is in accordance with IEEE 383-1974 EXCEPT FOR THE 600V. POWER & CONTROL CABLES ASSOCIATED WITH THE ADDITION OF THE FIFTH DIESEL GEN. "E", WHERE THE GAS BURNER POSITION WAS IN ACCORDANCE WITH THE REQUIREMENTS OF REGULATORY GUIDE 1.131.
(5) Panel internal wires are not qualified to Regulatory Guide 1.131. THE CLASS IE PANEL INTERNAL WIRING ASSOCIATED WITH THE FIFTH DIESEL GEN. "E" IS QUALIFIED IN ACCORDANCE WITH THE REQUIREMENTS OF IEEE 383-1974.

The electric cables, field splices, and connections for the NSSS scope of supply have not been evaluated against this regulatory guide.

PENNSYLVANIA POWER & LIGHT COMPANY
SUSQUEHANNA STEAM ELECTRIC STATION UNITS 1 AND 2
DIESEL GENERATOR E FACILITY

DESIGN DESCRIPTION REPORT.

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Appendix C - Seismic Analysis Procedures and Models for The Diesel Generator E Building

1.0 DESIGN APPROACH

The diesel generator E facility including the components contained therein is a nuclear safety related, Seismic Category I, Class 1E facility that will be used to provide emergency power to Susquehanna Steam Electric Station (SSES) when one of the four existing diesel generators is out of service.

The location of the diesel generator E facility is shown on drawing C-5003 "Plot Plan, Diesel Generator E Facility Site Development Plan" contained in Appendix A to this report. The location of the building was selected to satisfy the requirements listed below:

- Close to the existing diesel generator buildings.
- Close to the tie-in points for water, air and electrical.
- Clearance around the building for construction equipment.
- Clearance between the building and the security fence, both in its temporary and final positions.
- Clearance between the building and existing structures above ground and underground.
- Accessibility to the railroad for off loading the diesel generator and setting it on the pedestal.
- Close to the underground sound rock.

Codes, standards, and regulations applicable to this project are generally those in effect on September 22, 1983. A list of the applicable codes, standards, and regulations is contained in Appendix B to this report.

Diesel generator E uses the existing indications and controls when it is in the place of an existing diesel generator.

1.1 Purpose of Diesel Generator E

The Susquehanna Steam Electric Station Technical Specifications state that a diesel generator may be inoperable for 72 hours, after which a two unit shutdown must commence. The fifth diesel generator will be used as a replacement and will have the capability of supplying the emergency loading for any one of the four existing diesel generators. As such, the main purpose of diesel generator E is to allow maintenance to be performed on any one of the four existing diesel generators without the necessity for a two unit outage.

After the existing diesel generator has been replaced by diesel generator E, testing and maintenance can be performed on the existing diesel generator for as long as required, within the limitation of mechanical maintenance and "no load" testing.

1.2 Control of Diesel Generator E

Diesel generator E utilizes the same metering and controls used for the replaced diesel generator. A new control board is not required. The use of a transfer switching system minimizes costs, reduces electrical wiring separation problems, conserves space and minimizes changes in the main control room. Furthermore, the human factors value of the present arrangement are retained. Since diesel generator E is essentially a replacement for any one of the four existing units, the presence of a fifth display could cause unnecessary confusion in a four-channel system.

1.3 Substitution of Diesel Generator

The sequence for transferring control of an existing diesel to the E diesel is described below. The sequence described is for substituting diesel generator E for diesel generator A however the same sequence applies to the other diesels with the suffix letters changing for the diesel being substituted.

1. Place HS-00057A on OC512A in "Disable" position. This action removes auto start signal from diesel generator A. The operator must change the position of this switch as the first step in the switching sequence.

2. Close the emergency service water valves for diesel generator A from OC-553 in the control room.

3. Place the located switches on OC512A to the diesel generator E position.

4. Trip and remove the 4.16Kv circuit breaker from OA510A01.

5. Rack in and close 4.16Kv circuit breaker removed from OA510A01 into OA510A02. This completes switching in diesel generator A.

6. Open the emergency service water valves for diesel generator E from OC-553 in the Control Room.

7. Place the listed switches on OC512E-A in the diesel generator A position.

8. Remove the 4.16Kv circuit breaker from OA51007.

9. Rack in and close 4.16Kv circuit breaker removed from OA51007 into OA51001.

10. Place HS000571E-A on OC512E-A in the "ENABLE" position. This switch permits autostart of diesel generator E. The operator must change the position of this switch as the last step in the electrical switching sequence. This completes the electrical switching, diesel generator E is now aligned for diesel generator A.

11. The alarm "Diesel Not in Auto" will sound in the control room when disabling a diesel generator for transfer to another diesel generator. This alarm will cease when the alignment is complete.

12. The sequence for placing diesel generator A back into service would be the reverse of the steps discussed above.

2.0 PHYSICAL DESCRIPTION

General arrangements of the diesel generator E building depicting location of major equipment are shown on drawing M-5200 contained in Appendix A to this report. The building is designed to Seismic Category I requirements and is protected from the effects of tornado missiles. It is a reinforced concrete two story structure with a penthouse and an additional level below grade. Reinforced concrete was selected for the walls and roof as being the most suitable material for protection against missiles, seismic loads and below grade construction. The floors of reinforced concrete are monolithically constructed with walls as a common practice. Entry to the building is at the grade elevation by doors protected from the effects of missiles with labyrinths.

The basement houses the 125-V dc battery room, battery charger, 4160-V switchgear, transfer panels, termination cabinets, building auxiliary services panel, non-class 1E auto transfer switch, non-class 1E MCC, 125-V dc switchboard, starting air compressors skids and, sump. Underground piping is brought into the building at this level.

In addition to the diesel generator and its skid mounted accessories, the floor at grade contains the air receiver skid and the diesel generator control room, consisting of a generator and engine control cabinet, Class 1E motor control centers, synchronizing panel and, a 4160/480 V transformer.

The second story contains the air intake filter, silencer, intake piping, exhaust muffler and piping, and ventilation supply and exhaust fans. The penthouse contains the exhaust chamber for the diesel generator exhaust and ventilation exhaust.

The combustion air and ventilation air intake is taken from one end of the building via an opening which is protected from tornado missiles. To minimize recirculation of engine exhaust into the combustion air and ventilation air intake, the combustion exhaust and ventilation exhaust are located in the penthouse at the opposite end of the building, and are protected from the effects of tornado missiles by a concrete overhang. Tornado dampers have been provided for the ventilation air intake and exhaust openings. Both the intake and exhaust are located more than 30 feet above grade.

A port[illegible] of the north wall at grade elevation is removable to facilitate removal of the diesel or components on the auxiliary skid should this become necessary during the life of the facility. This portion of the wall is designed to withstand the effects of tornado missiles and seismic events. A 20 ton bridge crane is provided to permit handling of diesel generator and auxiliary skid components. The heaviest single piece (engine component) to be lifted during the maintenance is the turbo-charger which weighs approximately 5100 lbs.. Major equipment whose weight is less than the crane capacity includes the generator rotor, generator stator, generator shaft, flywheel, piston and connecting rod.

3.0 DESIGN

3.1 Mechanical Equipment

The mechanical equipment considered to be nuclear safety related includes the fuel oil storage and transfer system, combustion air intake and exhaust system, starting air system (from the receivers to the engine), the cooling water system, the jacket water system, and the lube oil system. The piping of pumps, tanks, and valves associated with these portions of the mechanical systems are designed as Safety Class 3, Seismic Category I components in accordance with Regulatory Guide 1.26. As such, they are protected from tornado missiles, floods, and other natural phenomena. Mechanical equipment in both non-nuclear safety related parts of the systems discussed above and systems which are entirely non-nuclear safety related, such as potable water and service air, are designed to preclude damage to nuclear safety-related equipment during and after a safe shutdown earthquake by seismically supporting such piping and components. Piping is seismically supported using the equations of ASME Section III, Nuclear Power Plant Components, 1971 issue with all addenda issued through winter 1972. Piping which is not required to be Safety Class 3 is procured as B31.1, is seismically supported, and is in accordance with ANSI B31.1-1973.

The effects of moderate energy breaks in piping systems are considered in the design of the diesel generator E building. The piping generally has been designed with stress levels low enough to preclude the postulation of moderate energy breaks. Where this is not possible essential equipment is protected from the wetting effects of a pipe crack by physical separation or barriers. Essential equipment is protected from flooding effects by mounting the equipment on pedestals, by barriers, or by operator action. A level alarm is provided to indicate the existence of a high water level in the building sump.

3.1.1 Fuel Oil Storage and Transfer System

The fuel oil storage and transfer system consists of an underground storage tank, a transfer pump, and associated piping, valves, and instrumentation. The tank will be filled from a new fill station. The storage tank is sized to contain 80,000 gallons of fuel oil which allows for approximately thirty (30) hours of testing of the diesel generator and seven (7) days of continuous operation, all at full load. The fuel oil transfer pump is capable of filling the day tank for the new diesel generator and (non-concurrently) the day tank on any one of the existing diesels. It can also fill any of the existing diesel fuel oil storage tanks. The transfer pump is actuated automatically from its associated day tank. Filling of existing day tanks with the diesel generator E transfer pump is controlled manually.

The fuel oil storage and transfer system is designed as a Safety Class 3, Seismic Category I system, in accordance with the requirements of Regulatory Guides 1.26 and 1.137 and ANSI Standard N-195.

The flow diagram for the fuel oil storage and transfer system serving diesel generator E is shown on drawing M-120, Sheet 2, in Appendix A. Instrumentation and control diagrams are shown on drawing J-120, sheets 3,4, and 5, also in Appendix A.

3.1.2 Cooling Water System

The Emergency Service Water System (ESW) is used to supply cooling water to the following components of diesel generator E:

- o Lube Oil Cooler
- o Jacket Water Cooler
- o Fuel Oil Cooler
- o Intercoolers

The existing emergency service water system has been extended to the diesel generator E building via four (4) 10 inch pipes. One each for loop A supply, loop A return, loop B supply, and loop B return. A motor operated butterfly valve is provided on each of these lines. When diesel generator E is used to replace another diesel, loop A is the primary cooling source, with either a manual or an automatic transfer to loop B if loop A becomes unavailable.

The flow diagram for the emergency service water system serving diesel generator E is shown on drawing M-111, sheet 3, in Appendix A. Instrumentation and control diagrams are shown on drawing J-111, sheets 10, 11, 13, 14, 14A and 15, also Appendix A.

3.1.3 Heating and Ventilation

The design temperature parameters and heat rejection to the space by the diesel generator and other heat producing devices were used to size the ventilation system for the diesel generator E building. The design parameters are detailed in Table 3.1.

The capacity of the ventilating system fans was selected to handle the heat rejection to the space by diesel generator E and to maintain the space temperature below 120°F in summer when the diesel generator is operating.

Two (2) 50 percent capacity supply fans, two (2) 50 percent capacity exhaust fans and one (1) 100 percent capacity battery room and basement exhaust fan were selected to ventilate the building.

The first set of interlocked supply and exhaust fans maintain space temperature below 104°F by means of damper modulation and starting of fans from the space thermostat. The second set of interlocked supply and exhaust fans start when the indoor temperature rises above 104°F. This arrangement of one (1) 50 percent capacity supply and one (1) 50 percent capacity exhaust fan running during the normal ventilation mode is furnished to conserve energy. No filtration or cooling is provided in the ventilation system. The modulating damper system controls temperature and is designed for fail safe operation to permit full ventilation.

The exhaust fan for the battery room and basement is manually operated, runs continuously and was selected for explosion-proof construction. Ventilation air for the battery room/charger area and basement is transferred from the building space and leakage through dampers when the ventilation supply fan is not operating. The ventilating system is designed as safety related and Seismic Category I.

The heating system for all areas consists of electric unit heaters and electric baseboard heaters. The heaters are not safety related and are designed to commercial industry standards. They are however, supported to Seismic Category I requirements to avoid II/I safety impact concerns. The heaters have built-in thermostats to automatically maintain space temperature in accordance with the design parameters listed in Table 3-1.

When diesel generator E is not operating, actuation of the fire detection system will automatically stop all the supply and exhaust fans and override the temperature controls.

The flow diagram for the heating and ventilating system serving diesel generator E is shown on drawing M-182, sheet 2, in Appendix A. Instrumentation and control diagrams are shown on drawing V-182, sheets 7, 8, 8A, 9, 9A, 10, 11, 13, 13A, 14, 15, and 16, also Appendix A.

3.1.4 Plumbing and Drainage

Plumbing and drainage systems for the diesel generator E facility are designed and sized to accommodate the various types of drainage in the building. Roof drains are piped to the storm sewer. Equipment and floor drains from elevations 675'-6" and 708'-0" are piped to an underground waste water storage tank located outside the diesel generator building. Equipment and floor drains from elevation 656'-6" (except floor drain from battery room) and effluent from the waste water storage tank are discharged by gravity to an oil/water separator located inside the building in a sump. The floor drain of the battery room discharges to an acid neutralizing sump, where waste is neutralized and discharged to the oil/water separator. The effluent of the oil/water separator discharges into the building sump. The building sump is equipped with duplex sump pumps of 100 GPM capacity each. Building sump contents (waste water) are pumped to the plant oily waste system. The oil separated in the oil/water separator is pumped and collected in a 550 gallon underground waste oil storage tank located outside the diesel generator E building.

The underground waste water storage tank is designed to contain fire protection water from the 10 minutes of operation of pre-action sprinkler system.

3.1.5 Fire Protection/Detection

The design of the fire protection and detection system is in accordance with 10CFR50, Appendix R, Section III G, J and O; NRC Branch Technical Position 9.5.1, NFPA National Fire Codes, and FM standards.

The fire suppression system gets its water from the plant yard loop. The sprinkler and fire standpipe systems are designed for a water supply from one 2500 gpm/125 psi fire pump delivering water through a yard main with the shortest route assumed to be unavailable.

The fire standpipe system and hoses are located so that all interior sections of the building can be reached per NFPA Class III requirements.

The type, number, and location of portable fire extinguishers are in accordance with NFPA requirements.

Operation of the fire detection and protection systems is interlocked with the ventilation system so as to shut down those systems (except during emergency operation of the diesel generator) which will interfere with fire fighting, control, containment, and suppression of the fire.

In addition to the fire protection system, an early warning fire detection system is provided for the building. Detector spacing and types of detectors are consistent with the type of service required. The detection system is compatible and interfaces with the existing plant fire protection multiplexing system.

The fire protection panel is fed from a battery back-up package furnished by the smoke and temperature detection panel vendor.

The flow diagram for the fire protection system serving diesel generator E is show on drawing M-122, sheet 9, contained in Appendix A. The instrument and logic diagram for the system, indicating fire detectors, is shown on Figure F-1006 in Appendix A.

3.1.6 Diesel Generator Starting Air System

As in the existing diesel generators, diesel generator E has a starting air system which supplies high pressure air sequentially to the diesel engine cylinders. The system (both loops) consists of air compressors (2), air receivers (4), air filters, air dryers, air precoolers moisture separators, and associated piping, valves and instrumentation.

Two redundant air starting systems are provided for diesel generator E to increase starting reliability. Additionally, a cross-tie is provided to allow either compressor to charge all 4 air receivers. Each air start loop is capable of performing a total of five (5) - 10 second starts without recharging the air receivers.

All equipment mounted in the air received skid is safety class 3, Seismic Category 1 in accordance with Regulatory Guide 1.26. All equipment mounted on the air compressor skid is commercial grade.

The flow diagram for the Starting Air System serving diesel generator E is shown on drawing M-134 sheet 2, in Appendix A.

3.1.7 Lube Oil System

The diesel generator E lube oil system is essentially identical to the existing diesel generators system and consists of an engine driven pump, standby A.C. motor driven pump, circulating pump, lube oil heater, lube oil heat exchanger and associated piping, valves and instrumentation.

The primary purpose of the lube oil system is to lubricate bearings and other moving parts in the engine. Additionally, this system is used to lubricate turbo-charger bearings, keep the engine warm in the standby mode to enhance immediate startup, cool the pistons, and maintain engine cleanliness by preventing rust and corrosion.

The engine driven pump provides the required lube oil pressure during normal operation. A standby A.C. motor driven pump will automatically start upon failure of the engine driven pump. A circulating pump and electric immersion type heater are used to maintain lube oil at a prescribed temperature during standby periods. A thermostatic control valve is used to maintain lube oil temperature during these periods.

All equipment mounted on the auxiliary skid is designed as Safety Class 3, Seismic Category 1 in accordance with Regulatory Guides 1.26 and 1.29. All equipment supplied by the engine manufacturer has been seismically qualified.

The flow diagram for the lube oil system serving diesel generator E is shown on drawing M-134 sheet 2, in Appendix A.

3.1.8 Jacket Water System

The diesel generator E jacket water system is similar to the existing diesel's jacket water system and consists of a standpipe, engine driven pump, standby A.C. motor driven pump, circulation pump, jacket water heater, jacket water cooler and associated piping, valves, and instrumentation.

The jacket water system is a closed loop system which uses treated water to cool the engine cylinder jackets, turbo-charger, and the governor oil cooler. This system circulates warm jacket water through the heater portion of the air intercoolers to heat the combustion air during startup.

The engine driven pump provides the required jacket water pressure during normal engine operation. An A.C. motor driven pump is provided in the event of engine driven pump failure. This pump will automatically turn-on upon loss of lube oil pressure. A circulating pump and electric immersion type heater are used to keep jacket water at around 120°F during stand-by periods to enhance immediate start-up. A thermostatic control valve is used to maintain jacket water temperature during these periods.

All equipment mounted on the auxiliary skid is designed as safety class 3, seismic category 1 in accordance with the requirements of U.S. Regulatory Guide 1.26. In addition, all equipment supplied by the engine manufacturer and mounted on the engine has been seismically qualified.

The flow diagram for the jacket water system serving diesel generator E is shown on drawing M-134, sheet 2, in Appendix A.

3.1.9 Fuel Oil System

The diesel generator E fuel oil system is essentially identical to the existing diesel generators system and consists of an engine driven pump, D.C. motor driven pump, twenty (20) injection pumps, fuel oil day tank, fuel oil heat exchanger, filters, strainers and associated piping, valves, and instrumentation.

Flow from the day tank supplies fuel to the engine driven pump which in turn supplies fuel at 35 psig to the injection pumps. A relief valve is utilized at the discharge of the engine driven pump to maintain pressure at 35 psig. The fuel oil cooler is used to cool the fuel oil which is bypassed by the relief valve back to the day tank. The filters and strainers are used to assure clean fuel to the high pressure injection pumps. A D.C. motor driven fuel oil pump is provided to replace the engine driven pump in the event of engine driven pump failure. This pump will automatically start upon loss of pressure at the discharge of the engine driven pump.

All equipment mounted on the auxiliary skid is designed as Safety Class 3, Seismic Category 1 in accordance with Regulatory Guides 1.26 and 1.29. All equipment supplied by the engine manufacturer and mounted on the engine has been seismically qualified.

The flow diagram for the diesel generator E fuel oil system is shown on drawing M-134, Sheet 2, in Appendix A.

3.2 Structural Design

The diesel generator E building is a Seismic Category 1, two-story structure with a penthouse and a basement consisting primarily of reinforced concrete walls, floor slabs, and roof. The diesel generator pedestal is also constructed of reinforced concrete. A gap between the building floor and the pedestal at grade level is provided so that vibrations from the diesel generator are not transmitted to the building. A curb plate has been installed to prevent excessive water and oil from leaking down to the basement from the operating floor (el. 675'-6") through this gap.

The foundation system was constructed by first removing the volume of soil from the existing grade down to the sound rock with the plan area slightly larger than that of the building. This volume was filled with lean concrete extending from the sound rock to a convenient elevation, which is the bottom elevation of the building basement floor mat.

The foundation system for diesel generator support E is similar to that used for the existing diesel generators. It consists of a reinforced concrete block approximately 34' long x 9' wide x 21'-6" high, with four very small openings and is founded on the lean concrete which in turn is bonded to the bedrock. This type of foundation pedestal has a high rigidity and consequently its frequency of the lowest fundamental mode of vibration will be more than 1.5 times the speed of diesel engine (600 rpm). This will preclude any support related vibration problems.

The outer reinforced concrete walls and roof of the diesel generator E building have sufficient thickness to resist effects of tornado missiles. A portion of an outer wall is removable to facilitate diesel generator installation and/or emergency removal and maintenance operation. This removable wall portion is designed to resist the effects of tornado missiles and seismic loads. Since the high ground water level for design purpose is at elevation 665'-0", a waterproofing membrane is installed on the outside of the basement walls up to elevation 665'-0" and on the bottom surface of the basement floor mat. Waterstops are provided at construction joints below elevation 665'-0".

A description of the seismic analysis procedure and models for the diesel generator E building is contained in Appendix C to this report.

3.2.1 Civil Design

The site was reviewed and evaluated for existing conditions relating to soils and rock materials, drainage patterns, pavements and other ground covers, susceptibility to erosion, site accessibility, and controls for survey work; and to establish a basis for verifying the exact location of all above grade tie-in systems and all underground safety and non safety related systems that could impact design or construction activities. A licensed surveyor determined the horizontal and vertical locations of key points for these systems and the data was assembled on a single Composite Utility Plan, tied into the plant grid and datum. This Composite Plan was used throughout preliminary and final design to maintain control of the location of tie-in work and all new underground systems (all piping systems, utilities, and structures including water and sanitary sewer lines, storm drainage lines, electric duct banks, fuel lines, and any other lines). It also serves as a basis for defining the "as-built" conditions.

Based on a review of available existing subsurface data, additional borings were recommended to establish a design basis for excavation and backfill operations. The results of these investigations including construction stage sheeting and bracing considerations, recommendations for excavation and backfill operations and dewatering are presented in Gibbs & Hill document 3544-SR-001 entitled "Report on Subsurface Investigations for Diesel Generator E Facility".

Erosion and sedimentation controls were imposed on construction activities based on guidelines stipulated in Commonwealth of Pennsylvania Department of Environmental Resource Rules and Regulations, Chapter 102.

The site storm drainage system is designed to provide adequate drainage throughout the life of the facility. The building site is graded to drain away from the diesel generator E structure. The peak rate of stormwater runoff from the site was determined using the Rational Method of design based on precipitation values derived from criteria presented in Section 6.3.7.1 of Technical Specification G-1001. Surface runoff will be conveyed to a peripheral ditch for discharge through the existing storm drainage system.

3.3 Electrical Design

Electrical separation of control and power circuits in the existing diesel building is as described in the Susquehanna Steam Electric Station Final Safety Analysis Report (FSAR) sections 3.12.3.4.2, 8.1.6.1.h and 8.3.1.11.4. For drawings and tables see the referenced FSAR sections.

Electrical separation of control and power circuits in diesel generator E building is as described in IEEE-384, 1981 and; Regulatory Guide 1.75, Rev. 2, 1978 as interpreted (FSAR) section 8.1.6.1.h. For drawings see E81-1, E81-2 and E81-3 of Appendix A.

3.3.1 Medium Voltage System

Diesel generator E is connected directly to the switchgear in the deisel generator E facility. The switchgear is Class 1E and consists of metal-clad, dead-front, free-standing steel structures, complete with buses, draw-out circuit breakers, current and potential transformers, control switches, instruments, and other equipment necessary for proper operation. The circuit breakers are rated 1200A, 250MVA, 4.16kV, with commensurate bus bracing. Each of the four empty positions in the switchgear is connected to a Class 1E switching point located at an existing diesel generator. Each switching point consists of a manual circuit breaker and an empty position. A manual circuit breaker is provided for insertion into only one of the four positions in the switchgear in the diesel generator E facility, and a manual circuit breaker is provided for insertion at each switching point located at an existing diesel generator. Proper alignment allows the spare diesel to be connected in place of any one of the existing diesels. When not in use, the manual circuit breakers are stored in a spare cubicle in the switchgear in the diesel generator E building. A circuit breaker is also provided for connection to the 4.15kV primary of the new indoor transformer. A cubicle is provided for auxiliary metering and/or instrumentation, and for connection to the test facility.

Changes to the diesel generator control panel located in the main control room have been minimized. A system for control transfer has been developed, with consideration to cable separation requirements and Human Factors Engineering.

3.3.1.1 New Switchgear

The following are located at the new switchgear in the diesel generator E building:

- Incoming line compartment
  - Voltmeter
  - Voltmeter switch
- Equipped space (total of four)
  - Ammeter
  - Ammeter switch
  - Local control switch with three indicating lights (breaker open, breaker closed, breaker in test)
- Transformer feeder
  - Circuit breaker
  - Ammeter and ammeter switch
  - 50/51 short circuit/overcurrent protective relays
  - 50G ground current protective relay
  - Local control switch with three indicating lights (breaker open, breaker closed, breaker in test)
  - Key interlock, for disconnect switch on transformer -to preclude operating switch unless breaker is open

- Lockout relay

- Test Facility compartment

- Breaker storage compartment

3.3.1.2 Switching Points

The following are located at each of the four new switching points in the existing diesel generator buildings.

- Circuit breaker compartment

  - Manual, draw-out breaker
  - Local control switch with three indicating lights (breaker open, breaker closed, breaker in test)
  - Ammeter
  - Ammeter switch

- Equipped space

  - Voltmeter
  - Voltmeter switch
  - Ammeter switch
  - Local control switch with three indicating lights (breaker open, breaker closed, breaker in test)

3.3.2 480-Volt System

The secondary of the new indoor transformer is connectable to a Class 1E Motor Control Center (MCC), to supply the E diesel generator auxiliary loads. This Class 1E MCC is connected to a new non-Class 1E MCC via two shunt-trip circuit breakers, each activated by an undervoltage or LOCA signal. The non-Class 1E MCC is normally powered via an automatic transfer switch from either a Unit 1 or Unit 2 non-Class 1E load center. Both MCC's are enclosed, free-standing cabinet-type with main and vertical buses, combination motor starters, feeder protection devices, and other equipment as required.

3.3.3 Class 1E 125-Volt DC System

The Class 1E dc system supplies power for operation of the new 4.16kV switchgear lineup, ESW valves, diesel controls, field flashing, and similar requirements. It is composed of one battery, one charger, one switchboard, one MCC, and one distribution panel in the diesel generator E building. The components are suitably sized to meet the requirements of the system and are shown on the 125V DC one-line drawing E-11, Sheet 11 in Appendix A. The battery charger is capable of supporting the necessary loads while recharging the battery within 8 hours, as well as providing the battery float and equalizing charge.

3.3.4 Transfer Switching System

A system for transfer switching has been developed, with consideration to cable separation requirements, Human Factors Engineering, and to minimizing changes to the control boards in the main control room.

3.3.4.1 Transfer Panels

The transfer switching system involves operation of transfer switches on panels located in the diesel generator E building and in the existing diesel generator buildings. Several grouping of controls, metering, and alarms will be transferred.

The transfer switches in the specific transfer panels in the diesel generator E building are used to select the path to the controls of the specific diesel generator to be replaced. The transfer switch at the individual transfer panel in each existing diesel generator building is used to transfer controls of the specific diesel generator to be replaced to diesel generator E. These two switches in series provide a double break in control circuits to preclude problems in the new building from being propagated into any of the existing diesel generator controls. This same principle applies to the two power circuit breakers in series; there are always two breaks between diesel generator E and an existing nonaligned diesel generator. Also, the diesel generators cannot be paralleled.

The location of the switchgear and transfer panels at Elevation 710' in the existing diesel generator buildings provides some protection from missiles. If a fire or missile from an existing diesel generator were to occur at a switching point, it will disable the switching point in a manner such that repair would be required before diesel generator E could be used in place of the particular existing diesel generator.

3.3.4.2 Local Engine-Generator Control Panels

The generator control panel for diesel generator E includes protective relaying, and is located in the diesel generator E building. This panel is similar to the panels provided for each of the existing diesel generators. (Refer to Table 3-2).

The new engine control panel for the diesel generator E engine includes instrumentation, and is located in the diesel generator E building. This panel is similar to the panels provided for each of the existing diesel generators. (Refer to Table 3-3).

3.3.4.3 Devices to be Transferred

The devices associated with the replaced diesel generator are used for diesel generator E, via the transfer switching system. (Refer to Table 3-3).

The new devices to be re-used, as above, on the main control board are:

- Alarms
  - Diesel generator tripped
  - High priority alarm

- Low priority alarm
- Diesel generator breaker trip
- Diesel generator fails to start
- Diesel generator at near full load
- Diesel generator not in automatic mode
- Room flooded

o Controls

- Start-Stop
- Synchronize
- Frequency adjustment
- Voltage adjustment
- Manual or automatic voltage regulator selection
- Isochronous and droop selection
- "Ready to run" light
- BIS signals (See Section 3.3.4.4)

o Meters

- Voltage
- Current
- Frequency
- Kilowatt output

3.3.4.4 Bypassed and Inoperable Status (BIS) Panel

For each of the systems listed below, the switches and indications for each of the existing diesel generators are used, via a switching transfer system, when diesel generator E is used in place of any one of the existing four diesel generators.

o Diesel Generator Control System
o Diesel Generator Output System
o Diesel Generator Auxiliary System
o ESW System

Each of these systems exists for the existing diesel generators. Table 3-4 lists indicating lights in existing BIS panels.

3.3.4.5 Dedicated Devices

The following new devices, located on the main control board, are dedicated to the diesel generator E facility:

o Alarms

- 4.16kV System for Diesel Generator E Facility-Trouble
- DC System for Diesel Generator E Facility-Trouble
- HVAC Failure in Diesel Generator E Facility
- Control Switches Not Properly Aligned
- Diesel Generator E Building Sump Level High

- Indicating Lights

A series of five indicating lights are provided to status the replacement diesel generator E as follows:

- Diesel Generator E not aligned as a replacement
- Diesel Generator E aligned as replacement for Diesel Generator A
- Diesel Generator E aligned as replacement for Diesel Generator B
- Diesel Generator E aligned as replacement for Diesel Generator C
- Diesel Generator E aligned as replacement for Diesel Generator D

- Local-Remote Selector Switch

This device is a dedicated switch, similar to the switches for the existing diesel generators.

- Emergency Service Water Valves Operation

Individual open-closed indicating lights and control switches are provided on the existing main control board for each of the four emergency service water valves associated with diesel generator E. These valves are powered from existing Division I and Division II MCCs.

3.3.5 Lighting System

Lighting fixtures operate on 277-V ac (Security lights operate at 400v; explosion-proof lights operate at 120v). Indoor lighting is metal halide or fluorescent depending on the particular application. Outdoor lighting is high pressure sodium. In hazardous areas such as the battery room, incandescent explosion proof lighting is used. The lighting system is powered from diesel generator E's essential ac power distribution which is backed up by a diesel generator in the event of loss of off-site power. Additional fixtures, energized by the main plant's normal ac power distribution are also provided to augment the essential lighting to provide the minimum illumination levels. Exit lighting is energized by diesel generator E's essential ac power distribution system, and is provided as required, this includes self-contained battery-powered lighting fixtures. The outdoor lighting system is powered from a source traceable to the existing security system emergency power supply. Lighting systems are in accordance with the National Electrical Code.

3.3.6 Grounding System

A bare copper ground loop consisting of 250-MCM bare copper cable embedded near the base of the foundation perimeter is installed, and connected to the applicable equipment with a 4/0-AWG bare copper wire. This is interconnected to the existing station grid.

3.3.7 Communications System

The communications system is compatible with and connected to the existing main plant communications system. Sufficient speakers and public address system stations for paging/communications are provided, as well as Plant Maintenance/Test Jack system stations. The system is designed in accordance with the latest issue of the NEC. The PA system is designed so that alarm messages can be heard under all conditions of operation.

3.3.8 Security System

The diesel generator E facility is classified as a vital area, therefore the security system is designed to satisfy all the applicable requirements of 10CFR73. In addition, the intrusion alarm system design meets the criteria outlined in Regulatory Guide 5.44.

The existing security fence was temporarily relocated prior to construction to accommodate construction progress without endangering vital area plant security.

All security devices and equipment are designed to be compatible with, and connected to, the existing plant security system.

3.3.9 Test Facility

The purpose of the test facility is to provide a means for periodic testing of diesel generator E when diesel generator E is not aligned to the Class 1E distribution system.

The diesel generator E test facility consists of an interconnection between the diesel generator E 4.16 kV Class 1E switchgear and the Non-Class 1E 13.8 kV switchgear (Bus 10) located in the existing turbine building. The connection to Bus 10 is via a splice tap to the Makeup Water Intake Structure 13.8 kV feeder.

The test facility interconnection consists of the following major items:

- 4.16 kV switchgear compartment and associated controls, metering and protective devices.
- 4.16 kV circuit breaker (this is the same circuit breaker which is also utilized in the substitution of diesel generator E for any one of the existing diesel generators.
- 4.16 kV/13.2 kV, 10.5/13.15 MVA OA/FA 55C, step-up transformer.
- 13.8 kV outdoor switchgear unit with associated control and protective devices (used to deenergize 4.16 kV/13.2 kV transformer when test facility is not in use)
- Synchronizing panel (for synchronizing D.G. E4.16 kV output to 13.8 kV Bus 10; synchronizing is across the 4.16 kV circuit breaker).

3.3.10 Mild Environment

The diesel generator E building environment will at no time be significantly more severe than the environment that would occur during normal power plant operation, including anticipated operational occurrences. It is therefore considered to be a "mild environment". Class 1E equipment located in a mild environment is not required to be environmentally qualified by type test. Adherence to the requirements of 10CFR Part 50, Appendices A and B, and the guidance in Regulatory Guide 1.33, Revision 3, ensures adequate performance of the safety-related equipment located in the mild environment. The Class 1E equipment located in a mild environment is subject to the plant seismic requirements, except that preconditioning (aging) prior to seismic testing is not required.

3.4 Instrumentation and Controls

The control logic for activating diesel generator E is based on a review of existing diesel generator controls, discussions with the operating staff, and consideration of the Human Factors involved in placing the E diesel generator in service.

Table 3-2

PROTECTIVE RELAYS, METERS AND CONTROL DEVICES ON THE GENERATOR CONTROL PANEL FOR DIESEL GENERATOR E

The new generator control panel is located in the diesel generator E building and includes the following:

o Protective relays:

40/76	Field failure
64F	Field Ground Sensor
60	Voltage balance
27V	Undervoltage
50/51	Overcurrent, short circuit - phases A, B, C
32	Reverse Power
51NF	Generator Near Full Load
59	Overvoltage
81	Underfrequency
59N	Neutral overvoltage
87GE	Differential Protection, with lockout relay 86D

The connected 87GE relay is switched via transfer panels.

o Meters:

DC Field current

DC Field voltage

Generator amperes, with ammeter switch

Generator kilowatts

Generator Kilovars

Generator voltage, with voltmeter switch

Generator frequency

Generator kilowatt hours

Table 3-1

DIESEL GENERATOR E BUILDING VENTILATION SYSTEM DESIGN PARAMETERS

	Summer	Winter
Outdoor Ambient Conditions	92°Fd.B/78°F w.b.	-5°F
Indoor Design Conditions		
o Elevation 675'-6" and 708'-0" with D/G 'E' "On"	120°F (Max)	70°F (Min)
o Elevation 675'-6" and 708'-0" with D/G 'E' "Off"	104°F (Max)	70°F (Min)
o Elevation 656'-6" - Battery Room with D/G 'E' "On" or "Off"	104°F (Max)	65°F (Min)
o Elevation 656'-6" - Remaining Area with D/G 'E' "On"	120°F (Max)	60°F (Min)
o Elevation 656'-6" - Remaining Area with D/G 'E' "Off"	104°F (Max)	60°F (Min)

Table 3-2 (Cont'd)

- Control Devices:

DC Control power	- White light
Field Flash power	- White light
Protective Relaying-reset	- Pushbutton
Volts/Vars	- Selector switch Raise - lower
Field Flash - Manual	- Pushbutton
Generator Breaker	- Lockout Relay 52GBT Reset-trip lights
Voltage Regulator	- Selector switch Manual-Auto
Generator Field	- Lockout Relay 86ESD Reset-trip lights
Excitation Shutdown	- Pushbutton
Bridge Transfer Switch	- Switch
Test Block Metering-Current	- Test block Transformers
Test Block Metering-Potential Transformers	- Test block Transformers

Table 3-3

DEVICES, ALARMS AND SHUTDOWN SIGNALS ON THE ENGINE CONTROL PANEL FOR DIESEL GENERATOR E

The new diesel engine control panel is located in the diesel generator E building and includes the following:

o Devices:

Jacket Water Press/After Cooler Press	- Dual Indicator
Engine hours	- Meter
Turbo-charger oil filter differential pressure	- Indicator
Fuel oil supply/discharge pressure	- Dual Indicator
Power Cylinder Exhaust Temperature	- Indicator
Temperature	- Indicator
Engine lubeoil press/turbo lubeoil press	- Dual Indicator
Turbo-charger Air & Crankcase pressures	- Indicator
Power cylinder exhaust and turbo temp.	- Meter
RTD temperature	- Meter
Manifold pressure	- Indicator
Turbo-discharge press Air Manifold Left Bank/Right Bank	- Dual Gauge Press.
Starting Air Pressure Receiver 1/ Receiver 2	- Dual Indicator
Engine Speed	-
Governor Mode	- Selector Switch Isochronous-Parallel
Speed Control	- Selector Switch Raise-Off-Lower
Master trip circuit - Trip	- Green light
Master trip circuit - Reset	- Amber light
Turbo exhaust outlet, turbo air in/breakcase	- Dual gauge pressure
Turbo charger speed	- Meter

Table 3-3 (Cont'd)

Fuel oil day tank level	- Meter
Fuel oil storage tank level	- Meter
Sequence indication - step	- Red light
Control Mode selector	- Selector switch Remote-off-local Local/remote White lights
Engine Control	- Pushbutton Start - Stop
Sequence Indication - Crank	- White light
Sequence Indication - Running idle	- White light
Sequence Indication - Running loaded	- White light
Unit in Emergency mode	- White light
Master trip circuit	- Lockout relay (86) Trip - Reset
Annunciator	- Selector switch Test-Off-Reset Pushbutton Acknowledge
DC power on circuit #1	- White light
DC power on circuit #2	- White light
DG available for Emergency	- White light
Emergency stop	- Pushbutton Stop-Reset
Air Compressor #1	- Selector Switch Hand-Off-Auto with G/R/A lights
Air Compressor #2	- Selector Switch Hand-Off-Auto with G/R/A lights
Standby jacket water pump	- Selector Switch Hand-Off-Auto with G/R/A lights
Jacket water circulating pump	- Selector Switch

Table 3-3 (Cont'd)

	Hand-Off-Auto with G/R/A lights
Jacket water heater	- Selector Switch Hand-Off-Auto with G/R/A lights
Standby lube oil pump	- Selector Switch Hand-Off-Auto with G/R/A lights
Lube oil circulating pump	- Selector Switch Hand-Off-Auto with G/R/A lights
Lube oil heater	- Selector Switch Hand-Off-Auto with G/R/A lights
Fuel oil transfer pump	- Selector Switch Hand-Off-Auto with G/R/A lights
Standby Fuel oil pump	- Selector Switch Hand-Off-Auto with G/R/A lights

- Local Alarms and Shutdown Signals:

  Engine lube oil pressure low

  Turbo lube oil pressure low

  Main & Conn. Rod Brg. high temp.

  Engine Vibration

  Turbo thrust brg. failure

  Jacket water temp. high

  Engine overspeed

  Turbo overspeed

  Generator Brg. high temp.

  Generator Reverse power

  Generator Loss of Field

  Generator Overexcitation

Table 3-3 (Cont'd)

Generator Differential

Generator Underfrequency

Generator Overvoltage

Emergency Service Water

Emergency shutdown

Incomplete sequence

- Local Alarms

  Engine lube oil pressure low

  Turbo lube oil pressure low

  Engine lube oil pressure high

  Engine crankcase pressure high

  Engine crankcase level low

  Engine lube oil temp off normal

  Jacket water temp. off normal

  Jacket water pressure low

  Jacket water standpipe level low

  Jacket water standpipe level high

  Lube oil filter diff. press high

  Fuel oil pressure low

  Fuel oil pressure high

  Fuel oil filter diff. press. high

  Fuel oil strainer diff. press. high

  Aux. Standby Jacket water pump on

  Fuel oil day tank level low

  Fuel oil day tank level high

  Fuel oil storage tank level low

Table 3-3 (Cont'd)

Lube Oil circulating

Prelube pump malfunction

Lube oil heater malfunction

Jacket water heater malfunction

Jacket water circulating pump malfunction

DG Bypasses or inoperable

Generator field ground

Generator voltage unbalance

Generator neutral overvoltage

Generator overcurrent

Near full load

Voltage reg. transfer to standby

MCC not proper for auto operation

Control switches not proper for remote auto operation

Starting air pressure low or system malfunction

Failure to start

Table 3-4

INDICATING LIGHTS ON EXISTING BIS PANELS

A separate panel is provided for Unit 1 and Unit 2 for each of the four existing diesel generators. The following is provided on each panel.

- o Diesel-Generator Control System Out-of-Service.

  Selector switch, (normal-bypass) with green indicating light.

  One (1) green indicating light for each of the following:

    Diesel-generator, d-c control power loss.

    Diesel-generator, field-flash and excitation power loss.

    4-kV bus, transformer, circuit breaker disabled.

    Diesel-generator, control switch in local.

    Diesel-generator, building cooling fan disabled.

  One (1) green indicating light as common for all of the above signals.

- o Diesel-Generator Output System Out-of-Service.

  Selector switch (normal-bypass) with green indicating light.

    Diesel-generator, circuit breaker racked out.

    Diesel-generator, control power loss.

    4-kV bus, transformer circuit breaker disabled.

- o Diesel-Generator Auxiliary System Out-of-Service.

  Selector Switch (normal-bypass), with green indicating light.

  One (1) green indicating light for each of the following:

    Diesel-generator auxiliary supply/control power loss.

    Diesel-generator auxiliaries not in automatic.

    Pump OP- disabled.

  One (1) green indicating light as common for all of the above signals.

Table 3-4 (Cont'd)

- o ESW System Out-of-Service

  Selector Switch (normal-bypass), with green indicating light.

  One (1) green indicating light for the following:

  ESW valves control power loss

Table 3-5

SIGNALS TO BE TRANSFERRED FOR EACH OF THE FOUR EXISTING DIESEL GENERATORS

Signal	Shown on Exist DG Dwg No.		Shown on DG E Dwg. No.	
Auto Start (Back Up Circuit)	G5-553-109	Sh. 2	G5-553-243	Sh. 2
Circuit Breaker Control (52T1)	G5-553-109	Sh. 1	G5-553-243	Sh. 1
Ready To Close Generator Breaker (Unit 2)	G5-553-109	Sh. 10	G5-553-143	Sh. 12
Generator Breaker Trip Signal (Unit 2)	G5-553-109	Sh. 10	G5-553-243	Sh. 12
SEVR Auto/Manual Switch	3-E12-03-B	Sh. 1b	G5-553-366	Sh. 4
Field Current To Computer Unit No. 1	3-E12-03-B	Sh. 3a	G5-253-366	Sh. 1
Field Current To Computer Unit No. 2	3-E12-03-B	Sh. 3a	G5-553-366	Sh. 1
Voltmeter	3-E12-03-B	Sh. 3a	G5-253-366	Sh. 5
Frequency Meter	3-E12-03-B	Sh. 3a	G5-253-366	Sh. 5
Totalizer	3-E12-03-B	Sh. 3b	Not transferred	
Watt Meter	3-E12-03-B	Sh. 3b	G5-253-366	Sh. 5
VAR Meter	3-E12-03-B	Sh. 3b	G5-253-366	Sh. 5
Diesel Generator DC Control Power Loss (BIS Unit 1)	G-5-553-109	Sh. 10	G5-553-243	Sh. 12
Diesel Generator Field Flash and Exciter Power Loss (BIS Unit 1)	3-E12-03-B	Sh. 2a	G5-253-366	Sh. 5
Diesel Generator Control Switch in Local (BIS Unit 1)	G5-553-109	Sh. 10	G5-553-243	Sh. 12
Diesel Generator Aux Supply/ ControlPower Loss (BIS Unit 1)	E-259	Sh. 9	E-259	Sh. 23
ESW Return Water Temperature	J-411	Sh. 4	J-411	Sh. 4A
Diesel Generator Aux Not in Auto (BIS Unit 1)	E-259	Sh. 9	G5-553-243	Sh. 13

Table 3-5 (Cont'd)

Oil Pump Disabled (BIS Unit 1)	E-257		E-257	Sh. 2
Diesel Generator DC Control Power Loss (BIS Unit 2)	G5-553-109	Sh. 10	G5-553-243	Sh. 12
Diesel Generator Field Flash and Exciter Power Loss (BIS Unit 2)	3-E-12-03-B	Sh. 2a	G5-253-366	Sh. 5
Diesel Generator Control Switch In Local (BIS Unit 2)	G5-558-109	Sh. 10	G5-553-243	Sh. 12
Diesel Generator Aux. Supply/ Control Power Lose (BIS Unit 2)	E-259	Sh. 9	E-259	Sh. 23
Diesel Generator Aux. Not In Auto (BIS Unit 2)	E-259	Sh. 9	G5-553-243	Sh. 13
Oil Pump Disabled (BIS Unit 2)	E-257		E-257	Sh. 2
Auto Start Emergency Service Water Pump	G5-553-109	Sh. 10	G5-553-243	Sh. 12
Synchronizing	3-E12-030B	Sh. 3a	G5-253-366	Sh. 2
Ammeter	3-E12-03-B	Sh. 3b	G5-253-366	Sh. 1
Diesel Generator Tripped Alarm	G5-553-109	Sh. 10	G5-553-243	Sh. 12
High Priority Alarm	G5-553-109	Sh. 10	G5-553-243	Sh. 12
Low Priority Alarm	G5-553-109	Sh. 10	G5-553-243	Sh. 12
Diesel Generator fails to start (Incomplete Sequence) Alarm	G5-553-109	Sh. 10	G5-553-243	Sh. 12
Diesel Generator Near Full Load Alarm	3-E12-03-B	Sh. 2a	G5-253-366	Sh. 5
Diesel Generator Not In Auto Mode Alarm	E-259	Sh. 9	G5-553-243 (Multiple Contacts of 74R3)	Sh. 13
Auto Start (Primary Circuit)	G5-553-109	Sh. 1	G5-553-243	Sh. 1
Generator Breaker Open/Closed	G5-553-109	Sh. 1	G5-553-243	Sh. 2
Manual Start	G5-553-109	Sh. 1	G5-553-243	Sh. 3

Table 3-5 (Cont'd)

Manual Stop	G5-553-109	Sh. 9	G5-553-243	Sh. 3
Governor Lower Raise	G5-553-109	Sh. 6	G5-553-243	Sh. 8
Ready to Close Generator Breaker - Unit 1	G5-553-109	Sh. 10	G5-553-243	Sh.12
Ready to Close Generator Breaker - Unit 2	G5-553-109	Sh. 10	G5-553-243	Sh. 12
Isochronous/Droop	E-259	Sh. 9	G5-553-243	Sh. 1
Overcurrent with Voltage Restraint Block 51V Unit 1	3-E12-03-B	Sh. 2a	G5-253-366	Sh. 5
Overcurrent with Voltage Restraint Block 51V Unit 2	3-E12-03-B	Sh. 2a	G5-553-366	Sh. 5
Diesel Generator Differential	3-E12-03-B	Sh. ___	G5-253-366	Sh. 1
Overcurrent Voltage Restraint 51V	E-23	Sh. 6	E-23	Sh. 10
ESW Valve HV-01112A,B,C,D Control Switch (close circuit)	E-146-	Sh. 9	E-146	Sh. 17
ESW Valve HV-01112A,B,C,D Control Switch (open circuit)	E-146	Sh. 9	E-146	Sh. 17
ESW Valve HV-01112A,B,C,D Over Room Bypass	E-146	Sh. 9	E-146	Sh. 17
ESW Valve HV-01112A,B,C,D Indicating Lights	E-146	Sh. 9	E-146	Sh. 18
ESW Valve HV-01122A,B,C,D Control Switch (Close Circuit)	E-146	S. 9	E-146	Sh. 18
ESW Valve HV-01122A,B,C,D Control Switch (Open Circuit)	E-146	Sh. 9	E-146	Sh. 18
ESW Valve HV-01122A,B,C,D Overload Bypass	E-146	Sh. 9	W-146	Sh. 18
ESW Valve HV-01122A,B,C,D Indicating Lights	E-146	Sh. 9	E-146	Sh. 18
ESW Valve HV-01110A,B,C,D Control Switch (close circuit)	E-146	Sh.10	E-146	Sh. 19
ESW Valve HV-01110A,B,C,D Control Switch (Open Circuit)	E-146	Sh.10	E-146	Sh. 19

Table 3-5 (Cont'd)

ESW Valve HV-01110A,B,C,D Overload Bypass	E-146	Sh. 10	E-146	Sh. 19
ESW Valve HV-01110A,B,C,D Indicating Lights	E-146	Sh. 10	E-146	Sh. 19
ESW Valve HV-01120A,B,C,D Control Switch (Close Circuit)	E-146	Sh. 10	E-146	Sh. 20
ESW Valve HV-01120A,B,C,D Control Switch (Open Circuit)	E-146	Sh. 10	E-146	Sh. 20
ESW Valve HV-01120A,B,C,D Overload Bypass	E-146	Sh. 10	E-146	Sh. 20
ESW Valve HV-01120A,B,C,D Indicating Lights	E-146	Sh. 10	E-146	Sh. 20
ESW Valve HV-01110A,B,C,D Auto Loop Transfer	E-146	Sh. 10	E-146	Sh. 19
ESW Valve HV-01120A,B,C,D Auto Loop Transfer	E-146	Sh. 10	E-146	Sh. 20
ESW Valves loop "A" BIS Indication	E-146	Sh. 33	E-146	Sh. 33A
ESW Valves loop "B" Bypass Indication	E-146	Sh. 33	E-146	Sh. 33B
ESW Valves HV-01110A,B,C,D Auto Loop Transfer	E-146	Sh. 11	E-146	Sh. 1
HVAC Vent Supply Fan Control Switch (Start)	E-193	Sh. 1	E-193	Sh. 6
HVAC Vent Supply Fan Control Switch (Auto)	E-193	Sh. 1	E-193	Sh. 6
HVAC Vent Supply Fan Indicating Lights	E-193	Sh. 1	E-193	Sh. 6

4.0 STUDIES

A gas bottle missile analysis (Gibbs & Hill Calculation No. MC-MI-001) was performed to determine the maximum velocity which could be achieved by a gas bottle due to the postulated failure of the gas relief valve. The analysis assumed a sudden opening of one (1) inch diameter occurred in the bottle thereby maximizing the gas exit mass flow rate and causing the gas bottle to become a missile.

Calculation results for the gas cylinders of the type and size used at Susquehanna Steam Electric Station showed that the most severe impact is due to the 143 pound oxygen bottle with a maximum velocity of 262 fps while the 70 pound zero gas bottle reached the highest velocity (342 fps). These calculated maximum velocities are significantly less than the 900 fps discussed in Susquehanna Susquehanna Electric Station Final Safety Analysis Report (FSAR) Section 3.5.1.5 and consequently the missile characteristics as described in the FSAR (i.e. missile weight and velocity) can be modified to conform to the calculated worst case conditions.

Structural analyses evaluating the effects of these identified worst case missiles were incorporated into the final design calculations for the diesel generator E building.

5.0 TIE-IN DESCRIPTION

The tie-in of the diesel generator E facility with the operating plant is planned in such a way as to minimize the effect on plant operations. Insofar as it is possible, the tie-in systems are designed so that most of the piping and cabling can be installed without actually connecting to the existing plant services.

The exact location of all above-ground tie-in systems as well as underground safety-related and critical non safety-related system that may impact design or construction activities was established. Although every effort is being made to minimize exposure of safety and critical non-safety related systems to potential damage from construction activities, specific protective measures were taken including the following:

- Excavation was staged to minimize exposure of critical areas.
- Hand excavation methods were employed when excavations were within three to four feet of critical utilities or facilities.
- Maximum effective cover was maintained by using steel plate or an equivalent composite of earth and steel plate (or steel casing pipe).
- Temporary supports and/or concrete encasement were utilized where required.

The detailed tie-in description considers but is not limited to, the following:

- Relocation of existing systems
- Relocation of existing systems encountered in areas where tie-ins are required.
- Tie-in connections also can be performed during the outages from the existing plant systems up to an isolation device such as a circuit breaker or valve; the balance of the system would be installed later in the construction. This would allow continued construction without disturbing plant operation. These isolation devices will serve as the "plug-in" interface between the additional diesel and the existing systems.

The following is a list of systems which require tie-in connections:

- Storm drainage systems
- Power supply systems
- Control room panel interface system

- Computer system
- Emergency Service water system
- Fuel oil system
- Sump Effluent disposal system
- Potable water system
- Demineralized water system
- Station air system
- Fire protection and detection system
- Plant security system

APPENDIX A

DRAWINGS

This Appendix contains the following drawings:

Drawing Number	Title
C-5003	Diesel Generator E Facility Site Development Plan
M-5200, Sheet 1	Diesel Generator E Building General Arrangement Plans
M-5200, Sheet 2	Diesel Generator E Building General Arrangement Sections
M-120, Sheet 2	Flow Diagram Diesel Oil Storage and Transfer Diesel Generator E Building
J-120, Sheets 3, 4, 5	ICD Diesel Generator E Building Diesel Oil and Storage System
M-111, Sheet 3	Flow Diagram Emergency Service Water System Diesel Generator E Building
J-111, Sheets 10, 11, 13, 14, 14A, 15	ICD Diesel Generator E Building Emergency Service Water System
M-182, Sheet 2	Diesel Generator E Building Air Flow Diagram
V-182, Sheets 7, 8, 8A, 9, 9A, 10, 11, 13, 13A, 14, 15, 16	ICD Diesel Generator E Building Air Flow System
M-122, Sheet 9	Flow Diagram Fire Protection Diesel Generator E Building
Fig. F-1006	Emergency Diesel E Generator Instrument and Logic Flow Diagram Fire Protection System
M-134, Sheet 2	Flow Diagram Diesel Auxiliaries Diesel Generator E Building
E5, Sheet 5	Single Line Meter & Relay 4.16 kV diesel generator E

Drawing Number	Title
E9, Sheet 77	One Line Diagram 480 V MCC - 0B565 Diesel Generator E Units 1 & 2
E9, Sheet 78	One Line Diagram 480 V MCC - 0B566 Diesel Generator E Units 1 & 2
E11, Sheet 11	125V dc One Line Diagram Diesel Generator E Units 1 & 2
E23, Sheet 10	4.16 kV Three Line Diagram Diesel Generator E
E23, Sheet 12	Schematic Diagram Switch Contact Development Transfer Panels 0C512 E-A, E-B, E-C & E-D
E23, Sheet 6A	Schematic Meter & Relay Diagram 4.16 kV Diesel Generator A, B, C & D Transfer Control - Diesel Generator E Units 1 & 2
E23, Sheet 7	Schematic Meter & Relay Diagram 4.16 kV Diesel Generators A, B, C & D Transfer Control - Diesel Generator E Units 1 & 2
E23, Sheet 8	Schematic Meter & Relay Diagram 4.16 kV Diesel Generator A, B, C & D Transfer Control - Diesel Generator E Units 1 & 2
E23, Sheet 8A	Schematic Meter & Relay Diagram 4.16 kV Diesel Generator A, B, C & D Transfer Control - Diesel Generator E Units 1 & 2
E26, Sheet 13	Schematic Meter & Relay Diagram 125 DC Diesel Generator E
E102, Sheet 38	13.8 kV Breaker Connection Diagram.
E105, Sheet 13	4.16 kV Breaker Schematic Diagram
E105, Sheet 18	Schematic Diagram 4.16 kV Bus 0A510 Diesel Generator Circuit Breaker 51006 Control Common
E23, Sheet 9	Schematic Meter & Relay Diagram 4.16 kV Diesel Generator A, B, C & D Transfer Control - Diesel Generator E Units 1 & 2

Drawing Number	Title
E23, Sheet 11	Schematic Meter & Relay Diagram 4.16 kV Diesel Generator A, B, C & D Transfer Control - Diesel Generator E Units 1 & 2
E103, Sheet 25	Schematic Diagram 4.16 kV Buses Auxiliary Relay Transfer Control Diesel Generator E Units 1 & 2
E105, Sheet 27	Schematic Diagram 4.16 kV Bus Diesel Generator Circuit Breakers Transfer Control Diesel Generator E Unit 1
E105, Sheet 28	Schematic Diagram 4.16 kV Bus Diesel Generator Circuit Breakers Transfer Control Diesel Generator E Unit 1
E105, Sheet 29	Schematic Diagram 4.16 kV Bus "1A, 1B, 1C, 1D" & "2A, 2B, 2C, 2D" Diesel Generator Circuit Breaker - Trip Interlock With Diesel Generator "A, B, C, D, & E" Transfer Units 1 & 2
E105, Sheet 30	Schematic Diagram 4.16 kV Bus "1A, 1B, 1C, 1D" & 2A, 2B, 2C, 2D Diesel Generator Circuit Breaker - Trip Interlock With Diesel Generator A, B, C, D, & E Transfer Units 1 & 2
E146, Sheet 9A	Schematic Diagram ESW Diesel Cooler Valves Loop A HV-01112 A, B, C, D & E Transfer Common
E146, Sheet 9B	Schematic Diagram ESW Diesel Cooler Valves Loop A HV-01112 A, B, C, D & E Transfer Common
E146, Sheet 9C	Schematic Diagram ESW Diesel Cooler Valves Loop A HV-01112 A, B, C, D & E Transfer Common
E146, Sheet 9D	Schematic Diagram ESW Diesel Cooler Valves Loop A HV-01122 A, B, C, D & E Transfer Common
E146, Sheet 9E	Schematic Diagram ESW Diesel Cooler Valves Loop A HV-01122 A, B, C, D & E Transfer Common

Drawing Number	Title
E146, Sheet 9F	Schematic Diagram ESW Diesel Cooler Valves Loop A HV-01122 A, B, C, D & E Transfer Common
E146, Sheet 10A	Schematic Diagram ESW Diesel Cooler Valves Loop B HV-01110 A, B, C, D & E Transfer Common
E146, Sheet 10B	Schematic Diagram ESW Diesel Cooler Valves Loop B HV-01110 A, B, C, D & E Transfer Common
E146, Sheet 10C	Schematic Diagram ESW Diesel Cooler Valves Loop B HV-01110 A, B, C, D & E Transfer Common
E146, Sheet 10D	Schematic Diagram ESW Diesel Cooler Valves Loop B HV-01120 A, B, C, D & E Transfer Common
E146, Sheet 10E	Schematic Diagram ESW Diesel Cooler Valves Loop B HV-01120 A, B, C, D & E Transfer Common
E146, Sheet 10F	Schematic Diagram ESW Diesel Cooler Valves Loop B HV-01120 A, B, C, D & E Transfer Common
E146, Sheet 11A	Schematic Diagram ESW Diesel Cooler Valves Auto Loop Transfer HV-01110A, B, C, D & E Common
E146, Sheet 21	Schematic Diagram ESW Diesel Cooler Valves Auto Loop Transfer HV-01110A, B, C, D & E Common
E184, Sheet 15	Schematic Diagram Diesel Generator Auto Start (Primary) Transfer Control Diesel Generator E Common
E184, Sheet 16	Schematic Diagram Diesel Generator Auto Start (Back-up). Transfer Control Diesel Generator E Common
E185, Sheet 12A	Schematic Diagram Bypass Indication System (BOP) Transfer Control Diesel Generator E Unit 1
E185, Sheet 12B	Schematic Diagram Bypass Indication System (BOP) Transfer Control Diesel Generator E Unit 1

Drawing Number	Title
E185, Sheet 12C	Schematic Diagram Bypass Indication System (BOP) Transfer Control Diesel Generator E Unit 1
E185, Sheet 26A	Schematic Diagram Bypass Indication System (BOP) Transfer Control Diesel Generator E Unit 2
E185, Sheet 26B	Schematic Diagram Bypass Indication System (BOP) Transfer Control Diesel Generator E Unit 2
E185, Sheet 26C	Schematic Diagram Bypass Indication System (BOP) Transfer Control Diesel Generator E Unit 2
E185, Sheet 33A	Schematic Diagram ESW Loop A Bypass Indication System (BOP) Common
E185, Sheet 33B	Schematic Diagram ESW Loop A Bypass Indication System (BOP) Common
E193, Sheet 1A	Schematic Diagram - HVAC Diesel Generator Building. Vent System Vent Supply Fans Transfer Scheme - Common
E193, Sheet 1B	Schematic Diagram - HVAC Diesel Generator Building Vent System Vent Supply Fans Transfer Scheme - Common
E259, Sheet 1A	Schematic Diagram Diesel Generator Excitation Transfer Control Diesel Generator E Common
E259, Sheet 9A	Schematic Diagram Diesel Generator Engine Transfer Control Diesel Generator E Common
E259, Sheet 9B	Schematic Diagram Diesel Generator Engine Transfer Control Diesel Generator E Common
E259, Sheet 9C	Schematic Diagram Diesel Generator Engine Transfer Control - Diesel Generator E Common
E259, Sheet 29	Schematic Diagram Diesel Generator "A" -Diesel Generator E Transfer Alignment Indication Common
E259, Sheet 30	Schematic Diagram Diesel Generator "B" -Diesel Generator E Transfer Alignment Indication Common

Drawing Number	Title
E259, Sheet 31	Schematic Diagram Diesel Generator "C" -Diesel Generator E Transfer Alignment Indication Common
E259, Sheet 32	Schematic Diagram Diesel Generator "D" -Diesel Generator E Transfer Alignment Indication Common
E331, Sheet 13	Schematic Diagram - Annunciator Plant Operating Bench Board 0C653 Transfer Control - Diesel Generator E Common
E331, Sheet 14	Schematic Diagram - Annunciator Plant Operating Bench Board 0C653 Transfer Control - Diesel Generator E Common
E331, Sheet 14	Schematic Diagram - Annunciator Plant Operating Bench Board 0C653 Transfer Control - Diesel Generator E Common
E332, Sheet 4A	Schematic Diagram - Annunciator HVAC Control Board 0C681 Transfer Scheme-Common
E105, Sheet 31, 40	4.16 kV Breaker Connection Diagram
E146, Sheet 17	ESW Motor Operated Valve No. 1 Schematic and Connection Diagram
E146, Sheet 18	ESW Motor Operated Valve No. 2 Schematic and Connection Diagram
E146, Sheet 19	ESW Motor Operated Valve No. 3 Schematic and Connection Diagram
E146, Sheet 20	ESW Motor Operated Valve No. 4 Schematic and Connection Diagram
E259, Sheet 13	Diesel Generator Standby Jacket Water Pump Schematic and Connection Diagram
E259, Sheet 14	Diesel Generator Jacket Water Circuit Pump Schematic and Connection Diagram
E259, Sheet 15	Diesel Generator Jacket Water Heater Schematic and Connection Diagram
E259, Sheet 16	Diesel Generator Standby Lube Oil Circuit Pump Schematic and Connection Diagram

Drawing Number	Title
E259, Sheet 18	Diesel Generator Lube Oil Heater Schematic and Connection Diagram
E257, Sheet 2	Diesel Generator Fuel Oil Transfer Pump Schematic and Connection Diagram
E259, Sheet 19	Diesel Generator Auxiliaries - Air Compressor No. 1 Schematic & Connection Diagram
E259, Sheet 20	Diesel Generator Auxiliaries - Air Compressor No. 2 and Connection Diagram
E259, Sheet 21	Diesel Generator Standby Fuel Oil Pump (DC) Schematic and Connection Diagram
E259, Sheet 22	Diesel Generator Generator Auxiliary Miscellaneous Systems Connection Diagram
E259, Sheet 17	Diesel Generator Preventative Lube Pump Schematic and Connection Diagram
E193, Sheet 6	H&V Supply Fan Schematic and Connection Diagram
E193, Sheet 7	H&V Supply Fan Schematic and Connection Diagram
E193, Sheet 9	Dampers Schematic and Connection Diagram
E193, Sheet 8	H&V Exhaust Fan, Schematic and Connection Diagram
E193, Sheet 10	H&V Exhaust Fan Schematic and Connection Diagram
E193, Sheet 5	H&V Battery Room Exhaust, Schematic and Connection Diagram
E259, Sheet 23	Miscellaneous Equipment and Devices Schematic and Connection Diagram
E259, Sheet 27	Miscellaneous Equipment and Devices Schematic and Connection Diagram
E259, Sheet 28	Miscellaneous Equipment and Devices Schematic and Connection Diagram

Drawing Number	Title
E326, Sheet 22	Annunciator, Alarms PNL 0C577E Schematic Diagram
E301, Sheet 105	Computer Inputs Schematic and Connection Diagram
E81, Sheet 1	Diesel Generator E Building Tray and Conduit Plan.
E81, Sheet 2	Diesel Generator E Building Tray and Conduit Plan.
E81, Sheet 3	Diesel Generator E Building Tray and Conduit Plan.
E-105, Sheet 19	Schematic Diagram 4.16 kV Bus 0A510P Diesel Generator Circuit Breaker 510A02 Control-Common
E-105, Sheet 20	Schematic Diagram 4.16 kV Bus 0A510A Diesel Generator Circuit Breaker 510A01 Control-Common
E-105, Sheet 21	Schematic Diagram 9.16 kV Bus 0A510B Diesel Generator Circuit Breaker 510B02 Control-Common
E-105, Sheet 22	Schematic Diagram 4.16 kV Bus 0A510B Diesel Generator Circuit Breaker 510B01 Control-Common
E-105, Sheet 23	Schematic Diagram 4.16 kV Bus 0A510C Diesel Generator Circuit Breaker 510C02 Control-Common
E-105, Sheet 24	Schematic Diagram 4.16 kV Bus 0A510C Diesel Generator Circuit Breaker. 510C01 Control - Common
E-105, Sheet 25	Schematic Diagram 4.16 kV Bus 0A510D Diesel Generator Circuit Breaker 510D02 Control-Common
E-105, Sh 26	Schematic Diagram 4.16 kV Bus 0A510D Diesel Generator Circuit Breaker 510D01 Control-Common
E-105, Sheet 37	Connection Diagram 4.16 kV Bus 0A510A Diesel Generator Circuit Breaker 510A02 Control-Common

Drawing Number	Title
E-105, Sheet 38	Connection Diagram 4.17 kV Bus 0A510A Diesel Generator Circuit Breaker 510A01 Control-Common
E-105, Sheet 39	Connection Diagram 4.16 kV Bus 0A510B Diesel Generator Circuit Breaker 510B02 Control-Common
E-105, Sheet 40	Connection Diagram 4.16 kV Bus 0A510B Diesel Generator Circuit Breaker 510B01
E-105, Sheet 41	Connection Diagram 4.16 kV Bus 0A510C Diesel Generator Circuit Breaker 510C02 Control-Common
E-105, Sheet 42	Connection Diagram 4.16 kV Bus 0A510C Diesel Generator Circuit Breaker 510C01 Control Common
E-105, Sheet 43	Connection Diagram 4.16 kV Bus 0A510D Diesel Generator Circuit 510D02 Control - Common
E-105, Sheet 44	Connection Diagram 4.16 kV Bus 0P510D Diesel Generator Circuit Breaker 510D01 Control-Common
E-259, Sheet 29A	Schematic Diagram Diesel Generator "A" -Diesel Generator E Transfer Alignment Indication - Common
E-259, Sheet 30A	Schematic Diagram Diesel Gnerator "B" -Diesel Generator E Transfer Alignment Indication - Common
E-259, Sheet 31A	Schematic Diagram Diesel Generator "C" -Diesel Generator E Transfer Alignment Indication-Common
E-259, Sheet 32A	Schematic Diagram Diesel Generator "D" -Diesel Generator E Transfer Alignment Indication-Common
E-331, Sheet 14	Schmetic Diagram Annunicator Plant Operating Bench Board 0C653 Transfer Control - Diesel Generator E - "A" Common.
E-331, Sheet 14A	Schematic Diagram Annunciator Plant Operating Bench Board 0C653 Transfer Control - Diesel Generator E - "A" Common

Drawing Number	Title
E-331, Sheet 14B	Schematic Diagram Annunciator Plant Operating Bench Board 0C653 Transfer Control - Diesel Generator E - "C" Common
E-331, Sheet 14C	Schematic Diagram Annun. Plant Operating Bench Board 0C653 Transfer Control - Diesel Generator E - "D" Common

APPENDIX B

Codes Standards, and Regulations Applicable to Diesel Generator E Facility

This general document presents a partial listing of codes, standards, and regulations applicable to the Diesel Generator E Facility at the Susquehanna Steam Electric Station - Unit 1 and Unit 2. This listing is segregated by issuing organization, and provides the code, standard, or regulation identification, title, and effective date. Where the effective date is not given, the most recent issue in effect on September 22, 1983 will apply.

1. AMERICAN CONCRETE INSTITUTE (ACI) STANDARDS

a.	ACI-211.1	Standard Practice for Selecting Proportions for Normal and Heavyweight Concrete	1981
b.	ACI-214	Recommended Practice for Evaluation of Compression Test Results of Field Concrete	1977
c.	ACI-301	Specifications for Structural Concrete for Buildings	1981
d.	ACI-304	Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete	1978
e.	ACI-305R	Hot Weather Concreting	1977
f.	ACI-306R	Cold Weather Concreting	1978
g.	ACI-308	Standard Practice for Curing Concrete	1981
h.	ACI-309	Recommended Practice for Consolidation of Concrete	1972
i.	ACI-315 (SP-66)	ACI Detailing Manual	1980
j.	ACI-318	Building Code Requirements of Reinforced Concrete	1977
k.	ACI-347	Recommend Practice for Concrete Formwork	1978
l.	ACI-349	Code Requirements for Nuclear Safety-Related Safety-Related Concrete Structures	1980
m.	SP-2	ACI Manual of Concrete Inspection	1981

2. AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

a.	AISC	Specification for the Design, Fabrication and Erection of Structural Steel for Buildings	1978
b.	AISC	Code of Standard Practice for Steel Buildings and Bridges	1976
c.	AISC	Manual of Steel Construction	1980
d.	AISC	Specification for Structural Joints Using ASTM A325 or A490 Bolts	1978

3. AMERICAN IRON & STEEL INSTITUTE (AISI)

a. C 1008 Standards Steels Specification

b. Cold Formed Steel Design Manual 1977

4. AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

a.	A 380	Recommended Practice for Cleaning and Descaling Stainless Steel Parts, Equipment and Systems	1978
b.	ANS-52.1	American National Standard Nuclear Safety Criteria for the Design of Stationary Boiling Water Reactor Plants	1983
c.	B1.1	Unified Inch Screw Threads (UN and UNR Thread Form)	1982
d.	B2.1	Pipe Threads (Except Dryseal)	1973
e.	B16.1	Cast Iron Pipe Flanges and Flanged Fittings	1975
f.	B16.3	Malleable Iron Screwed Fittings, 150 lbs. and 300 lbs.	1977
g.	B16.5	Steel Nickel Alloy and Other Special Alloys Pipe Flanges and Flanged Fittings	1981
h.	B16.9	Steel Buttwelding Fitting	1973
i.	B16.10	Face-to-Face and End-to-End Dimensions of Ferrous Valves	1973
j.	B16.11	Socket-Welding and Threaded Forged Steel Fittings	1980
k.	B16.21	Nonmetallic Flat Gasket for Pipe Flanges	1978
l.	B16.25	Buttwelding Ends	1979
m.	B16.34	Flanged and Buttwelding End Valves, Steel, Nickel Alloy, and Other Special Alloys	1981
n.	B30.2.0	Overhead and Gantry Cranes	1976
o.	B31.1	Power Piping (Use B31.1 - 1967 for pipe supports for nuclear piping, with allowable stresses per B31.1 - 1973. Use B31.1 - 1973 for pipe supports for non-nuclear piping.)	1980
p.	B36.10	Welded and Seamless Wrought Steel Pipe	1979
pl.	B36.19	Stainless Steel Pipe	1979
q.	C1-NEC	Specification of General Requirements for a Quality Program	1968

r.	C37.04	Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical.Current Basis	1982
s.	C37.06	Preferred Ratings and Related Required capabilities for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis	1979
t.	C37.09	Test Procedures for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis	1979
u.	C37.11	Requirements for Electrical Control for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis and a Total Current Basis	1979
v.	C37.010	Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis	1982
w.	C37.20	Switchgear Assemblies, Including Metal-Enclosed Bus (IEEE 27) [includes ANSI/IEEE supplements C37.20a-1970, C37.20b-1972, and C37.20c-1974]	1969
x.	C37.98	Seismic Testing of Relays	1978
y.	C37.100	Definitions for Power Switchgear	1980
z.	C57.12.80	Terminology for Power and Distribution Transformers	1978
aa.	C57.13	Requirements for Instrument Transformers	1978
bb.	C533	Specification for Calcium Silicate Block and Pipe Thermal Insulation	1980
cc.	H35.1	Alloy and Temper Designation System for Aluminum	1982
dd.	MC96.1	Temperature Measurement Thermocouple	1982
ee.	N18.7	Administrative Controls and Quality Assurance for the Operational Phase of Nuclear Power Plants	1976
ff.	N42.2	High-Voltage Connectors for Nuclear Instruments	1971
gg.	N45.2	Quality Assurance Program Requirements for Nuclear Facilities	1977
hh.	N45.2.2	Packaging, Shipping, Receiving, Storage and Handling of Items for Nuclear Power Plants (During the Construction Phase)	1978
ii.	N45.2.5	Supplementary Quality Assurance Requirements for Installation, Inspection and Testing of Structural	1974

		Concrete and Structural Steel During the Construct-tion Phase of Nuclear Power Plants	
jj.	N45.2.6	Qualifications of Inspection, Examination, and Testing Personnel for Nuclear Power Plants	1978
kk.	N45.2.9	Requirements for Collection, Storage and Maintenance of Quality Assurance Records for Nuclear Power Plants	1974
ll.	N45.2.10	Quality Assurance Terms and Definitions	1973
mm.	N45.2.11	Quality Assurance Requirements for the Design of Nuclear Power Plants	1974
nn.	N45.2.12	Requirements for Auditing of Quality Assurance Programs for Nuclear Power Plants	1977
oo.	N45.2.13	Quality Assurance Requirements for Control of Procurement of Items and Services for Nuclear Power Plants	1976
pp.	N45.2.23	Qualifications of Quality Assurance Program Audit Personnel for Nuclear Power Plants	1978
qq.	N101.4	Quality Assurance for Protective Coatings Applied to Nuclear Facilities.	1972
rr.	N195	Fuel Oil Systems for Standby Diesel-Generators	1976
ss.	N626.3	Qualifications and Duties of Personnel Engaged in ASME Boiler and Pressure Vessel Code, Section III, Division 1 and 2, Certifying Activities.	1979

5. AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

a. Standards of the American Society for Testing and Materials

6. AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

a.	Paper No. 3269	Wind forces on Structures - Final Report of the Task Committee on Wind Forces, Committee on Loads and Stresses, Structural Division	1961

7. AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

a. ASME Boiler and Pressure Vessel Code, Section III, Nuclear Power Plant Components - 1971 Edition Through and including Winter 1972 Addendum

b. ASME Boiler and Pressure Vessel Code, Section II, 1971 or later Edition, Material Specifications, as referenced by Section III

c. ASME Boiler and Pressure Vessel Code, Section IX, Edition, Welding Qualifications, as referenced by Section III. 1983

d. ASME Boiler and Pressure Vessel Code, Section XI, 1980 Edition, through and including Winter 1980 Addendum, Rules for In-Service Inspection of Nuclear Power Plant Components Reactor Coolant Systems 1980

8. AMERICAN WATER WORKS ASSOCIATION (AWWA)

a.	D 100	Standard for Welded Steel Tanks for Water Storage	1979
b.	M 11	Steel Pipe Manual	1964

9. AMERICAN WELDING SOCIETY (AWS)

a.		Welding Handbook Six and Seventh Editions	
b.	A2.4	Symbols for Welding and Nondestructive Testing Including Brassing	1979
c.	A5.1	Spec. for Covered Carbon Steel Arc Welding Electrodes	1981
d.	A5.2	Specification & Steel Oxyfuel Gas Welding Rods	1980
e.	A5.3	Specification for Aluminum and Aluminum Alloy Covered Arc Welding Electrodes	1980
f.	A5.4	Specification for Covered Corrosion Resisting Chromium Nickel Steel Welding Electrodes	1981
g.	A5.5	Specification Low Alloy Stud Covered Arc Welding Electrodes	1981
h.	A5.6	Specification for Cooper and Copper-Alloy Covered Electrodes	1976
i.	A5.7	Specification for Copper and Copper-Alloy Bare Welding Rods and Electrodes	1977
j.	A5.8	Specification for Brazing Filler Metal	1981
k.	A5.9	Specification for Corrosion Resisting Chromium and Chromium - Nickel Steel Bare and Composite Metal Cord and Stranded Welding Rods	1981
l.	A5.10	Specification for Aluminum and Aluminum Alloy Bare Welding Rods and Electrodes	1980
m.	A5.11	Specification for Nickel and Nickel Alloy Covered Welding Electrodes	1976
n.	A5.12	Specification for Tungstem Arc Welding Electrodes	1980
o.	A5.13	Specification for Solid Surface Welding Rods and Electrodes	1980
p.	A5.14	Specification for Nickel and Nickel Alloy Bare Welding Rods and Electrodes	1976
q.	A5.15	Specification for Welding Rods and Covered Electrodes for Cast Iron	1982
r.	A5.16	Specification for Titanium and Titanium Alloy Bare Welding Rods & Electrodes	1970

s.	A5.17	Specification for Carbon Steel Electrodes and Fluxes for submerged Arc Welding	1980
t.	A5.18	Specification for Carbon Steel Filler Metals for Gas Shielded Arc Welding	1979
u.	A5.19	Specification for Magnesium Alloy Welding Rods and Bare Electrodes	1980
v.	A5.20	Specification for Carbon Steel Electrodes for Flux Covered Arc Welding	1979
w.	A5.21	Specification for Composite Surfacing Welding Rods and Electrodes	1980
x.	A5.22	Specification for Flux Cord Corrosion-Resisting Chrominum and Chromium-Nickel Steel Electrodes	1980
y.	A5.23	Specification for Low Alloy Steel Electrodes and Fluxes for submerged Arc Welding	1980
z.	B3.0	Standard Qualification Procedure	1977
aa.	D1.1	Structural Welding Code	1983

10. CONCRETE REINFORCED STEEL INSTITUTE (CRSI)

a. Manual of Standard Practice 1981

11. INSTITUTE OF ELECTRICAL & ELECTRONICS ENGINEERS (IEEE)

a.	IEEE-4	Standard Techniques for High Voltage Testing (ANSI C68.1	1978
b.	IEEE-93	Guide for Transformer Impulse Tests	1968
c.	IEEE-279	Criteria for Protection Systems for Nuclear Power Generating Systems	1971
d.	IEEE-308	Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations	1980
e.	IEEE-323	Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations	1974
f.	IEEE-334	Standard for Type Test of Continuous Duty Class 1E Motors for Nuclear Power Generating Stations	1974
g.	IEEE-336	Installation, Inspection, and Testing Requirements for Instrumentation and Electric Equipment During the Construction of Nuclear Power Generating Stations (ANSI N45.2.4)	1980
h.	IEEE-338	Standard Criteria for the Periodic Testing of Nuclear Power Generating Station Safety Systems	1977
i.	IEEE-344	IEEE Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations	1975
j.	IEEE-378	Trial Use Criteria for the Periodic Testing of Nuclear Power Generating Station Protection Systems	1971
k.	IEEE-379	Standard Application of the Single-Failure Criterion to Nuclear Power Generating Station Class 1E Systems	1977
l.	IEEE-381	Standard Criteria for Type Tests of Class 1E Modules Used in Nuclear Power Generating Stations	1977
m.	IEEE-382	Standard for Qualification of Safety-Related Valve Actuators	1980
n.	IEEE-383	Standard for Type Test of Class 1E Electric Cables, Field Splices, and	1974

		Connections for Nuclear Power Generating Stations	
o.	IEEE-384	Standard Criteria for Independence of Class 1E Equipment and Circuits	1981
p.	IEEE-387	Standard Criteria for Diesel-Generator Units Applied as Standby Power Supplies for Nuclear Generating Stations	1977
q.	IEEE-415	Guide for Planning of Pre-Operational Testing Programs for Class 1E Power Systems for Nuclear Power Generating Stations	1976
r.	IEEE-420	Standard Design and Qualification of Class 1E Control Boards, Panels and Racks used in Nuclear Power Generating Stations	1982
s.	IEEE-450	Recommended Practice for Maintenance, Testing, and Replacement of Large Load Storage Batteries for Generating Stations and Substations	1980
t.	IEEE-467	Quality Assurance Program Requirements for the Design and Manufacture of Class 1E Instrumentation and Electric Equipment for Nuclear Power Generating Stations	1980
u.	IEEE-484	Recommended Practice for Installation Design and Installation of Large Lead Storage Batteries for Generating Stations and Substations	1981
v.	IEEE-485	Recommended Practice for Sizing and Large Lead Storage Batteries for Generating Stations and Substations	1978
w.	IEEE-494	Standard Method for Identification of Documents Related to Class 1E Equipment and Systems for Nuclear Power Generating Stations	1974
x.	IEEE-498	Standard Requirements for the Calibration and Control of Measuring and Test Equipment Used in the Construction and Maintenance of Nuclear Power Generating Stations	1980
y.	IEEE-535	Standard Qualification of Class 1E Lead Storage Batteries for Nuclear Power Generating Stations	1979

z.	IEEE-603	Standard Criteria for Safety Systems for Nuclear Power Generating Stations	1980
aa.	IEEE-622	Recommended Practice for the Design Installation of Electric Pipe Heating Systems for Nuclear Power Generating Stations	1979
bb.	IEEE-627	Standard for Design Qualification of Safety Systems Equipment Used in Nuclear Power Generating Stations	1980
cc.	IEEE-649	Standard for Qualifying Class 1E Motor Control Centers for Nuclear Power Generating Stations	1980
dd.	IEEE-650	Qualifications of Class 1E Static Battery Chargers and Inverters for Nuclear Power Generating Stations	1979

12. INSTRUMENT SOCIETY OF AMERICA (ISA)

a.	.55.1	Instrumentation Symbols	1973
b.	RP 18.1	Specification and Guides for the Use of General Purpose Annunciators	1965
c.	RP 42.1	Nomenclature for Instrument Tubing Fittings	1965

13. INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

a. P-46-426 Power Cable Ampacities, Copper Conductors (IEEE S-135-1)

b. P54-440 Ampacities - Cables in Open Top Cable Trays (NEMA WC-51)

c. S-19-81 Rubber-Insulated Wire & Cable for the Transmission and Distribution of Electrical Energy (NEMA WC-3)

d. P-32-382 Short-Circuit Characteristics of Insulated Cables

e. S-66-524 Cross-Linked-Thermosetting-Polyethylene- Insulated Wire & Cable for the Transmission and Distribution of Electrical Energy (NEMA WC-7)

f. S-68-516 Ethylene-Propylene Rubber Insulated Wire and Cable for the Transmission and Distribution of Electric Energy (NEMA WC-8)

14. INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS

a. Uniform Building Code

15. NATIONAL ELECTRIC CODE (NEC)

a. National Electric Code 1981

16. NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

a.	AB1	Molded Case Circuit Breakers	1975
b.	DC-10	Temperature Limit Controls for Electric Base Board Heater	1977
c.	DC-13	Line Voltage Integrally Mounted Thermostats for Electric Heaters	1979
d.	FUI	Low-Voltage Cartridge Fuses	1978
e.	ICS	Industrial Controls and Systems	1978
f.	ICS 6	Enclosures for Industrial Controls and Systems	1978
g.	MG1	Motors and Generator	1978
h.	PB-1	Panelboards	1977
i.	PB-2	Deadfront Distribution Switchboard	1978
j.	SG3	Low-Voltage Power Circuit Breakers	1981
k.	SG4	Alternating Current High Voltage Circuit Breakers	1975
l.	SG5	Power Switchgear Assemblies	1981
m.	SG6	Power Switching Equipment	1974
n.	TR27	Commercial, Institutional and Industrial Dry-Type Transformers	1965
o.	VE1	Cable Tray Systems	1979

17. NATIONAL FIRE PROTECTION ASSOCIATION (NEPA)

a.	NEC	National Fire Codes	1981
b.	NEPA 13	Sprinkler Systems	1983
c.	NPFA 15	Water Spray Fixed Systems	1982
d.	NEPA 30	Flammable and Combustible Liquids Code	1981
e.	NEPA 37	Installation and Use of Stationary Combustion Engines and Gas Turbines	1979
f.	NFPA 72A	Local Protective Signaling Systems	1979
g.	NFPA 72D	Proprietary Protection Signaling Systems	1979
h.	NFPA 72E	Automatic Fire Detectors	1982

18. UNDERWRITERS LABORATORY (UL)

a.		Fire Protection Equipment Directory	1983
b.	UL-50	Cabinets and Boxes	1980
c.	UL-58	Steel Underground Tanks for Flammable and Combustible Liquids	1976
d.	UL-67	Panelboards	1979
e.	UL-499	Safety Standards for Electric Heating Appliances	1978
f.	UL-507	Electric Fans	1976
g.	UL-845	Standard for Motor Control Centers	1980
h.	UL-883	Safety Standards for Fan Coil Units and Room Fan Heater Units	
i.	UL-1025	Electric Air Heaters	1980
j.	UL-1042	Electric Base Board Heating Equipment	1978

19. U.S. NUCLEAR REGULATORY COMMISSION (US NRC)

a.	10 CFR 21	Reporting of Defects and Noncompliance
b.	10 CFR 50	Licensing of Production and Utilization Facilities
c.	10 CFR 50 Appendix B	Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants
d.	10 CFR 50 Appendix R Sections III.G and III.J	Fire Protection Program for Nuclear Power Facilities Operating Prior to January 1, 1979
e.	BTP 9.5-1 Appendix A	Guidelines for Fire Protection for Nuclear Power Plants
f.	NUREG 0588 Rev. 1	Interim Staff Position on Environmental Qualification of Safety Related Electrical Equipment

20. U.S. NUCLEAR REGULATORY COMMISSION (US NRC) REGULATORY GUIDES

a.	1.6 Rev. 0	Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems	3/71
b.	1.9 Rev. 2	Selection, Design and Qualification of Diesel-Generator Units Used As Standby (Onsite) Electric Power Systems at Nuclear Power Plants	12/79
c.	1.17 Rev. 1	Protection of Nuclear Power Plant Against Industrial Sabotage	6/73
d.	1.22 Rev. 0	Periodic Testing of Protection System Actuation Functions	2/72
e.	1.26 Rev. 3	Quality Group Classifications and Standards for Water, Sean, and Radio-Active-Waste-Containing Components of Nuclear Power Plants	2/76
f.	1.28 Rev. 1	Quality Assurance Program Requirements (Design & Construction)	3/78
g.	1.29 Rev. 3	Seismic Design Classification	9/78
h.	1.30 Rev. 0	Quality Assurance Requirements for the Installation, Inspection, and Testing of Instrumentation and Electric Equipment	8/72
i.	1.31 Rev. 3	Control of Ferrite Content in Stainless Steel Weld Metal	4/78
j.	1.32 Rev. 2	Criteria for Safety Related Electric Power Systems for Nuclear Power Plants	2/77
k.	1.33 Rev. 2	Quality Assurance Program Requirements (Operation)	2/78
l.	1.36 Rev. 0	Nonmetallic Thermal Insulation for Austenitic Stainless Steel	2/73
m.	1.37 Rev. 0	Quality Assurance Requirements for Cleaning of Fluid Systems and Associated Components of Water-Cooled Nuclear Power Plants	3/73

n.	1.38 Rev. 2	Quality Assurance Requirements for Packaging, Shipping, Receiving, Storage, and Handling of Items for Water-Cooled Nuclear Power Plants	5/77
o.	1.39 Rev. 2	Housekeeping Requirements for Water-Cooled Nuclear Power Plants	9/77
p.	1.41 Rev. 0	Preoperational Testing of Redundant On-Site Electric Power Systems to Verify Proper Load Group Assignments	3/73
q.	1.47 Rev. 0	Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems	5/73
r.	1.48 Rev. 0	Design Limits and Loading Combination for Seismic Category I Fluid System Components	5/73
s.	1.50 Rev. 0	Control of Preheat Temperature for Welding of Low-Alloy Steel	5/73
t.	1.53 Rev. 0	Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems	6/73
u.	1.54 Rev. 0	Quality Assurance Requirements for Protective Coatings Applied to Water-Cooled Nuclear Power Plants	6/73
ul.	1.58 Rev. 1	Qualification of Nuclear Power Plant Inspection, Examination, and Testing Personnel	9/80
v.	1.60 Rev. 1	Design Response Spectra for Seismic Design of Nuclear Power Plants	12/73
w.	1.61 Rev. 0	Dampling Values for Seismic Design of Nuclear Power Plants	10/73
x.	1.62 Rev. 0	Manual Initiation of Protective Actions	10/73
y.	1.64 Rev. 2	Quality Assurance Requirements for the Design of Nuclear Power Plants	6/76
z.	1.68 Rev. 2	Initial Test Programs for Water-Cooled Reactor Power Plants	8/78
aa.	1.74 Rev. 0	Quality Assurance Terms and Definitions	2/74

bb.	1.75 Rev. 2	Physical Independence of Electric Systems	9/78
cc.	1.76 Rev. 0	Design Basis Tornado for Nuclear Power Plants	4/74
dd.	1.81 Rev. 1	Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants	1/75
ee.	1.84 Rev. 19	Design and Fabrication Code Case Acceptability ASME Section III Division I	4/82
ff.	1.85 Rev. 19	Materials Code Case Acceptability ASME Section III Division I	4/82
gg.	1.88 Rev. 2	Collection, Storage, and Maintenance of Nuclear Power Plant Quality Assurance Records	10/76
hh.	1.89 Proposed Rev. 1	Qualification of Class 1E Equipment for Nuclear Power Plants	11/74
ii.	1.92 Rev. 1	Combining Modal Responses and Spatial Components in Seismic Response Analysis	2/76
jj.	1.93 Rev. 0	Availability of Electric Power Sources	12/74
kk.	1.94 Rev. 1	Quality Assurance Requirements for Installation, Inspection, and Testing of Structural Concrete and Structural Steel During the Construction Phase of Nuclear Power Plants	4/76
ll.	1.100 Rev. 1	Seismic Qualification of Electric Equipment for Nuclear Power Plants	8/77
mm.	1.105 Rev. 1	Instrument Setpoints	11/76
nn.	1.106 Rev. 1	Thermal Overload Protection for Electric Motors on Motor-Operated Valves	3/77
oo.	1.108 Rev. 1	Periodic Testing of Diesel Generator Units Used as Onsite Electric Power Systems at Nuclear Power Plants	8/77
pp.	1.115 Rev. 1	Protection Against Low-Trajectory Turbine Missiles	7/77

qq.	1.116 Rev. 0	Quality Assurance Requirements for Installation, Inspection, and Testing of Equipment and Systems	6/76
rr.	1.117 Rev. 1	Tornado Design Classification	4/78
ss.	1.118 Rev. 2	Periodic Testing of Electric Power and Protection Systems	6/78
tt.	1.122 Rev. 1	Development of Floor Design Response Spectra for Seismic Design of Floor-Supported Equipment or Components	2/78
uu.	1.123 Rev. 1	Quality Assurance Requirements for Control of Procurement of Items and Services for Nuclear Power Plants	7/77
vv.	1.128 Rev. 1	Installation Design and Installation of Large Lead Storage Batteries for Nuclear Power Plants	10/78
ww.	1.129 Rev. 1	Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Nuclear Power Plants	2/78
xx.	1.131 Rev. 0	Qualification Tests of Electric Cables, Field Splices, and Connections for Light-Water-Cooled Nuclear Power Plants	8/77
yy.	1.132 Rev. 1	Site Investigations for Foundations of Nuclear Power Plants	3/79
zz.	1.137 Rev. 1	Fuel-Oil Systems for Standby Diesel Generators	10/79
aaa.	1.142 Rev. 1	Safety-Related Concrete Structures for Nuclear Power Plants (other than Reactor Vessels and Containments)	10/81
aaa1.	1.144 Rev. 0	Auditing of Quality Assurance Programs for Nuclear Power Plants	1/79
aaa2.	1.146 Rev. 0	Qualification of Quality Assurance Program Audit Personnel for Nuclear Power Plants	8/80
bbb.	1.147 Rev. 2	Inservice Inspection Code Case Acceptability ASME Section XI Division I	6/83

ccc.	1.148 Rev. 0	Functional Specification for Active Valve Assemblies in Systems Important to Safety in Nuclear Power Plants	3/81
ddd.	1.151 Rev. 0	Instrument Sensing Lines	7/83

APPENDIX C

Seismic Analysis Procedure and Models for
The Diesel Generator E Building

TABLE OF CONTENTS

1. Introduction

This document describes the procedure for the development of the mathematical models of the Diesel Generator E Building and the Diesel Generator Pedestal. It also describes the procedure for the seismic analysis of the models and the development of the floor response spectral curves.

2. Dynamic Models

Two mathematical models (one horizontal and one vertical) for the Diesel Generator E Building and one mathematical model for the diesel generator pedestal are constructed for the seismic analysis purposes. The model sketches are shown in Figures 1 to 3.

The horizontal Diesel Generator E building model consists of four lumped masses (1,2,3 and 4) located at the mass centers of the penthouse roof, the main roof and the two lower floor elevations. The model has six degree-of-freedoms (DOF's) per node. This model has been used for the dynamic analyses of earthquake in two perpendicular horizontal directions. Since the model established reflects the eccentricity effect of the asymmetrical building configuration, it is capable of producing torsional response due to a horizontal earthquake.

The vertical Diesel Generator E building model is essentially the same as the horizontal model, except that is has four additional lumped masses (5,6,7 and 8) representing the flexible floors, connected by vertical springs to the four lumped masses of the building to form an eight lumped mass system. This model has been used for the vertical analysis only.

The diesel generator pedestal model has three lumped masses (1,2 and 3) located at the mass center of the diesel generator, and the top and the midpoint of the pedestal. This model has six DOF's per node and has been used for the dynamic analysis of earthquake in three perpendicular directions.

The Diesel Generator E building models and the diesel generator pedestal model were fixed at the bases in the seismic analysis. This was considered because the structures are supported on the rock foundation (Reference 1, US NRC Standard Review Plan 3.7.2) which has a relatively high Young's modulus of elasticity of approximately 3 million psi. Consequently, the soil-structure interaction effect and the interaction effect between the two structures can be ignored. The two models can therefore be analyzed separately for their dynamic responses.

2.1 Generation of Stiffness Matrices

A. Horizontal Diesel Generator E Building Model

The stiffness of the horizontal Diesel Generator E building model has been generated from a finite element model constructed for the building swalls consisting of plate and beam elements, and condesned to the lumped mass locations at floor elevations. In generating this condensed stiffness, the floor was considered to be rigid in the horizontal directions.

The computation of the model stiffness was carried out by using the MSC version of the NASTRAN program (Gibbs & Hill Program No. 3030).

The model stiffness obtained above represents the gross stiffness of the building. This model does not include additinal DOF's to represent the lateral vibrations of the wall panels. The amplification effect due to the lateral flexibility of a wall panel was therefore separately evaluated using a single DOF system as described in Section 7.2.

B. Vertical Diesel Generator E Building Model

The stiffness of the vertical Diesel Generator E building model consists of two parts. The first part is contributed from the building walls and is identical to that of the horizontal model described above. The second part is the stiffnesses of the floor slabs in the vertical direction which are represented by the vertical springs attached to the lumped mass points at the floor elevations (see Figure 2).

In order to derive the vertical spring for a floor, a separate finite element model of the floor is constructed by using beam and plate elements and the floor frequencies are analyzed. The spring constant is then computed based on the floor frequency and the vertical effective floor mass derived in Section 2.2B.

C. Diesel Generator Pedestal Model

The stiffness of the Diesel Generator pedestal model was computed based on the elastic beam theory. The diesel generator is connected to the top of pedestal by an equivalent beam. The equivalent beam properties were evaluated such that the vibrational frequencies of the diesel generator model itself in the horizontal and vertical directions are equal to the given frequencies of 29 Hz and 33 Hz, respectively (Reference 8).

2.2 Computation of Mass Matrices

A. Horizontal Diesel Generator E Building Model

The masses and mass moments of inertia of the horizontal Diesel Generator E building model were evaluated at the four lumped mass points (1,2,3 and 4) located at the mass centers on the four floor elevations. Described below is the information which has been considered in the computation of these lumped masses:

A.1 The structural mass of the building including floors and walls

A.2 The masses of major equipment on each floor

A.3 The effective masses for the line loads considered to be one-eighth of the full live loads (L) listed below (Reference 2):

On Roof	L=30	psf to account for snow and ice
On elevated floors	L=200	psf (excluding 50 psf as described below in Item A.4)

A.4 The mass equivalent to the uniform load of 50 psf on concrete floors to account for piping, electrical trays and ducts (Reference 2)

The masses on each floor as described above in Items A.2 to A.4 and the structural mass of the floor in Item A.1 were lumped to the mass center on that floor. The structural mass of the walls between the two floor elevations was divided and lumped to the mass centers on the two adjacent floor.

The full live loads (L) described above are not expected to occur simultaneously with the design earthquakes, and most of them will be absent during the plant operation. One-eighth of these loads considered as effective and included in the modeling is intended to simulate the dynamic characteristics of the structure (frequencies and mode shpaes) so that the overall dynamic responses (accelerations and response spectra) can be realistically predicted.

B. Vertical Diesel Generator E Building Model

The masses and mass moments of inertia (at lumped mass points 1,2,3 and 4) of the vertical Diesel Generator E building model are the same as those of the horizontal model described above, except that the vertical mass compoents were reduced by the amounts of effective floor masses described below. These effective floor masses were attached to the top of the springs (at lumped mass points 5,6,7 and 8) mentioned above in Section 2.1B.

The effective mass for each floor was evaluated by equating the kinetic energy of the fundamental mode of vibration of the entire floor in the vertical direction to the kinetic energy of the equivalent one-mass system consisting of the effective mass. This statement can be formulated as follows:

in which m are the nodal masses, v = wxd , v = wxd , and w is the fundamental frequency of the floor. d are the components of the fundamental eigenvector and d is the maximum value of d . The above equation can be simplified to:

from which the equivalent mass M was evaluated.

C. Diesel Generator Pedestal Model

The diesel generator mass was lumped to the nodal point located at the mass center of the diesel generator. Appropriate structural masses were computed and lumped to the two nodal points (2 and 3) representing the pedestal.

The mass associated with the upper portion of the pedestal was lumped to the top of pedestal. This will slightly lower the frequencies of the diesel generator pedestal system, and is therefore considered to be a conservative approach from the seismic analysis point of view.

3. Modal Frequencies and Participation Factors of the Models

Free vibration analyses have been separately performed on the Diesel Generator E building models and diesel generator pedestal model to obtain the natural frequencies and modal participation factors. The MSC/NASTRAN program was used to carry out the computation.

4. Structural Damping Values

The percents of critical damping considered for the reinforced concrete structure (Reference 6) are:

4 % for Operating Basis Earthquake (OBE) case

7 % for Safe Shutdown Earthquake (SSE) case

5. Seismic Input

5.1 Ground Design Response Spectra

The maximum horizontal and vertical ground accelerations considered are 0.1 g for SSE and 0.05 g for OBE. The horizontal and vertical design response spectral curves used in the analysis are based on the spectral curves defined in the US NRC Regulatory Guide 1.60 (Reference 3) scaled down to match the above maximum ground accelerations.

5.2 Ground Motion Time Histories

One horizontal and one vertical synthetic ground motion time histories compatible with the ground design response spectra were generated for the time history analysis of the models in order to develop floor response spectra. Response spectra at the damping values of 1%, 2%, 5%, 7% and 10% were developed using these time histories and compared with the ground design response spectra (Reference 7).

6. Seismic Analysis by Modal Response Spectrum Method

The lumped mass models of the Diesel Generator E building and the diesel generator pedestal have been separately analyzed for the following earthquake cases by employing the modal response spectrum method to determine the structural responses.

SSE - X earthquake

SSE - Y earthquake

SSE - Z earthquake

OBE - X earthquake

OBE - Y earthquake

OBE - Z earthquake

where X and Z are along the N-S and E-W directions respectively, and Y is along the vertical direction.

The analyses have been performed by using the computer program MSC/NASTRAN (Gibbs & Hill Program Nos. 3030). The ground response spectral curves described in Section 5 were used as input loads. The program computed structural responses (accelerations and relative displacements) mode by mode and combine the modal responses by means of the SRSS method according to the US NRC Regulatory Guide 1.92 (Reference 4). The analysis results obtained were used for the seismic design of the structures.

7. Development of Floor Response Spectra

7.1 Time History Analyses of Dynamic Models

In order to develop response spectra, time history analyses were first performed on the dynamic models. The input to the analysis are the modal shapes, frequencies, participation factors (see Section 3), and the ground motion time histories described in Section 5. The resulting time histories were obtained at each lumped mass location of the models.

Additional time histories were generated at the crane runway girder location by using a separate local crane runway model that includes the flexibilities of the runway girders and supporting columns. The input loads to this model are the time history responses of the upper supporting floor. The resulting time histories generated at the runway girder locations were used to develop response spectra for the crane design.

The above analyses have been performed for the same earthquake cases as mentioned in Section 6. The time step size of 0.005 seconds was used in the numerical integration.

7.2 Development of Floor Response Spectral Curves

The acceleration time history responses generated from the time history analysis described in Item 7.1 above were used to develop floor response spectra. The maximum time step siz used in this analysis is 0.005 seconds.

The floor response spectra were generated at sufficient discrete frequency points obtained in accordance with the requirements of the US NRC Regulatory Guide 1.122 (Reference 5), and at the damping values (percents of critical damping) listed below:

for OBE: 0.5%, 1%, 2%, 3%, 4%, and 5%

SSE: 1%, 2%, 3%, 4%, 5%, and 7%

The computer program RESPECT (Gibbs & Hill Program No. 3914) was used to carry out the numerical computation.

The response spectra developed at each floor elevation in a specific direction for the three orthogonal earthquakes were combined by the SLSS method.

As mentioned in Section 2.1A, the horizontal Diesel Generator E building model does not reflect the local lateral flexibilities of the wall panels. The horizontal response spectrum of a wall in the lateral direction was therefore separately analyzed by using a single DOF system and the time history at the upper supporting floor elevation as input. The maximum response was then obtained by enveloping the horizontal response spectra developed from both the wall and the building models.

The resulting response spectra obtained above were then smoothened and broadened by 15% on each side of the response spectral peaks to become the final response spectral curves. These final spectral curves were used for the analysis and design of the piping and equipment inside the building.

8. Computer Programs

The computer programs, briefly described below, have been used in the above seismic analyses.

A. MSC/NASTRAN (Gibbs & Hill Program No. 3030), from Macneal-Schwendler Corporation, is a general purpose finite element computer program for the solution of static, dynamic, transient, stability, and heat transfer problems in structural engineering and other allied fields. Current version number for IBM machine is 61.

B. RESPECT (Gibbs & Hill Program No. 3914), by Gibbs & Hill, Inc., is a response spectra generation program. It can be used to generate response spectral values, plot spectral curves on linear or semi-logarithemic scales, smooth and broaden the curves on each sides of spectral peaks.

The above mentioned Gibbs & Hill in-house programs have been verified and documented in accordance with Gibbs & Hill QA procedure. The verification includes checking of basic formulation, comparison of the analysis results from a few sample runs with the results from either hand computation or the analyses based on other verified computer programs.

9. References

1. US NRC Standard Review Plan, Section 3.7.2 - Seismic System Analysis, Rev. 1, July 1981

2. PP&L Specification G-1001 - Design Input Technical Specification for New Emergency Diesel Generator Facility, Rev. 1, September 22, 1983

3. US NRC Regulatory Guide 1.60 - Design Response Spectra for Seismic Design of Nuclear Power Plants, Rev. 1, December 1973

4. US NRC Regulatory Guide 1.92 - Combining Modal Responses and Spatial Components in Seismic Response Analysis, Rev. 1, February 1976

5. US NRC Regulatory Guide 1.122 - Development of Floor Design Response Spectra for Seismic Design of Floor-Supported Equipment or Components, Rev. 1, February 1978

6. US NRC Regulatory Guide 1.61 - Damping Values for Seismic Design of Nuclear Power Plants, October 1973

7. US NRC Standard Review Plan, Section 3.71 - Seismic Input, June 1975

8. PP&L Letter G&H/EDG-132, "Natural Frequency of the E Diesel Generator", dated February 28, 1984

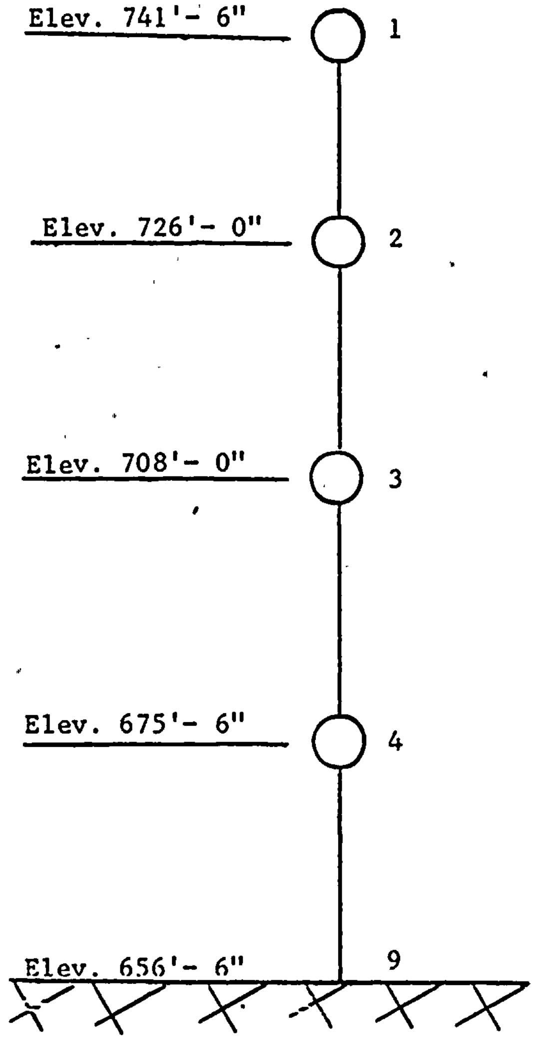

FIGURE 1

HORIZONTAL DIESEL GENERATOR E BUILDING MODEL

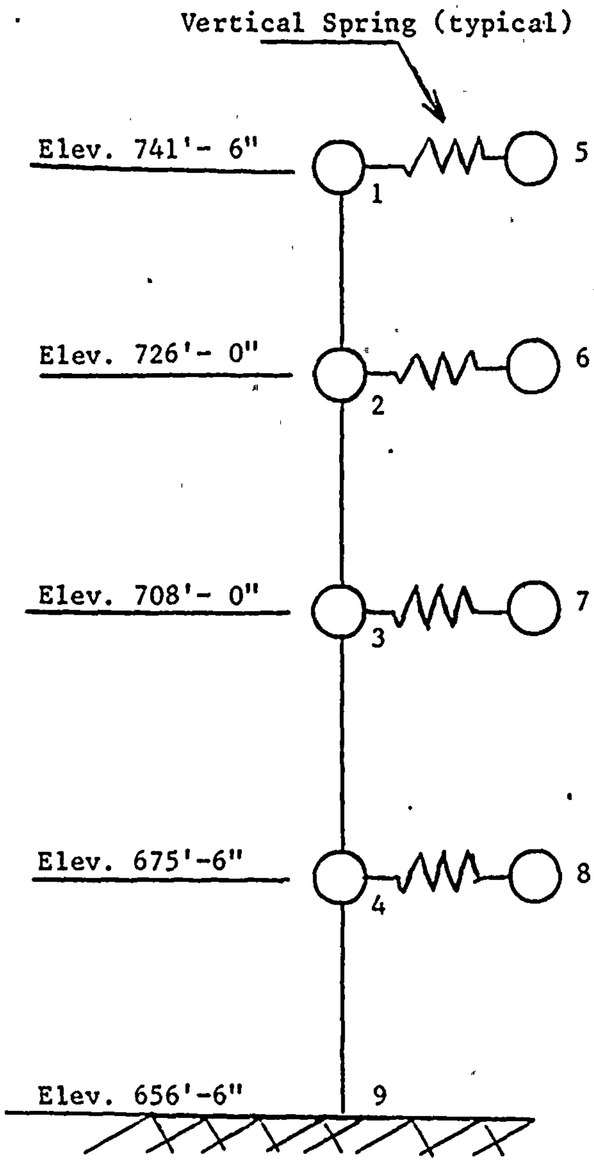

FIGURE 2

VERTICAL DIESEL GENERATOR E BUILDING MODEL

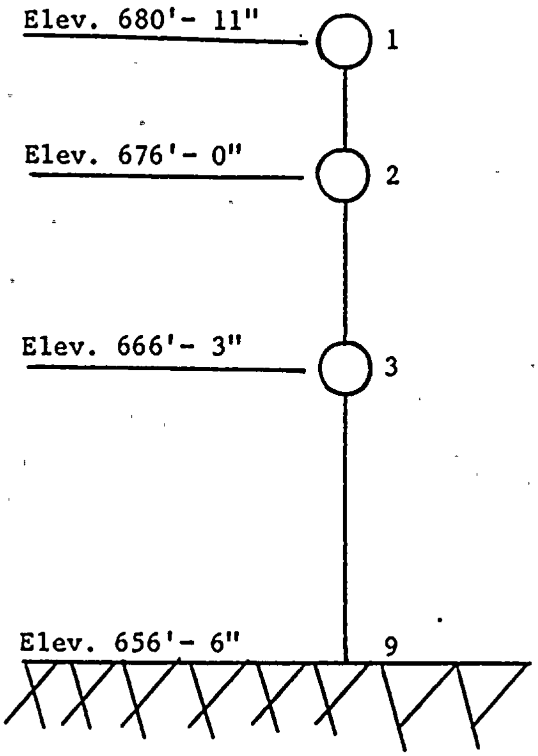

FIGURE 3
DIESEL GENERATOR E PEDESTAL MODEL

SUSQUEHANNA STEAM ELECTRIC STATION, UNITS 1 AND 2

PENNSYLVANIA POWER & LIGHT COMPANY

GIBBS & HILL PROJECT 3544

THIS DOCUMENT COVERS NUCLEAR

SAFETY RELATED STRUCTURES

DESIGN CRITERIA

FOR

CIVIL/STRUCTURAL WORK FOR

NEW EMERGENCY DIESEL GENERATOR FACILITY

3544-SDC-001
ISSUE NO. 0
JANUARY 1984

GIBBS & HILL, INC.
ENGINEERS, DESIGNERS, CONSTRUCTORS
NEW YORK, NEW YORK

CONTENTS

1.0 GENERAL DESCRIPTION

The design criteria presented herein are intended to cover the structural design and civil design work associated with the construction of the new Emergency Diesel Generator (EDG) Facility of the Susquehanna Steam Electric Station.

Specifically the criteria cover the design of the following major components of the new EDG facility.

a. Emergency Diesel Generator building structure

b. Foundation and the manhole cover for the underground diesel fuel oil storage tank.

c. Underground electrical duct banks.

d. Site civil work consisting of access and patrol roads, paved areas, storm drainage system and final grading.

e. Any other seismic Category I structural components.

All of the above components except item 'd' are safety related.

1.1 Description of Safety Related Structures

1.1.1 Emergency Diesel Generator (EDG) Building:

The EDG building is a Seismic Category 1, two-story structure with a basement, consisting primarily of reinforced concrete walls, floor slabs, and roof. The diesel generator pedestal is also of reinforced concrete. The building together with the pedestal is founded on sound rock. A gap between the building floor and the pedestal at grade level is provided so that no vibrations from the diesel generator are transmitted to the building.

A portion of outer wall shall be designed to be removable in order to facilitate the diesel generator installation and/or emergency removal of DG for maintenance.

1.1.2 Underground Diesel Fuel Oil Storage Tank Support Structure:

The foundation slab and the cover for the tank manhole are of reinforced concrete construction.

2.0 CIVIL AND SITE WORK DESIGN CRITERIA

2.1 Plant Datum and Orientation

a. Plant datum corresponds to U.S. Geological Survey Mean Sea Level (MSL) datum. Approximate plant grade is 675 above MSL.

b. Plant North corresponds to true north.

c. Horizontal control shall conform to the Pennsylvania State Grid System currently in use at the site.

2.2 Design Depth for Frost Protection

Bottoms of all foundations shall be located at a minimum depth of 4 feet below the grade. All water piping shall have a minimum cover of 4 ft. 6 in.

2.3 Design Elevation of Ground Water

At plant structures - 665 ft. above MSL.

2.4 Roadways

a. Minimum lane width - 10 ft.

b. Maximum grade - 9%

c. Road alignment and geometry shall be based on the turning movements of expected operations and maintenance vehicles, but not smaller than standard AASHTO 50 feet long semitrailer.

2.5 Site Drainage

2.5.1 Design Flow

Runoff flow shall be calculated by the rational formula: $Q = C\ i\ A$
where the precipitation intensity, i shall be determined as follows:

a. For drainage ditches and culverts, precipitation intensity shall be derived from rainfall intensity-duration curves for Scranton, Pennsylvania, 1903-1951, Technical Paper No. 25, published by the U.S. Department of Commerce.

Return period of 25 years shall be assumed for all culverts.

b. For yard storm sewers, precipitation intensity shall be assumed as 6 in. per hour on building roofs.

2.5.2 Design Velocity and Size

a. Minimum diameter of main yard storm sewers - 8 in.
b. Minimum diameter of laterals - 4 in.
c. Minimum design velocity - 2 fps.

2.5.3 External Loads

Culverts and storm sewers beneath roads shall be designed for H20-S16 live loading.

2.6 Earthwork Slopes

a. Maximum earth embankment slopes - 1-1/2 Horiz. to 1 Vert.

b. Recommended rock slopes - 1 Horiz. to 4 Vert.

3.0 DESIGN CRITERIA FOR CATEGORY I STRUCTURES

3.1 Design Loads

The following loads shall be considered in the design of seismic Category I structures:

3.1.1 D = Dead load of structure and any permanent equipment. Hydrostatic loads shall be considered as dead loads.

3.1.2 L = Live Loads

Live loads are conventional floor or roof live loads, including live loads resulting from moving of equipment components, snow, etc. Soil pressure loads due to fluctuations of ground water elevation and due to surcharge, shall be considered as live loads. An allowance of 50 pounds per square foot (lbs./ft.^{2}) is included in the floor live loads specified below, to account for the support of hung loads such as piping, electrical conduits and trays and heating, ventilation and air conditioning (HVAC) ducts.

3.1.2.1 The following values of live load shall be used unless more realistic uniform or concentrated loads are determined after equipment information has been evaluated:

Roof	- 30 psf
Ground and elevated floors	- 250 psf
Exhaust pipe enclosure room	- 150 psf
Grating and checkered plate floors and platforms	- 100 psf
Stairways and walkway	- 100 psf
Stair hand rails and guard rails	- 25 pounds/linear foot applied at top of railing or 200 pounds concentrated load applied in any direc-

tion at top of railing.

Surcharge outside and adjacent to structures - 250 psf

3.1.2.2 Supplementary Concentrated Live Loads:

a. In addition to the specified uniform live loads, the beams and girders shall be designed for the concentrated load of 5 kips. This load shall be applied at points of maximum moment and shear. However, it is not cumulative and is not carried to columns and shall not be considered in access control areas.

b. The slabs shall be designed for a concentrated load of 5 kips distributed over an area of 3 square feet at the points of maximum moment and shear, or uniform live loads specified in Section 3.1.2.1, whichever is greater. The concentrated load is not cumulative and is not carried to columns and shall not be considered in control access areas.

3.1.2.3 When designing floor members in areas where fixed equipment will be located and where the operating weight of the equipment will be larger than the floor design live load, the floor members shall be designed taking into consideration the floor area covered by the equipment to be loaded by the equipment weight, and the surrounding floor area to be loaded by the design live load.

3.1.2.4 Impact Loads and Dynamic Loads

Crane lifted load shall be increased 25 percent to account for impact. The crane girder shall be designed to carry the dead load and lifted load as well as a lateral load of 20 percent of the combined weight of the lifted load and the weight of the crane trolley applied one-half on each side of the runway and at the top of rail. The crane girder shall also be designed for a longitudinal load of 10 percent of the maximum wheel load applied at the top of the rail. Supports for hoists and monorails shall be designed assuming the nominal vertical load capacity increased by 15 percent to allow for impact. The above noted impact loads shall not be assumed to act concurrently with seismic loads.

3.1.3 Wind and Tornado Loading

The structural components of new EDG facility shall be designed for wind and tornado loading with appropriate load combinations specified in Sections 3.2 and 3.3.

3.1.3.1 W = Wind Load

The design wind velocity for the EDG Building is 80 miles per hour for a 100 year recurrence interval. The corresponding wind pressure with considerations for height variations and shape coefficients shall be calculated in accordance with American Society of Civil Engineers (ASCE) Paper No. 3269, "Wind Forces on Structures - Final Report of the Task Committe on Wind Forces, Committee on Loads and Stresses, Structural Division".

The vertical wind velocity distribution and corresponding effective wind pressures to be used on building walls are as shown on the following table:

Wind Load on Structures

Height Zone	Basic Wind Velocity	Dynamic Pressure	WIND LOADS Windward Pressure	Leeward Suction	Total Des. Pressure	Suction on Roof
Feet	MPh	q (psf)	0.8q	0.5q	1.3q	0.6q
0-50	80	20	16	10	26	12
50-150	95	30	24	15	39	18

3.1.3.2 W_t = Tornado load:

The structural components of EDG facility shall be designed to withstand the effect of the Design Basis Tornado as outlined in Reg. Guide 1.76. Tornado loading shall include (a) Dynamic Wind, (b) Differential

Pressure and (c) Tornado Generated Missiles. Total tornado loading shall be determined using the following design parameters:

a. W_w = Dynamic wind loading

Wind speeds corresponding to tornado conditions shall be as follows:

Maximum wind speed	- 360 mph
Rotational wind speed	- 290 mph
Translational wind speed	- 70 mph (maximum) 5 mph (minimum)

b. W_p = Differential pressure loading

The differential pressure shall be assumed to vary from zero to 3 psi at the rate of 2 psi per second, remain at 3 psi for 2 seconds and then return to zero psi at 2 psi/second.

c. W_m = Tornado generated missile load

For design parameters for tornado generated missiles including missiles to be considered, see Section 3.1.4.1.

d. Total tornado load:

Total tornado load shall be calculated using following combinations:

I. $W_t = W_w$

II. $W_t = W_p$

III. $W_t = W_m$

IV. $W_t = W_w + 0.5W_p$

V. $W_t = W_w + W_m$

VI. $W_t = W_w + 0.5W_p + W_m$

3.1.4 Missile Protection Loads

The individual postulated missile shall be evaluated and adequate missile protection shall be provided to prevent perforation and spalling of the inside face of the missile barrier walls. The methodology used in designing missile barriers shall be in agreement with the procedures outlined in the Standard Review Plan Section 3.5.3, "Barrier Design Procedures", Rev. 1.

Following two categories of missile loads shall be considered:

3.1.4.1 W_m = Tornado Generated Missile Load

Following tornado generated missile parameters shall be used in calculating missile loads:

Missile	Weight (lb)	Impact Velocity (fps)
A) Wood plank, 4 in. x 12 in. x 12 ft., traveling end-on	108	440
B) Steel pipe, 3 in. dia., Schedule 40, 10 ft. long, traveling end-on	72	147
C) Steel pipe, 6 in. dia., Schedule 40, 15 ft. long	285	170
D) Steel pipe, 12 in. dia., Schedule 40, 15 ft. long	750	155
E) Steel rod 1-inch dia. x 3 ft. long	8	317
F) Automobile flying through the air at not more than 25 ft. above the ground and having contact area of 20 sq. ft.	4000	195
G) Utility pole 13.5 in. dia,		

Missile	Weight (lb)	Impact Velocity (fps)
35 ft. long	1490	211

Note:

The vertical velocities will be considered equal to 80 percent of the horizontal velocities mentioned above.

3.1.4.2 W_{ms} = Site Proximity Missile Loads

Following parameters shall be used in calculating site proximity missile loads:

SITE PROXIMITY MISSILE PARAMETERS

Missile	Weight	Impact Velocity:
A) Rifle bullet fired by vandals	2 oz.	2667 fps
B) Fragment from a truck explosion	6 oz. fragment	15 fps

3.1.5 Seismic Loads

The following two magnitudes of earthquake shall be considered.

3.1.5.1 E = Loads generated by operating basis earthquake (OBE)

3.1.5.2 E' = Loads generated by safe shutdown earthquake (SSE)

3.2 Loading Combinations-Reinforced Concrete Structures:

The following combinations of service and factored loadings shall be considered in the design of reinforced concrete seismic Category I structures. U is the requried ultimate load capacity of the structure as defined in American Concrete Institute (ACI) Standard 349-76. In determining the most critical loading condition to be used for design, the absence of a load or loads shall be considered as appropriate.

3.2.1 Service Load Combinations:

a. $U = 1.4D + 1.7L$

b. $U = 1.4D + 1.7L + 1.9E$

c. $U = 1.4D + 1.7L + 1.7W$

d. $U = 1.2D + 1.9E$

e. $U = 1.2D + 1.7W$

Where soil or hydrostatic pressures are present and have been included in L and D, in addition to all the preceding combinations, the requirements of Sections 9.2.4 and 9.2.5 of ACI 318.77 shall be satisfied.

3.2.2 Factored Load Combinations

a. $U = 1.0D + 1.0L + 1.0E'$

b. $U = 1.0D + 1.0L + 1.0W_t$

c. $U = 1.0D + 1.0L + 1.0W_{ms}$

3.2.3 Regarding preceding loads which are variable, the full range of variation shall be considered in order to determine the most critical combination of loading.

3.3 Loading Combinations-Structural Steel

The following combinations of loadings shall be considered in the design of structural steel seismic Category I structures. S is the required section strength based on the elastic design methods and the allowable stresses defined in Part I of American Institute of Steel Construction (AISC) Specification for the Design, Fabrication and Erection of Structural Steel for Buildings, November, 1978, except that the 33-percent increase in allowable stresses for seismic or wind loadings will not be permitted. In determining the most critical loading condition to be used in design, the absence of a load or loads shall be considered as appropriate.

3.3.1 Service Load Combinations

a. S = D + L

b. S = D + L + E

c. S + D + L + W

3.3.2 Factored Load Combinations

a. 1.6S = D+L+E'

b. $1.6S = D+L+W_t$

c. $1.6S = D+L+W_{ms}$

3.4 Factor of Safety

For all structures, minimum factor of safety against overturning, sliding and flotation shall be maintained as follows:

Load Combination	Minimum Factor of Safety: Overturning	Sliding	Flotation
a. D+H+W	1.5	1.5	-
b. $D+H+W_t$ or $D+H+W_{ms}$	1.1	1.1	-
c. D+H+E	1.5	1.5	-
d. D+H+E'	1.1	1.1	-
e. D+F	-	-	1.1

H = Lateral earth pressure

F = Buoyant Force due to ground water pressure

3.5 Methods of Analysis and Design

3.5.1 Static analysis and design of structures shall be consistent with generally accepted engineering practice and shall be by methods suitable for hand analysis. The seismic analysis of new EDG Building shall be performed by using computer programs. For description of seismic analysis procedure, see document No. 3544-SDC-002.

3.5.2 All steel structures shall be designed by working stress methods in accordance with Part I of American Institute of Steel Construction's specification for Design, Fabrication and Erection of Structural Steel for Buildings.

3.5.3 Reinforced Concrete Structures shall be designed by Ultimate Strength Design method in accordance with American Concrete Institute's "Code Requirements for Nuclear Safety Related Concrete Structures" (ACI 349-~~76~~ 80).

3.6 Materials

3.6.1 Concrete

Minimum compressive strength of concrete at 28 days for various structures and its applications shall be as follows:

Item	Design Strength f'c (psi)
Structural Concrete: Mat foundation, walls, slabs, etc.	4000
Mass Concrete fill, mud mat and duct banks	2000

3.6.2 Reinforcing Steel shall be deformed billet steel of Grade 60 conforming to ASTM A615.

3.6.3 Structural Steel shall conform to ASTM-A36 or other ASTM desginations listed in Section 1.4.1.1 of AISC Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings, where considered necessary.

3.6.4 Anchor bolts shall be unfinished bolts conforming to requirements of ASTM A307 or threaded rods conforming to ASTM A36. Bolt material conformfing to other ASTM standards will be used as required.

3.6.5 Welding electrodes shall be E70XX and all welding shall be in accordance with AWS D1.1.

4.0 APPLICABLE CODES, STANDARDS AND SPECIFICATIONS

4.1 Code Requirements for Nuclear Safety Related Concrete Structures (ACI 349-~~76~~80) shall be used for design of reinforced concrete structures.

4.2 Building Code Requirements for Reinforced Concrete ACI 318-77 shall be used as supplement to ACI349-~~76~~80 for items not covered in ACI 349-~~76~~80

4.3 AISC Specification for the Design, Fabrication and Erection of Structural Steel for Buildings, Eighth Edition, shall be used for the design of steel structures.

4.4 American Association of State Highway and Transportation Officials (AASHTO)

4.5 Form 408 specifications - Department of Transportation - Commonwealth of Pennsylvania.

4.6 American Welding Society (AWS) -"Structural Welding Code" AWS D1.1-81.

4.7 US NRC Regulatory Guide 1.142, Revision 1 - Safety-Related Concrete Structures for Nuclear Power Plants (other than Reactor Vessels and Containments).

5.0 QUALITY CONTROL PROCEDURES

The design shall comply with the Gibbs & Hill Quality Assurance Manual and the exceptions to it stated in the Project Guide.

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3.3.1 WIND LOADINGS

REVIEW RESPONSIBILITIES

Primary - Structural Engineering Branch (SEB)

Secondary - None

I. AREAS OF REVIEW

The following areas relating to the design of structures that have to withstand the effects of the design wind* specified for the plant are reviewed to assure conformance with the requirements of General Design Criterion 2 (Ref. 1).

1. The design wind velocity and its recurrence interval, the velocity variation with height, and the applicable gust factors are reviewed from the standpoint of use in defining the input parameters for the structural design criteria appropriate to account for wind loadings. The bases for the selection and the values of these parameters are within the review responsibility of the Meteorology Section of the Accident Evaluation Branch (AEB) as stated in SRP Sections 2.3.1 and 2.3.2.

2. The procedures that are utilized to transform the design wind velocity into an effective pressure applied to structures are reviewed taking into consideration the geometrical configuration and physical characteristics of the structures and the distribution of wind pressure on the structures.

II. ACCEPTANCE CRITERIA

SEB accepts the design of structures that must withstand the effects of the design wind load if the relevant requirements of General Design Criterion 2 concerning natural phenomena are complied with. The criteria necessary to meet the relevant requirements of GDC 2 are as follows:

*Referred to as 100-year return period "fastest mile of wind" in SRP Section 2.3.1.

Wind velocities of 80 MPH (0-50 Ft.) and 95 MPH (50-150 Ft.) were used in the design of the Diesel Generator (DG) "E" building. These are the same wind velocities used in the design of all existing Category I structures. Refer to Susq. SES's FSAR Section 3.3.1.1. A gust factor of 1.1 was used for ASCE paper No. 3269 entitled "Wind Forces on Structures".

These wind velocities were transformed into equivalent pressures using the expression provided in this SRP section.

The various pressure loads applied are presented in Ref. 3, Page 6. These are the same pressure loads used in the design of all existing Category I Structures.

1. The wind used in the design shall be the most severe wind that has been historically reported for the site and surrounding area with sufficient margin for the limited accuracy, quantity, and period of time in which historical data has been accumulated.

2. The acceptance criteria for the design wind velocity and its recurrence interval, the velocity variation with height, the applicable gust factors, and the bases for determining these site-related parameters, are established by the Accident Evaluation Branch (AEB) and are contained in SRP Sections 2.3.1 and 2.3.2. The approved values of these parameters should serve as basic input to the review and evaluation of the structural design procedures.

3. The procedures utilized to transform the wind velocity into an effective pressure to be applied to structures and parts and portions of structures, as delineated in ANSI A58.1, "Building Code Requirements for Minimum Design Loads in Buildings and Other Structures" (Ref. 2), are acceptable. In particular, the procedures utilized are acceptable if found in accordance with the following:

   For a design wind velocity of V_{30} mph specified at a height of 30 feet above the ground, the velocity pressure, q_{30}, is given by:

$$q_{30} = 0.00256\ V_{30}^2 \text{ psf}$$

   The effective pressure for structures, q_F, and for portions thereof, q_p, at various heights above the ground should be in accordance with Table 5 and Table 6 of ANSI A58.1, respectively. Since most nuclear power plants are located in relatively open country, Exposure C, as defined in ANSI A58.1, should be selected for both tables.

   Depending upon the structure geometry and physical configuration, pressure coefficients may be selected in accordance with Section 6.4 of ANSI A58.1. Geometrical shapes that are not covered in this document are reviewed on a case-by-case basis. ASCE Paper No. 3269, "Wind Forces on Structures" (Ref. 3), may be used to obtain the effective wind pressures for cases which ANSI A58.1 does not cover.

III. REVIEW PROCEDURES

The reviewer selects and emphasizes material from the review procedures described below as may be appropriate for a particular case.

1. The site-related parameters described in subsection I.1 are reviewed by the Accident Evaluation Branch (AEB) under SRP Sections 2.3.1 and 2.3.2. The structural reviewer examines the approved values of these parameters to assure that they are consistent with those contained in SRP Sections 2.3.1 and 2.3.2.

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3.3.2 TORNADO LOADINGS

REVIEW RESPONSIBILTIES

Primary - Structural Engineering Branch (SEB)

Secondary - None

I. AREAS OF REVIEW

The following areas relating to the design of structures that have to withstand the effects of the design basis tornado specified for the plant are reviewed to assure conformance with the requirements of General Design Criterion 2 (Ref. 1).

1. The design parameters applicable to the tornado, including the tornado wind translational and tangential velocities, the tornado-generated pressure differential and its associated time interval, and the spectrum of tornado-generated missiles including their characteristics, are reviewed from the standpoint of use in defining the input parameters for the structural design criteria appropriate to account for tornado loadings. The bases for the selection and the values of these parameters are within the review responsibility of the Accident Evaluation Branch (AEB) as stated in SRP Sections 2.3.1, 2.3.2, and 3.5.1.4.

2. The procedures that are utilized to transform the tornado parameters into effective loads on structures are reviewed, including the following:

   a. The transformation of the tornado wind into an effective pressure applied to structures, taking into consideration the geometrical configuration and physical characteristics of the structures and the distribution of wind pressure on the structures.

   b. If venting of a structure is used, the procedures for transforming the tornado-generated differential pressure into an effective reduced pressure are reviewed by the Auxiliary Systems Branch (ASB) upon SEB request.

1&2) The tornado design for DG "E" building is per Reg. Guide 1.76 for Region I.

Maximum Wind Speed	360 MPH
Rotational Speed	290 MPH
Max. Translational Speed	70 MPH
Min. Translational Speed	5 MPH
Radius of Maximum Rotational Speed	150 Ft.
Pressure Drop	3.0 PSI
Rate of Pressure Drop	2.0 PSI/Sec

(See Ref. 1, Page 3.3-2 - 3.3-4 and Ref. 3, Pages 6 and 7.)

3. i) The tornado wind velocity was transformed into an equivalent pressure using the expression provided in this SRP section.

ii) The tornado wind velocity was taken to be constant with height.

iii) Applied tornado wind pressures are calculated using the maximum tornado wind velocity.

c. The transformation of tornado-generated missile loadings, which are impactive dynamic loads, into effective loads.

d. The combination of the above individual loadings in a manner that will produce the most adverse total tornado effect on structures.

3. The information provided to demonstrate that failure of any structure or component not designed for tornado loads will not affect the capability of other structures or components to perform necessary safety functions.

II. ACCEPTANCE CRITERIA

SEB accepts the design of structures that must withstand the effects of the design tornado wind load and the associated missiles if the relevant requirements of General Design Criterion 2 concerning natural phenomena are complied with. The criteria necessary to meet the relevant requirements of GDC 2 are as follows:

1. The tornado wind and associated missiles generated by the tornadic winds used in the design shall be the most severe wind that has been historically reported for the site and surrounding area with sufficient margin for the limited accuracy, quantity, and period of time in which historical data has been accumulated.

2. The acceptance criteria for the tornado wind velocity, the differential pressure and its associated time interval, the spectrum of tornado-generated missiles and their characteristics, and the bases for determining these parameters, are established by the Accident Evaluation Branch (AEB) as described in SRP Sections 2.3.1, 2.3.2, and 3.5.1.4. The approved values of these paramenters should serve as basic input to the review and evaluation of the structural design procedures.

3. The acceptance criteria for the procedures used to transform the tornado parameters into effective loadings on structures are as follows:

   a. For transforming the tornado wind velocity into an effective pressure applied to structures, the criteria delineated in either the American Society of Civil Engineers (ASCE) Paper No. 3269, "Wind Forces on Structures" (Ref. 2), or in ANSI A58.1, "Building Code Requirements for Minimum Design Loads in Buildings and Other Structures" (Ref. 3), are, in general, acceptable. In particular, the following shall apply:

      (i) The maximum velocity pressure, p, should be based upon the maximum tornado velocity, V, using the following formula:

      $$p = 0.00256\ V^2 \text{ psf, in which V is in mph.}$$

      (ii) The velocity pressure should be assumed constant with height.

      (iii) The maximum velocity pressure, p, applies at the radius of the tornado funnel at which the maximum velocity occurs. The tangential velocity varies with the radial distance from the center of the tornado core. The variation may be considered in accordance with that described in the paper, "Tornado Resistant Design of Nuclear Power Plants" (Ref. 4).

iv) Shape and pressure coefficients are taken from ASCE Paper No. 3269.

A gust factor of unity is used.

b. Venting of the DG "E" building is not used to reduce the tornado-generated differential pressure. The full 3 PSI differential pressure is applied as a static load.

c. Equivalent static loads were determined using Ref. 7 of SRP 3.5.3. Allowable ductility ratios were taken from AC1-349. The modified NDRC formula was used to calculate the depth of missile penetration. The thicknesses of the DG "E" building's walls and roof exceed those values listed in Table 1 of SRP 3.5.3.

d. The three individual tornado-generated loads (wind, differential pressure and missile) are combined per the method presented in this SRP section. (See Ref. 3, Page 7.)

4. a&b There are no structures adjacent to the DG "E" building. Thus, no structures are postulated to collapse or fail on to the DG "E" building.

The tornado-generated missiles used in the design of the DG "E" building are the more severe missiles of those listed in the FSAR Table 3.5-4 and the Spectrum II missiles for Region I. (See Ref. 1, Table 3.5-4a.) The vertical velocities were considered to be equal to 80 percent of the horizontal velocities.

(iv) For calculating velocity pressures on external surfaces of structures, on external portions thereof, and on internal surfaces, where there are openings in the structure, appropriate shape coefficients shall be used in accordance with ASCE Paper No. 3269 (Ref. 2). Gust factors may be taken as unity.

b. If venting of a structure is adopted as a design measure to permit transforming the tornado-generated differential pressure into an effective reduced pressure, the acceptance criteria are established on a case-by-case basis, upon request, by the Auxiliary Systems Branch (ASB).

c. The acceptance criteria for transforming the tornado-generated missile impact into an effective or equivalent static load on structures are delineated in subsection II of SRP Section 3.5.3.

d. Having established the effective loads for each of the above three individual tornado-generated effects, the combination thereof should then be determined in a conservative manner for each particular structure, as applicable. An acceptable method of combining these effects is as follows:

(i) $W_t = W_w$

(ii) $W_t = W_p$

(iii) $W_t = W_m$

(iv) $W_t = W_w + .5\ W_p$

(v) $W_t = W_w + W_m$

(vi) $W_t = W_w + .5\ W_p + W_m$

where: W_t ..... total tornado load,
W_w ..... tornado wind load,
W_p ..... tornado differential pressure load, and
W_m ..... tornado missile load.

For each particular structure or portion thereof, the most adverse of the above combinations should be used, as appropriate.

These combined effects constitute the total tornado load which should then be combined with other loads as specified in SRP Sections 3.8.1, 3.8.4, and 3.8.5.

4. The information provided to demonstrate that failure of any structure or component not designed for tornado loads will not affect the capability of other structures or components to perform necessary safety functions, is acceptable if found in accordance with either of the following:

a. The postulated collapse or structural failure of structures and components not designed for tornado loads, including missiles, can be shown not to result in any structural or other damage to safety-related structures or components.

b. Safety-related structures are designed to resist the effects of the postulated structural failure, collapse, or generation of missiles from structures and components not designed for tornado loads.

III. REVIEW PROCEDURES

The reviewer selects and emphasizes material from the review procedures described below, as may be appropriate for a particular case.

1. The site-related parameters described in subsection I.1. are reviewed by the Accident Evaluation Branch (AEB) in accordance with SRP Sections 2.3.1, 2.3.2, and 3.5.1.4. The structural reviewer examines the approved values of these parameters to assure that they are consistent with those contained in the SRP sections stated above.

2. After the acceptability of the site-related parameters is established, the SEB reviewer proceeds with his review of the structural aspects of tornado design in the following manner:

   a. The procedures used by the applicant to transform tornado wind velocities into effective pressures are reviewed and compared with those procedures delineated in either ASCE Paper No. 3269 or in ANSI A58.1, whichever is selected, and, in particular, with the acceptance criteria delineated in subsection II.3.a.

   b. Where venting is used, procedures for transforming the tornado-generated differential pressure into an effective reduced pressure are reviewed, upon request, by the Auxiliary Systems Branch (ASB) upon SEB request.

   c. The treatment of tornado-generated missiles is covered in SRP Section 3.5.1.4 and the review procedures for design of missile barriers are described in SRP Section 3.5.3.

   d. After procedures for determining the individual tornado effects are reviewed, the manner in which these effects are then combined to arrive at the most adverse total tornado effect is reviewed and compared with the acceptance criteria delineated in subsection II.3.d. Other proposed methods which may depend upon the geometry and configuration of a particular structure are reviewed on a case-by-case basis.

3. The information provided to demonstrate that failure of any structure or component not designed for tornado loads will not affect the capability of other structures or components to perform necessary safety functions is reviewed to assure that one of the acceptance criteria of subsection II.4 is satisfied.

IV. EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided to satisfy the requirements of this SRP section, and concludes that his evaluation is sufficiently complete and adequate to support the following type of statement to be included in the staff's safety evaluation report.

The tornado-generated missiles used in the design of the DG "E" facility are the more severe missiles of those listed in FSAR Table 3.5-4 and the Spectrum II missiles for Region I. (See Ref. 1, Table 3.5-4a.) The vertical velocities were considered to be equal to 80 percent of the horizontal velocities.

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3.5.1.4 MISSILES GENERATED BY NATURAL PHENOMENA

REVIEW RESPONSIBILITIES

Primary - Auxiliary Systems Branch (ASB)

Secondary - None

I. AREAS OF REVIEW

The applicant's assessment of possible hazards due to missiles generated by the design basis tornado, flood, and any other natural phenomena identified in Section 3.5 of the safety analysis report (SAR) is reviewed and evaluated by the ASB to assure that appropriate design basis missiles have been chosen and properly characterized, and to assure that the effects caused by these missiles are acceptable. Currently, only missiles from the design basis tornado are consistently considered in the plant design bases. Missiles from other phenomena are considered on a case-by-case basis when they are identified.

The ASB also reviews the identification of those structures, systems and components that should be protected against missile impact under Standard Review Plan (SRP) Section 3.5.2.

The Structural Engineering Branch (SEB) determines the acceptability of the design analysis, procedures and criteria used to establish the ability of seismic Category I structures and/or missile barriers to withstand the effects of tornado missiles as part of its primary review responsibility for SRP Section 3.5.3. The acceptance criteria and their methods of application are combined in that SRP section.

II. ACCEPTANCE CRITERIA

The acceptability of the assessment as described in the applicant's Safety Analysis Report (SAR) is based on compliance with: General Design Criteria 2 and 4 as it relates to the capability of structures, systems, and components important to safety to withstand the effects of tornadoes and other natural phenomena. Acceptance is based on meeting the guidelines of Regulatory Guide 1.76 and 1.117. The

methodology of identification of appropriate design basis missiles generated by natural phenomena shall be consistent with the acceptance criteria defined for the evaluation of potential accidents from external sources in SRP Section 2.2.3.

III. REVIEW PROCEDURES

The procedures below are used during the construction permit (CP) review to determine that the design criteria and bases and the preliminary design as set forth in the preliminary safety analysis report meet the acceptance criteria given in subsection II. For review of operating license (OL) applications, the procedures are utilized to verify that the initial design criteria and bases have been appropriately implemented in the final design as set forth in the final safety analysis report.

Upon request from the primary reviewer, SEB will provide input for the areas of review stated in subsection I. The primary reviewer obtains and uses such input as required to assure that this review procedure is complete.

The reviewer will select and emphasize material from this SRP section, as may be appropriate for a particular case.

The judgment on areas to be given attention and emphasis in the review is to be based on an inspection of the material presented to see whether it is similar to that recently reviewed on other plants and whether items of special safety significance are involved.

.1 The SAR is reviewed for the identification of the design basis natural phenomena which could possibly generate missiles. Postulated missiles are reviewed for proper characterization.

2. The probability per year of damage to the total of all important structures, systems, and components (as discussed in Regulatory Guide 1.117) due to a specific design basis natural phenomena capable of generating missiles is estimated.

3. If this probability is greater than the acceptable probability stated in Regulatory Guide 1.117, then specific design provisions must be provided to reduce the estimate of damage probability to an allowable level.

4. All plants are required to be designed to protect safety-related equipment against damage from missiles which might be generated by the design basis tornado for that plant. The reviewer verifies that the applicant has postulated missiles that include at least three objects: a massive high kinetic energy missile which deforms on impact, a rigid missile to test penetration resistance, and a small rigid missile of a size sufficient to just pass through any openings in protective barriers. Until more definitive guidelines are established, these missiles may be assumed to be an 1800 Kg automobile, a 125 Kg 8" armor piercing artillery shell, and a 1" solid steel sphere, all impacting at 35% of the maximum horizontal windspeed of the design basis tornado. The first two missiles are assumed to impact at normal incidence, the last to impinge upon barrier openings in the most damaging directions. These missiles are identified as Spectrum I.

   Alternately, the missiles selected by the National Bureau of Standards as representative of construction site debris in report NBSIR 76-1050 may be

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3.5.1.5 SITE PROXIMITY MISSILES (EXCEPT AIRCRAFT)

REVIEW RESPONSIBILITIES

Primary - Siting Analysis Branch (SAB)

Secondary - NONE

I. AREAS OF REVIEW

The staff reviews the nature and extent of offsite activities identified in SRP Section 2.2.1-2.2.2 to determine whether any missiles resulting from such activities, other than aircraft (aircraft hazards are reviewed separately in SRP Section 3.5.1.6), have the potential for adversely affecting structures, systems, and components (SSC) essential to safety. In the event that an offsite activity has the potential for missile production (e.g., explosion) and is found to be a design basis event according to SRP Section 2.2.3, the staff reviews the plant design to determine whether the plant is adequately protected against the effects of the postulated missiles. The SSC that should be protected against missiles are identified in accordance with SRP Section 3.5.2 as part of the primary review responsibility of the Auxiliary Systems Branch (ASB). The Siting Analysis Branch (SAB) identifies and characterizes any offsite missiles that are required to be accommodated within the plant design basis in order to protect adequately the safety-related SSC. The Structural Engineering Branch (SEB) on request by SAB reviews the missile impact effects on the safety-related SSC. The acceptance criteria necessary for the review and the methods of application for the above reviews are contained in the referenced SRP section.

II. ACCEPTANCE CRITERIA

SAB acceptance criteria are based on meeting the relevant requirements of one of the following regulations:

1. 10 CFR Part 100, §100.10 indicates that the site location, in conjunction with other considerations (such as plant design, construction, and operation), should insure a low risk of public exposure. This requirement is met if the probability of site proximity missiles impacting the plant and causing radiological

The following site proximity missiles were considered in the design of the DG "E" facility:

Missile	Weight	Velocity
Riffle bullet	2 Oz.	2667 fps
Fragment from a truck explosion	6 Oz.	15 fps
Oxygen bottle	143 lb.	262 fps
Acetylene bottle	198 lb.	179 fps
Zero gas bottle	70 lb.	342 fps

(See Ref. 2, Page 4-1 and Ref. 3, Page 9.)

consequences greater than 10 CFR Part 100 exposure guidelines is less than about 10^{-7} per year (see SRP Section 2.2.3). If the results of the review do not indicate that the above criterion is met, then the acceptance criterion described in 2 below applies.

2. General Design Criterion (GDC) 4 of 10 CFR Part 50, Appendix A, requires that structures, systems, and components (SSC) important to safety be appropriately protected against the effects of missiles that may result from events and conditions outside the nuclear power unit. The plant complies with GDC 4 and is considered adequately protected against site proximity missiles if the following criterion is met: The SSC important to safety are capable of withstanding the effects of the postulated missiles without loss of safe shutdown capability and without causing a release of radioactivity which would exceed 10 CFR Part 100 dose criteria.

III. REVIEW PROCEDURES

The reviewer selects and emphasizes aspects of the areas covered by this SRP section as may be appropriate for a particular case. The judgment on areas to be given attention and emphasis in the review is based on an inspection of the material presented to see whether it is similar to that recently reviewed on other plants and whether items of special safety significance are involved.

1. The identification and description of accidents which could possibly generate missiles is obtained from the review performed in accordance with SRP Section 2.2.1-2.2.2 and SRP Section 2.2.3.

2. The SSC identified by ASB in reference to SRP Section 3.5.2 are reviewed with respect to missile vulnerability. Using conservative assumptions, and experience gained from past reviews on similar SSC missile interactions, a determination is made of those portions of the plant which clearly have the potential for unacceptable missile damage. If all SSC appear to be adequately protected against the effects of the postulated missiles, then the review is terminated and evaluation findings are written in terms of design basis considerations (See subsection II.2 of this SRP section).

3. The total probability of the missiles striking a vulnerable critical area of the plant is estimated. The total probability per year (P_T) may be estimated by using the following expression:

$$P_T = P_E \times P_{MR} \times P_{SC} \times P_P \times N$$

where:

P_E = probability per year of design basis event obtained from the review performed under SRP Section 2.2.3,

P_{MR} = probability of missiles reaching the plant,

P_{SC} = probability of missiles striking a vulnerable critical area of the plant,

P_P = probability of missiles exceeding the energies required to penetrate to vital areas (e.g., based on wall thickness provided for tornado

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3.7.1 SEISMIC DESIGN PARAMETERS

REVIEW RESPONSIBILITIES

Primary - Structural Engineering Branch (SEB)

Secondary - None

I. AREAS OF REVIEW

The following areas relating to seismic design parameters are reviewed.

1. Design Ground Motion

For the seismic design of nuclear power plants it is customary to specify the earthquake ground motion which is exerted on the structure or on the soil-structure interaction system. The design ground motion, sometimes known as the seismic input, is based on the seismicity and geologic conditions at the site and expressed in such a manner that it can be applied to the dynamic analysis of structures. The design ground motions for the operating basis earthquake (OBE) and safe shutdown earthquake (SSE) are reviewed. They should be consistent with the information on seismic environment at the site provided in SRP Section 2.5.2, which includes the variation in and distribution of peak ground acceleration in the free field at different depths across the soil profile, sources and directions of motion, propagation and transmission of seismic waves, and other response characteristics.

a. Design Response Spectra

A response spectrum is a plot of the maximum response of a family of single-degree-of-freedom damped oscillators with different frequency characteristics when the base of the oscillator is subjected to vibratory motion indicated by an appropriate time motion record. The response spectra are usually displayed on tripartite log-log graph paper. When obtained from a recorded earthquake, the response spectrum tends to be irregular, with a number of peaks and valleys. A design response spectrum is a relatively smooth plot, obtained from a number of individual a&b) The maximum ground acceleration values are based on the most severe earthquakes that have been historically reported for the site and surrounding area. The values used in the design of the DG "E" facility are the same as those values utilized in the design of existing Susquehanna SES seismic Category I structures. The NRC has previously reviewed and accepted these maximum ground acceleration values.

For the DG "E" building and pedestal, which are founded on sound bedrock, the maximum ground accelerations were taken to be 0.10g for SSE and 0.05g for OBE. For the DG "E" facility's fuel tank, which is founded on soil, the values are 0.15g for SSE and 0.08g for OBE. (See Ref. 1, Page 3.7b-1.)

In practical seismic analysis, which usually employs linear methods of analysis, damping is also used to account for many nonlinear effects such as changes in boundary conditions, joint slippage, plastic hinges, concrete cracking, gaps, and other effects which tend to alter response amplitude. In real structures, it is often impossible to separate "true" material damping from system damping, which is the measure of the energy dissipation, from the nonlinear effects. Overall structural damping used in design is normally determined by observing experimentally the total response of the structure.

Only the overall damping used for Category I structures, systems, and components are reviewed. When applicable, the basis for any damping values that differ from those given in Regulatory Guide 1.61 (Ref. 4) is reviewed.

3 Supporting Media for Category I Structures

The description of the supporting media for each Category I structure is reviewed, including foundation embedment depth, depth of soil over bedrock, soil layering characteristics, width of the structural foundation, total structural height, and soil properties to permit evaluation of the applicability of finite element or lumped spring approaches for soil-structure interaction analysis.

4. SEB coordinates other branches' evaluations that interface with structural engineering aspects of the review as follows:

Review of geological and seismological information to establish the free field ground motion is performed by the Geosciences Branch as described in SRP Section 2.5. Hydrologic and Geotechnical Engineering Branch reviews the geotechnical parameters and methods employed in the analysis of free field soil media and soil properties as described in SRP Section 2.5. Structural Engineering Branch accepts the results of the reviews performed by these branches including the maximum seismic ground accelerations for the Operating Basis Earthquake (OBE) and the Safe Shutdown Earthquake (SSE), site dependent free field ground motion records, soil properties, etc., as an integral part of the seismic analysis review of Category I structures.

For those areas of review identified above as being reviewed as part of the primary review responsibility of other branches, the acceptance criteria necessary for the review and their methods of application are contained in the referenced SRP section of the corresponding primary branch.

II. ACCEPTANCE CRITERIA

SEB accepts the design of structures that are important to safety and must withstand the effects of the earthquakes if the relevant requirements of General Design Criterion 2 (Ref. 1) and Appendix A to 10 CFR Part 100 (Ref. 2) concerning material phenomena are complied with. The relevant requirements of GDC 2 and Appendix A to 10 CFR Part 100 are:

a. For Design Criterion 2 - The earthquakes used in the design should be the most severe ones that have been historically reported for the site and surrounding area with sufficient margin for the limited accuracy, quantity and period of time in which historical data has been accumulated.

The design response spectra for the DG "E" facility is constructed by linearly scaling down the amplification factors presented in Tables I and II of Reg. Guide 1.60. The scaling factor used is the ratio of the Susquehanna SES maximum ground acceleration to the 1.0g acceleration value associated with the above tables (See Ref. 1, Page 3.7b-1.).

For the DG "E" facility, the maximum vertical ground acceleration was taken to be the same as the maximum horizontal ground acceleration (See Ref. 1, Page 3.7b-2.)

For the DG "E" Facility, two synthetic time histories (one vertical and one horizontal) were developed to carry out time history analyses (See. Ref. 1, Page 3.7b-2).

b. For Appendix A to 10 CFR Part 100 - Two earthquake levels, the safe shutdown earthquake (SSE) and the operating basis earthquake (OBE), shall be considered in the design of the safety-related structures, components and systems.

Specific criteria necessary to meet the relevant requirements of GDC 2 and Appendix A to 10 CFR Part 100 are described below.

The acceptance criteria for the areas of review described in subsection I above are as follows:

1. Design Ground Motion

a. Design Response Spectra

Design response spectra for the OBE and SSE are considered to be acceptable if the associated amplification factors are in accordance with Regulatory Guide 1.60, "Design Response Spectra for Nuclear Power Plants," for all damping values.

As noted in Regulatory Guide 1.60, there are site circumstances where the design response spectra are more appropriately developed to suit the particular site characteristics. Design response spectra based upon site-dependent analysis must be derived considering in situ variable soil properties, a representative number of site earthquake records, vertical amplification, possible slanted soil layers, and the influence of any predominant soil layers. Variable soil properties and nonlinear stress-strain relations in the soil media should be considered.

If site-dependent design response spectra are used, the data and bases from which the spectra are derived should be consistent with those provided in Section 2.5.2 of the SAR.

To be acceptable the design response spectra should be specified for three mutually orthogonal directions; two horizontal and one vertical. Current practice is to assume that the maximum ground accelerations in the two horizontal directions are equal, while the maximum vertical ground acceleration is 2/3 of the maximum horizontal acceleration. For the western United States (West of Rockies), the response spectrum for vertical motion can be taken as 2/3 the response spectrum for horizontal motion over the entire range of frequencies.

b. Design Time History

The design time history to be used at various depths in the free-field of the soil media shall be consistent with that developed or specified in Section 2.5.2.

When no specific time history is provided in Section 2.5.2 of the SAR, an artificial time history may be generated for use in the seismic analysis. The artificial time history is acceptable if the response spectra in the free field at the specified level of the site

Time history response spectra have been shown to envelope the design response spectra (See Ref. 1, Page 3.7b-2.)

The design ground motion is applied to the DG "E" Bldg. at the basemat level.

Time history response spectra have met this criteria. (See Ref. 1, Page 3.7b-2 and the provided figures.)

Response spectra have been computed at these suggested frequencies. (See Ref. 1, Page 3.7b-2.)

Damping values utilized for the DG "E" Facility are those presented in Reg. Guide 1.61. (See Ref. 1, Page 3.7b-3.) Most conduit and box supports utilize damping values associated with the existing plant criteria. This was done to take advantage of the numerous typical conduit/box supports that are available for the existing criteria.

obtained from such time history envelop the design response spectra at the same location for all damping values actually used in the analysis. Appendix A to 10 CFR 100 specifies that for soil structure interaction analysis or for seismic design of structures, the design ground motion (sometimes called the control motion or reference motion) is applied at the foundation level of Category I structures in the free field.

When spectral values are calculated from the design time history the frequency intervals are to be small enough such that any reduction in these intervals does not result in more than 10% change in the computed spectra. Table 3.7.1-1 provides an acceptable set of frequencies at which the response spectra may be calculated. Another acceptable method is to choose a set of frequencies such that each frequency is within 10% of the previous one.

The acceptance criterion for meeting the spectra-enveloping requirement is that no more than five points of the spectra obtained from the time history should fall below, and no more than 10% below, the design response spectra.

Table 3.7.1-1
Suggested Frequency Intervals for Calculation of Response Spectra

Frequency Range (hertz)	Increment (hertz)
0.2 - 3.0	.10
3.0 - 3.6	.15
3.6 - 5.0	.20
5.0 - 8.0	.25
8.0 - 15.0	.50
15.0 - 18.0	1.0
18.0 - 22.0	2.0
22.0 - 34.0	3.0

2. Critical Damping Values

The specific percentage of critical damping values used in the analyses of Category I structures, systems, and components are considered to be acceptable if they are in accordance with Regulatory Guide 1.61, "Damping Values for Seismic Design of Nuclear Power Plants." Higher damping values may be used in a dynamic seismic analysis if documented test data are provided to support them. These values would be reviewed and accepted by the staff on a case-by-case basis. The damping value for soil must be based upon actual measured values or other pertinent laboratory data considering variation in soil properties and strains within the soil.

A general description of the supporting media is provided in Ref. 2, Page 3-6.

Seven borings were taken to determine the soil and rock conditions in the area of the DG "E" facility. A plan showing the location of the borings, the seven boring logs and soil/rock profiles are provided in Section 2.5 of Ref. 1.

The excavation for the DG "E" building was carried to unweathered bedrock by using soldier beams and laggings. The excavation for DG "E" facility's fuel tank was carried out in open cut (See Ref. 1, Page 2.5-98.). About 8 feet (north end) and 20 feet (south end) of sand, gravel and boulders are below the foundation grade of the fuel tank. Four standard penetration tests performed on the soil beneath the fuel tank were noted to have values exceeding 40 blows/foot. (See Ref. 1, Page 2.5-91 through 2.5-94.)

The foundation mat for the DG "E" fuel tank is 17 feet wide, 57 feet long and 5 feet thick. The bearing pressure and settlement of the soil beneath the fuel tank were determined to be less than the allowable values (See Ref. 1, Page 2.5-108.)

For the DG "E" building, lean concrete was used as fill for the volume between the sound bedrock and the bottom elevation of the building basement floor mat.

The excavated area for the DG "E" fuel tank was backfilled with sand-cement-flyash to two (2) feet below finished grade.

3. Supporting Media for Category I Structures

To be acceptable, the description of supporting media for each Category I structure must include foundation embedment depth, depth of soil over bedrock, width of the structural foundation, total structural height, and soil properties such as shear wave velocity, shear modulus, and density as a function of depth.

III. REVIEW PROCEDURES

For each area of review, the following review procedure is followed. The reviewer will select and emphasize material from the procedures given below as may be appropriate for a particular case. The scope and depth of review procedures must be such that the acceptable criteria described above are met.

1. Design Ground Motion

a. Design Response Spectra

Design response spectra for the OBE and SSE for all damping values are checked to assure that the spectra are in accordance with the acceptance criteria as given in subsection II. Any differences between the regulatory guide spectra and the proposed response spectra which have not been adequately justified are identified and the applicant is informed of the need for additional technical justification.

b. Design Time History

Methods of defining the design time history are reviewed to ascertain that the acceptance criteria of subsection II.2 of this SRP section are met.

2. Critical Damping Values

The specific percentage of critical damping values for the OBE and SSE used in the analyses of Category I structures, systems, and components are checked to assure that the damping values are in accordance with the acceptance criteria as given in subsection II.2 of this SRP section. Any differences in damping values which have not been adequately justified are identified and the applicant is informed of the need for additional technical justification.

3. Supporting Media for Category I Structures

The description of the supporting media is reviewed to verify that sufficient information, as specified in the acceptance criteria of subsection II.3 of this SRP section is included. Any deficiency in the required information is identified and a request for additional information is transmitted to the applicant.

IV. EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided and that his evaluation supports conclusions of the following type, to be included in the staff's safety evaluation report:

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3.7.2 SEISMIC SYSTEM ANALYSIS

REVIEW RESPONSIBILITIES

Primary - Structural Engineering Branch (SEB)

Secondary - None

I. AREAS OF REVIEW

The following areas related to the seismic system analysis described in the applicant's safety analysis report (SAR) are reviewed.

1. Seismic Analysis Methods

For all Category I structures, systems, and components, the applicable seismic analysis methods (response spectra, time history, equivalent static load) are reviewed. The manner in which the dynamic system analysis method is performed, including the modeling of foundation torsion, rocking and translation, is reviewed. The method chosen for selection of significant modes and an adequate number of masses or degrees of freedom is reviewed. The manner in which consideration is given in the seismic dynamic analysis to maximum relative displacements between supports is reviewed. In addition, other significant effects that are accounted for in the dynamic seismic analysis such as hydrodynamic effects and nonlinear response are reviewed. If tests or empirical methods are used in lieu of analysis for any Category I structure, the testing procedure, load levels, and acceptance basis are also reviewed.

2. Natural Frequencies and Responses

For the operating license review, significant natural frequencies and responses for major Category I structures are reviewed. In addition, the response spectra at major Category I equipment elevations and points of support are reviewed.

13. Analysis Procedure for Damping

The analysis procedure to account for the damping in different elements of the model of a coupled system is reviewed.

14. Determination of Category I Structure Overturning Moments

The description of the method and procedure used to determine design overturning moments for Category I structures is reviewed.

15. SEB coordinates other branches' evaluations that interface with structural engineering aspects of the review as follows:

Review of geological and seismological information to establish the free field ground motion is performed by the Geosciences Branch as described in SRP Section 2.5. Hydrologic and Geotechnical Engineering Branch reviews the geotechnical parameters and methods employed in the analysis of free field soil media and soil properties as described in SRP Section 2.5. Structural Engineering Branch accepts the results of the reviews performed by these branches including the maximum seismic ground accelerations for the Operating Basis Earthquake (OBE) and the Safe Shutdown Earthquake (SSE), site-dependent free field ground motion records, soil properties, etc., as an integral part of the seismic analysis review of Category I structures.

For those areas of review identified above as being reviewed as part of the primary review responsibility of other branches, the acceptance criteria necessary for the review and their methods of application are contained in the referenced SRP section of the corresponding primary branch.

II. ACCEPTANCE CRITERIA

The acceptance criteria for the areas of review described in subsection I of this SRP section are given below. Other approaches which can be justified to be equivalent to or more conservative than the stated acceptance criteria may be used. SEB accepts the design of structures, systems, and components that are important to safety and must withstand the effects of earthquakes if the relevant requirements of General Design Criterion (GDC) 2 (Ref. 1) and Appendix A to 10 CFR Part 100 (Ref 2) concerning natural phenomena are complied with. The relevant requirements of GDC 2 and Appendix A to 10 CFR Part 100 are:

A. General Design Criterion 2 as it relates to the earthquakes used in the design should be the most severe ones that have been historically reported for the site and surrounding area with sufficient margin for the limited accuracy, quantity, and period of time in which historical data has been accumulated.

B. Appendix A to 10 CFR Part 100 as it relates to the requirement that two earthquake levels, the safe shutdown earthquake (SSE) and the operating basis earthquake (OBE), be considered in the design of safety-related structures, components, and systems. Appendix A to 10 CFR Part 100 further states that the design used to ensure that the required safety functions are maintained during and after the vibratory ground motion associated with the safe shutdown earthquake shall involve the use of either a

1. The DG "E" building and pedestal were analyzed by the response spectrum method to obtain the structural responses (accelerations and relative displacements). See Ref. 2, Page C-7.

   The DG "E" building and pedestal were analyzed by the time history method to develop floor response spectra. See Ref. 2, Page C-7 & C-8.

2. The DG "E" building and pedestal are founded on sound bedrock. As a result, the soil-structure interaction effect is insignificant.

3. The DG "E" building's horizontal dynamic model reflects the eccentricity effect of the asymmetrical building configuration. Thus, it is capable of producing torsional response due to a horizontal earthquake. (See Ref. 2, Page C-5 and Ref. 1, Page 3.7b-11.)

4. For the DG "E" building and pedestal dynamic models, the number of degrees of freedom exceed twice the number of modes with frequencies less than 33 Hz.

5. For the DG "E" building and its pedestal all modes were considered. (See Ref. 1, Page 3.7b-5.)

6. A modal response spectrum analysis was performed using the DG "E" building and pedestal models to determine the relative displacements. (See Ref. 2, Page C-7.)

7. Piping inside the D.G. "E" building is analyzed independently using the floor response spectra. (See Ref. 2, Page C-8.) No externally applied structural restraints are considered for the DG "E" building analysis. Hydrodynamic loads (SRV & LOCA) need not be considered due to the physical location of the DG "E" building. Stress levels are kept below allowable levels, thus, nonlinear responses are not considered.

suitable dynamic analysis or a suitable qualification test to demonstrate that structures, systems, and components can withstand the seismic and other concurrent loads, except where it can be demonstrated that the use of an equivalent static load method provides adequate conservatism.

Specific criteria necessary to meet the relevant requirements of GDC 2 and Appendix A to Part 100 are as follows:

1. <u>Seismic Analysis Methods</u>

The seismic analysis of all Category I structures, systems, and components should utilize either a suitable dynamic analysis method or an equivalent static load method, if justified.

a. <u>Dynamic Analysis Method</u>

A dynamic analysis (e.g., response spectrum method, time history method, etc.) should be used when the use of the equivalent static load method cannot be justified. To be acceptable such analyses should consider the following items:

(1) Use of either the time history method or the response spectrum method.

(2) Use of appropriate methods of analysis to account for effects of soil-structure interaction.

(3) Consideration of the torsional, rocking, and translational responses of the structures and their foundations.

(4) Use of an adequate number of masses or degrees of freedom in dynamic modeling to determine the response of all Category I and applicable non-Category I structures and plant equipment. The number is considered adequate when additional degrees of freedom do not result in more than a 10% <u>increase</u> in responses. Alternately, the number of degrees of freedom may be taken equal to twice the number of modes with frequencies less than 33 cps.

(5) Investigation of a sufficient number of modes to assure participation of all significant modes. The criterion for sufficiency is that the inclusion of additional modes does not result in more than a 10% <u>increase</u> in responses.

(6) Consideration of maximum relative displacements among supports of Category I structures, systems, and components.

(7) Inclusion of significant effects such as piping interactions, externally applied structural restraints, hydrodynamic (both mass and stiffness effects) loads, and nonlinear responses.

b. <u>Equivalent Static Load Method</u>

An equivalent static load method is acceptable if:

The equivalent static load method as described here is used for the design of some safety related systems and equipment found within the DG "E" facility.

For the DG "E" building and pedestal, modal frequencies and participation factors are presented in Ref. 1, Table 3.7b-8. Mode shapes have been calculated and are presented in the computer output.

Floor response spectra have been calculated and available upon request.

All subsystems (equipment, piping, HVAC ducts, cable trays, etc.) have been decoupled from the DG "E" building models based on the small ratio of individual subsystem mass to building mass. However, the diesel generator has not been decoupled from the diesel generator pedestal. An approximate model of the diesel generator is included in the pedestal model.

(1) Justification is provided that the system can be realistically represented by a simple model and the method produces conservative results in terms of responses. Typical examples or published results for similar structures may be submitted in support of the use of the simplified method.

(2) The design and associated simplified analysis account for the relative motion between all points of support.

(3) To obtain an equivalent static load of a structure, equipment, or component which can be represented by a simple model, a factor of 1.5 is applied to the peak acceleration of the applicable floor response spectrum. A factor of less than 1.5 may be used if adequate justification is provided.

2. <u>Natural Frequencies and Response Loads</u>

To be acceptable for the operating license review, the following information should be provided.

a. A summary of natural frequencies, mode shapes, modal and total responses, for a representative number of major Category I structures, including the containment building, or a summary of the total responses if the method of direct interaction is used.

b. A time history of acceleration (or other parameters of motion) or response spectrum at the major plant equipment elevations and points of support.

3. <u>Procedures Used for Analytical Modeling</u>

A nuclear power plant facility consists of very complex structural systems. To be acceptable, the stiffness, mass, and damping characteristics of the structural systems should be adequately incorporated into the analytical models. Specifically, the following items should be considered in analytical modeling:

a. <u>Designation of Systems Versus Subsystems</u>

Major Category I structures that are considered in conjunction with foundation and its supporting media are defined as "seismic systems." Other Category I structures, systems, and components that are not designated as "seismic systems" should be considered as "seismic subsystems."

b. <u>Decoupling Criteria for Subsystems</u>

It can be shown, in general, that frequencies of systems and subsystems have negligible effect on the error due to decoupling. It can be shown that the mass ratio, R_m, and the frequency ratio, R_f, govern the results where R_m and R_f are defined as:

$$R_m = \frac{\text{Total mass of the supported subsystem}}{\text{Total mass of the supporting system}}$$

$$R_f = \frac{\text{Fundamental frequency of the supported subsystem}}{\text{Dominant frequency of the support motion}}$$

c) A description of the methodology used to compute the lumped masses for the DG "E" building and its pedestal is presented in Ref. 2, Pages C-4 through C-6.

d) Two lumped mass stick models (1-horizontal and 1 vertical) for the DG "E" building and 1 model for the pedestal were developed. A description of these models along with the way they were used is provided in Ref. 2, Page C-3.

4) The DG "E" building and pedestal are founded on sound bedrock. As a result, the soil-structure interaction effect is insignificant.

The following criteria are acceptable:

(1) If R_m <0.01, decoupling can be done for any R_f.

(2) If $0.01 \leq R_m \leq 0.1$, decoupling can be done if $0.8 \geq R_f \geq$ 1.25.

(3) If R_m >0.1, an approximate model of the subsystem should be included in the primary system model.

If the subsystem is comparatively rigid in relation to the supporting system, and also is rigidly connected to the supporting system, it is sufficient to include only the mass of the subsystem at the support point in the primary system model. On the other hand, in case of a subsystem supported by very flexible connections, e.g., pipe supported by hangers, the subsystem need not be included in the primary model. In most cases the equipment and components, which come under the definition of subsystems, are analyzed (or tested) as a decoupled system from the primary structure and the seismic input for the former is obtained by the analysis of the latter. One important exception to this procedure is the reactor coolant system, which is considered a subsystem but is usually analyzed using a coupled model of the reactor coolant system and primary structure.

c. Lumped Mass Considerations

The acceptance criteria given under subsection II.1.a(4) of this SRP section are applicable.

d. Modeling for Three Component Input Motion

In general, three-dimensional models should be used for seismic analyses. However, simpler models can be used if justification can be provided that the coupling effects of those degrees of freedom that are omitted from the three-dimensional models are not significant.

4. Soil-Structure Interaction

An analytical model of a soil-structure interaction system is acceptable if both the structure model and the supporting soil model are properly coupled and the design motion is properly addressed. The coupled model is subjected to the design ground motion as specified in SRP Section 3.7.1 or to the regenerated excitation system described in Section II.4 (iii) below. A suitable dynamic analysis using the time history method is performed for the entire soil-structure system and the dynamic responses at various locations of the system are calculated. All assumptions to simplify the analysis should be justified and the resulting errors be studied. Any dynamic decoupling or condensation procedure should be substantiated by theoretical verification and mathematical proofs.

At present most commonly used methods are the half-space and the finite boundaries modeling methods and there is no indication as to which one is more reliable, especially when too many assumptions are involved. Therefore, modeling methods for implementing the soil-structure interaction analysis should include both the half-space and finite boundaries approaches. Category I structures, systems, and components should be designed to accommodate responses obtained by one of the following:

ii) The DG "E" Building and pedestal dynamic models assume a fixed base since they represent structures which are supported on rock. Additional borings taken in the area of the DG "E" facility indicate that the bedrock is of the same type as that found under the existing Seismic Category 1 structures located nearby. Previous testing determined the Reactor Area's bedrock compression wave velocity to be approximately 15,000 fps and the shear wave velocity to be approximately 7,000 fps. (Refer to FSAR Table 2.5-7.)

This methodology was used in the development of floor response spectra for the DG "E" facility. See Ref. 2, Page C-8.

a. Envelope of results of the two methods,

b. Results of one method with conservative design considerations of effects from use of the other method,

c. Combination of a. and b. with provision of adequate conservatism in design.

The acceptance criteria for the constituent parts of the entire soil-structure interaction system are as follows:

i. Modeling of Structure

The acceptance criteria given under subsection II.3 of this SRP section are applicable.

ii. Modeling of Supporting Soil

The effect of embedment of structure and the layering effect of soil should be accounted for. For the half-space modeling of the soil media, the lumped parameter (soil spring) method and the compliance function methods are acceptable. For the method of modeling soil media with finite boundaries, all boundaries should be properly simulated and the use of types of boundaries should be justified and reviewed on a case-by-case basis. Finite element and finite difference methods are acceptable methods for discretization of a continuum. The properties used in the soil-structure interaction analysis should be those corresponding to the low strains which are consistent with the realistic soil strain developed during the design earthquake. Use of high strain parameters needs to be adequately justified on a case-by-case basis.

For structures supported on rock, a fixed base assumption is acceptable.

iii. Generation of Excitation System

Appendix A to 10 CFR Part 100 states that the vibratory ground motion produced by the safe shutdown earthquake shall be defined by response spectra corresponding to the maximum vibratory acceleration at the elevations of the foundations of the nuclear power plant structure. A regenerated excitation system is acceptable if, when applied to the soil model, it produces at the structural foundation level in the free field a response motion whose response spectra envelop the design response spectra of earthquake motion.

5. <u>Development of Floor Response Spectra</u>

To be acceptable, the floor response spectra should be developed taking into consideration the three components of the earthquake motion. The individual floor response spectral values for each frequency are obtained for one vertical and two mutually perpendicular horizontal earthquake motions and are combined according to the "square root of the sum of the squares" method to predict the total floor response spectrum for that particular frequency (Ref. 3).

A time history approach was used in the development of floor response spectra, See Ref. 2, Page C-8.

For the DG "E" facility the responses due to three simultaneous orthogonal components of an earthquake are combined by the square root of the sum of the squares method per Reg. Guide 1.92, Rev. 1. (See Ref. 1, Page 3.7b-8.)

For the DG "E" facility, the total response is obtained by combining the absolute values of all closely spaced modal responses with the square root sum of the squares of the remaining modal responses. Two consecutive modes are defined as closely spaced when their frequencies differ from each other by 10 percent or less. Reg. Guide 1.92 is followed for the combination of modal responses. (See Ref. 1, Page 3.7b-8.)

In general, development of the floor response spectra is acceptable if a time history approach is used. If a modal response spectra method of analysis is used to develop the floor response spectra, the justification for its conservatism and equivalency to that of a time history method must be demonstrated by representative examples.

6. Three Components of Earthquake Motion

Depending upon what basic methods are used in the seismic analysis, i.e., response spectra or time history method, the following two approaches are considered acceptable for the combination of three-dimensional earthquake effects. (Ref. 4)

a. Response Spectra Method

When the response spectra method is adopted for seismic analysis, the maximum structural responses due to each of the three components of earthquake motion should be combined by taking the square root of the sum of the squares of the maximum codirectional responses caused by each of the three components of earthquake motion at a particular point of the structure or of the mathematical model.

b. Time History Analysis Method

When the time history analysis method is employed for seismic analysis, two types of analysis are generally performed depending on the complexity of the problem. (1) To obtain maximum responses due to each of the three components of the earthquake motion: in this case the method for combining the three-dimensional effects is identical to that described in item 6.a except that the maximum responses are calculated using the time history method instead of the spectrum method. (2) To obtain time history responses from each of the three components of the earthquake motion and combine them at each time step algebraically: the maximum response in this case can be obtained from the combined time solution. When this method is used, to be acceptable, the earthquake motions specified in the three different directions should be statistically independent.

7. Combination of Modal Responses

When the response spectrum method of analysis is used to determine the dynamic response of damped linear systems, the most probable response is obtained as the square root of the sum of the squares of the responses from individual modes. Thus, the most probable system response, R, is given by

$$R = \left(\sum_{k=1}^{N} R_k^2\right)^{1/2} \qquad (1)$$

where R_k is the response for the k^{th} mode and N is the number of significant modes considered in the modal response combination.

When modes with closely spaced modal frequencies exist, the methods delineated in Ref. 4 are acceptable. Two modes having frequencies within 10% of each other are considered as modes with closely spaced frequencies.

The collapse of any non-category I structure will not strike the DG "E" building.

Response spectral peaks were smoothed and broadened by 15% on each side. (See Ref. 2, Page C-8.)

Constant vertical static factors were not used in the seismic design of the DG "E" building. Constant vertical static factors were used in the seismic design of seismic Category I subsystems where shown to be appropriate.

The method used to account for torsional effects is presented in Ref. 1, Page 3.7b-11.

Other approaches which give an equivalent degree of conservatism to the above methods, and which are adequately justified are also acceptable.

8. Interaction of Non-Category I Structures with Category I Structures

To be acceptable, the interfaces between Category I and non-Category I structures and plant equipment must be designed for the dynamic loads and displacements produced by both the Category I and non-Category I structures and plant equipment. In addition, a statement indicating the fact that all non-Category I structures meet any one of the following requirements should be provided.

a. The collapse of any non-Category I structure will not cause the non-Category I structure to strike a seismic Category I structure or component.

b. The collapse of any non-Category I structure will not impair the integrity of seismic Category I structures or components.

c. The non-Category I structures will be analyzed and designed to prevent their failure under SSE conditions in a manner such that the margin of safety of these structures is equivalent to that of Category I structures.

9. Effects of Parameter Variations on Floor Response Spectra

Consideration should be given in the analysis to the effects on floor response spectra (e.g., peak width and period coordinates) of expected variations of structural properties, dampings, soil properties, and soil-structure interactions. Any reasonable method for determining the amount of peak widening associated with the structural frequency can be used, but in no case should the amount of peak widening be less than ± 10%. If no special study is performed for this purpose, the peak width should be increased by a minimum of ± 15% to be acceptable. (Ref. 3)

10. Use of Equivalent Static Factors

The use of equivalent static load factors as vertical response loads for the seismic design of all Category I structures, systems, and components in lieu of the use of a vertical seismic system dynamic analysis is acceptable only if it can be justified that the structure is rigid in the vertical direction. The criterion for rigidity is that the lowest frequency in the vertical direction is more than 33 cps.

11. Methods Used to Account for Torsional Effects

An acceptable method of treating the torsional effects in the seismic analysis of Category I structures is to carry out a dynamic analysis which incorporates the torsional degrees of freedom. An acceptable alternative, if properly justified, is the use of static factors to account for torsional accelerations in the seismic design of Category I structures in lieu of the use of a combined vertical, horizontal and torsional system dynamic analysis. To account for accidental torsion, an additional seismicity of ± 5% of the maximum building dimension at the level under consideration shall be assumed.

12. For the DG "E" building, comparison of the response spectra of the time history and the design response spectra are shown in Figures 3.7b-109 through 3.7b-118 of Ref. 1. The structural accelerations of the DG "E" building obtained from the modal response spectrum analysis compared closely with those obtained from the time history analysis.

13. For the DG "E" facility, the damping values are taken from Reg. Guide 1.61. For a structural system consisting of various components having different materials, composite modal damping is computed using equation (4) presented herein. (See Ref. 1, Page 3.7b-12.)

12. Comparison of Responses

The responses obtained from both modal analysis response spectrum and time history methods at selected points in typical Category I structures should be compared to demonstrate approximate equivalency between the two methods.

13. Analysis Procedure for Damping

Either the composite modal damping approach or the modal synthesis technique can be used to account for element-associated damping.

For the composite modal damping approach, two techniques of determining an equivalent modal damping matrix or composite damping matrix are commonly used. They are based on the use of the mass or stiffness as a weighting function in generating the composite modal damping. The formulations lead to:

$$\bar{\beta}_j = \{\phi\}^T [\bar{M}] \{\phi\} \tag{3}$$

$$\bar{\beta}_j = \frac{\{\phi\}^T [\bar{K}] \{\phi\}}{K^*} \tag{4}$$

where

$K^* = \{\phi\}^T [K] \{\phi\}$

$[K]$ = assembled stiffness matrix,

$\bar{\beta}_j$ = equivalent modal damping ratio of the j^{th} mode,

$[\bar{K}]$, $[\bar{M}]$ = the modified stiffness or mass matrix constructed from element matrices formed by the product of the damping ratio for the element and its stiffness or mass matrix, and

$\{\phi\}$ = j^{th} normalized modal vector.

For models that take the soil-structure interaction into account by the lumped soil spring approach, the method defined by equation (4) is acceptable. For fixed base models, either equation (3) or (4) may be used. Other techniques based on modal synthesis have been developed and are particularly useful when more detailed data on the damping characteristics of structural subsystems are available. The modal synthesis analysis procedure consists of (1) extraction of sufficient modes from the structure model, (2) extraction of sufficient modes from the finite element soil model, and (3) performance of a coupled analysis using the modal synthesis technique, which uses the data obtained in steps (1) and (2) with appropriate damping ratios for structure and soil subsystems. This method is based upon satisfaction of displacement compatibility and force equilibrium at the system interfaces and utilizes subsystem eigenvectors as internal generalized coordinates. This method results in a nonproportional damping matrix for the composite structure and equations of motion have to be solved by direct integration or by uncoupling them by use of complex eigenvectors.

The method used to determine overturning moments is presented in Ref. 1, Page 3.7b-12.

Other techniques which are also considered acceptable for estimating the equivalent modal damping of a soil-structure interaction model are reviewed on a case-by-case basis.

14. Determination of Category I Structure Overturning Moments

To be acceptable, the determination of the design moment for overturning should incorporate the following items:

a. Three components of input motion.

b. Conservative consideration of vertical and lateral seismic forces.

III. REVIEW PROCEDURES

For each area of review, the following procedure is implemented. The reviewer will select and emphasize material from the procedures given below, as may be appropriate for a particular case. The scope and depth of review procedures must be such that the acceptance criteria described above are met.

1. Seismic Analysis Methods

For all Category I structures, systems, and components, the applicable methods of seismic analysis (response spectra, time history, equivalent static load) are reviewed to ascertain that the techniques employed are in accordance with the acceptance criteria as given in subsection II.1 of this SRP section. If empirical methods or tests are used in lieu of analysis for any Category I structure, these are evaluated to determine whether or not the assumptions are conservative, and whether the test procedure adequately models the seismic response.

2. Natural Frequencies and Response Loads

For the operating license review, the summary of natural frequencies and response loads is reviewed for compliance with the acceptance criteria in subsection II.2 of this SRP section.

3. Procedures Used for Analytical Modeling

The procedures used for modeling for seismic system analyses are reviewed to determine whether the three-dimensional characteristics of structures are properly modeled in accordance with the acceptance criteria of subsection II.3 of this SRP section, and all significant degrees of freedom have been incorporated in the models. The criteria for decoupling of a structure, equipment, or component and analyzing it separately as a subsystem are reviewed for conformance with the acceptance criteria given in subsection II.3 of this SRP section.

4. Soil-Structure Interaction

The methods of soil-structure interaction analysis used are examined to determine that the techniques employed are in accordance with the acceptance criteria as given in subsection II.4 of this SRP section. Typical mathematical models for soil-structure interaction analysis are reviewed

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SECTION 3.7.3 SEISMIC SUBSYSTEM ANALYSIS

REVIEW RESPONSIBILITIES

Primary - Structural Engineering Branch (SEB)

Secondary - None

I. AREAS OF REVIEW

The following areas related to the seismic subsystem analysis are reviewed:

1. Seismic Analysis Methods

   The information reviewed is similar to that described in subsection I.1 of Standard Review Plan (SRP) Section 3.7.2, but as applied to seismic Category I subsystems.

2. Determination of Number of Earthquake Cycles

   Criteria or procedures used to establish the number of earthquake cycles during one seismic event and the maximum number of cycles for which applicable Category I subsystems and components are designed are reviewed.

3. Procedures Used for Analytical Modeling

   The criteria and procedures used for modeling the seismic subsystem are reviewed.

4. Basis for Selection of Frequencies

   As applicable, criteria or procedures used to separate fundamental frequencies of components and equipment from the forcing frequencies of the support structure are reviewed.

5. Analysis Procedure for Damping

   The information reviewed is similar to that described in subsection I.13 of SRP Section 3.7.2, but as applied to Category I subsystems.

6. Three Components of Earthquake Motion

The information reviewed is similar to that described in subsection I.6 of SRP Section 3.7.2, but as applied to Category I subsystems.

7. Combination of Model Responses

The information reviewed is similar to that described in subsection I.7 of SRP Section 3.7.2, but as applied to Category I subsystems.

8. Interaction of Other Systems With Category I Systems

The seismic analysis procedures to account for the seismic motion of non-Category I systems in the seismic design of Category I systems are reviewed.

9. Multiply-Supported Equipment and Components with Distinct Inputs

The criteria and procedures for seismic analysis of equipment and components supported at different elevations within a building and between buildings with distinct inputs are reviewed.

10. Use of Equivalent Static Factors

The information reviewed is similar to that described in subsection I.10 of SRP Section 3.7.2, but as applied to Category I subsystems.

11. Torsional Effects of Eccentric Masses

The criteria and procedures that are used to consider the torsional effects of eccentric masses in seismic subsystem analyses are reviewed.

12. Category I Buried Piping, Conduits, and Tunnels

For Category I buried piping, conduits, tunnels, and auxiliary systems, the seismic criteria and methods which consider the compliance characteristics of soil media, dynamic pressures, settlement due to earthquake, and differential movements at support points, penetrations, and entry points into structures provided with anchors are reviewed.

13. Methods for Seismic Analysis of Category I Dams

The analytical methods and procedures that will be used for seismic analysis of Category I dams are reviewed. The assumptions made, the boundary conditions used, the hydrodynamic effects considered, and the procedures by which strain-dependent materials properties are incorporated in the analysis are reviewed.

II. ACCEPTANCE CRITERIA

The acceptance criteria for the areas of review described in subsection I of this SRP section are given below. Other criteria which can be justified to be equivalent to or more conservative than the stated acceptance criteria may be used. SEB accepts the design of subsystems that are important to safety and must withstand the effects of earthquakes if the relevant requirements of General Design Criterion (GDC) 2 (Ref. 1) and Appendix A to 10 CFR Part 100

a) Equipment has been qualified by analysis and/or testing. Both dynamic analysis method and equivalent static load method have been used. (See Ref. 1, Section 3.10.) Supports for HVAC ducts and electrical raceway have used the equivalent static load method. For piping, this acceptance criteria is met by following Ref. 3.7b-14 (Ref. 1) which complies with the SRP.

b) One SSE and 5 OBE's are considered in the design of Category 1 subsystems. The synthetic time history has a duration of 25 seconds. For piping, this requirement is satisfied as described on Page 3.7b-19 of Ref. 1.

c) The coupling criteria given in SRP 3.7.2, Section II.3, as well as the other guidelines are followed in analytical modeling. (See also the response to SRP 3.7.2, Section II.3.)

The DG "E" facility's piping is modeled based on Ref. 3.7b-14 (Ref. 1) which complies with the SRP. Main line and branch runs were analyzed together. No decoupling criteria had to be considered. The number of masses satisfy the criteria of number of DDOF equal to two times the number of modes with frequency less than 33 Hz. A three dimensional model was used.

d) Components and equipment are designed/qualified for the loads developed from the application of the appropriate DG "E" facility's floor response spectra.

e) Damping values utilized for the DG "E" facility are those presented in Reg. Guide 1.61 (See Ref. 1, Page 3.7b-3). Most conduit and box supports utilize damping values associated with the existing plant criteria. This was done to take advantage of the numerous typical conduit/box supports that are available for the existing criteria.

(Ref. 2) concerning material phenomena are complied with. The relevant requirements of GDC 2 and Appendix A to 10 CFR Part 100 are:

1. General Design Criterion 2, as it relates to the earthquakes used in the design should be the most severe ones reported to have affected the site and surrounding area with sufficient margin for the limited accuracy, quantity, and period of time in which historical data have been accumulated.

2. Appendix A to 10 CFR Part 100 as it relates to the requirement that two earthquake levels, the safe shutdown earthquake (SSE) and the operating basis earthquake (OBE), be considered in the design of safety-related structures, components, and systems. Appendix A to 10 CFR Part 100 further states that the design used to ensure that the required safety functions are maintained during and after the vibratory ground motion associated with the safe shutdown earthquake shall involve the use of either a suitable dynamic analysis or a suitable qualification test to demonstrate that structures, systems, and components can withstand the seismic and other concurrent loads, except where it can be demonstrated that the use of an equivalent static load method provides adequate conservatism.

   Specific criteria necessary to meet the relevant requirements of GDC 2 and Appendix A to Part 100 are as follows:

   a. <u>Seismic Analysis Methods</u>

      The acceptance criteria provided in SRP Section 3.7.2, subsection II.1, are applicable.

   b. <u>Determination of Number of Earthquake Cycles</u>

      During the plant life at least one safe shutdown earthquake (SSE) and five operating basis earthquakes (OBE) should be assumed. The number of cycles per earthquake should be obtained from the synthetic time history (with a minimum duration of 10 seconds) used for the system analysis, or a minimum of 10 maximum stress cycles per earthquake may be assumed.

   c. <u>Procedures Used for Analytical Modeling</u>

      The acceptance criteria provided in SRP Section 3.7.2, subsection II.3, are applicable.

   d. <u>Basis for Selection of Frequencies</u>

      To avoid resonance, the fundamental frequencies of components and equipment should preferably be selected to be less than 1/2 or more than twice the dominant frequencies of the support structure. Use of equipment frequencies within this range is acceptable if the equipment is adequately designed for the applicable loads.

   e. <u>Analysis Procedure for Damping</u>

      The acceptance criteria provided in SRP Section 3.7.2, subsection II.13, are applicable.

f) For seismic Category I subsystems located within the DG "E" facility the response due to three orthogonal components of an earthquake are combined by the square root of the sum of the squares method per Reg. Guide 1.92, Rev. 1 (See Ref. 1, Page 3.7b-8)*.

g) For seismic Category I subsystems located within the DG "E" facility and analyzed by the response spectrum method, the total response was obtained by using the criteria presented in Reg. Guide 1.92 for the combination of modal responses. (See Ref. 1, Page 3.7b-8.)

h) Non-Category I subsystems have either been located, physically isolated, or designed such that they will not interfere with the function of Category I subsystems during a seismic event.

The attached Non-Category I piping was analyzed as a Category I pipe in order not to cause failure of Category I systems. (See Ref. 3.7b-14 of Ref. 1.)

i) An upper bound envelope of excitations at multi-support points of equipment is used in the seismic analysis of equipment.

The piping supported at different elevations was analyzed using an upper bound envelope of the individual response spectra. In addition, the relative displacement of the support points due to equipment movement was considered in the most conservative way; the absolute sum of the absolute maximum relative displacements (See Ref. 3.7b-14 of Ref. 1).

*For the majority of the Class 1E conduit routings, the existing plant criteria was applied to take advantage of the numerous typical conduit/box supports that are available for the existing criteria. These supports have been designed by combining the more severe response from one of the horizontal earthquakes with the response from the vertical earthquake by the absolute sum method. To compensate for this variation from the methodology presented in Reg. Guide 1.92, the permissible attachment loads for these supports are reduced by 25%. An evaluation determined that typical existing supports meet the Reg. Guide 1.92 requirements (i.e. combination of the responses from the three orthogonal earthquakes by the square root sum of the squares method) if the permissible attachment loads are reduced by 25%.

f. <u>Three Components of Earthquake Motion</u>

The acceptance criteria provided in SRP Section 3.7.2, subsection II.6, are applicable.

g. <u>Combination of Modal Responses</u>

The acceptance criteria provided in SRP Section 3.7.2, subsection II.7, are applicable.

h. <u>Interaction of Other Systems With Category I Systems</u>

To be acceptable, each non-Category I system should be designed to be isolated from any Category I system by either a constraint or barrier, or should be remotely located with regard to the seismic Category I system. If it is not feasible or practical to isolate the Category I system, adjacent non-Category I systems should be analyzed according to the same seismic criteria as applicable to the Category I system. For non-Category I systems attached to Category I systems, the dynamic effects of the non-Category I systems should be simulated in the modeling of the Category I system. The attached non-Category I systems, up to the first anchor beyond the interface, should also be designed in such a manner that during an earthquake of SSE intensity it will not cause a failure of the Category I system.

i. <u>Multiply-Supported Equipment and Components With Distinct Inputs</u>

Equipment and components in some cases are supported at several points by either a single structure or two separate structures. The motions of the primary structure or structures at each of the support points may be quite different.

A conservative and acceptable approach for equipment items supported at two or more locations is to use an upper bound envelope of all the individual response spectra for these locations to calculate maximum inertial responses of multiply-supported items. In addition, the relative displacements at the support points should be considered. Conventional static analysis procedures are acceptable for this purpose. The maximum relative support displacements can be obtained from the structural response calculations or, as a conservative approximation, by using the floor response spectra. For the latter option, the maximum displacement of each support is predicted by $S_d = S_a g/\omega^2$, where S_a is the spectral acceleration in "g's" at the high frequency end of the spectrum curve (which, in turn, is equal to the maximum floor acceleration), g is the gravity constant, and ω is the fundamental frequency of the primary support structure in radians per second. The support displacements can then be imposed on the supported item in the most unfavorable combination. The responses due to the inertia effect and relative displacements should be combined by the absolute sum method.

In the case of multiple supports located in a single structure, an alternate acceptable method using the floor response spectra involves determination of dynamic responses due to the worst single floor response spectrum selected from a set of floor response spectra obtained

j) Constant vertical static factors were used in the seismic design of Seismic Category I subsystems where shown to be appropriate.

Constant vertical static factors are not used in the seismic analysis of Category 1 piping.

k) Modeling of seismic Category I subsystems' actual mass and locations are considered, thereby, accounting for any eccentricity.

The location of mass points in the piping model reflects the torsional effects of eccentric masses such as valves and valve operators (See Page 3.7b-22 and Ref. 3-7b-14 of Ref. 1).

l) The DG "E" buried Category I pipes were analyzed in accordance with Ref. 3.7b-13 of Ref. 1. During a SSE event, the differential displacement between the DG "E" building and the surrounding soil which supports the pipes was included in the computation of piping stress.

m) No Category I dams have been added as a result of the DG "E" facility.

at various floors and applied identically to all the floors, provided there is no significant shift in frequencies of the spectra peaks. In addition, the support displacements should be imposed on the supported item in the most unfavorable combination using static analysis procedures.

In lieu of the response spectrum approach, time histories of support motions may be used as excitations to the subsystems. Because of the increased analytical effort compared to the response spectrum techniques, usually only a major equipment system would warrant a time history approach. The time history approach does, however, provide more realistic results in some cases as compared to the response spectrum envelope method for multiply-supported systems.

j. Use of Equivalent Static Factors

The acceptance criteria provided in SRP Section 3.7.2, subsection II.10, are applicable.

k. Torsional Effects of Eccentric Masses

For seismic Category I subsystems, when the torsional effect of an eccentric mass is judged to be significant, the eccentric mass and its eccentricity should be included in the mathematical model. The criteria for judging the significance will be reviewed on a case-by-case basis.

l. Category I Buried Piping, Conduits, and Tunnels

For Category I buried piping, conduits, tunnels, and auxiliary systems, the following items should be considered in the analysis:

(1) The inertial effects due to an earthquake upon buried systems and tunnels should be adequately accounted for in the analysis. In case of buried systems sufficiently flexible relative to the surrounding or underlying soil, it is acceptable to assume that the systems will follow essentially the displacements and deformations that the soil would have if the systems were absent. Procedures which take into account the phenomena of wave travel and wave reflection in compacting soil displacements from the ground displacements are acceptable.

(2) The effects of static resistance of the surrounding soil on piping deformations or displacements, differential movements of piping anchors, bent geometry and curvature changes, etc., should be adequately considered. Procedures utilizing the principles of the theory of structures on elastic foundations are acceptable.

(3) When applicable, the effects due to local soil settlements, soil arching, etc., should also be considered in the analysis.

m. Methods for Seismic Analysis of Category I Dams

For the analysis of all Category I dams an appropriate approach which takes into consideration the dynamic nature of forces (due

to both horizontal and vertical earthquake loadings), the behavior of the dam material under earthquake loadings, soil structure interaction effects, and nonlinear stress-strain relations for the soil, should be used. Analysis of earth-filled dams should include an evaluation of deformations. For rock-filled dams, the analytical procedure used will be reviewed on a case-by-case basis.

III. REVIEW PROCEDURES

For each area of review, the following review procedure is followed. The reviewer will select and emphasize material from the procedures given below, as may be appropriate for a particular case. The review procedures are such as to satisfy the requirements of acceptance criteria stated in subsection II.

1. Seismic Analysis Methods

   The seismic analysis methods are reviewed to determine that these are in accordance with the acceptance criteria of SRP Section 3.7.2, subsection II.1.

2. Determination of Number of Earthquake Cycles

   Criteria or procedures used to establish the number of earthquake cycles are reviewed to determine that they are in accordance with the acceptance criteria as given in subsection II.2 of this SRP section. Justification for deviating from the acceptance criteria is requested from the applicant, as necessary.

3. Procedures Used for Analytical Modeling

   The criteria and procedures used for modeling for the seismic subsystem analysis are reviewed to determine that these are in accordance with the acceptance criteria of SRP Section 3.7.2, subsection II.3.

4. Basis for Selection of Frequencies

   As applicable, criteria or procedures used to separate fundamental frequencies of components and equipment from the forcing frequencies of the support structure are reviewed to determine compliance with the acceptance criteria of subsection II.4 of this SRP section.

5. Analysis Procedure for Damping

   The analysis procedure to account for damping in different elements of the model of a coupled system is reviewed to determine that it is in accordance with the acceptance criteria of SRP Section 3.7.2, subsection II.13.

6. Three Components of Earthquake Motion

   The procedures by which the three components of earthquake motion are considered in determining the seismic response of subsystems are reviewed to determine compliance with the acceptance criteria of SRP Section 3.7.2, subsection II.6.

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SECTION 3.8.4 OTHER SEISMIC CATEGORY I STRUCTURES

REVIEW RESPONSIBILITIES

Primary - Structural Engineering Branch (SEB)

Secondary - None

I. AREAS OF REVIEW

The following areas relating to all seismic Category I structures and other safety-related structures that may not be classified as seismic Category I, other than the containment and its interior structures, are reviewed:

1. Description of the Structures

The descriptive information including plans and sections of each structure, is reviewed to establish that sufficient information is provided to define the primary structural aspects and elements relied upon for the structure to perform the safety-related function. Also reviewed is the relationship between adjacent structures including the separation provided or structural ties, if any. Among the major plant structures that are reviewed, together with the descriptive information reviewed for each, are the following:

a. Containment Enclosure Building

The containment enclosure building, which may surround all or part of the primary concrete or steel containment structure, is primarily intended to reduce leakage during and after a loss-of-coolant (LOCA) from within the containment. Concrete enclosure buildings also protect the primary containment, which may be of steel or concrete, from outside hazards.

The enclosure building is usually either a concrete structure or a structural steel and metal siding building.

Where it is a concrete structure, it usually has the geometry of the containment and, as applicable, the descriptive information reviewed is

Special construction techniques, if proposed, are reviewed on a case-by-case basis to determine their effects on the structural integrity of the completed structure.

In addition, the information contained in items a, b, and c of subsection I.6 of Standard Review Plan Section 3.8.3 is also reviewed.

7. Testing and Inservice Surveillance Programs

If applicable, any post-construction testing and inservice surveillance programs are reviewed on a case-by-case basis.

8. Masonry Walls

Areas of review pertaining to masonry walls should include, as a minimum, those items identified in Appendix A to this SRP section.

SEB coordinates other branches evaluations that interface with structural engineering aspects of the review as follows: determination of structures which are subject to quality assurance programs in accordance with the requirements of Appendix B to 10 CFR Part 50 is performed by the Mechanical Engineering Branch (MEB) as part of its primary review responsibility for SRP Sections 3.2.1 and 3.2.2. SEB will perform its review of safety-related structures on that basis. Determination of pressure loads from high energy lines located in safety related structures other than containment is performed by the Auxiliary Systems Branch (ASB) as described as part of its primary review responsibility for SRP Section 3.6.1. SEB accepts the loads thus generated as approved by the ASB to be included in the load combination equations of this SRP section. Determination of loads generated due to pressure under accident conditions is performed by the Containment Systems Branch (CSB) as part of its primary review responsibility for SRP Section 6.2.1. SEB accepts the loads thus generated, as approved by the CSB to be included in the load combinations in this SRP section. The review for quality assurance is coordinated and performed by the Quality Assurance Branch as part of its primary review responsibility for SRP Section 17.0.

For those areas of review identified above as being reviewed as part of the primary review responsibility of other branches, the acceptance criteria necessary for the review and their methods of application are contained in the referenced SRP section of the corresponding primary branch.

II. ACCEPTANCE CRITERIA

SEB acceptance criteria for the design of structures other than containment are based on meeting the relevant requirements of the following regulations:

A. 10 CFR Part 50, §50.55a and General Design Criterion 1 as they relate to safety related structures being designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety function to be performed.

B. General Design Criterion 2 as it relates to the design of the safety-related structures being capable to withstand the most severe natural phenomena such as wind, tornadoes, floods, and earthquakes and the appropriate combination of all loads.

A description of the DG "E" facility is provided in Ref. 1.

ACI349-1980 and AISC-1978 were followed in the design of the DG "E" facility. The AISC 33% increase in allowable stresses for seismic or wind loading is not used. (See Ref. 3, Page 10.)

Reg. Guides 1.10, 1.15 and 1.55 were withdrawn (see US NRC distribution list, Division 1, July 8, 1981).

C. General Design Criterion 4 as it relates to safety-related structure being capable of withstanding the dynamic effects of equipment failures including missiles and blowdown loads associated with the loss of coolant accidents.

D. General Design Criterion 5 as it relates to sharing of structures important to safety unless it can be shown that such sharing will not significantly impair their validity to perform their safety functions.

E. Appendix B to 10 CFR Part 50 as it relates to the quality assurance criteria for nuclear power plants.

The Regulatory Guides and industry standards identified in item 2 of this subsection provides information, recommendations and guidance and in general describes a basis acceptable to the staff that may be used to implement the requirements of 10 CFR Part 50, §50.55a and GDC 1, 2, 4, 5 and Appendix B to 10 CFR Part 50. Also, specific acceptance criteria necessary to meet the relevant requirements of these regulations for the areas of review, described in subsection I of this SRP section are as follows:

1. Description of the Structures

The descriptive information in the SAR is considered acceptable if it meets the minimum requirements set forth in Section 3.8.4.1 of the "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants" (Ref. 4).

Deficient areas of descriptive information are identified by the reviewer and a request for additional information is initiated at the application acceptance review. New or unique design features that are not specifically covered in the "Standard Format..." may require a more detailed review. The reviewer determines the additional information that may be required to accomplish a meaningful review of the structural aspects of such new or unique features.

2. Applicable Codes, Standards, and Specifications

The design, materials, fabrication, erection, inspection, testing, and surveillance, if any, of Category I structures are covered by codes, standards, and guides that are either applicable in their entirety or in portions thereof. A list of such documents is as follows:

Specification	Title
ACI 349	"Code Requirements for Nuclear Safety-Related Concrete Structures"
AISC	"Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings"

Regulatory Guides	
1.10	Mechanical (Caldweld) Splices in Reinforcing Bars of Category I Concrete Structures

Reg. Guide 1.69 is not applicable to the D.G. "E" facility.

The same truck explosion fragment as that considered in the design of the existing Category 1 structures, was considered in the design of the DG "E" building (Refer to PP&L's response to SRP 3.5.1.5).

The design of the DG "E" building complies with Reg. Guide 1.94.

Reg. Guide 1.115 is not applicable to the DG "E" facility.

The design of the DG "E" building complies with the applicable provisions of Reg. Guide 1.142.

Reg. Guide 1.143 is not applicable to the DG "E" facility.

1.15	Testing of Reinforcing Bars for Category I Concrete Structures
1.55	Concrete Placement in Category I Structures
1.69	Concrete Radiation Shields for Nuclear Power Plants
1.91	Evaluations of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plants
1.94	Quality Assurance Requirements for Installation, Inspection, and Testing of Structural Concrete
1.115	Protection Against Low Trajectory Turbine Missiles
1.142	Safety-Related Concete Structures for Nuclear Power Plants (Other Than Reactor Vessels and Containments)
1.143	Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in LWR Plants

3. Loads and Load Combinations

The specified loads and load combinations are acceptable if found to be in accordance with the following:

a. Loads, Definitions, and Nomenclature

All the major loads to be encountered or to be postulated are listed below. All the loads listed, however, are not necessarily applicable to all the structues and their elements. Loads and the applicable load combinations for which each structure has to be designed will depend on the conditions to which that particular structure may be subjected.

Normal loads, which are those loads to be encountered during normal plant operation and shutdown, include:

D - Dead loads or their related internal moments and forces, inluding any permanent equipment loads.

L - Live loads or their related internal moments and forces, including any movable equipment loads and other loads which vary with intensity and occurrence, such as soil pressure.

T_o - Thermal effects and loads during normal operating or shutdown conditions, based on the most critical transient or steady state condition.

No high-energy piping exists in the DG "E" facility.

R_o - Pipe reactions during normal operating or shutdown conditions, based on the most critical transient or steady state condition.

Severe environmental loads include:

E - Loads generated by the operating basis earthquake.

W - Loads generated by the design wind specified for the plant.

Extreme environmental loads include:

E' - Loads generated by the safe shutdown earthquake.

W_t - Loads generated by the design tornado specified for the plant. Tornado loads include loads due to the tornado wind pressure, the tornado-created differential pressure, and to tornado-generated missiles.

Abnormal loads, which are those loads generated by a postulated high-energy pipe break accident, include:

P_a - Pressure equivalent static load within or across a compartment generated by the postulated break, and including an appropriate dynamic load factor to account for the dynamic nature of the load.

T_a - Thermal loads under thermal conditions generated by the postulated break and including T_o.

R_a - Pipe reactions under thermal conditions generated by the postulated break and including R_o.

Y_r - Equivalent static load on the structure generated by the reaction on the broken high-energy pipe during the postulated break, and including an appropriate dynamic load factor to account for the dynamic nature of the load.

Y_j - Jet impingement equivalent static load on a structure generated by the postulated break, and including an appropriate dynamic load factor to account for the dynamic nature of the load.

Y_m - Missile impact equivalent static load on a structure generated by or during the postulated break, as from pipe whipping, and including an appropriate dynamic load factor to account for the dynamic nature of the load.

In determining an appropriate equivalent static load for Y_r, Y_j, and Y_m, elasto-plastic behavior may be assumed with appropriate ductility ratios, provided excessive deflections will not result in loss of function of any safety-related system.

The working stress design method was not used in the design of the DG "E" facility.

The ultimate strength design method and these load combinations were used in the design of the DG "E" facility. (See Ref. 3, Page 10.)

b. Load Combinations for Concrete Structures

For concrete structures, the load combinations are acceptable if found in accordance with the following:

(i) For service load conditions, either the working stress design (WSD) method as outlined in ACI 318 Code or the strength design method may be used.

(a) If the WSD method is used, the following load combinations should be considered:

(1) $D + L$

(2) $D + L + E$

(3) $D + L + W$

If thermal stresses due to T_o and R_o are present, the following combinations should be also considered:

(4) $D + L + T_o + R_o$

(5) $D + L + T_o + R_o + E$

(6) $D + L + T_o + R_o + W$

Both cases of L having its full value or being completely absent should be checked.

(b) If the strength design method is used, the following load combinations should be considered:

(1) $1.4\ D + 1.7\ L$

(2) $1.4\ D + 1.7\ L + 1.9\ E$

(3) $1.4\ D + 1.7\ L + 1.7\ W$

If thermal stresses due to T_o and R_o are present, the following combinations should also be considered:

(4) $(0.75)\ (1.4D + 1.7L + 1.7T_o + 1.7R_o)$

(5) $(0.75)\ (1.4D + 1.7L + 1.9E + 1.7T_o + 1.7R_o)$

(6) $(0.75)\ (1.4D + 1.7L + 1.7W + 1.7T_o + 1.7R_o)$

In addition, the following combinations should be considered:

(7) $1.2\ D + 1.9\ E$

(8) $1.2\ D + 1.7\ W$

(ii) For factored load conditions which represent extreme environmental, abnormal, abnormal/severe environmental, and

Factored load combinations (a) & (b) were considered. Since no high energy piping exists, factored load combinations (c), (d) & (e) were not considered. In addition the following load combination was considered.

D + L + Wms

where Wms = Site Proximity Missile Loads

(See Ref. 3, Page 10.)

For loads which are variable, the full range of variation was considered in order to determine the most critical combination of loading.

The elastic working stress design method and these load combinations were used in the design of steel for the DG "E" facility. (See Ref. 3, Page 11.)

abnormal/extreme environmental conditions, the strength design method should be used and the following load combinations should be considered:

(a) $D + L + T_o + R_o + E'$

(b) $D + L + T_o + R_o + W_t$

(c) $D + L + T_a + R_a + 1.5\ P_a$

(d) $D + L + T_a + R_a + 1.25\ P_a + 1.0\ (Y_r + Y_j + Y_m) + 1.25\ E'$

(e) $D + L + T_a + R_a + 1.0\ P_a + 1.0\ (Y_r + Y_j + Y_m) + 1.0\ E'$

In combinations (c), (d), and (e), the maximum values of P_a, T_a, R_a, Y_j, Y_r, and Y_m, including an appropriate dynamic load factor, should be used unless a time-history analysis is performed to justify otherwise. Combinations (b) and (d) and (e) and the corresponding structural acceptance criteria of subsection II.5 of this SRP section should be satisfied first without the tornado missile load in (b) and without Y_r, Y_j, and Y_m in (d) and (e). When considering these concentrated loads, local section strength capacities may be exceeded provided there will be no loss of function of any safety-related system.

Where any load reduces the effects of other loads, the corresponding coefficient for that load should be taken as 0.9 if it can be demonstrated that the load is always present or occurs simultaneously with other loads. Otherwise the coefficient for that load should be taken as zero.

Where the structural effects of differential settlement, creep, or shrinkage may be significant, they should be included with the dead load, D, as applicable.

c. Load Combinations for Steel Structures

For steel interior structures, the load combinations are acceptable if found in accordance with the following:

(i) For service load conditions, either the elastic working stress design methods of Part 1 of the AISC specifications, or the plastic design methods of Part 2 of the AISC specifications, may be used.

(a) If the elastic working stress design methods are used, the following load combinations should be considered:

(1) $D + L$

(2) $D + L + E$

(3) $D + L + W$

Thermal loads are not present in the DG "E" facility.

The plastic design method was not used in the design of the DG "E" facility.

Factored load combinations (1) & (2) were considered. Since no high energy piping exists, factored load combinations (3), (4) & (5) were not considered. In addition the following load combination was considered:

$D + L + W_{ms}$

(See Ref. 3, Page 11.)

If thermal stresses due to T_o and R_o are present, the following combinations should be also considered:

(4) $D + L + T_o + R_o$

(5) $D + L + T_o + R_o + E$

(6) $D + L + T_o + R_o + W$

(b) If plastic design methods are used, the following load combinations should be considered:

(1) $1.7\ D + 1.7\ L$

(2) $1.7\ D + 1.7\ L + 1.7\ E$

(3) $1.7\ D + 1.7\ L + 1.7\ W$

If thermal stresses due to T_o and R_o are present, the following combinations should also be considered:

(4) $1.3\ (D + L + T_o + R_o)$

(5) $1.3\ (D + L + E + T_o + R_o)$

(6) $1.3\ (D + L + W + T_o + R_o)$

(ii) For factored load conditions the following load combinations should be considered:

(a) If elastic working stress design methods are used:

(1) $D + L + T_o + R_o + E'$

(2) $D + L + T_o + R_o + W_t$

(3) $D + L + T_a + R_a + P_a$

(4) $D + L + T_a + R_a + P_a + 1.0\ (Y_r + Y_j + Y_m) + E$

(5) $D + L + T_a + R_a + P_a + 1.0\ (Y_r + Y_j + Y_m) + E'$

(b) If plastic design methods are used:

(1) $D + L + T_o + R_o + E'$

(2) $D + L + T_o + R_o + W_t$

(3) $D + L + T_a + R_a + 1.5\ P_a$

(4) $D + L + T_a + R_a + 1.25\ P_a + 1.0\ (Y_r + Y_j + Y_m) + 1.25\ E$

(5) $D + L + T_a + R_a + 1.0\ P_a + 1.0\ (Y_r + Y_j + Y_m) + E'$

In determining the most critical loading condition to be used in design, the absence of a load or loads was considered as appropriate.

a. The DG "E" facility's design and analysis procedures comply with ACI-349.

b. The DG "E" facility's design and analysis procedures comply with AISC Spec., except the 33% increase in allowable stresses for seismic or wind loading is not followed.

c. The computer programs (MSC/NASTRAN and RESPECT) used for the DG "E" building seismic analyses meet the requirements of subsection II.4.e of SRP Section 3.8.1.

d. A design description report along with various drawings for the DG "E" facility have been submitted to the NRC. Additional information is available upon request.

f. Not applicable to the DG "E" facility.

In the above factored load combinations, thermal loads can be neglected when it can be shown that they are secondary and self-limiting in nature and where the material is ductile.

In combinations (3), (4), and (5), the maximum values of P_a, T_a, R_a, Y_j, Y_r, and Y_m, including an appropriate dynamic load factor, should be used unless a time-history analysis is performed to justify otherwise. Combinations (2), (4) and (5) and the corresponding structural acceptance criteria of subsection II.5 of this SRP section should first be satisfied without the tornado missile load in (2) and without Y_r, Y_j, and Y_m in (4) and (5). When considering these concentrated loads, local section strength may be exceeded provided there will be no loss of function of any safety-related system.

Where any load reduces the effects of other loads, the corresponding coefficient for that load should be taken as 0.9, if it can be demonstrated that the load is always present or occurs simultaneously with other loads. Otherwise, the coefficient for that load should be taken as zero.

Where the structural effect of differential settlement may be significant it should be included with the dead load, D.

4. <u>Design and Analysis Procedures</u>

The design and analysis procedures utilized for Category I structures, including assumptions on boundary conditions and expected behavior under loads, are acceptable if found in accordance with the following:

a. For concrete structures, the procedures are in accordance with ACI-349, "Code Requirements for Nuclear Safety Related Structures" (Ref. 1).

b. For steel structures, the procedures are in accordance with the AISC "Specification..." (Ref. 3).

c. Computer programs are acceptable if the validation provided is found in accordance with procedures delineated in subsection II.4.e of SRP Section 3.8.1.

d. Design report is considered acceptable if it contains the information specified in Appendix C to this SRP section.

e. Structural audit is conducted in accordance with the provisions of Appendix B to this SRP section.

f. Design of spent fuel pool and rods is considered acceptable when the requirements of Appendix D to this SRP section are met.

5. <u>Structural Acceptance Criteria</u>

For each of the loading combinations delineated in subsection II.3 of this SRP section, the following defines the allowable limits which constitute the structural acceptance criteria:

The limits provided herein were used in the load combinations for concrete structures. (See Ref. 3, Page 10.)

The limits provided herein were used in the load combinations for steel structures. (See Ref. 3, Page 11.)

a. In Combinations for Concrete	Limit
Paragraphs 3.b.(i)(a)(1), (2), and (3)	S[1]
Paragraphs 3.b.(i)(a)(4), (5), and (6)	1.3 S
Paragraphs 3.b.(i)(b)(1), (2), and (3)	U[2]
Paragraphs 3.b.(i)(b)(4), (5), and (6)	U
Paragraphs 3.b.(i)(6), (7), and (8).	U
Paragraphs 3.b.(ii)(a), (b), (c), (d), and (e) . . .	U

b. In Combinations for Steel	Limit
Paragraphs 3.c.(i)(a)(1), (2), and (3)	S
Paragraphs 3.c.(i)(a)(4), (5), and (6)	1.5 S
Paragraphs 3.c.(i)(b)(1), (2), and (3)	Y[3]
Paragraphs 3.c.(i)(b)(4), (5), and (6)	Y
Paragraphs 3.c.(ii)(a)(1), (2), (3), and (4)[4]. . .	1.6 S
Paragraphs 2.(c)(ii)(a)(4), and (5)[4]	1.7 S
Paragraphs 3.c.(ii)(b)(1), (2), (3), (4), and (5). .	Y

Notes

(1) S - For concrete structures, S is the required section strength based on the working stress design method and the allowable stresses defined in ACI 318 Code.

For structural steel, S is the required section strength based on elastic design methods and the allowable stresses defined in Part 1 of the AISC "Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings" (Ref. 3)

The one-third increase in allowable stresses for concrete and steel due to seismic or wind loadings is not permitted.

(2) U - For concrete structures, U is the section strength required to resist design loads based on the strength design methods described in ACI 349 Code (Ref. 1).

(3) Y - For structural steel, Y is the section strength required to resist design loads and based on plastic design methods described in Part 2 of the AISC "Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings" (Ref. 3).

(4) - For these two combinations, in computing the required section strength, S, the plastic section modulus of steel shapes, except for those which do not meet the AISC criteria for compact sections, may be used.

6. No special construction techniques were used for the DG "E" facility. Welding of rebar was not permitted. The applicable codes referred to here are complied with.

7. No special testing or in-service surveillance requirements for the DG "E" structure were required.

8. No masonry walls are used in the DG "E" facility.

6. Materials, Quality Control, and Special Construction Techniques

For Category I structures outside the containment, the acceptance criteria for materials, quality control, and any special construction techniques are in accordance with the codes and standards indicated in subsection I.6 of SRP Section 3.8.3, as applicable.

7. Testing and Inservice Surveillance Requirements

At present there are no special testing or inservice surveillance requirements for Category I structures outside the containment. However, where some requirements become necessary for special structures, such requirements are reviewed on a case-by-case basis.

8. Masonry Walls

Acceptance criteria for masonry walls are contained in Appendix A to this SRP section.

III. REVIEW PROCEDURES

The reviewer selects and emphasizes material from the review procedures described below, as may be appropriate for a particular case.

1. Description of the Structures

After the type of structure and its functional characteristics are identified, information on similar and previously licensed plants is obtained for reference. Such information, which is available in safety analysis reports and amendments of previous license applications, enables identification of differences for the case under review. These differences require additional scrutiny and evaluation. New and unique features that have not been used in the past are of particular interest and are thus examined in greater detail. The information furnished in the SAR is reviewed for completeness in accordance with the "Standard Format..." (Ref. 4). A decision is then made with regard to the sufficiency of the descriptive information provided. Any additional required information not provided is requested from the applicant at an early stage of the review process.

2. Applicable Codes, Standards, and Specifications

The list of codes, standards, guides, and specifications is compared with the list in subsection II.2 of this SRP section. The reviewer assures himself that the appropriate code or guide is utilized and that the applicable edition and stated effective addenda are acceptable.

3. Loads and Loading Combinations

The reviewer verifies that the loads and load combinations are as conservative as those specified in subsection II.3 of this SRP section. Any deviations from the acceptance criteria for loads and load combinations that have not been adequately justified are identified as unacceptable and transmitted to the applicant.

U.S. NUCLEAR REGULATORY COMMISSION
STANDARD REVIEW PLAN
OFFICE OF NUCLEAR REACTOR REGULATION

3.8.5 FOUNDATIONS

REVIEW RESPONSIBILITIES

Primary - Structural Engineering Branch (SEB)

Secondary - None

I. AREAS OF REVIEW

The following areas related to the foundations of all seismic Category I structures are reviewed.

1. Description of the Foundations

The descriptive information, including plans and sections of each foundation, is reviewed to establish that sufficient information is provided to define the primary structural aspects and elements relied upon to perform the foundation function. Also reviewed is the relationship between adjacent foundations, including the methods of separation provided where such separation is used to minimize seismic interaction between the buildings. In particular, the type of foundation is identified and its structural characteristics are examined. Among the various types of foundations reviewed are mat-foundations and footings, including individual column footings, combined footings supporting more than one column, and wall footings supporting bearing walls.

Other types of foundations that may also be used are pile foundations, drilled caissons, caissons for water front structures, such as a pumphouse, and rock anchor systems. These types of foundation are reviewed on a case-by-case basis.

The major plant Category I foundations that are reviewed, together with the descriptive information, are listed below:

A description of the DG "E" facility's foundation is provided in Ref. 1, Section 3.8.5.1. Additional information is provided in Ref. 2, Page 3-6.

Earthquake (OBE) and the Safe Shutdown Earthquake (SSE), site dependent free field ground motion records, soil properties, etc., as an integral part of the seismic analysis review of Category I structures. The review for Quality Assurance is coordinated and performed by the Quality Assurance Branch as part of its primary review responsiblity for SRP Section 17.0.

For those areas of review identified above as being reviewed as part of the primary review responsibility of other branches, the acceptance criteria necessary for the review and their methods of application are contained in the referenced SRP section of the corresponding primary branch.

II. ACCEPTANCE CRITERIA

SEB acceptance criteria for the design of seismic Category I foundations are based on meeting the relevant requirements of the following regulations:

A. 10 CFR Part 50, K50.55a and General Design Criterion 1 as they relate to safety-related structures being designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety function to be performed.

B. General Design Criterion 2 (Ref. 3) as it relates to appropriate considerations being given to the most severe of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated, and to the combinations of the effects of normal and accident conditions with the effects of the natural phenomena.

C. General Design Criterion 4 (Ref. 4) as it relates to structures, systems, and components important to safety being appropriately protected against dynamic effects, including the effects of missiles, pipe whipping, and discharging fluids, that may result from equipment failures and from events and conditions outside the nuclear power unit.

D. General Design Criterion 5 (Ref. 5) as it relates to structures, systems, and components important to safety not being shared among nuclear power units unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions.

The Regulatory Guides and industry standards identified in item 2 of this subsection provides information, recommendations and guidance and in general describes a basis acceptable to the staff that may be used to implement the requirement of 10 CFR Part 50, K50.55a, and GDC 1, 2, 4, and 5. Also, specific acceptance criteria necessary to meet these relevant requirements of these regulations for the areas of review, described in subsection I of this SRP Section are as follows:

1. Description of the Foundation

   The descriptive information in the SAR is considered acceptable if it meets the minimum requirements set forth in Section 3.8.5.1 of Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants."

A list of the codes standards and regulations considered in the design of the DG E facility's foundation is provided in Ref. 2.

The loads and load combinations used in the design of the DG "E" foundation comply with those listed in Subsection II.

The listed load combinations were used to check against sliding and overturning due to earthquakes, winds and tornados and, against floatation due to floods. (See Ref. 3, Page 11.)

a. The design of the DG "E" facility's foundation does not consider soil-structure interaction since it is founded on sound bedrock.

   Hydrodynamic loads need not.be considered since the DG "E" facility is located far enough away from the containment structures.

   Dynamic soil pressure has been considered in the design of the DG "E" facility.

b. The design and analysis procedures for the DG "E" facility's foundation comply with ACI-349.

c. The AISC specification is not applicable for the design and analysis procedures used in the design of the DG "E" facility's foundation since it is constructed out of reinforced concrete.

Deficient areas of descriptive information are identified by the reviewer and a request for additional information is initiated. New or unique design features that are not specifically covered in the "Standard Format...", require a more detailed review. The reviewer determines the additional information required for a meaningful review of such new or unique design features.

2. Applicable Codes, Standards, and Specifications

The design, materials, fabrication, erection, inspection, testing, and surveillance, if any, of seismic Category I foundations are covered by codes, standards, and guides that are either applicable in their entirety or in portions thereof. A list of such documents is contained in subsection I.2 of the SRP Section 3.8.3. In addition the documents listed in subsection II.2 of SRP Section 3.8.1 are acceptable for the containment foundation.

3. Loads and Load Combinations

The specified loads and load combinations used in the design of seismic Category I foundations are acceptable if found to be in accordance with those combinations referenced in subsection II.3 of SRP Section 3.8.1 for the containment foundation, and with those combinations listed in subsection II.3 of SRP Section 3.8.4 for all other seismic Category I foundations.

In addition to the load combinations referenced above, the combinations used to check against sliding and overturning due to earthquakes, winds, and tornados, and against floatation due to floods, are found acceptable if in accordance with the following:

a. $D + H + E$
b. $D + H + W$
c. $D + H + E'$
d. $D + H + W_t$
e. $D + F'$

where D, E, W, E', W_t are as defined in SRP Section 3.8.4, H is the lateral earth pressure, and F' is the bouyant force of the design basis flood. Justification should be provided for including live loads or portions thereof in these combinations.

4. Design and Analysis Procedures

The design and analysis procedures used for seismic Category I foundations are acceptable if found in accordance with the following:

a. The design should consider the soil-structure interaction, hydrodynamic effect, and dynamic soil pressure.

b. For seismic Category I concrete foundations other than the containment foundations, the procedures are in accordance with the ACI-349 Code, as augmented by Regulatory Guide 1.142.

c. For Category I steel foundations, the procedures are in accordance with the AISC "Specifications...".

d. Not applicable to the DG "E" facility.

e. A design description report along with various drawings for the DG "E" facility have been submitted to the NRC. Additional information is available upon request.

5. The allowable limits listed in Subsection II.5 of SRP Section 3.8.4 were used in the design of the DG "E" foundation.

The listed factors of safety against overturning, sliding and floatation are used in the design of the DG "E" facility. (See Ref. 3, Page 11.)

6. The criteria pertaining to containment foundations is not applicable for the DG "E" facility. No special construction techniques were used for the DG "E" facility's foundation. Welding of rebar was not permitted. The applicable codes referred to here are complied with.

7. No special testing or in-service surveillance requirements for the DG "E" foundation were required.

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d. For the containment foundation, the design and analysis procedures referenced in subsection II.4 of SRP Section 3.8.1 are acceptable.

e. The design report is found acceptable if it satisfies the guidelines contained in Appendix C to SRP Section 3.8.4.

f. The structural audit is conducted as described in Appendix B to SRP Section 3.8.4.

For determining the overturning moment due to an earthquake, the three components of the earthquake should be combined in accordance with methods described in SRP Section 3.7.2. Computer programs are acceptable if the validation provided is found in accordance with procedures delineated in subsection II.4.e of SRP Section 3.8.1.

5. Structural Acceptance Criteria

For each of the loading combinations referenced in subsection II.3 of this SRP Section, the allowable limits which constitute the acceptance criteria are referenced in subsection II.5 of SRP Section 3.8.1 for the containment foundation, and are listed in subsection II.5 of SRP Section 3.8.4 for all other foundations. In addition, for the five additional load combinations delineated in subsection II.3 of this SRP section, the factors of safety against overturning, sliding and floatation are acceptable if found in accordance with the following:

For Combination	Minimum Factors of Safety Overturning	Sliding	Floatation
a. ------------------------	1.5	1.5	--
b. ------------------------	1.5	1.5	--
c. ------------------------	1.1	1.1	--
d. ------------------------	1.1	1.1	--
e. ------------------------	--	--	1.1

6. Materials, Quality Control, and Special Construction Techniques

For the containment foundation, the acceptance criteria for materials, quality control, and any special construction techniques are referenced in subsection II.6 of SRP Section 3.8.1. For all other seismic Category I foundations, the acceptance criteria are similar to those referenced in subsection II.6 of SRP Section 3.8.4.

7. Testing and Inservice Surveillance Requirements

At present there are no special testing or in-service surveillance requirements for seismic Category I foundations other than those required for the containment foundation, which are covered in subsection II.7 of SRP Section 3.8.1. However, should some requirements become necessary for special foundations, they will be reviewed on a case-by-case basis.

III. REVIEW PROCEDURES

The reviewer selects and emphasizes material from the review procedures described below, as may be appropriate for a particular case.

1.2.2.4.16 Standby ac Power Supply

The Standby ac Power Supply System consists of four diesel-generator sets. The diesel-generators are sized so that three diesels can supply all the necessary power requirements for one unit in the design basis accident condition, plus the necessary required loads to effect the safe shutdown of the second unit. The diesel generators are specified to start up and attain rated voltage and frequency within 10 seconds. Four independent 4 kV engineered safety feature switchgear assemblies are provided for each reactor unit. Each diesel-generator feeds an independent 4 kV bus for each reactor unit.

Each diesel-generator starts automatically upon loss of off-site power or detection of a nuclear accident. The necessary engineered safety feature system loads are applied in a preset time sequence. Each generator operates independently and without paralleling during a loss of off-site power or LOCA signal.

1.2.2.4.17 dc Power Supply

Each reactor unit is provided with four independent 125 V and two independent 250 V dc systems. Each dc system is supplied from a separate battery bank and battery charger. The 125 V dc systems are provided to supply station dc control power and dc power to four diesel generators and their associated switchgears. The 250 V dc systems are provided to supply power required for the larger loads such as dc motor driven pumps and valves. A SEPARATE CLASS 1E, 125V DC SUBSYSTEM IS PROVIDED FOR THE FIFTH DIESEL GENERATOR. The 125/250-V dc System is designed to supply power adequate to satisfy the engineered safety feature load requirements of the unit with the postulated loss of off-site power and any concurrent single failure in the dc system.

1.2.2.4.18 Residual Heat Removal Service Water System

A Residual Heat Removal Service Water System is provided to remove the heat rejected by the Residual Heat Removal System during shutdown operation and accident conditions.

1.2.2.4.19 Emergency Service Water System

The Emergency Service Water System supplies water to cool the standby diesel-generators and the ECCS and Engineered Safety Features equipment rooms, and other essential heat loads.

Additionally, a fifth diesel generator is provided which has the capability of the emergency loading for any one of the four diesel generators after manual realignment

Power from the generators is stepped up from 24 kV to 230 kV on Unit No. 1 and from 24 kV to 500 kV on Unit No. 2 by the unit main transformers and supplied by overhead lines to the 230 kV and 500 kV switchyards, respectively.

1.2.2.6.2 Electric Power Distribution Systems

The electric power distribution system includes Class IE and non-Class IE ac and dc power systems. The class IE power system supplies all safety related equipment and some non-class IE loads while the non-Class IE system supplies the balance of plant equipment.

The Class IE ac system for each unit consists of four independent load groups. Two independent off-site power systems provide the normal electric power to these groups. Each load group includes 4.16 kV switchgear, 480 V load centers, motor control centers and 120 V control and instrument power panel. The vital ac instrumentation and control power supply systems include battery systems, static inverters. Voltages listed are nominal values, and all electrical equipment essential to safety is designed to accept a range of ±10 percent in voltage.

Four independent diesel generators are shared between the two units. Each diesel generator is provided as a standby source of emergency power for one of the four Class IE ac load groups in each unit. Assuming the total loss of off-site power and failure of one diesel generator, the remaining diesel generators have sufficient capacity to operate all the equipment necessary to prevent undue risk to public health and safety in the event of a design basis accident on one unit and a forced shutdown of the second unit.

(ADD INSERT "A" HERE-SEE ATTACHED)

The non-Class IE ac system includes 13.8 kV switchgear, 4.16 kV switchgear, 480 V load centers and motor control centers.

Four independent Class IE 125 Vdc batteries and two independent Class IE 250 Vdc batteries and associated battery chargers provide direct current power for the Class IE dc loads of each unit. Power for non-Class IE dc loads is supplied from the Class IE 125 and 250 V batteries through an additional circuit breaker for redundant fault protection.

(ADD INSERT "B" HERE-SEE ATTACHED)

These systems are discussed in Chapter 8.

Insert "A" (to page 1.2-26)

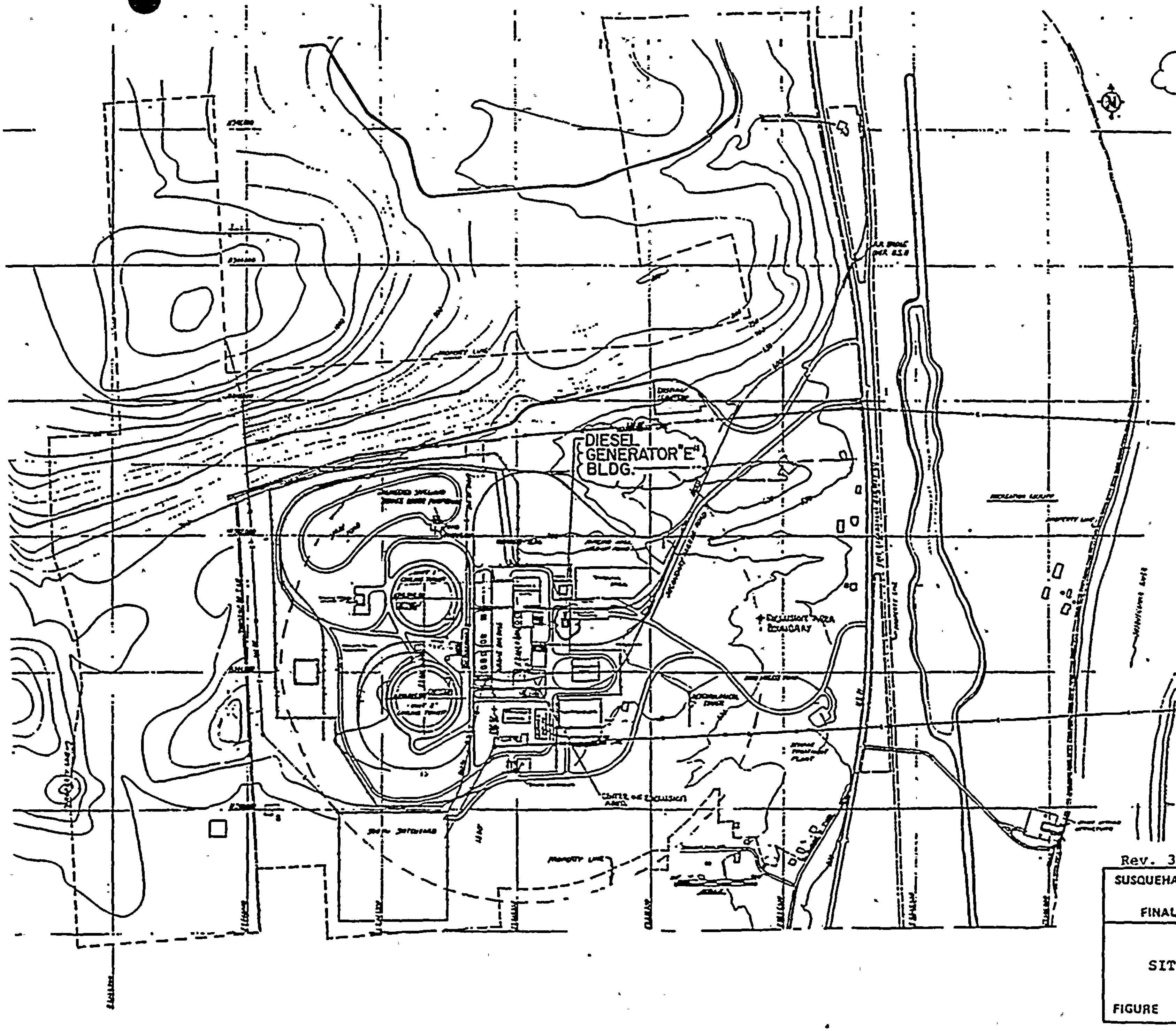
Additionally, a fifth diesel generator is provided which has the capability of the emergency loading for any one of the four diesel generators after manual realignment.

INSERT "B" (to page 1.2-26)

A separate Class 1E, 125 V DC Subsystem is provided for the fifth standby diesel generator.

DRAFTING NOTE

= G&H Change

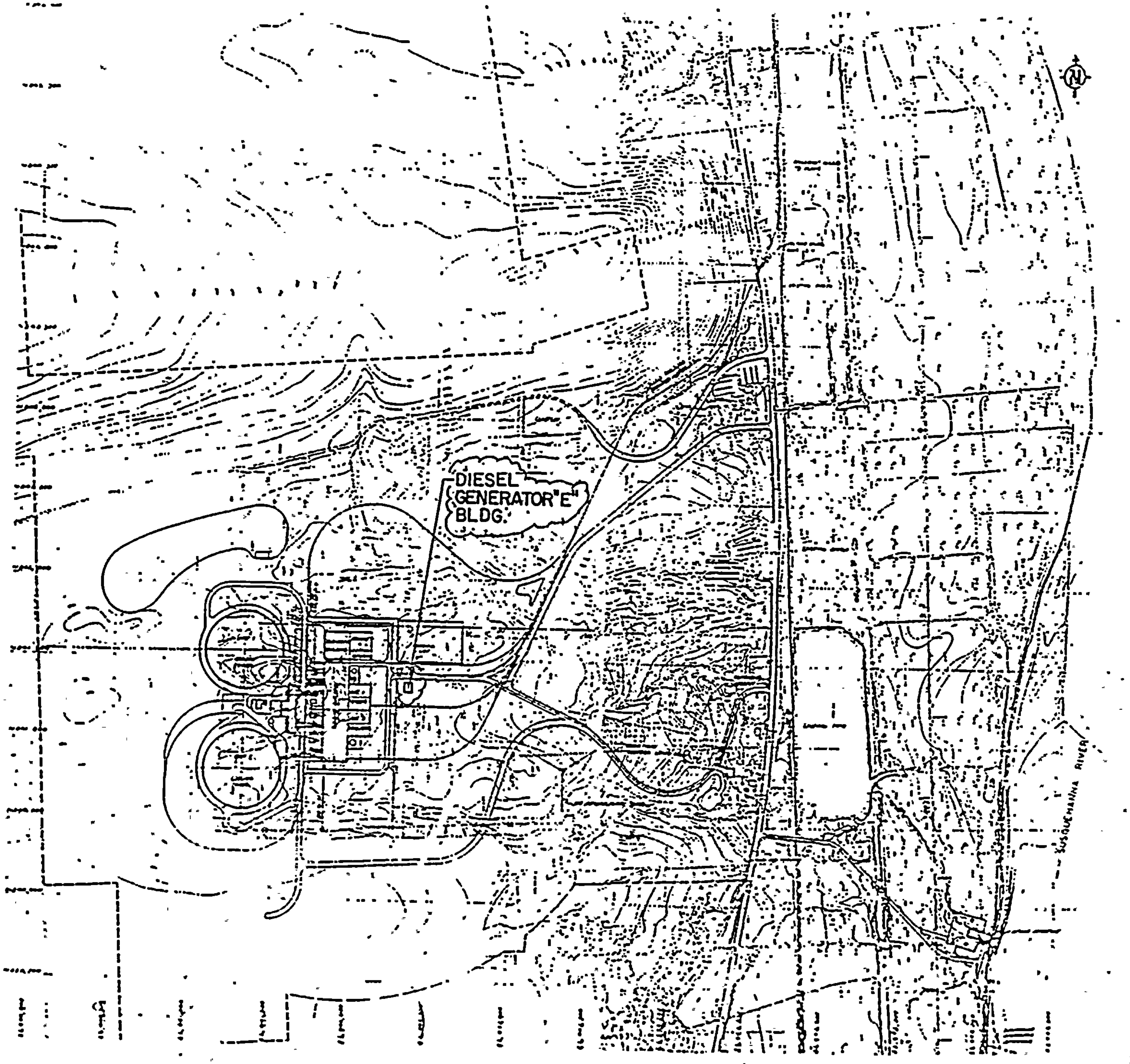


Rev. 35, 07/84

SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

SITE FACILITIES PLAN

FIGURE 2.1-2

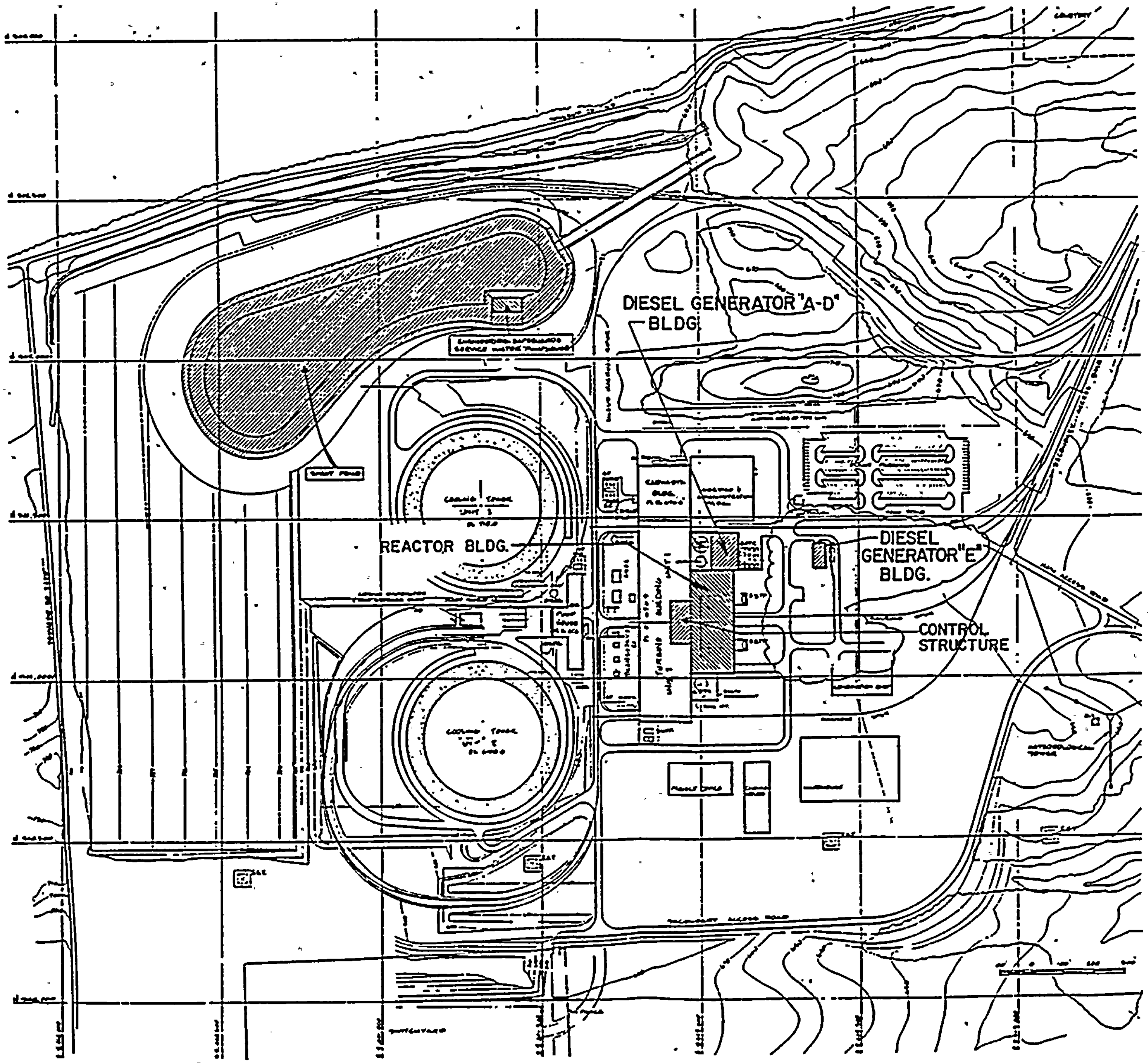


Rev. 35, 07/84

SUSQUEHANNA STEAM ELECTRIC STA
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

SITE LOCATION WITH RESPEC
TO SURROUNDING TOPOGRAPHY

FIGURE 2.4-1



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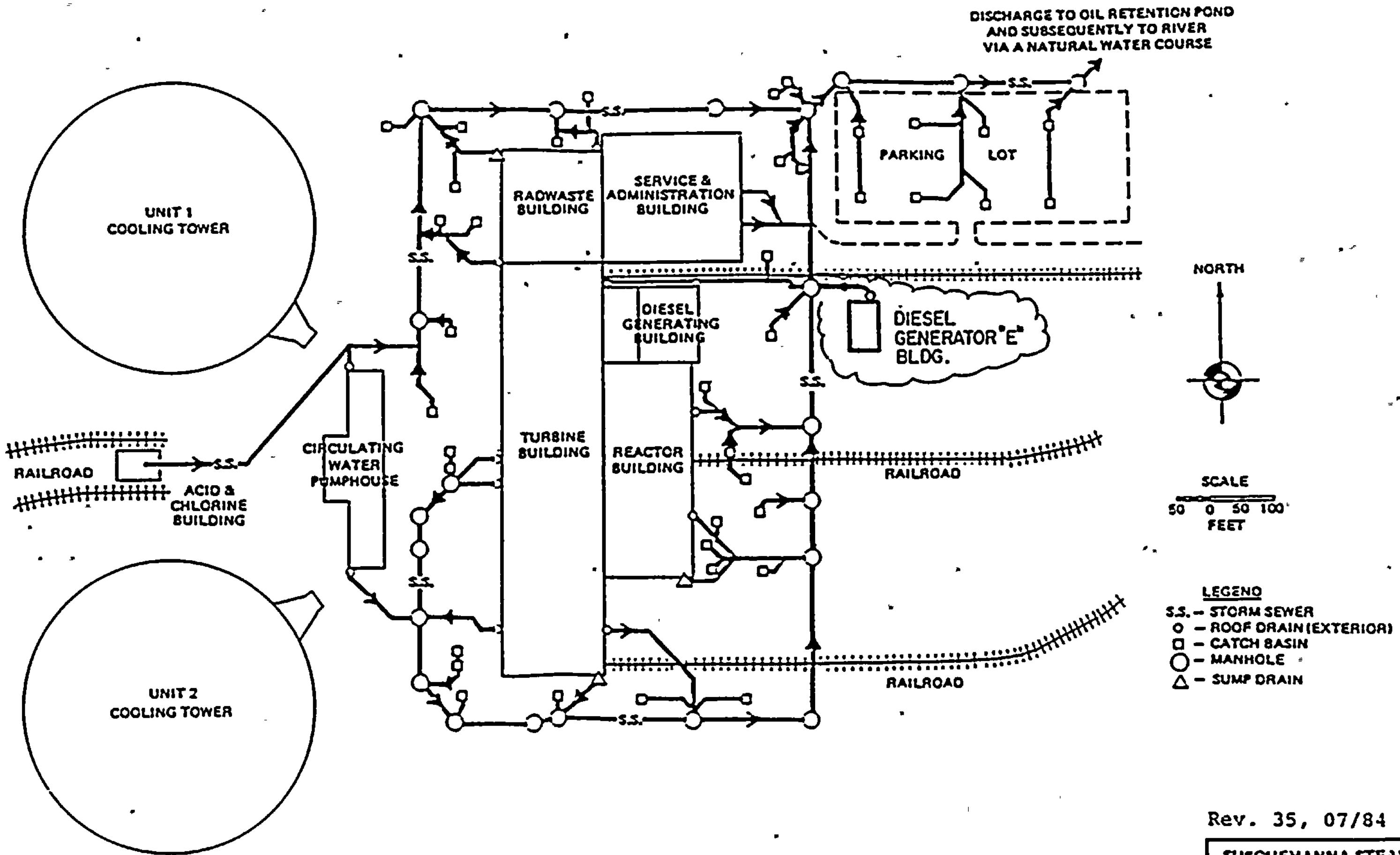
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

PLAN SHOWING SAFETY RELATED FACILITIES ON PLANT SITE

FIGURE 2.4-2



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UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

PLANT COMPLETE SHOWING STORM DRAIN PIPE LAYOUT

FIGURE 2.4-3

the north and west branches of the Susquehanna River. Post-Olean advances did not reach the site vicinity (Ref. 2.5-5 and 2.5-6).

Peltier (Ref. 2.5-5) mapped discontinuous kame terraces along the Susquehanna River in the site vicinity. The highest such terrace formed by ice marginal streams occurs at about 650 feet above sea level at the site. Refer to Subsections 2.5.1.2.2 and 2.5.1.2.3.3 for further discussion of Pleistocene erosion and deposition at the site.

Since the retreat of the Wisconsinan ice sheets from the region, broad regional uplift appears to have occurred, probably at least in part as a result of crustal rebound subsequent to the removal of ice load. Erosion has continued and soil profiles have formed.

2.5.1.2.5 Engineering Geology Evaluation

Site subsurface exploration is described and discussed in Subsection 2.5.4.3. Laboratory tests of foundation materials, and in situ geophysical tests of the foundation materials are discussed in Subsections 2.5.4.2 and 2.5.5. Geologic mapping of the final foundations is described in Subsections 2.5.1.2.2, 2.5.1.2.3 and 2.5.4.1.3. It was concluded from these studies and evaluations that the site geologic and foundation conditions are entirely suitable for the construction and operation of the plant.

2.5.1.2.5.1 Geologic Conditions Under Category 1 Structures

and diesel fuel tank for diesel generator "E" building,

All Seismic Category 1 plant facilities, except the spray pond and the Engineered Safeguard Service Water (ESSW) pumphouse and pipeline, are founded on bedrock. The ESSW pipeline trench is excavated partly in soil and partly in rock. The location of these facilities is shown on Figure 2.5-24.

The foundation rock is a hard, indurated siltstone, a member of the Devonian Mahantango Formation. In the foundations area it is quite massive and lithologically homogeneous, with bedding generally not well defined, and lacking the bedding plane fissility usually associated with less well indurated shaly siltstones and silty shales. In places the rock exhibits a slaty cleavage, further evidence of its indurated nature. All Category 1 rock foundations were excavated to unweathered bedrock. Geologic maps and sections of the Category 1 excavations in rock are shown in Figures 2.5-18 and 2.5-19. More detailed discussion of the foundation geologic conditions is contained in Subsections

Revise foundation rock mapping to include diesel generator "E" building area (By draftman) (see Ref. 2.5-117)

DRAFTING NOTE

2.5.1.2.2 and 2.5.1.2.3. Engineering properties of the foundation rock are described in Subsection 2.5.4.

The spray pond is situated over a glacial or preglacial, east-west trending bedrock valley as outlined by contours on top of bedrock (Figure 2.5-17). The valley is filled with dense gravelly and sandy glacial outwash and till deposits which attain a maximum thickness of about 110 feet adjacent to the spray pond area. They were deposited no later than the Olean substage (early Wisconsinan) of the Wisconsinan glaciation which occurred over 50,000 years ago. In general, the deposits are permeable and consist of a sequence of sand, gravel, and boulders overlain by sand and gravel, overlain in turn by silty sand. The entire sequence is highly variable in grain size distribution and sorting, and contains discontinuous pockets of similar materials. As a rule, grain size decreases and sorting increases toward the top of the sequence.

The southwestern tip of the spray pond is cut into bedrock while the remainder was excavated in these permeable glacial materials. The thickness of the glacial deposits beneath the bottom of the spray pond ranges from zero at the rock contact to 93 feet at the eastern end of the pond. The spray pond is lined to minimize seepage losses to the underlying permeable glacial deposits. The foundation of the pumphouse structure located at the southeastern corner of the pond is underlain by 35 to 60 feet of glacial material. The ESSW circulation pipelines between the pumphouse and the plant intersect bedrock at an elevation of 668 feet, approximately 260 feet southeast of the pumphouse (refer to Figure 2.5-17A). A geologic map of the spray pond area is presented on Figure 2.5-15. Further discussion of conditions at the ESSW pumphouse and spray pond are contained in Subsections 2.5.1.2.2, 2.5.3 and 2.5.5.

The area underlying the diesel fuel tank for diesel generator "E" building consists of a dense to very dense glacial outwash and till deposit. The deposit consists of a sequence of sand, gravel, cobbles and boulders overlain by sand and gravel, overlain

2.5.1.2.5.2 Landslide Potential

Natural slopes adjacent or close to the principal plant structures are relatively flat. Most of these slopes are composed of soil; few rock slopes occur (Figure 2.5-17 shows areas of rock outcrops).

North of the spray pond the Trimmers Rock Formation forms a relatively steep ridge rising approximately 380 ft. above the pond. The south-facing slope of this ridge is essentially a rock slope underlain by flaggy, resistant sandstone thinly mantled with soil and rock fragments. The closest approach of this slope to the spray pond is along the northern perimeter of the pond; the toe of the slope, at elevation 710-720 feet, is 250 feet or more from the edge of the pond (at elevation 679 feet). The maximum slope along the ridge is about 2 horizontal to 1

1,000 ft. This rock contains no unstable minerals and provides highly stable foundation conditions.

Soils at the site are glacial in origin, deposited mostly by flowing glacial meltwater, much under torrential conditions. The soil is noncalcareous. Most of the rock fragments consist of indurated sandstones. The origin and mineralogy of these soils is such that they present no hazardous conditions (refer to Subsection 2.5.1.2.5.7).

2.5.4.2 Properties of Subsurface Materials

A few of the safety-related principal plant structures are founded on soil. These structures consist of the Engineered Safeguard Service Water (ESSW) pumphouse, the spray pond, and portions of the Seismic Category I pipeline linking the reactor building to the spray pond and diesel fuel tank for diesel generator "E" building. Most other plant structures are founded on rock. The location of these structures is shown on Figure 2.5-24; soil and rock foundations are identified on Figure 2.5-17A.

The static and dynamic engineering properties of the site bedrock and overburden soils were determined by field investigation and laboratory testing. The results of laboratory testing of the materials sampled from the project site are covered in two reports (Ref. 2.5-97 and 2.5-98).

A detailed study of the soil properties at the site of the spray pond and ESSW pumphouse is given in Subsection 2.5.5.

2.5.4.2.1 Properties of Foundation Rock

The Category I reactor buildings and diesel generator building, as well as the non-Category I turbine and radwaste buildings (see Figure 2.5-24) are founded on unweathered siltstone bedrock. The siltstone, a member of the Mahantango Formation of Devonian age, is hard and indurated, and in the foundations area is lithologically homogeneous with bedding generally not well defined, and lacking the bedding plane fissility usually associated with less well indurated shaly siltstones and silty shales. In places the rock exhibits cleavage, further evidence of its indurated nature.

In the area of the principal plant structures, bedrock bedding where observed generally dips gently (less than 10°) south; locally, such as north of the circulating water pumphouse, beds dip slightly north. At the north end of the radwaste building and the north side of the Unit 1 cooling tower, bedding dips more that are slightly lower, by a factor of about 15 percent; that is, a V value of about 14,000 fps and V of about 6,200 fps. These in site results are in good agreement with the laboratory determinations. Additional cross-hole and up-hole in situ seismic velocity measurements were made in the spray pond area (Ref. 2.5-99). Results of the cross-hole explorations at the site are further discussed in Subsections 2.5.4.2.2 and 2.5.4.4.

Plate load tests were carried out on sound rock near the center of the Units 1 and 2 reactor building excavation in the vicinity of boring 105 (refer to Figure 2.5-18). Plates 24, 13.5, and 8 in. in diameter were subjected to successively increasing total loadings of 7, 22, and 60 tons per square foot (tsf), respectively. A total deflection of .062 in. occurred when the 24 in. plate was loaded to a maximum of 7 tsf. An additional deflection of 0.036 in. was recorded on subsequent loading to 22 tsf, and another 0.036 in. of deflection on application of the 60 tsf maximum load, producing a total settlement of 0.134 in. for the three-stage loading to 60 tsf. Recovery of the rock by elastic rebound upon release of these loads was substantial: 68, 75, and 80 percent repeatable elastic recovery of the total deflections were recorded after release of the 7, 22, and 60 tsf loadings, respectively. Additional deflections due to cyclic loading were small. Application of 14 cycles of load at 7, 15, and 30 tsf resulted in additional settlements of only 0.012, 0.003, and 0.002 in., respectively, over the corresponding single loadings. These results are consistent with the high modulus values and seismic velocities of the foundation rock, and indicate structurally strong, competent material for foundations in unweathered rock.

It is concluded from the engineering properties of the unweathered bedrock of the Mahantango Formation that the rock provides adequate support for the major plant structures under both static and dynamic conditions. Settlement of structures under static loading is insignificant. It consists of pseudo-elastic compression of the underlying rocks and occurs essentially upon load application. Moreover, the bedrock will undergo no loss of strength and will experience negligible additional settlement under earthquake loading.

A summary of the properties of the foundation rock is compiled in Table 2.5-5.

2.5.4.2.2 Properties of Foundation Soils

The results of detailed exploration of the soils in the spray pond area are given in Subsection 2.5.5. Only information on the properties of the pumphouse foundation soils is given in this subsection.

and diesel fuel tank for diesel generator "E" building

and diesel fuel tank for diesel generator "E" building

The natural soils at the pumphouse site are normally consolidated and consist predominantly of sand, gravel, cobbles, and boulders. The soils are poorly stratified, starting as sand or sandy gravel at the surface and grading to mostly cobbles and boulders near bedrock. The depth of the soil deposit below foundation grade ranges from about 35 ft at the south end of the pumphouse to about 60 ft at the north end. A subsurface cross-section through the pumphouse site is shown on Figure 2.5-30, cross-section D-D. The soils below the foundation level are predominantly sandy gravels with large amounts of cobbles and boulders. The properties of these sandy and gravelly soils are as follows:

(By draftsman) (See attachments) Add a generalized cross-section through diesel fuel tank for D.G. "E" building

Figure 2.5-30a showing a plan and

a) Grain Size Distribution

Grain size distribution tests were made on most of the split spoon samples for classification purposes. Sieve and hydrometer analyses were performed according to ASTM Procedure D-422. The range of grain size curves is shown on Figure 2.5-31. The mean grain size (D50) of the gravelly soils, which are the predominant material below the pumphouse, was found to be in the range of 4.5 to 25.0 mm. Wherever the sand is present below the pumphouse, the D50 size is in the range of 0.14 to 3.0 mm.

and diesel fuel tank for diesel generator "E" building,

About eight (8) feet and twenty (20) feet of sand, gravel and boulders are below the foundation grade of diesel fuel tank for D.G. "E" Building at north and south end respectively

b) Relative Density

Relative density data were derived from standard penetration test results using the Gibbs and Holtz procedure (Ref. 2.5-100). This procedure is valid for normally consolidated sands.

Values of relative density obtained in this way are summarized on Figure 2.5-32. A direct comparison of relative density from 'N' values given in Figure 2.5-32 and from undisturbed samples and/or in site density tests cannot be made because no relative density tests were made. The soil deposits are glacial in nature. The deposits are quite variable in particle size and sorting and contain discontinuous sand pockets and gravel pockets. Grain size in general increases with depth. At the foundation level of the pumphouse, the maximum sizes of the particles are in the range of 3 to 12 inches. Undisturbed tube samples could not be obtained in the gravelly soils. The gravel also will influence the results of in site density tests so that they may not represent the in site condition as a whole. The Standard Penetration resistance versus elevation is given on Figure 2.5-33. The 'N' values will be

and diesel fuel tank for diesel generator "E" building,

influenced by gravel. Because of this the higher blowcounts were not considered representative of site conditions. A value of N = 40 was selected for design. Of the 49 standard penetration tests made beneath the foundation level at the ESSW Pumphouse, and 4 standard penetration tests beneath the diesel fuel tank for the diesel generator "E" building, 43 exceeded 40 blows per foot. Of the 6 values that were less than 40 blows per foot only one was less than 30 blows per foot. 47

c) Static and Dynamic Shear Strength

Undisturbed sampling of gravelly soils was not possible. Therefore, shear strength testing was conducted only on the sands. The shear strength of the gravelly soils was then conservatively assumed to be equal to that of the sands.

The details of the testing procedures and selection of design strengths are given in Subsection 2.5.5. The effective angle of internal friction was selected from the test data to be 35° (Figure 2.5-34). The cyclic shear stress ratios at the two effective consolidation pressures 1.0 ksf and 6.0 ksf were determined to be 0.320 and 0.260, respectively, for 5 loading cycles (Figure 2.5-35, Subsection 2.5.5). A linear relationship was assumed in computing cyclic shear stress ratios at other effective consolidation pressures.

d) Shear Wave Velocity and Shear Moduli

Cross-hole shear wave velocity measurements were performed by Weston Geophysical Engineers, Inc. (ref. 2.5-99). Compressional and shear wave velocities obtained from the measurements are given on Figure 2.5-36.

Shear moduli were computed from the values of shear wave velocity:

$$G = \frac{\gamma}{g} V_S^2$$

Where:

G = shear modulus, psf

γ = unit weight, pcf

g = gravitational acceleration, ft/sec^2

NOTE INSERT BORING LOGS

V = shear wave velocity, fps

A discussion on how the shear modulus is influenced by the confining pressure, the strain amplitude, and the relative density is given in Subsection 2.5.5.2.

2.5.4.3 Exploration

The location of all field explorations is shown on the plot plan, Figure 2.5-22.

A total of approximately 250 exploratory borings was made in soil and rock at the site. Borings were logged in detail; boring logs are contained in Ref.s. 2.5-97, 2.5-98 and 2.5-99 and Appendix 2.5C. The soils were classified in accordance with the Unified Soil Classification System. Rock logs include RQD (rock quality designation) values. Coring in rock was performed using NX double-tubed coring equipment.

Drilling was conducted in late 1970 (100 and 200 series borings) to establish general geologic relationships over the site area and to determine general soil and rock conditions at the site. A more intensive program (300 series borings) was conducted in the Spring of 1971 to define foundation conditions in the principal plant structures area. Four 45-degree angle holes were drilled in the reactor area. Additional exploration drilling was necessary to locate the site for the Susquehanna River intake and discharge structures (700-800 series borings), to define soil and rock conditions at the spray pond and ESSW pumphouse site (1100 series and some 400 series borings), and to investigate foundation conditions for the cooling towers (borings B1 to B10) and the railroad spur and bridge over State Highway 11 (borings 417 to 455 and 929 to 940). An investigation for an (Borings 1 through 7) was conducted in 1983 to determine soil and rock conditions in the area of diesel generator "E" building. Boring logs are contained in Appendix 2.5C. Because of the safety-related (Category I) function of the spray pond, ~~and~~ ESSW pumphouse and diesel fuel tanks for diesel generator "E" building, the exploration program for these facilities was comprehensive and included split spoon and undisturbed samples, laboratory testing, hydrologic surveys, permeability tests, and seismic cross-hole and up-hole surveys. After completion of geologic borings, static water levels were measured in some of the borings drilled on the site. Perforated plastic pipes were installed in a number of the borings to allow collection of future water level data. These borings are denoted on the plot plan, Figure 2.5-22.

Forty-seven test pits were excavated by backhoe at selected locations to observe soil and rock conditions. Two north-south trenches totalling over 700 ft in length were excavated to obtain information on physical properties, structure, and variability of the near-surface materials at the site. Logs of the test pits and trenches are compiled in Appendix 2.5C.

2.5.4.5.2 Excavation Methods and Dewatering

2.5.4.5.2.1 Excavations in Rock

All Seismic Category I rock foundations were carried to or well below unweathered bedrock. Rock foundations for the turbine and radwaste buildings, although they are not Seismic Category I structures, were prepared according to the same general procedures and criteria used in preparing the Seismic Category I rock foundations.

Excavation of rock proceeded by initial ripping of any weathered surficial rock material followed where necessary by line blasting and presplitting in holes drilled to provide slopes of 1 horizontal to 4 vertical. Essentially vertical slopes in unweathered rock proved stable throughout the duration of construction and no special protective measures were required. Weathered rock was cut on slopes of 1 horizontal to 2 vertical. In a few places, wire mesh was used for protection of higher weathered rock slopes that were exposed for extended periods.

The surface of the excavated foundation rock was scaled to remove loose debris and jetted with water or air to remove loose fragments and to prepare the surface for concrete. Before placement of structural concrete or concrete backfill to design elevation, all Seismic Category I foundations were inspected by an engineering geologist to verify the suitability of the rock and its proper surface preparation to receive concrete. All foundation rock bearing a Seismic Category I structure was geologically mapped (see Figure 2.5-18).

Foundations for each of the cooling towers (nonseismic-Category I structures) consist of 40 individual pedestals supporting the columns and extended to bedrock. Excavation proceeded by cutting a ring trench and preparing for each pedestal a suitable surface in unweathered or partly weathered bedrock by ripping or blasting as necessary, followed by scaling and jetting.

During construction of principal plant structures founded on rock, excavations extended below the water table and some dewatering was required. Due to the low permeability of the rock, groundwater inflow was small. Dewatering was accomplished by surface drains and sumps.

2.5.4.5.2.2 Excavations in Soil

The excavation for the spray pond, ~~and~~ ESSW Pumphouse, was predominantly in soils. Excavation proceeded initially by using

and diesel fuel tank for diesel generator "E" building

large earth moving equipment, then finished by using more refined procedures. On completion of excavation, the surface layer of the natural soil formation was recompacted as follows:

a) For soils having not more than 12 percent passing the No. 200 sieve size, 80 percent relative density as determined by ASTM D2049

b) For all other soils, 95 percent of maximum dry density as determined by ASTM D1557 .

Test Results are included in Appendix 2.5C. The location of test specimens with respect to the spray pond is shown on Figure 2.5-59. A statistical analysis of the test results was made and is summarized on Figure 2.5-60. The required compaction was met or exceeded.

A protective concrete mat was immediately placed over the compacted soil under the ESSW Pumphouse and a minimum of 5 in. thick reinforced concrete liner placed over the entire spray pond area.

All temporary slopes in soil were formed at a maximum slope of 1 1/2 horizontal to 1 vertical. The temporary slopes in the vicinity of the ESSW Pumphouse were protected with a 3 in. layer of concrete to maintain the natural soil formation intact. All permanent slopes in soil were formed at a slope of 3 horizontal to 1 vertical.

The excavation for the Seismic Category 1 pipelines in soil was carried out similarly. All slopes were cut at a maximum of 1 1/2 horizontal to 1 vertical. The minimum clearances were 1 ft beneath the pipe and 2 ft to the sides.

Insert "A"

2.5.4.5.3 Backfill and Compaction

Generally, the excavated area, for a minimum distance of 10 ft surrounding the major structures, was backfilled with a non-corrosive lean mix concrete known as sand-cement-flyash backfill. A minimal amount of backfilling has taken place using granular backfill, with the exception of the spray pond and vicinity addressed later in this section.

The Seismic Category I pipelines were generally backfilled with the sand-cement-flyash; otherwise granular material was used.

Buried Seismic Category I electrical ductbanks are composed of reinforced concrete encasements around plastic or metal ducting; the concrete encasement being cast directly against the excavated

Insert "A"

The excavation for diesel generator "E" building was carried to unweathered bedrock by using soldier beams and laggings. All timber laggings were treated with preservative by pressure process. The soldier beams and laggings were left in place. The disturbed soils adjacent to the soldier beams and laggings were densified by compaction grouting. The results of compaction grouting were verified by standard penetration tests. The results of standard penetration tests indicate that the blow count numbers are equal to or exceed those of original soils.

The excavation for diesel fuel tank for diesel generator "E" building was carried out in open cut. All slopes were cut at a maximum of 1½ horizontal to 1 vertical.

large earth moving equipment, then finished by using more refined procedures. On completion of excavation, the surface layer of the natural soil formation was recompacted as follows:

a) For soils having not more than 12 percent passing the No. 200 sieve size, 80 percent relative density as determined by ASTM D2049

b) For all other soils, 95 percent of maximum dry density as determined by ASTM D1557

Test Results are included in Appendix 2.5C. The location of test specimens with respect to the spray pond is shown on Figure 2.5-59. A statistical analysis of the test results was made and is summarized on Figure 2.5-60. The required compaction was met or exceeded.

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The excavation for the Seismic Category 1 pipelines in soil was carried out similarly. All slopes were cut at a maximum of 1 1/2 horizontal to 1 vertical. The minimum clearances were 1 ft beneath the pipe and 2 ft to the sides.

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Generally, the excavated area, for a minimum distance of 10 ft surrounding the major structures, was backfilled with a non-corrosive lean mix concrete known as sand-cement-flyash backfill. A minimal amount of backfilling has taken place using granular backfill, with the exception of the spray pond and vicinity addressed later in this section.

Insert "B"

The Seismic Category I pipelines were generally backfilled with the sand-cement-flyash; otherwise granular material was used.

Buried Seismic Category I electrical ductbanks are composed of reinforced concrete encasements around plastic or metal ducting; the concrete encasement being cast directly against the excavated

Insert "B"

The excavated area for diesel fuel tank for diesel generator "E" building was backfilled with sand-cement-flyash to two (2) feet below finished grade.

material, thus meeting specification intent. The subgrade was also inspected for unsuitable material such as water, frozen, organic or deleterious material. Such material, when found, was removed.

The sand-cement-flyash bedding material was either mixed at the batch plant or obtained from an approved offsite source. The sand-cement-flyash was then placed in lifts not exceeding 30 inches in height nor 4 feet per hour. For pipes the pour was brought to the pipe spring line and was allowed to set. For duct banks the bedding was not placed until the duct bank concrete reached the required strength. Sand-cement-flyash was then poured to the top of the duct bank and allowed to set.

Analysis of the relevant field tests for bedding material is included in the summary given in Table 2.5-61.

2.5.4.6 Groundwater Conditions

Special measures for control of groundwater levels beneath Seismic Category I plant structures founded on rock are not required. However, control of groundwater levels and seepage is needed at the spray pond; discussion of design criteria for stability of the spray pond is presented in Subsection 2.5.5.

Periodic water level readings were obtained in the vicinity of the principal plant (power block) structures between December 1970 and August 1972. Groundwater fluctuations ranged from 1.5 ft in drill holes 209, 311, to 6.2 ft in drill hole 213.

The maximum groundwater level measured in the plant structures area during this preconstruction period ranged from approximately 690 ft at the west edge of the site of the turbine building, to about 655 ft at the east edge of the site of the reactor buildings (refer to Figure 2.5-55). These levels were obviously influenced by the topographic high of 749 ft just west of the site of the power block structures. However, subsequent excavation and grading in these areas preclude water levels from rising to this height in the future.

During construction, the area just west of the power block structures was graded to elevation 710 ft or less. Excavations for the foundations of the principal plant structures extended below the water table and some minor dewatering was required. Due to the low permeability of the rock, groundwater inflow was small and was confined to seepage from fractures. Dewatering was accomplished by pumping from low areas and sumps. Where seeps were noted issuing from fractures in the rock, holes were drilled into the fractures and pipes caulked in the holes to control water while the mudmat was placed. In the foundation for the

2

reactor building (elevation 639 ft) and in the turbine condensate pump pit (at elevation 635 ft), hydrostatic pressure caused lifting of small areas of the 3 inch thick concrete mudmat that had been placed over the impervious membrane. Approximately 20 relief wells drilled through the mudmat released the pressure and allowed the mat to settle back to its original position. The weight of the structural concrete slab subsequently placed on this mudmat was more than sufficient to resist any uplift pressures.

The highest seeps noted in the foundation rock during construction were at elevation 642 ft in the radwaste building excavation and at about the same elevation in the pipe trench in the southern part of the Unit 2 turbine building. Some seeps were also noted in the foundation rock for the reactor buildings at elevation 639 ft and in sumps below this. To the west of the turbine building in the circulating water pumphouse excavation, water was noted to enter the excavation to an elevation of approximately 660 ft. Hydrostatic lifting (described above) of the impervious membrane did not occur at foundation elevations above 640 ft.

Insert "C"

Additional information with regard to groundwater monitoring and water table fluctuations in the principal plant structures area is provided in Subsection 2.4.13 and Tables 2.4-31 and 2.4-32.

At the spray pond, water level information taken between July 29, 1974 and August 4, 1975, and from January through March 1977, indicate a minimum water level fluctuation of 4.0 ft recorded at observation wells 1111 and 1113, and a maximum fluctuation of 7.0 ft in 1115. Additional discussion of groundwater fluctuations in the spray pond area can be found in Subsection 2.5.5. Because groundwater levels at the pond will be higher than the maximum projected flood elevation (refer to Figure 2.5-38 and Subsection 2.4.3, respectively), flooding conditions will not significantly affect the groundwater levels.

Local wells within two miles of the plant site were inventoried and the information is given in Table 2.4-22.

Groundwater flows away from the principal plant structures area to the north, east, and south. However, the predominant direction of flow is to the east and southeast at gradients of 0.05 and 0.06, respectively. The flow rate in bedrock is estimated to be less than 1 ft per day as discussed in Subsection 2.4.13. Groundwater contours at the site are shown on Figure 2.5-38.

Permeability of the intact bedrock at the site is less than 1 ft/year. The average permeability of the glacial materials at the spray pond is 2,000 ft/year; however, this value has been considerably exceeded in some tests. For a complete description

Insert "C"

Excavation for diesel generator "E" building extended below the water table and some minor dewatering was required. The groundwater which seeped into the excavation area was diverted to a sump at a low point and was removed by pumping.

2.5.4.10 Static Stability

2.5.4.10.1 Static Stability of Safety-Related Structures Supported on Rock

The reactor buildings, control structure, and the diesel generator building, all of which are Seismic Category I structures, are founded on sound, unweathered siltstone bedrock. The Seismic Category I pipelines linking the reactor buildings with the spray pond are trenched partly in soil and partly in bedrock.

The strength of the unweathered bedrock amply accommodates the loads of the plant providing highly stable foundation conditions. As measured in the Seismic Category I reactor area, compressional velocities are in the range of 14,000 to 16,000 fps; shear wave velocity ranges between 6,200 and 7,500 fps. Static deformational moduli as measured on rock cores vary between 3.1 to 9.4×10^6 psi (refer to Table 2.5-3). Measurements of unconfined compressive strength of unweathered foundation rock from the vicinity of the principal plant structures were between 3,650 and 16,000 psi (Table 2.5-3). Static properties of the foundation rock are summarized in Table 2.5-5. Loads induced by the plant structures are less than the allowable bearing pressure of the rock and far below the ultimate bearing capacity. The structural loads will produce no significant total or differential settlement of the foundations.

Safety-related structures founded on rock were designed for a hydrostatic groundwater loading caused by a maximum groundwater level of 665 ft. This is higher than the expected maximum water level, as discussed in Subsection 2.4.13.

2.5.4.10.2 Static Stability of Safety-Related Structures Supported on Soil

The mat footing of the ESSW pumphouse is 112 ft long, 64 ft wide, and 3 ft thick. The total dead and live loads are 20,000 kips and 2,100 kips, respectively. The corresponding unit pressures are 2.80 ksf and 0.30 ksf, respectively. The bottom of the mat is at elevation 657 ft.

The ultimate bearing capacity of the mat can be estimated by the following equation (Ref. 2.5-115):

$$q'_d = 1/2\, B \gamma\, N_\gamma + D_f\, (N_q - 1)$$

Where:

2

q'_d = ultimate bearing capacity

B = width of the mat = 64 ft

γ = unit weight of the soil = 130 pcf

D_f = depth of surcharge, conservatively assumed to be zero

N_γ, N_q = bearing capacity factors

= 38, and 33, respectively (Ref. 2.5-115) corresponding to ϕ = 35° (Subsection 2.5.4.2.2)

The ultimate bearing capacity of the mat foundation was found to be 158 kips/sq ft. The factor of safety was computed to be 51, which indicates no danger in overstressing the supporting granular soil. Therefore, the allowable bearing pressure and settlement of the mat footing were evaluated by the method of limiting settlements suggested by Peck, Hanson, and Thornburn (Ref. 2.5-116). The allowable bearing pressure for a maximum settlement not to exceed 2 in. was computed by the formula:

$$q_a = 0.22\ C_n\ C_w\ N$$

Where:

q_a = allowable bearing pressures, tsf

N = number of blows per foot in the standard penetration test

C_n, C_w = correction factors for "N", for the effects of overburden pressure and location of groundwater surface

A conservative N value of 40 was selected to represent the soils below the mat foundation (Elevation 657 ft, Figure 2.5-38). The Standard Penetration Tests below the foundation level were made at an average overburden pressure of about 6,000 psf (Figure 2.5-39); the corresponding correction factor C_n was obtained from Figure 19.6 of Ref. 2.5-115 to be 0.63. Assuming that the groundwater surface is at 7 ft below the mat and no surcharge, the correction factor C_w was computed to be 0.55 by equation 19.4 of Ref. 2.5-115.

The allowable bearing pressure was computed to be 6.0 kips/sq ft based on the values of N, C_n, and C_w given above. At this bearing pressure, the settlement of the mat foundation should be less than 2 in. and the differential settlement should be less than 3/4 in. Therefore, by proportion, for a design total pressure of 3.1 kips/sq ft, the corresponding maximum and differential settlements would be less than 1 in. and 1/2 in., respectively. Settlement in sand and gravel deposits occurs almost simultaneously with the application of load. Since more than 80 percent of the total load is dead load, then less than 0.2 in. of settlement is expected after the completion of the construction.

Insert "D"

The structural stability of the ESSW pumphouse is discussed in Subsection 3.8.4 and 3.8.5.

The sustained load from the spray pond is less than the weight of overburden removed; therefore, there is an adequate factor of safety against overstressing the underlying soil. Soil rebound during excavation in granular soils of the type found at the spray pond is insignificant.

The maximum predicted elevation of the water table is below the base of the spray pond and ESSW pumphouse; therefore, hydrostatic water loadings were not considered in the design of these structures. A full discussion of the water table in this vicinity is in Subsection 2.5.5.

The lateral earth pressure acting on subterranean walls of Seismic Category I structures was computed assuming granular backfill having the properties stated in Subsection 2.5.4.5.3. The coefficient of earth pressure "at-rest" was used. Additionally, the walls were designed for surcharge loadings and dynamic soil pressures as appropriate. The typical pressure diagrams and combinations are shown on Figure 2.5-39.

Water levels in the spray pond area are discussed in Subsection 2.5.5.1.2. Contours of the groundwater table in the spray pond area are shown on Figure 2.5-38. Profiles of measured and projected profiles of the groundwater table beneath the spray pond are shown on Figure 2.5-40.

2.5.4.11 Design Criteria

2.5.4.11.1 Design Criteria of Safety-Related Structures on Rock

The plant structures founded on rock are designed for a maximum acceleration of 0.10g from an occurrence of the SSE event. From consideration of its engineering properties, it is evident that the foundation rock will not be measurably affected by seismic loadings, and negligible additional foundation settlement will accompany these maximum potential dynamic loads. The maximum contemplated total static and dynamic loads of 40 tsf are only a

Insert "D"

The same equations and procedures can be applied to compute the ultimate bearing capacity of the foundation soils and the allowable bearing pressure for a maximum settlement not to exceed 2 inches.

The foundation mat for the diesel fuel tank for diesel generator "E" building is 17 feet wide, 57 feet long and 5 feet thick. The total dead and live loads are 111.4 kips and 684.8 kips respectively. The corresponding unit pressures are 0.12 ksf and 0.71 ksf respectively. The bottom of the foundation mat is at elevation 645.0 ft.

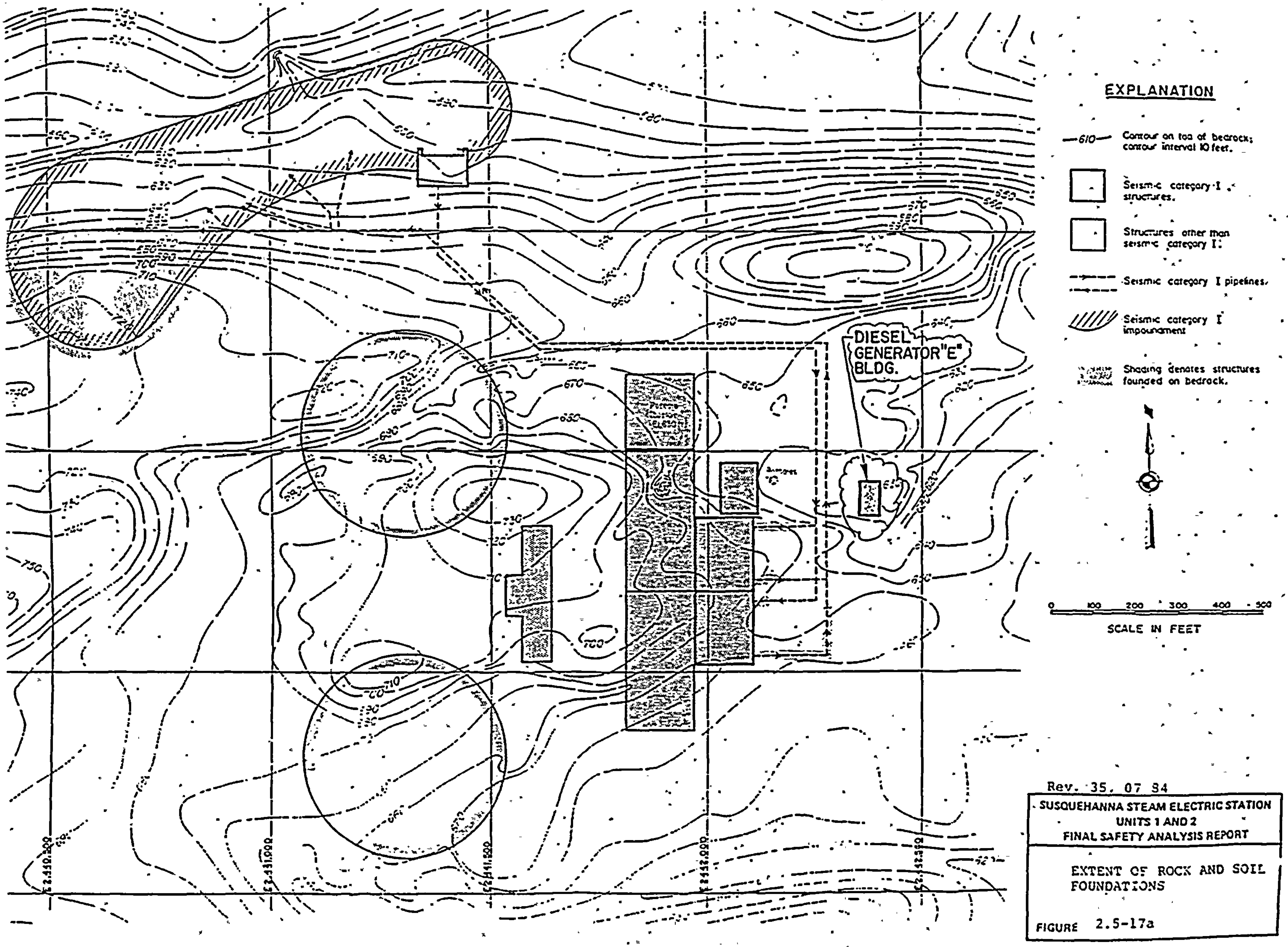
The ultimate bearing capacity of the foundation soils was found to be 42.0 ksf. The factor of safety against shear failure was computed to be 50 which indicates that there is ~~no~~ no danger of shear failure.

The allowable bearing pressure was found to be 12.0 ksf for a maximum settlement not to exceed 2 inches. By proportion, the maximum and differential settlement corresponding to a design total pressure of 0.83 ksf would be less than 1/8 in. and 1/16 in. respectively.

2.5-115 Peck, R.B., Hanson, W.E., and Thronburn, T.H., 1974, Foundation Engineering, 2nd Ed., John Wiley & Sons, Inc.

2.5-116 GIBBS & HILL, INC., Report on Subsurface Investigation for New Emergency Diesel Generator Facility, Susquehanna Steam Electric Station Units 1 & 2, January, 1984.

2.5-117. DAMES & MOORE, Geologic Map of The Emergency Diesel Generator Foundation, Susquehanna Steam Electric Plant, August, 1984.



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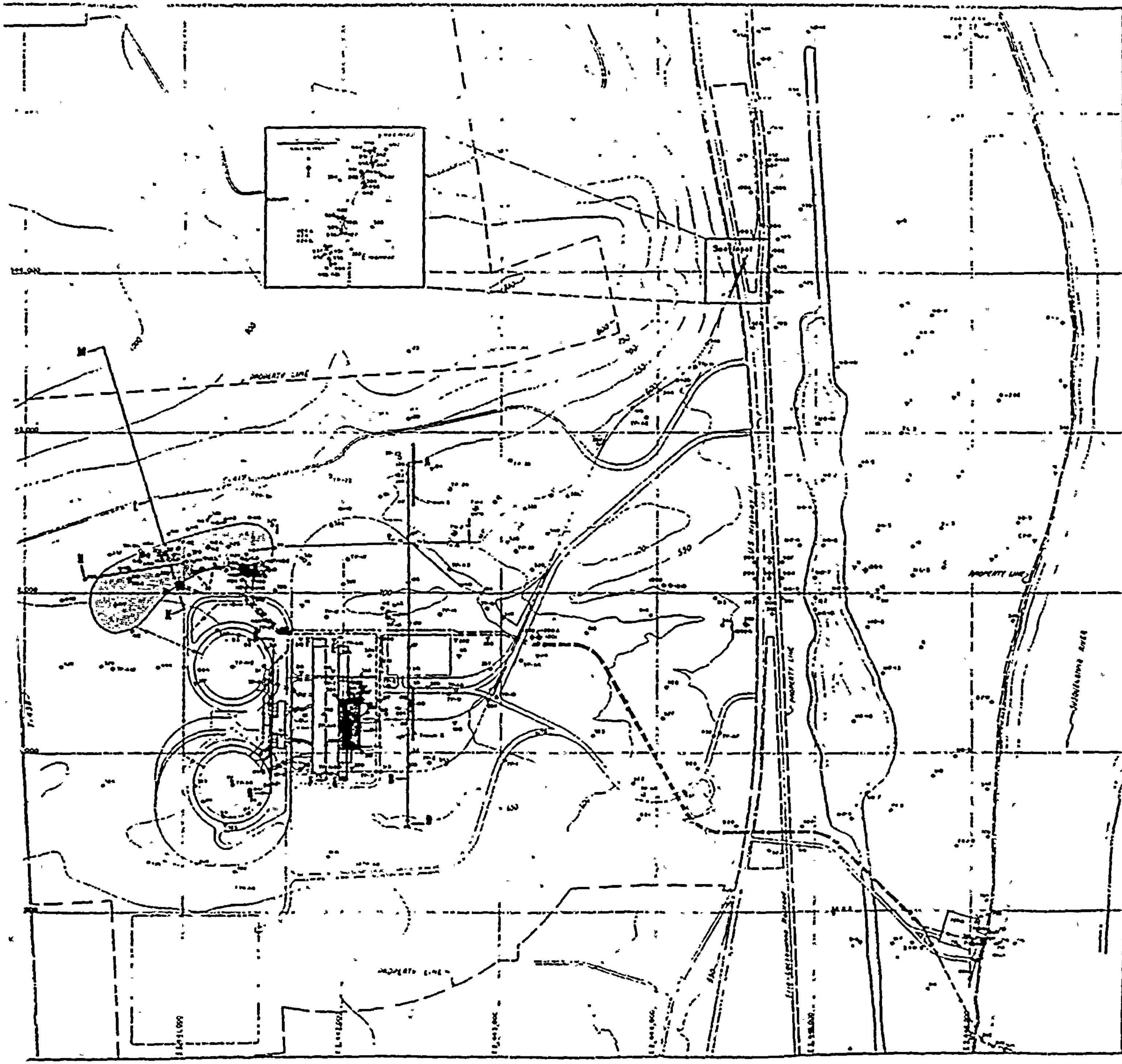
SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

EXTENT OF ROCK AND SOIL FOUNDATIONS

FIGURE 2.5-17a



EXPLANATION

NOTES:

1. GEOLOGIC SECTIONS ARE SHOWN IN FIGURES 2.5-19, 2.5-21A, 2.5-21B, 2.5-40 AND 2.5-56.
2. GEOPHYSICAL EXPLORATION AND DRILL HOLES USED FOR GEOPHYSICAL MEASUREMENTS ARE SHOWN IN FIGURE 2.5-29.
3. BORING 1118 AND 1121 WERE NOT DRILLED AND ARE THEREFORE NOT SHOWN ON THE PLOT PLAN.
4. WELL APW AND BORING MB-2 ARE NORTH OF PLOT PLAN AREA; THEIR TRUE LOCATIONS ARE INDICATED BY THE ARROWS AND DISTANCES SHOWN ON THE PLAN.

DRAFTING NOTE
Add new borings per attached Fig. 1, sh 2

N

0 100 200 600 1000
SCALE IN FEET

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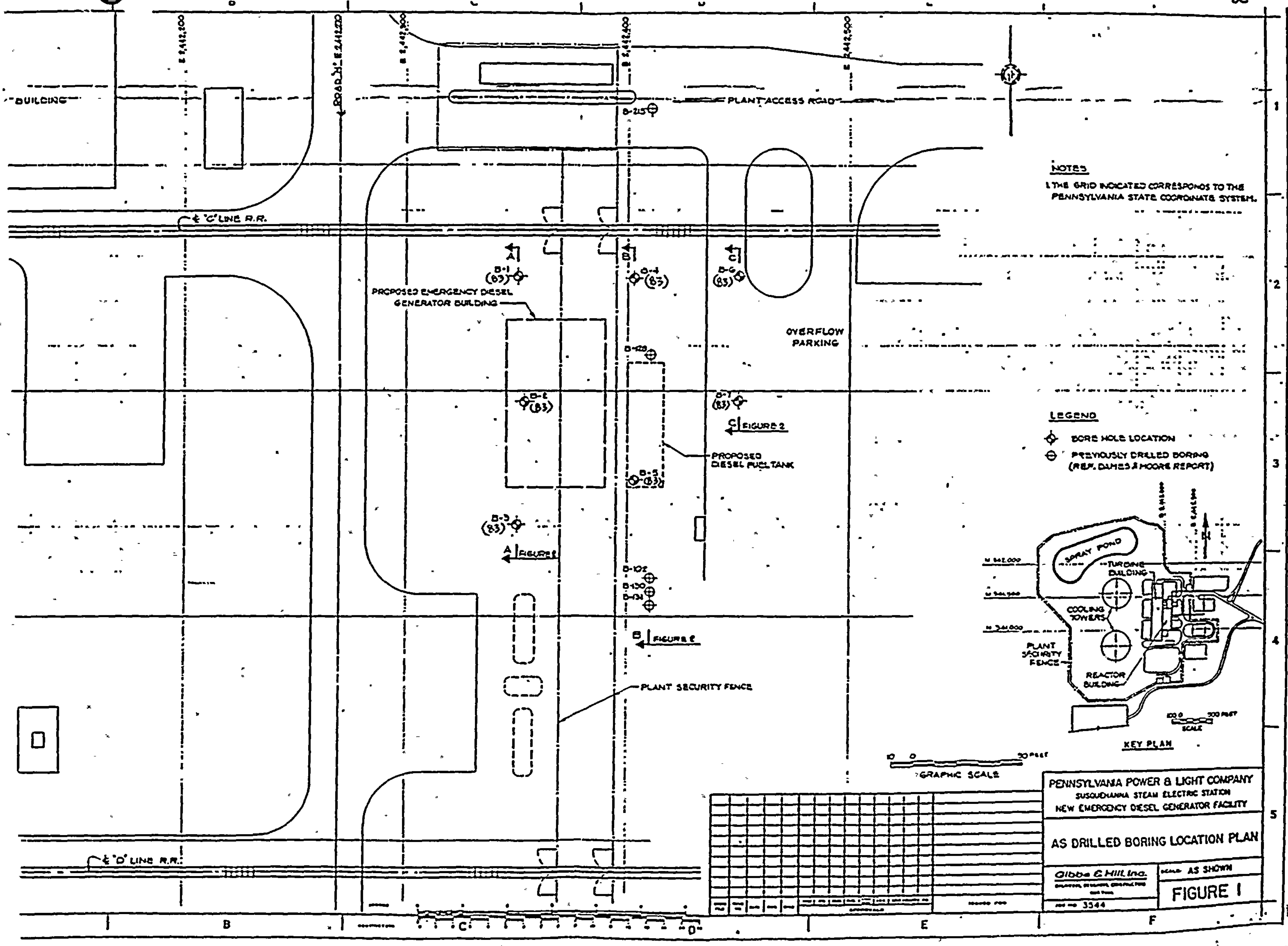
SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

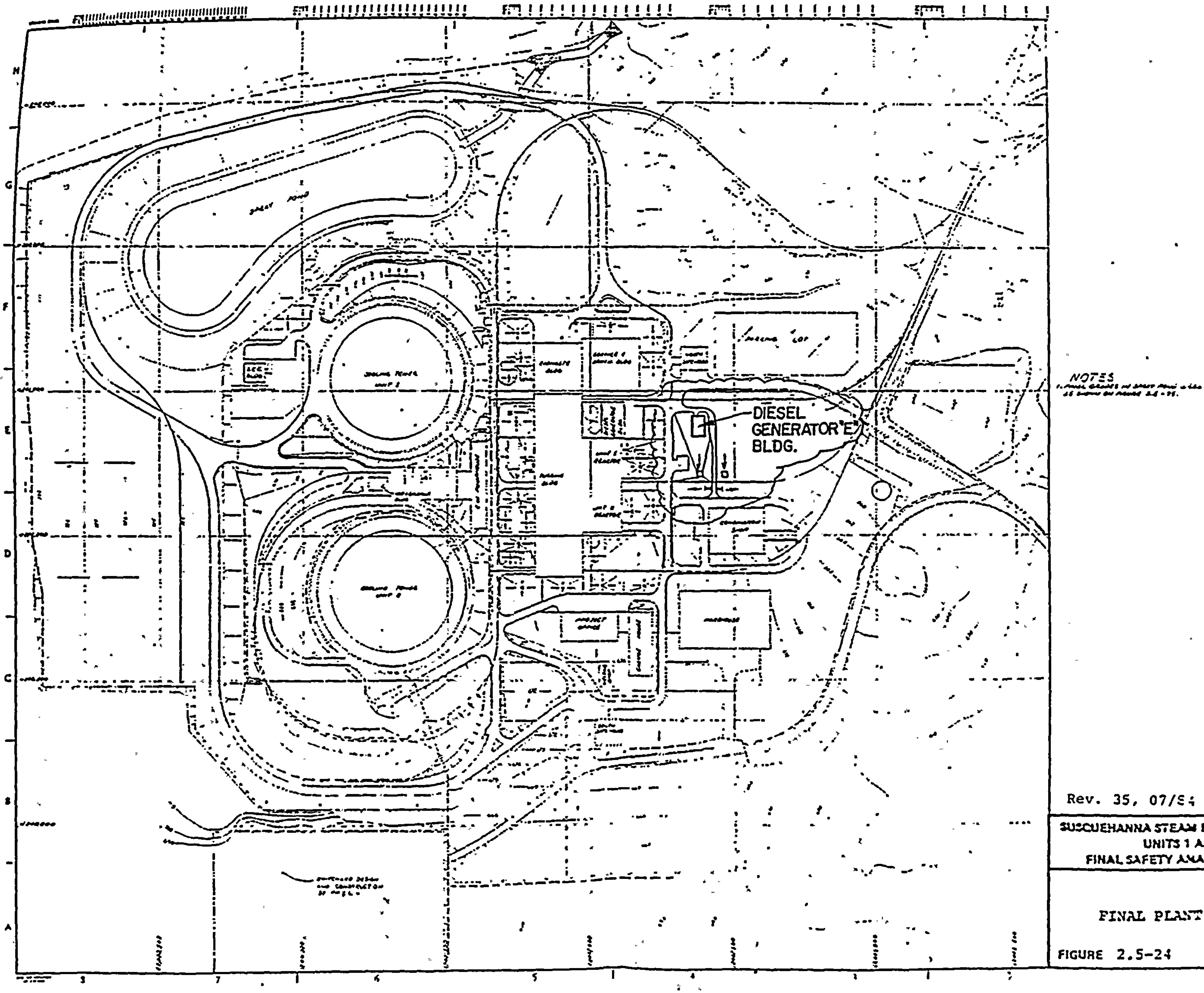
PLOT PLAN

FIGURE 2.5-22

Attachment to Fig 2.5-2 (sh 1)

2





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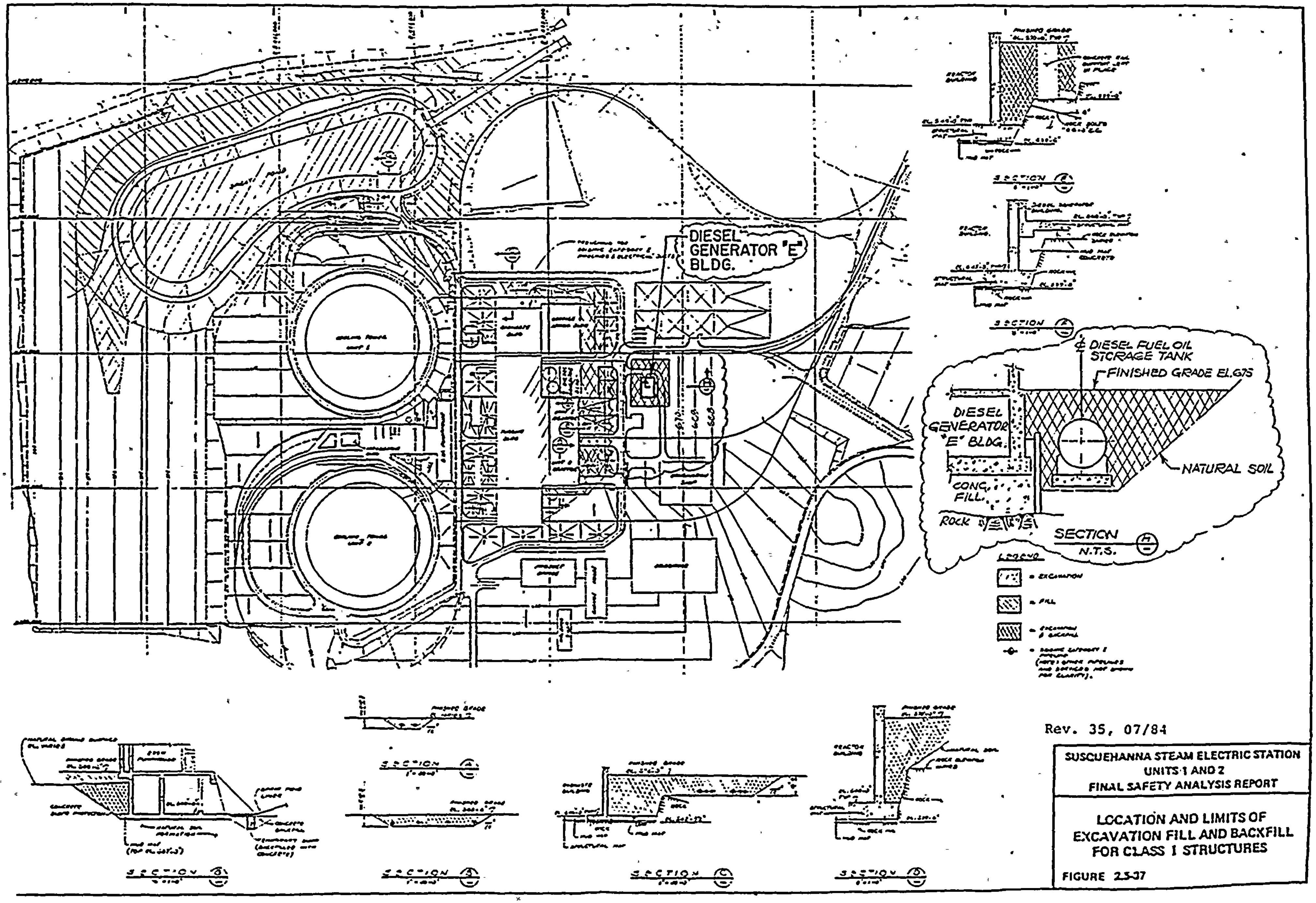
FINAL PLANT GRADES

FIGURE 2.5-24

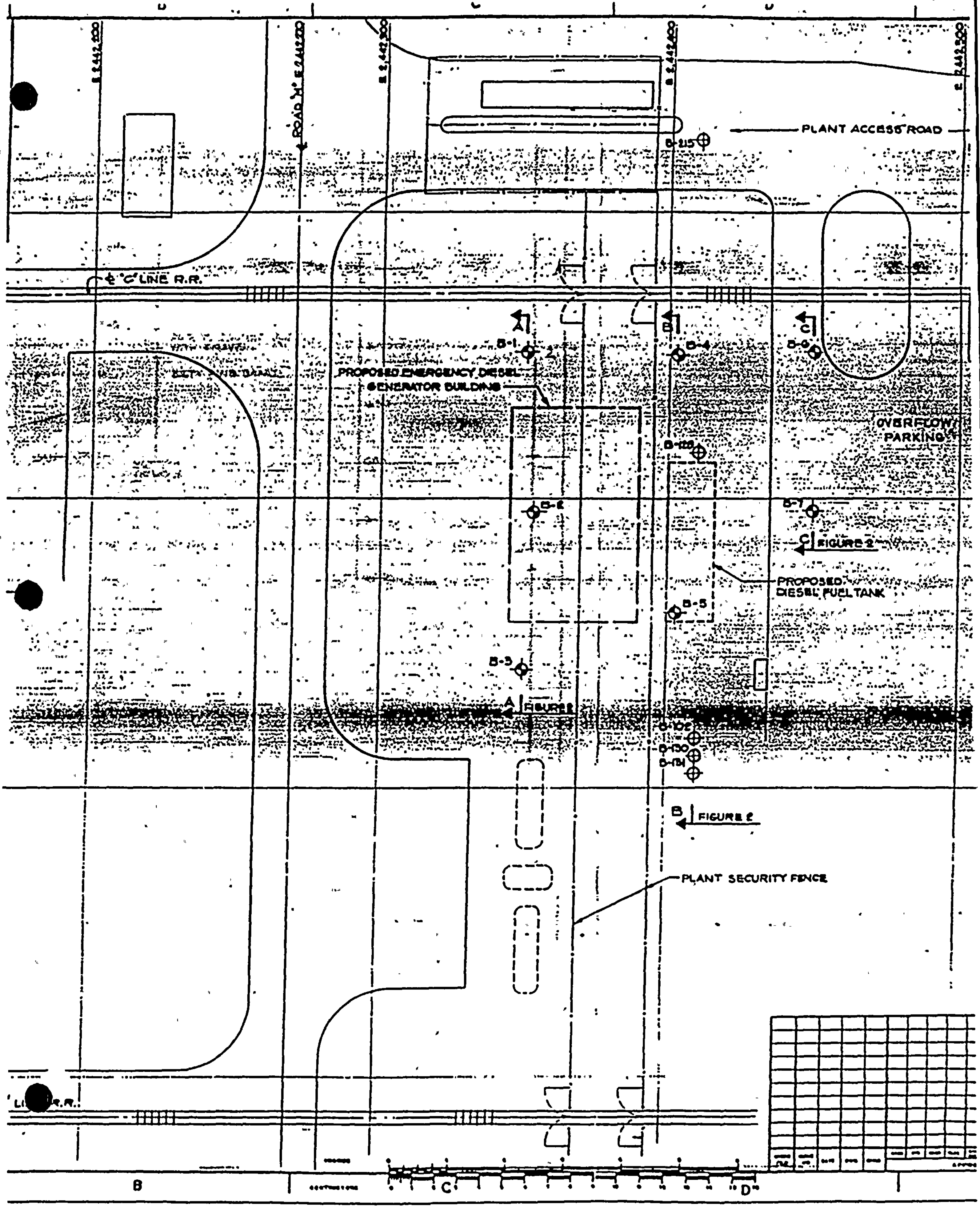


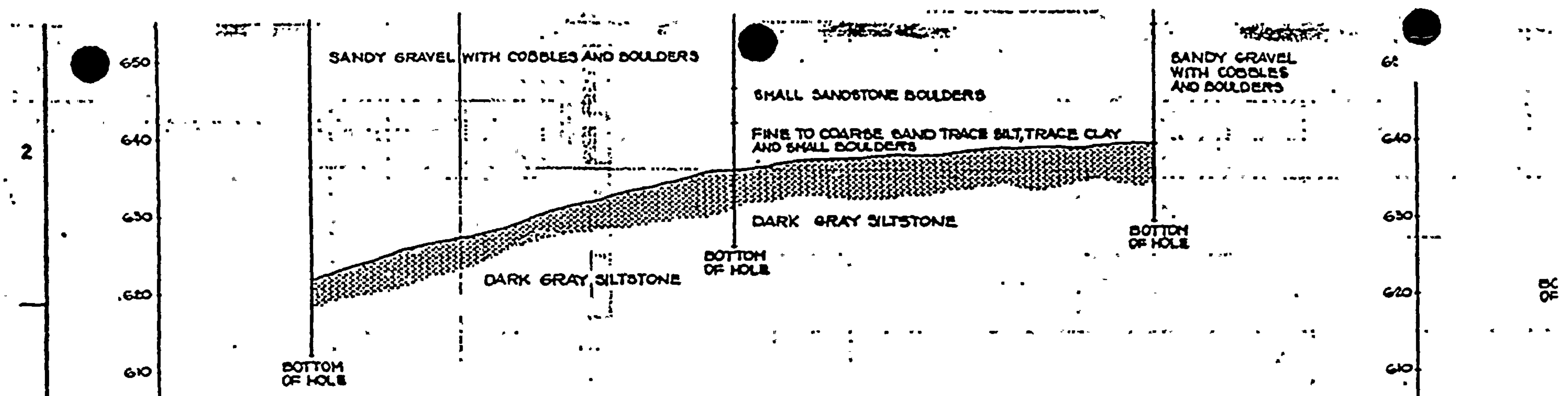
Rev. 35, 07/84

SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

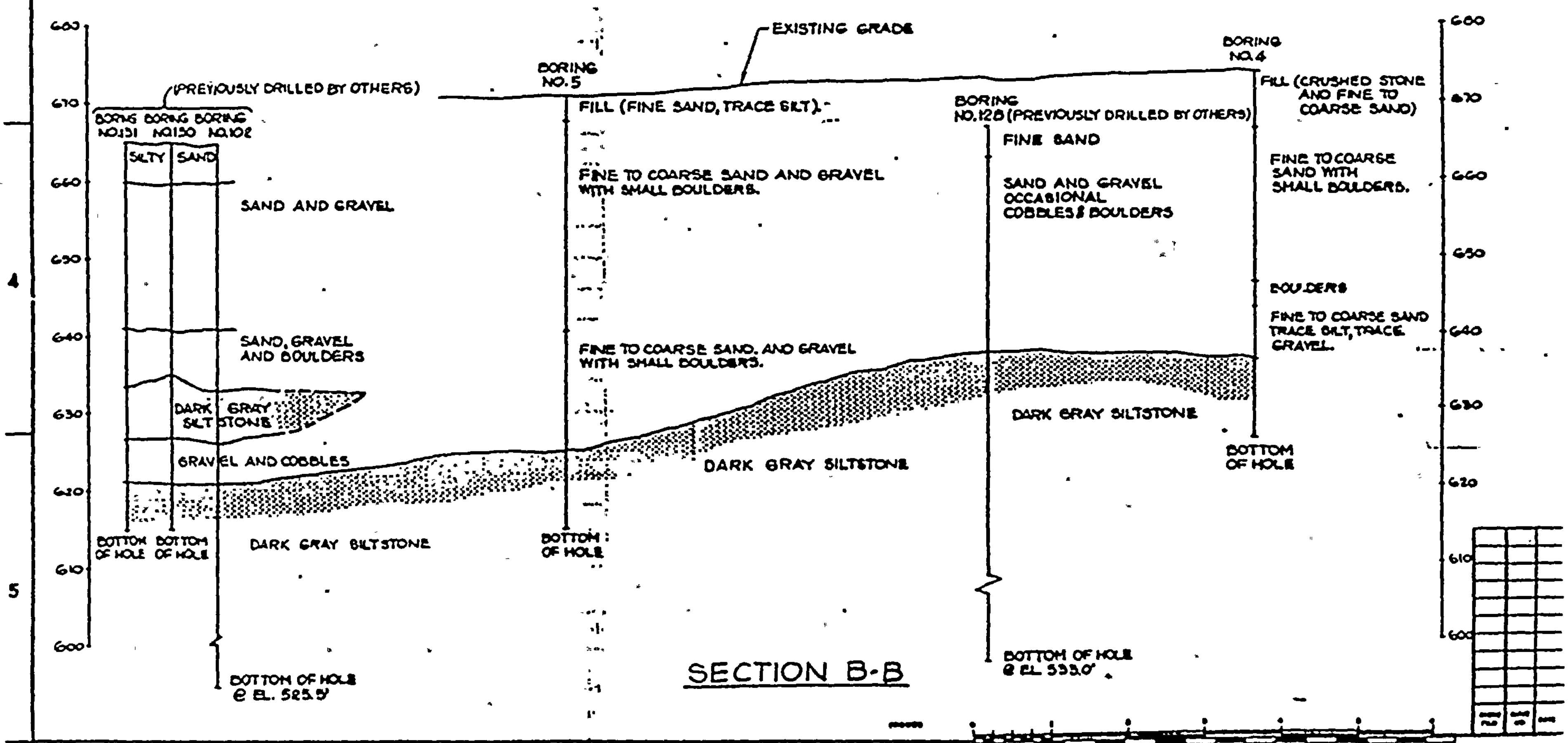
LOCATION AND LIMITS OF EXCAVATION FILL AND BACKFILL FOR CLASS I STRUCTURES

FIGURE 2.5-37


PLANT ACCESS ROAD
ROAD "H"
C LINE R.R.
PROPOSED EMERGENCY DIESEL GENERATOR BUILDING
OVERFLOW PARKING
PROPOSED DIESEL FUEL TANK
B-1
B-2
B-3
B-4
B-5
B-6
B-7
B-115
B-102
B-130
B-131
A FIGURE 2
B FIGURE 2
C FIGURE 2
PLANT SECURITY FENCE
B
C
D



SECTION A-A



SECTION B-B

2
3
4
5
A
B
C
D

Penn. Power & Light Co. CLIENT	**Gibbs & Hill, Inc.** ENGINEERS, DESIGNERS, CONSTRUCTORS	BORING No. 1 SHEET 1 OF 2
CONTRACTOR Borings, Soils and Testing Company	PROJECT No. 11-3544-547	BORING LOCATION:
FOREMAN-DRILLER J.R. Trude	PROJECT NAME Emergency Diesel Generating Facilities	N. 341,451.00 E. 2,442,350.00
INSPECTOR T.C. Shieh	LOCATION Berwick, Pa.	SURFACE ELEV. 674.11'

					CASING	SAMPLER	CORE BAR.		DRILLING START	DRILLING FINISH
WATER LEVEL	31.0'			TYPE		SS				
DATE	11/14/83			SIZE I.D.	3¼"	1-3/8"	NX	TIME		
HOURS	0			HAMMER W.T.	300 lbs.	140 lbs.	BIT			
CASING DEPTH				HAMMER FALL	18"	30"		DATE		11/14/83

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLE No.	TYPE	PEN.	REC.	DEPTH @ BOT.	BLOWS PER 6 IN. ON SAMPLER (FORCE ON TUBE) 0-6	6-12	12-18	CORING TIME PER FOOT	U.S.C.S. SYMBOL	SOIL DESCRIPTION AND REMARKS
0	27											
	50	1	SS	24"		2.0'	17	29	52	61		FILL (Dark brown fine to coarse
	101											SAND and small COBBLES, trace silt.)
	117											
	100											
5	57	RUN - 1				3.0'-6.0'		REC. = 33%				6.0'
	60											
	60	2	SS	24"		8.0'	31	30	29	33		Yellowish brown fine SAND, trace silt.
	69											
10	71											
	69											
	70	3	SS	24"		12.0'	16	27	27	31		
	70											
	74											
15	67											
	59											
	60	4	SS	24"		17.0'	20	25	30	39		
	71											18.0'
	120											Sandy GRAVEL with COBBLES and BOULDERS
20	137											
	100											
	111	5	SS	17'		21.4	57	69	70/5"			
	122											
	127	6	SS	24"		27.0	31	40	39	60		
25	148											
	130											
	127											
	146											
	147											
30	155	7	SS	0"		10.0'	50/0"					30.0'

NOTES: USED ____ IN. CASING TO ______ FT., THEN ____ IN. CASING TO ______ FT.

CODING: U.S.C.S. = UNIFIED SOIL CLASSIFICATION SYSTEM
H.S.A. = HOLLOW STEM AUGER   A = AUGER
S S = SPLIT SPOON SAMPLER   UD = UNDISTURBED SAMPLE
T = THINWALL   V = VANE SHEAR

CLIENT	Gibbs & Hill, Inc. ENGINEERS, DESIGNERS, CONSTRUCTORS	BORING No. 1 SHEET 2 OF 2
CONTRACTOR Borings, Soils and Testing Company	PROJECT No. 11-3544-547	BORING LOCATION:
FOREMAN-DRILLER J.R. Trude	PROJECT NAME Emergency Diesel Generating Facilities	
INSPECTOR T.C. Shieh	LOCATION Berwick, Pa.	SURFACE ELEV.

WATER LEVEL					CASING	SAMPLER	CORE BAR.		DRILLING START	DRILLING FINISH
DATE				TYPE		SS				
HOURS				SIZE I.D.	3½"	1-3/8"	NX	TIME		
CASING DEPTH				HAMMER W.T.	300 lbs.	140 lbs.	BIT	DATE		
				HAMMER FALL	18"	30"				

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLE No.	TYPE	PEN.	REC.	DEPTH @ BOT.	BLOWS PER 6 IN. ON SAMPLER (FORCE ON TUBE) 0-6	6-12	12-18	CORING TIME PER FOOT	U.S.C.S. SYMBOL	SOIL DESCRIPTION AND REMARKS
30												Sandy GRAVEL, with COBBLES and BOULDERS
	RUN	- 3			30.0'	-	34.5'		REC.	= 33%		34.5'
35												Dark gray SILTSTONE.
40												
	RUN	- 4			34.5'	-	44.5'		REC.	= 100%		44.5' Bottom of hole @ 44.5'
45									RQD	= 90%		
50												
55												
60												

NOTES: USED ___ IN. CASING TO ___ FT., THEN ___ IN. CASING TO ___ FT.

CODING: U.S.C.S. = UNIFIED SOIL CLASSIFICATION SYSTEM
H.S.A. = HOLLOW STEM AUGER   A = AUGER
S S = SPLIT SPOON SAMPLER   U D = UNDISTURBED SAMPLE
T = THINWALL   V = VANE SHEAR

Penn. Power & Light Co. CLIENT	**Gibbs & Hill, Inc.** ENGINEERS DESIGNERS CONSTRUCTORS	BORING No. 2 SHEET 1 OF 2
CONTRACTOR Borings, Soils and Testing Company	PROJECT No. 11-3544-547	BORING LOCATION: N. 341,395.67 E. 2,442,353.00
FOREMAN-DRILLER J.R. Trude	PROJECT NAME Emergency Diesel Generating Facilities	
INSPECTOR T.C. Shieh	LOCATION Berwick, Pa.	SURFACE ELEV. 672.11'

WATER LEVEL	26.4'	27.3'	27.3'	
DATE	11/10/83	11/15/83		
HOURS	0	11/16/83		
CASING DEPTH				

	CASING	SAMPLER	CORE BAR.
TYPE		SS	
SIZE I.D.	3½"	1-3/8"	NX
HAMMER W.T.	300 lbs.	140 lbs.	BIT
HAMMER FALL	18"	30"	

	DRILLING START	DRILLING FINISH
TIME		
DATE		11/10/83

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLE No.	TYPE	PEN.	REC.	DEPTH @ BOT.	BLOWS PER 6 IN. ON SAMPLER (FORCE ON TUBE) 0-6	6-12	12-18	CORING TIME PER FOOT	U.S.C.S. SYMBOL	SOIL DESCRIPTION AND REMARKS
0	20											
	27	1	SS	24"		2.0'	15	27	31	30		FILL (Dark gray fine to coarse
	30											SAND and crushed stone).
	31											
	37											
5	30											7.0'
	29	2	SS	24"		7.0'	26	44	32	53		Reddish brown fine to coarse SAND
	31											and crushed stone, trace silt, trace
	37											clay, grading with cobbles and small
10	40											boulders.
	50											
	57	3	SS	24"		12.0'	8	9	17	31		
	117											
	127											
15	149											
	160	4	SS	4"		15.3'	50/4"					
	70											
	69											
	65											
20	72											
	100											
	117	5	SS	19"		21.6'	31	37	49	50/1"		
	124											
	171											25.0'
25	222	6	SS	0"		25.0'	50/0"					Small sandstone BOULDERS.
	107											
	127											
	312											
	290											
30	310	RUN	-	1		25.0	- 30	0'	REC. ROD.	48% 0%		30.0'

NOTES: USED ___ IN. CASING TO ___ FT., THEN ___ IN. CASING TO ___ FT.

CODING: U.S.C.S. = UNIFIED SOIL CLASSIFICATION SYSTEM
H.S.A. = HOLLOW STEM AUGER A = AUGER
SS = SPLIT SPOON SAMPLER UD = UNDISTURBED SAMPLE
T = THINWALL V = VANE SHEAR

CLIENT	**Gibbs & Hill, Inc.** ENGINEERS, DESIGNERS, CONSTRUCTORS	BORING No. 2 SHEET 2 OF 2
CONTRACTOR Borings, Soils and Testing Company	PROJECT No. 11-3544-547	BORING LOCATION:
FOREMAN-DRILLER J.R. Trude	PROJECT NAME Emergency Diesel Generating Facilities	
INSPECTOR T.C. Shieh	LOCATION Berwick, Pa.	SURFACE ELEV.

WATER LEVEL					CASING	SAMPLER	CORE BAR.		DRILLING START	DRILLING FINISH
DATE				TYPE		SS				
HOURS				SIZE I.D.	3½"	1-3/8"	NX	TIME		
CASING DEPTH				HAMMER W.T.	300 lbs.	140 lbs.	BIT	DATE		
				HAMMER FALL	18"	30"				

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLE No.	TYPE	PEN.	REC.	DEPTH @ BOT.	BLOWS PER 6 IN. ON SAMPLER (FORCE ON TUBE) 0-6	6-12	12-18	CORING TIME PER FOOT	U.S.C.S. SYMBOL	SOIL DESCRIPTION AND REMARKS
30	70											
	79	7	SS	24"		32.0'	18	21	30	39		Reddish brown and gray fine to coarse SAND, trace silt, trace clay. Grading with small boulders.
	80											
	83											
35	100	8	SS	0"		35.0'	50/0"					
	272											36.0'
		RUN - 2				36.0'-38.0'				REC.=	100%	
										RQD.=	80%	Dark gray SILTSTONE.
40												
45		RUN - 3				38.0'-46.0'				REC.=	100%	46.0'
										RQD.=	97.5%	Bottom of hole @ 46.0'
50												
55												
60												

NOTES: USED ___ IN. CASING TO ___ FT., THEN ___ IN. CASING TO ___ FT.

CODING: U.S.C.S. = UNIFIED SOIL CLASSIFICATION SYSTEM
H.S.A. = HOLLOW STEM AUGER A = AUGER
SS = SPLIT SPOON SAMPLER UD = UNDISTURBED SAMPLE
T = THINWALL V = VANE SHEAR

6

Penn. Power & Light Co. CLIENT	Gibbs & Hill, Inc. ENGINEERS DESIGNERS CONSTRUCTORS	BORING No. 3 SHEET 1 OF 2
CONTRACTOR Borings, Soils and Testing Company	PROJECT No. 11-3544-547	BORING LOCATION:
FOREMAN-DRILLER J.R. Trude	PROJECT NAME Emergency Diesel Generating Facilities	N. 341,341.00 E. 2,442,350.00
INSPECTOR T.C. Shieh	LOCATION Berwick, Pa.	SURFACE ELEV. 669.51'

			CASING	SAMPLER	CORE BAR.		DRILLING START	DRILLING FINISH
WATER LEVEL	27.0'	TYPE		SS				
DATE	11/9/83	SIZE I.D.	3½"	1-3/8"	NX	TIME	9:45 a.m.	2:00 p.m.
HOURS	0	HAMMER W.T.	300 lbs.	140 lbs.	BIT	DATE	11/7/83	11/9/83
CASING DEPTH		HAMMER FALL	18"	30"				

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLE No.	TYPE	PEN.	REC.	DEPTH @ BOT.	BLOWS PER 6 IN. ON SAMPLER (FORCE ON TUBE) 0-6	6-12	12-18	CORING TIME PER FOOT	U.S.C.S. SYMBOL	SOIL DESCRIPTION AND REMARKS
0	10											FILL (Dark gray fine to coarse SAND
	37											with crushed stone).
	117	1	SS	24"		3.0'	15	25	27	57		(Hit concrete between 3.0' and 4.0').
	210											
5	30											5.0'
	30											Yellowish brown silty fine SAND.
	29	2	SS	24"		7.0'	17	15	10	13		
	29											
	31											
10	46	3	SS	0"		10.0'	50/0"					9.7'
	57											
	69											
	179											Sandy GRAVEL with cobbles and boulders.
	279	RUN - 1				12.0'-15.0'			REC. = 67%			
15	312	4	SS	0"		15.0'	50/0"					
	79											
	115											
	117											
	212											
20	192	RUN - 2				15.0'-20.0'			REC. = 22%			
	100											
	115											
	120											
	137											
25	141	RUN - 3				20.0' - 25.0'			REC. = 58%			
	100											
	110											
	127											
	131											
30	146	RUN - 4				25.0'-30.0'			REC. = 20%			

NOTES: USED ___ IN. CASING TO ___ FT., THEN ___ IN. CASING TO ___ FT.

CODING: U.S.C.S.= UNIFIED SOIL CLASSIFICATION SYSTEM
H.S.A. = HOLLOW STEM AUGER A = AUGER
S S = SPLIT SPOON SAMPLER U D = UNDISTURBED SAMPLE
T = THINWALL V = VANE SHEAR

Penn. Power & Light Co. CLIENT	Gibbs & Hill, Inc. ENGINEERS DESIGNERS CONSTRUCTORS	BORING No. 3 SHEET 2 OF 2
CONTRACTOR Borings, Soils and Testing Company	PROJECT No. 11-3544-547	BORING LOCATION:
FOREMAN-DRILLER J.R. Trude	PROJECT NAME Emergency Diesel Generating Facilities	
INSPECTOR T.C. Shieh	LOCATION Berwick, Pa.	SURFACE ELEV.

WATER LEVEL					CASING	SAMPLER	CORE BAR.		DRILLING START	DRILLING FINISH
DATE				TYPE		SS				
HOURS				SIZE I.D.	3½"	1-3/8"	NX	TIME		
CASING DEPTH				HAMMER W.T.	300 lbs.	140 lbs.	BIT	DATE		
				HAMMER FALL	18"	30"				

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLE No.	TYPE	PEN.	REC.	DEPTH @ BOT.	BLOWS PER 6 IN. ON SAMPLER (FORCE ON TUBE) 0-6	6-12	12-18	CORING TIME PER FOOT	U.S.C.S. SYMBOL	SOIL DESCRIPTION AND REMARKS
30	170											
	179	5	SS	13"		31.1'	25	36	50/1"			Sandy GRAVEL with Cobbles and boulders.
	160											
	175											
	179											
35	180		RUN - 5			32.0' - 36.0'			REC. = 62%			
	100	6	SS	0"		36.0'	50/0"					
	167											
	161											
40	170											
	177											
	170											
	171											
	176											
45	180											
			RUN - 6			41.0'-46.0'			REC. = 44%			
			RUN - 7			46.0' - 47.5'			REC. = 67%			47.5'
									RQD = 67%			Dark gray SILTSTONE.
50												
			RUN - 8			47.5' - 53.0'			REC. = 100%			
									RQD. = 82%			
55												
			RUN - 9			53.0'-57.5'			REC. = 100%			57.5'
									RQD. = 93%			Bottom of hole @57.5'
60												

NOTES: USED ___ IN. CASING TO ___ FT., THEN ___ IN. CASING TO ___ FT.

CODING: U.S.C.S.= UNIFIED SOIL CLASSIFICATION SYSTEM
H.S.A. = HOLLOW STEM AUGER   A = AUGER
SS = SPLIT SPOON SAMPLER   UD = UNDISTURBED SAMPLE
T = THINWALL   V = VANE SHEAR

Penn. Power & Light Co. CLIENT	Gibbs & Hill, Inc. ENGINEERS DESIGNERS, CONSTRUCTORS	BORING No. 4 SHEET 1 OF 2
CONTRACTOR Borings, Soils and Testing Company	PROJECT No. 11-3544-547	BORING LOCATION:
FOREMAN-DRILLER J.R. Trude	PROJECT NAME Emergency Diesel Generating Facilities	N. 341,449.92 E. 2,442,402.75
INSPECTOR T.C. Shieh	LOCATION Berwick, Pa.	SURFACE ELEV. 674.09'

WATER LEVEL	18.5'	34.6'			CASING	SAMPLER	CORE BAR.		DRILLING START	DRILLING FINISH
DATE	11/17	11/21		TYPE		SS		TIME		
HOURS	0			SIZE I.D.	3¼"	1-3/8"	NX	DATE		11/17/83
CASING DEPTH				HAMMER W.T.	300 lbs.	140 lbs.	BIT			
				HAMMER FALL	18"	30"				

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLE No.	TYPE	PEN.	REC.	DEPTH @ BOT.	BLOWS PER 6 IN. ON SAMPLER (FORCE ON TUBE) 0-6	6-12	12-18	CORING TIME PER FOOT	U.S.C.S. SYMBOL	SOIL DESCRIPTION AND REMARKS
0	12											FILL (Dark gray fine to coarse SAND and crushed stone).
	20	1	SS	24"		2.0'	39	62	58	70		
	31											
	40											
	46											
5	50											
	59	2	SS	24"		7.0'	20	37	35	41		7.0'
	70											Reddish gray fine to coarse SAND, grading with small boulders.
	22											
	27											
10	30											
	31	3	SS	24"		12.0'	6	7	6	9		
	37											
	40											
15	57											
	61	4	SS	4"		15.3'	50/4"					
	70											
	72											
	69											
20	71											
	67											
	71	5	SS	24"		22.0	13	13	14	19		
	127											
	60											
25	72											
	75											
	81	6	SS	24"		27.0	12	13	12	17		27.0'
	187											BOULDERS.
	212											
30	200											30.0'

NOTES: USED ___ IN. CASING TO ___ FT., THEN ___ IN. CASING TO ___ FT.

CODING: U.S.C.S. = UNIFIED SOIL CLASSIFICATION SYSTEM
H.S.A. = HOLLOW STEM AUGER   A = AUGER
SS = SPLIT SPOON SAMPLER   UD = UNDISTURBED SAMPLE
T = THINWALL   V = VANE SHEAR

CLIENT	Gibbs & Hill, Inc. ENGINEERS DESIGNERS, CONSTRUCTORS	BORING No. 4 SHEET 2 OF 2
CONTRACTOR Borings, Soils and Testing Company	PROJECT No. 11-3544-547	BORING LOCATION:
FOREMAN-DRILLER J.R. Trude	PROJECT NAME Emergency Diesel Generating Facilities	
INSPECTOR T.C. Shieh	LOCATION Berwick, Pa.	SURFACE ELEV.

WATER LEVEL				CASING	SAMPLER	CORE BAR.	DRILLING START	DRILLING FINISH
DATE			TYPE		SS			
HOURS			SIZE I.D.	3½"	1-3/8"	NX	TIME	
CASING DEPTH			HAMMER W.T.	300 lbs.	140 lbs.	BIT	DATE	
			HAMMER FALL	18"	30"			

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLE No.	TYPE	PEN.	REC.	DEPTH @ BOT.	BLOWS 0-6	BLOWS 6-12	BLOWS 12-18	CORING TIME PER FOOT	U.S.C.S. SYMBOL	SOIL DESCRIPTION AND REMARKS
30	111											Reddish brown fine to coarse SAND, trace silt, trace gravel.
	117	7	SS	24"		32.0'	29	37	41	36		
	129											
	130											
35	111											
	127											
	161	8	SS	24"		37.0'	26	30	39	56		37.3'
												Dark gray SILTSTONE
40												
45		RUN	-	1		37.3'	-47.3'		REC.	= 97%		
									RQD.	= 93%		47.3'
												Bottom of hole @ 47.3'
50												
55												
60												

NOTES: USED ___ IN. CASING TO ___ FT., THEN ___ IN. CASING TO ___ FT.

CODING: U.S.C.S. = UNIFIED SOIL CLASSIFICATION SYSTEM
H.S.A. = HOLLOW STEM AUGER   A = AUGER
SS = SPLIT SPOON SAMPLER   UD = UNDISTURBED SAMPLE
T = THINWALL   V = VANE SHEAR

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Penn. Power & Light Co. CLIENT	Gibbs & Hill, Inc. ENGINEERS, DESIGNERS, CONSTRUCTORS	BORING No. 5 SHEET 1 OF 2
CONTRACTOR Borings, Soils and Testing Company	PROJECT No. 11-3544-547	BORING LOCATION:
FOREMAN-DRILLER J.R. Trude	PROJECT NAME Emergency Diesel Generating Facilities	N. 341,360.75 E. 2,442,402.84
INSPECTOR T.C. Shieh	LOCATION Berwick, Pa.	SURFACE ELEV. 671.00'

		CASING	SAMPLER	CORE BAR.
WATER LEVEL	17.0' 25.9'			
DATE	11/16/83 AFTER	TYPE		SS	
HOURS	PLACING	SIZE I.D. 3½"	1-3/8"	NX
CASING DEPTH	PVC	HAMMER W.T. 300 lbs.	140 lbs.	BIT
		HAMMER FALL 18"	30"	

	DRILLING START	DRILLING FINISH
TIME		
DATE		11/16/83

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLE No.	TYPE	PEN.	REC.	DEPTH @ BOT.	BLOWS 0-6	6-12	12-18	CORING TIME PER FOOT	U.S.C.S. SYMBOL	SOIL DESCRIPTION AND REMARKS
0												FILL (Yellowish brown fine SAND, trace silt).
	27											
	50	1	SS	24"		3.0'	27	31	36	40		3.0'
	30											Reddish and grayish brown fine to coarse SAND and GRAVEL, with small boulders.
	31											
5	60	2	SS	6"		5.5'	56					
	70											
	71											
	79											
	75											
10	100											
	110	3	SS	24"		12.0'	20	27	27	39		
	90											
	99											
	120											
15	111											
	125	4	SS	24"		17.0'	16	29	31	46		
	161											
	170											
	176											
20	120											
	127	5	SS	20"		21.7'	25	37	46	50/2"		
	130											
	135											
	141											
25	100											
	99	6	SS	24"		27.0'	19	26	31	30		
	119											
	120											
30	137											30.0'

NOTES: USED ___ IN. CASING TO ___ FT., THEN ___ IN. CASING TO ___ FT.

CODING: U.S.C.S. = UNIFIED SOIL CLASSIFICATION SYSTEM
H.S.A. = HOLLOW STEM AUGER A = AUGER
S S = SPLIT SPOON SAMPLER UD = UNDISTURBED SAMPLE
T = THINWALL V = VANE SHEAR

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CLIENT	**Gibbs & Hill, Inc.** ENGINEERS DESIGNERS CONSTRUCTORS	BORING No. 5 SHEET 2 OF 2
CONTRACTOR Borings, Soils and Testing Company	PROJECT No. 11-3544-547	BORING LOCATION:
FOREMAN-DRILLER J.R. Trude	PROJECT NAME Emergency Diesel Generating Facilities	
INSPECTOR T.C. Shieh	LOCATION Berwick, Pa.	SURFACE ELEV.

WATER LEVEL			
DATE			
HOURS			
CASING DEPTH			

	CASING	SAMPLER	CORE BAR.
TYPE		SS	
SIZE I.D.	3½"	1-3/8"	NX
HAMMER W.T.	300 lbs.	140 lbs.	BIT
HAMMER FALL	18"	30"	

	DRILLING START	DRILLING FINISH
TIME		
DATE		

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLE No.	SAMPLE TYPE	SAMPLE PEN.	SAMPLE REC.	SAMPLE DEPTH @ BOT.	BLOWS PER 6 IN. ON SAMPLER (FORCE ON TUBE) 0-6	6-12	12-18	CORING TIME PER FOOT	U.S.C.S. SYMBOL	SOIL DESCRIPTION AND REMARKS
30	130											
	90	7	SS	24"		32.0'	61	50	49	48		Reddish brown fine to coarse SAND and GRAVEL, with small boulders.
	101											
	117											
	120											
35	97											
	111	8	SS	24"		37.0'	30	29	36	41		
	117											
	131											
	137											
40	140											
	119	9	SS	24"		42.0'	29	28	40	47		
	120											
	130											
	161	10	SS	0"		45.0'	50/0"					45.0'
45	212											46.0' - BOULDERS
50												
55		RUN - 1				46.0'-56.0'		REC. = 100%				
								RQD. = 96%				56.0' Bottom of hole @ 56.0'
60												

NOTES: USED ___ IN. CASING TO ___ FT., THEN ___ IN. CASING TO ___ FT.

CODING: U.S.C.S. = UNIFIED SOIL CLASSIFICATION SYSTEM
H.S.A. = HOLLOW STEM AUGER A = AUGER
SS = SPLIT SPOON SAMPLER UD = UNDISTURBED SAMPLE
T = THINWALL V = VANE SHEAR

Penn. Power & Light Co. CLIENT	**Gibbs & Hill, Inc.** ENGINEERS DESIGNERS, CONSTRUCTORS	BORING No. 6 SHEET 1 OF 2
CONTRACTOR Borings, Soils and Testing Company	PROJECT No. 11-3544-547	BORING LOCATION: N. 341,451.00 E. 2,442,450.00
FOREMAN-DRILLER J.R. Trude	PROJECT NAME Emergency Diesel Generating Facilities	
INSPECTOR T.C. Shieh	LOCATION Berwick, Pa.	SURFACE ELEV. 673.31'

							CASING	SAMPLER	CORE BAR.		DRILLING START	DRILLING FINISH
WATER LEVEL	23.5'			TYPE				SS				
DATE	11/23/83			SIZE I.D.			3½"	1-3/8"	NX	TIME		
HOURS	0			HAMMER W.T.			300 lbs.	140 lbs.	BIT			
CASING DEPTH				HAMMER FALL			18"	30"		DATE	11/22/83	11/23/83

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLE No.	TYPE	PEN.	REC.	DEPTH @ BOT.	BLOWS PER 6 IN. ON SAMPLER (FORCE ON TUBE) 0-6	6-12	12-18	CORING TIME PER FOOT	U.S.C.S. SYMBOL	SOIL DESCRIPTION AND REMARKS
0	17											
	30	1	SS	20"		1.7'	19	39	41	50/2"		FILL (Dark gray fine to coarse SAND, some crushed stone).
	41											
	50											
5	49											
	61											
	70	2	SS	24"		7.0'	30	37	51	70		7.0'
	71											Brownish gray fine to coarse SAND with gravel, grading with cobbles and boulders.
	40											
	46											
10	50	3	SS	2"		10.2'	50/2"					
	100											
	110											
	145											
	160											
15	80											
	97	4	SS	24"		17.0'	29	38	47	61		
	212											
	210											
	177											
20	101	5	SS	12"		21.0'	40	57				
	117											
	135											
	160											
25	179											
	116											
	121											
	127											
	130											
30	100	RUN - 1				25.0' - 30.0'			REC. = 20%			30.0'

NOTES: USED ___ IN. CASING TO ___ FT., THEN ___ IN. CASING TO ___ FT.

CODING:
U.S.C.S. = UNIFIED SOIL CLASSIFICATION SYSTEM
H.S.A. = HOLLOW STEM AUGER   A = AUGER
S S = SPLIT SPOON SAMPLER   U D = UNDISTURBED SAMPLE
T = THINWALL   V = VANE SHEAR

CLIENT	Gibbs & Hill, Inc. ENGINEERS DESIGNERS, CONSTRUCTORS	BORING No. 6 SHEET 2 OF 2
CONTRACTOR Borings, Soils and Testing Company	PROJECT No. 11-3544-547	BORING LOCATION:
FOREMAN-DRILLER J.R. Trude	PROJECT NAME Emergency Diesel Generating Facilities	
INSPECTOR T.C. Shieh	LOCATION Berwick, Pa.	SURFACE ELEV.

WATER LEVEL		CASING	SAMPLER	CORE BAR.		DRILLING START	DRILLING FINISH
DATE	TYPE		SS				
HOURS	SIZE I.D.	3½"	1-3/8"	NX	TIME		
CASING DEPTH	HAMMER W.T.	300 lbs.	140 lbs.	BIT	DATE		
	HAMMER FALL	18"	30"				

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLE No.	TYPE	PEN.	REC.	DEPTH @ BOT.	BLOWS 0-6	6-12	12-18	CORING TIME PER FOOT	U.S.C.S. SYMBOL	SOIL DESCRIPTION AND REMARKS
30	111											
	90	6	SS	24"		32.0'	23	27	27	31		Reddish brown fine to coarse SAND with gravel, trace silt.
	87											
	87											
35	97											35.0'
	60											Reddish brown silty fine SAND.
	61	7	SS	24"		37.0'	19	19	21	27		
	67											
	72											
40	86											
	100											41.7'
	212	8	SS	20"		41.7	20	30	29	50/2"		Dark gray SILTSTONE.
45												
50		RUN -		2		41.7'	- 51.7'		REC.	= 100%		51.7'
									RQD.	= 60%		Bottom of hole @ 51.7'
55												
60												

NOTES: USED ___ IN. CASING TO ___ FT., THEN ___ IN. CASING TO ___ FT.

CODING: U.S.C.S. = UNIFIED SOIL CLASSIFICATION SYSTEM
H.S.A. = HOLLOW STEM AUGER A = AUGER
S S = SPLIT SPOON SAMPLER UD = UNDISTURBED SAMPLE
T = THINWALL V = VANE SHEAR

Penn. Power & Light Co. CLIENT	**Gibbs & Hill, Inc.** ENGINEERS. DESIGNERS. CONSTRUCTORS	BORING No. 7 SHEET 1 OF 2
CONTRACTOR Borings, Soils and Testing Company	PROJECT No. 11-3544-547	BORING LOCATION:
FOREMAN-DRILLER J.R. Trude	PROJECT NAME Emergency Diesel Generating Facilities	N. 341,396.00 E. 2,442,450.00
INSPECTOR T.C. Shieh	LOCATION Berwick, Pa.	SURFACE ELEV. 672.55'

WATER LEVEL	28.6'		
DATE	11/22/83		
HOURS	0		
CASING DEPTH			

	CASING	SAMPLER	CORE BAR.
TYPE		SS	
SIZE I.D.	3¼"	1-3/8"	NX
HAMMER W.T.	300 lbs.	140 lbs.	BIT
HAMMER FALL	18"	30"	

	DRILLING START	DRILLING FINISH
TIME		
DATE	11/21/83	11/22/83

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLE No.	SAMPLE TYPE	SAMPLE PEN.	SAMPLE REC.	SAMPLE DEPTH @ BOT.	BLOWS PER 6 IN. ON SAMPLER (FORCE ON TUBE) 0-6	6-12	12-18	CORING TIME PER FOOT	U.S.C.S. SYMBOL
0	20										
	37	1	SS	18"		1.5'	27	40	61		
	60										
	100										
	121	2	SS	0"		5.0'	50/0"				
5	127										
	90										
	99										
	112										
	30										
10	27										
	29	3	SS	24"		12.0'	6	7	6	5	
	20										
	29										
	30	4	SS	24"		17.0'	2	2	1	3	
15	25										
	30										
	31										
	27										
	32										
20	70	5	SS	2"		20.2'	50/2"				
	100										
	115										
	75										
	69										
25	79										
	97	6	SS	24"		27.0'	21	30	29	46	
	101										
	117										
	130										
30											

SOIL DESCRIPTION AND REMARKS

FILL (Reddish brown & Dark gray medium to coarse SAND and CINDER, trace crushed stone.
Grading with boulders.

9.0'

Yellowish brown silty fine SAND with some crushed stone.
Grading with small boulders between 19.5' and 23.0'.

23.0'

Reddish brown medium to coarse SAND with some gravel, trace fine sand.

NOTES: USED ___ IN. CASING TO ___ FT., THEN ___ IN. CASING TO ___ FT.

CODING: U.S.C.S. = UNIFIED SOIL CLASSIFICATION SYSTEM
H.S.A. = HOLLOW STEM AUGER   A = AUGER
S S = SPLIT SPOON SAMPLER   UD = UNDISTURBED SAMPLE
T = THINWALL   V = VANE SHEAR

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CLIENT	**Gibbs & Hill, Inc.** ENGINEERS, DESIGNERS, CONSTRUCTORS	BORING No. 7 SHEET 2 OF 2
CONTRACTOR Borings, Soils and Testing Company	PROJECT No. 11-3544-547	BORING LOCATION:
FOREMAN-DRILLER J.R. Trude	PROJECT NAME Emergency Diesel Generating Facilities	
INSPECTOR T.C. Shieh	LOCATION Berwick, Pa.	SURFACE ELEV.

WATER LEVEL					CASING	SAMPLER	CORE BAR.	DRILLING START / DRILLING FINISH
DATE				TYPE		SS		
HOURS				SIZE I.D.	3½"	1-3/8"	NX	TIME
CASING DEPTH				HAMMER W.T.	300 lbs.	140 lbs.	BIT	DATE
				HAMMER FALL	18"	30"		

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLE No.	TYPE	PEN.	REC.	DEPTH @ BOT.	BLOWS PER 6 IN. ON SAMPLER (FORCE ON TUBE) 0-6	6-12	12-18	CORING TIME PER FOOT	U.S.C.S. SYMBOL	SOIL DESCRIPTION AND REMARKS
30	100											Reddish brown medium to coarse SAND
	110	7	SS	24"		32.0'	20	31	29	37		with some gravel, trace fine sand.
	139											
	130											33.4'
	110											
35	116	8	SS	5"		35.4'	60/5"					BOULDERS
	121											
	130											
	141											
40	160											40.0'
												Dark gray SILTSTONE.
45												
			RUN	-	1	40.0'	- 50.0'		REC.	= 96%		
									RQD.	= 81%		50.0'
50												Bottom of hole @ 50.0'
55												
60												

NOTES: USED ___ IN. CASING TO ___ FT., THEN ___ IN. CASING TO ___ FT.

CODING: U.S.C.S. = UNIFIED SOIL CLASSIFICATION SYSTEM
H.S.A. = HOLLOW STEM AUGER A = AUGER
SS = SPLIT SPOON SAMPLER UD = UNDISTURBED SAMPLE
T = THINWALL V = VANE SHEAR

Emergency Service Water System (ESWS)

The ESWS is designed to

a) Supply cooling water to the RHR pumps and their associated room coolers during the several non-emergency modes of RHP pump operation such as fuel pool cooling, normal shutdown, and hot standby

b) Supply cooling water to the various diesel generator heat exchangers, RHR pumps, room coolers, RBCCW and TBCCW heat exchangers during emergency shutdown conditions such as a LOCA.

The ESWS pumps are located in the ESWS pumphouse with the RHRSW pumps. The ESWS pumphouse is designed as Seismic Category I and the ESWS consists of two redundant loops (denoted A and B) each capable of providing 100 percent of the cooling water required by all the ESF equipment of both Units 1 and 2 simultaneously. The system is designed so that no single active or passive component failure will prevent it from achieving its safety related objective.

The system starts automatically on a diesel start signal.

For additional discussion, see Subsection 9.2.5.

Diesel Generators

The four diesel generators are housed in a Seismic Category I structure. They are separated from each other by concrete walls which provide missile protection. Loss of one diesel generator will not impair the capability to safely shutdown both units, since this can be done with three diesel generators. For additional discussion, see Subsection 8.3.1.4. ADDITIONALLY, A FIFTH STANDBY DIESEL GENERATOR IS PROVIDED AS A REPLACEMENT FOR ANY ONE OF THE FOUR. THIS UNIT IS HOUSED IN A SEPARATE SEISMIC CATEGORY I BUILDING. For descriptions of the Diesel Generator Fuel Oil System, Cooling Water System, Air Starting System, Lube Oil System, and the Intake and Exhaust Systems see Subsections 9.5.4, 9.5.5, 9.5.6, 9.5.7, and 9.5.8 respectively.

For missile protection see Subsection 3.5. Separation is discussed in Sections 3.12 and 8.3.

Ultimate Heat Sink (Spray Pond)

The spray pond provides the water for both the ESWS system and the RHRSW systems. It is the ultimate heat sink for both Units 1 and 2. The return lines from the ESWS and the RHRSW are combined and the total quantity of water from both these systems is discharged through spray networks, which dissipate the heat back

following a loss-of-coolant accident to assure that core cooling, containment integrity, and other vital safety functions are maintained.

Provisions shall be included to minimize the probability of losing electric power from any of the remaining supplies as a result of, or coincident with, the loss of power generated by the nuclear power unit, the loss of power from the transmission network, or the loss of power from the onsite electric power supplies.

Design Conformance

Two offsite power transmission systems and four onsite standby diesel generators (A, B, C & D) with their associated battery systems are provided. Either of the two offsite transmission power systems or any three of the four onsite standby diesel generator systems have sufficient capability to operate safety related equipment for cooling the reactor core and maintaining primary containment integrity and other vital functions in the event of a postulated accident in one unit with a safe shutdown of the other unit.

(ADD INSERT "K" HERE - See Attached)

The two independent offsite power systems supply electric power to the onsite power distribution system via the 230 kV transmission grid. Each of the offsite power sources is supplied from a transmission line which terminates in switchyards (or Substations) not common to the other transmission line. The two transmission lines are on separate rights-of-way. These two transmission circuits are physically independent and are designed to minimize the possibility of their simultaneous failure under operating and postulated accident and environment conditions.

Each offsite power source can supply all Engineered Safety Feature (ESF) buses through the associated transformers. Power is available to the ESF buses from their preferred offsite power source during normal operation and from the alternate offsite power source if the preferred power is unavailable. Each diesel generator (A, B, C & D) supplies standby power to one of the four ESF buses in each unit. Loss of both offsite power sources to an ESF bus results in automatic starting and connection of the associated diesel generator (A, B, C or D) within 10 seconds. Loads are progressively and sequentially added to avoid generator instabilities.

There are four independent ac load groups provided to assure independence and redundancy of equipment function. These meet the safety requirements assuming a single failure since any three of the four load groups have sufficient capacity to supply the minimum loads required to safely shut down the unit. Independent routing of the preferred and alternate offsite power source circuits to the ESF buses are provided to meet the single failure safety requirements.

INSERT "K" (to Page 3.1-18)

Additionally, a fifth diesel generator "E" (with its associated battery system) is provided as a replacement, and has the capability of supplying the emergency loading for any one of the other four diesel generators (A, B, C or D). Diesel generator "E" is not designed to automatically replace any one of the other four diesel generators in the event of a failure...

Filter housings		P	G,65	C	3	[illegible]/NA	I	Y	
Lube oil heater		P/[illegible]	G,65	NA	Other	NONE	NA	N	
Lube oil circulating pump		P/[illegible]	G,65	D	Other	NA	NA	N	24
Diesel starting air system									
piping and valves from downstream of tee following compressor discharge to engine skid		P	G,65	C	3	III-3	I	Y	
Piping and valves, others		P	G,65	D	Other	B31.1.0	NA	N	
Air receivers		P	G,65	C	3	III-3	I	Y	
Compressors		P/[illegible]	G,65	D	Other	NA	NA	N	
Jacket cooling water piping		P	G,65	D	Other	B31.1	NA	N	
Cooling jacket water heater		P [illegible]	G,65	NA	Other	NA	NA	N	
Cooling jacket water heater pump		P [illegible]	G,65	D	Other	NA	NA	N	24
Air intake & exhaust piping (except mufflers and expansion joints)		P	G,65	C	3	III-3	I	Y	
Dirty lube oil drain tank		P	G,65	NA	Other	NONE*	NA	N	
Heating, Ventilating and Air Conditioning Systems									
Control Structure	9.4.1								
Control Room & Computer Room HVAC									
Motors		P	CS	NA	3	NEMA MG1 IEEE-344/323	I	Y	

FL

Not Class 1

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* Refer to the General Notes at the end of this table.

TABLE 3.2-1 (Continued) ... 12

Principal Components (14*)	FSAR Section	Source of Supply (1)*	Location (2)*	Quality Group Classification (3)*	Safety Class (4)*	Principal Construction Codes and Standards (5)*	Seismic Category (6)*	Quality Assurance Requirement (7)*	[illegible]
Pump motors, fuel oil system		P/PL/GH	O,G,GS	NA	3	IEEE-323/344	I	Y	
Diesel generators		P/PL	G,GS	NA	3	IEEE-387	I	Y	
Electrical modules with safety functions		P/PL	G,GS	NA	3	IEEE-279/323	I	Y	
Cable, with safety functions		P/GH	G,GS	NA	3	IEEE-279/323/383	NA	Y	15
Diesel fuel storage tanks		P/GH	O	C	3	III-3	I	Y	
Diesel lube oil system piping and valves		P/PL	G,GS	C	3	B31.1	I	Y	
Heat exchangers: jacket water and lube oil		P/PL	G,GS	C	3	III-3/ TEMA C	I	Y	
Filter housings		P	G,GS	C	3	VIII/NA	I	Y	
Lube oil heater		P/PL	G,GS	NA	Other	NONE	NA	N	
Lube oil circulating pump		P/PL	G,GS	D	Other	NA	NA	N	24
Diesel starting air system									
piping and valves from downstream of tee following compressor discharge to engine skid		P	G,GS	C	3	III-3	I	Y	
Piping and valves, others		P	G,GS	D	Other	B31.1.0	NA	N	
Air receivers		P	G,GS	C	3	III-3	I	Y	
Compressors		P/PL	G,GS	D	Other	NA	NA	N	
Jacket cooling water piping		P	G,GS	D	Other	B31.1	NA	N	
Cooling jacket water heater		P	G,GS	NA	Other	NA	NA	N	
Cooling jacket water heater pump		P	G,GS	D	Other	NA	NA	N	24
Air intake & exhaust piping (except mufflers and expansion joints)		P	G,GS	C	3	III-3	I	Y	
Dirty lube oil drain tank		P	G,GS	NA	Other	NONE	NA	N	
Heating, Ventilating and Air Conditioning Systems									
Control Structure	9.4.1								
Control Room & Computer Room HVAC									
Motors		P	CS	NA	3	NEMA MG1 IEEE-344/323	I	Y	

h

PL

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* Refer to the General Notes at the end of this table.

Principal Components (34*)	FSAR Section	Source of Supply (1)*	Location (2)*	Quality Group Classification (3)*	Safety Class (4)*	Principal Construction Codes and Standards (5)*	Seismic Category (6)*	Quality Assurance Requirement (7)*	Comments *
Instrumentation Associated with Other Systems Required for Safety	7.6								
Spent fuel pooling cooling system		P	R	NA	2	IEEE-279	I	Y	
Fuel handling area ventilation isolation system		P	R	NA	2	IEEE-279	I	Y	
Control room panels		P	CS	NA	2	IEEE-279	I	Y	
Local instrument racks associated with safety related equipment		P	ALL	NA	2	IEEE-279	I	Y	
Instrumentation Associated with Systems Not Required for Safety	7.7								
Seismic instrumentation		P	ALL	NA	Other	NA	I	Y	
Area radiation monitoring		P	ALL	NA	Other	NA	NA	N	
Leak Detection Instrumentation									
Temperature elements		GE	C,R,T	NA	2	IEEE-323	I	Y	39
Differential temperature switch		GE	C,R	NA	2	IEEE-323	I	Y	39
Differential flow indicator		GE	CS	NA	2	IEEE-323	I	Y	39
Pressure switch		GE	C,R	NA	2	IEEE-323	I	Y	39
Differential pressure indicator switch		GE	CS	NA	2	IEEE-323	I	Y	39
Differential flow summer		GE	CS	NA	2	IEEE-323	I	Y	39
Process Radiation Monitors									
Electrical modules, main steam line and reactor building ventilation monitor		GE	R	NA	2	IEEE-323	I	Y	
Cable, main steam line and reactor building ventilation monitors		P	R	NA	2	IEEE-279/323/383	NA	Y	15
Electric Systems	8								
Engineered Safety Features AC Equipment	8.3								
4.16 kV switchgear		P/GH	0,65 7C5	NA	2	IEEE-308/323/344	I	Y	

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* Refer to the General Notes at the end of this table.

Principal Components (34*)	FSAR Section	Source of Supply (1)*	Location (2)*	Quality Group Classification (3)*	Safety Class (4)*	Principal Construction Codes and Standards (5)*	Seismic Category (6)*	Quality Assurance Requirement (7)*	Comments *
480 V load centers		P	O-?G5	NA	2	IEEE-308/ 323/344	I	Y	
480 V motor control centers		P/GH	O,G5	NA	2	IEEE/308/ 323/344	I	Y	
4.16KV-480V TRANSFORMER - DG "E"		GH	O	NA	2	323/344	I	Y	
Engineered Safety Features DC Equipment	8.3								
125 V and 250 V station batteries and racks, battery chargers		P	CS,G5	NA	2	IEEE-308/ 323/344	I	Y	
125 V switchgear and distribution panels		P/GH	CS,G5	NA	2	IEEE-308/ 323/344	I	Y	
125 V MOTOR CONTROL CENTER - DG "E"		GH	G5	NA	2		I	Y	
120 V Vital AC System Equipment	8.3								
Static inverters		P	CS	NA	2	IEEE-308/ 323/344	NA	Y	
120 V distribution panels		P	CS,R	NA	2	IEEE-308/ 323/344	I	Y	
Electric Cables for ESF Equipment	8.3								
5 kV power cables		P,GH	ALL	NA	2	IEEE-323/ 383	NA	Y	15
600 V power cables		P,GH	ALL	NA	2	IEEE-323/ 383	NA	Y	15
Control and instrumentation cables		P,GH	ALL	NA	2	IEEE-323/ 383	NA	Y	15
Miscellaneous Electrical	8								
Primary containment building electrical penetration assemblies		P	C	NA	2	IEEE-317/ 344/383	I	Y	
Conduit supports, safety related		P,GH	ALL	NA	2	IEEE-344	I	Y	15
TRAY & Tray supports, safety related		P,GH	ALL	NA	2	IEEE-344	I	Y	15
Emergency lighting systems		P,GH	ALL	NA	2	IEEE-344	I	Y	
Emergency communications systems		P,GH	ALL	NA	Other	NONE	NA	N	
Diesel generator		P/PL	G,G5	NA	2	IEEE-387	I	Y	
TRANSFER PANELS-DG "E"		GH	G5	NA	2	IEEE 323/344/	I	Y	
TERMINATION CABINETS-DG "E"		GH	G5	NA	2	IEEE 323/~~344~~	I	Y	

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* Refer to the General Notes at the end of this table.

TABLE 3.2-1 (Continued)

Principal Components (34*)	FSAR Section	Source of Supply (1)*	Location (2)*	Quality Group Classification (3)*	Safety Class (4)*	Principal Construction Codes and Standards (5)*	Seismic Category (6)*	Quality Assurance Requirement (7)*	Comments *
Demineralized Water Makeup System	9.2.9								
Tanks		P	CW	D	Other	VIII-1	NA	N	
Pumps		P	CW	D	Other	B31.1.0/ Hyd.I	NA	N	24
Motors		P	CW	NA	Other	NEMA MG1	NA	N	
Piping and valves		P	ALL	D	Other	B31.1.0	NA	N	
Buildings									
Reactor Building		P	R	B	2	ACI/AISC	I	Y	
Pressure resistant doors		P	R	B	2	ASTM/AWS AISC	NA	Y	
Watertight door		P	R	B	2	ASTM/AWS	NA	Y	
R. B. Equipment door		P	R	B	2	ASTM/AWS	NA	Y	
Primary Containment		P	C	B	2	ACI/AISC/ III	I	Y	27,30
Access hatches/locks/doors		P	C	B	2	III-MC	I	Y	
Liner plate		P	C	B	2	III-MC	I	Y	
Penetration assemblies		P	C	B	2	III-MC	I	Y	29
Vacuum relief valves		P	C	B	2	III-2	I	Y	
Downcomers		P	C	B	2	III-2	I	Y	44
Downcomer Bracing		P	C	B	2	AISC	I	Y	
Diesel generator building		P	G	NA	2	ACI/AISC	I	Y	
Control structure		P	CS	NA	2	ACI/AISC	I	Y	
Radwaste and offgas building		P	RW	NA	Other	ACI/AISC	NA	N	22
Turbine building		P	T	NA	Other	ACI/AISC	NA	N	21
Administration building		P	O	NA	Other	ACI/AISC	NA	N	
Circulating water pump house		P	O	NA	Other	ACI/AISC	NA	N	
ESSW pumphouse		P	O	NA	3	ACI/AISC	I	Y	
Low Level Radwaste Holding Facility		P	O	NA	Other	ACI/AISC/ UBC	NA	N	
DIESEL GENERATOR 'E' BUILDING		GRH	DG'E'	NA	2	ACI/AISC	I	Y	
Structures									
Roof Scuppers and Parapet Openings		P	R,CS,G	NA	2	ACI/AISC	NA	Y	
Spray pond & Emergency Spillway		P	O	NA	3	ACI	I	Y	
Condensate storage tank		P	O	D	Other	D100	NA	N	
Spent fuel pool		P	R	NA	2	ACI/AISC	I	Y	
Spent fuel pool liner		P	R	NA	2	ACI/AISC	I	Y	
Refueling water storage tank		P	O	D	Other	D100	NA	N	
Pipe Whip Restraints		P	R,C	NA	3	AISC	I	Y	

* Refer to the General Notes at the end of this table.

Principal Components (34*)	FSAR Section	Source of Supply (1)*	Location (2)*	Quality Group Classification (3)*	Safety Class (4)*	Principal Construction Codes and Standards (5)*	Seismic Category (6)*	Quality Assurance Requirement (7)*	Comments *
Missile Barriers for safety related equipment		P	C,R, CS,SW, G	NA	Other	ACI/AISC	I	Y	
Biological shielding within Primary containment, reactor Building and control building		P	C,R, CS	NA	Other	ACI/AISC	I	Y	42
Safety related masonry walls		P	R,G, CS	NA	Other	ACI/UBC	I	Y	

* Refer to the General Notes at the end of this table.

TABLE 3.2-1

SSES DESIGN CRITERIA SUMMARY (Continued)

General Notes and Comments

1) GE = General Electric

PL = Pennsylvania Power & Light

P = Bechtel as agents for Pennsylvania Power & Light

NA = Not Applicable, see comments

GH = GIBBS HILL & DCI AS AGENTS FOR PENNSYLVANIA POWER & LIGHT

2) Location

C	Part of or within primary containment
R	Reactor Building
T	Turbine Building
CS	Control Structure
RW	Radwaste and Offgas Building
G	Diesel Generator A,B,C & D Building
I	Intake Structure
A	Administration Building
CW	Circulating Water Pumphouse
SW	Engineering Safeguards Service Water (ESSW) Pumphouse
CA	Chlorine and Acid Storage Building
O	Outdoors, Onsite
G5	DIESEL GENERATOR "E" BUILDING

3) A,B,C,D - Quality group classification as defined in Regulatory Guide 1.26. The equipment shall be constructed in accordance with codes listed in Tables 3.2-2, 3.2-3, and 3.2-4.

NA - Not applicable to quality group classification

4) 1,2,3,4, other = safety classes defined in ANSI-N212 and Section 3.2.3.

NA - Not applicable to safety classification

③

TABLE 3.2-1

SSES DESIGN CRITERIA SUMMARY (Continued)

General Notes and Comments

1) GE = General Electric

PL = Pennsylvania Power & Light

P = Bechtel as agents for Pennsylvania Power & Light
G&H = GIBBS & HILL, INC. " " " "
NA = Not Applicable, see comments

2) Location

C	Part of or within primary containment
R	Reactor Building
T	Turbine Building
CS	Control Structure
RW	Radwaste and Offgas Building
G	Diesel Generator Building
DG'E'	DIESEL GENERATOR 'E' BUILDING
I	Intake Structure
A	Administration Building
CW	Circulating Water Pumphouse
SW	Engineering Safeguards Service Water (ESSW) Pumphouse
CA	Chlorine and Acid Storage Building
O	Outdoors, Onsite

3) A,B,C,D - Quality group classification as defined in Regulatory Guide 1.26. The equipment shall be constructed in accordance with codes listed in Tables 3.2-2, 3.2-3, and 3.2-4.

NA - Not applicable to quality group classification

4) 1,2,3,4, other = safety classes defined in ANSI-N212 and Section 3.2.3.

NA - Not applicable to safety classification

3.3 WIND AND TORNADO LOADINGS

3.3.1 WIND LOADINGS

All exposed structures are designed for wind loading.

3.3.1.1 Design Wind Velocity

The design wind velocity for all structures is 80 mph at 30 ft above ground for a 100-year recurrence interval. The design wind velocity is based on Figure 5 of Reference 3.3-1. (References are listed in Subsection 3.3.3).

The vertical velocity distribution is based on Table 1(a) of Reference 3.3-2. The velocity distribution is tabulated in Table 3.3-1.

A gust factor of 1.1, as given in Reference 3.3-2, is used.

3.3.1.2 Determination of Applied Forces

The procedure used to transform the wind velocity into an effective pressure applied to exposed surfaces of structures is as described in Reference 3.3-2 and is summarized as follows:

The dynamic pressure is given by:

$q = 0.002558\ V^2$ where,

q = Dynamic pressure in psf

V = Wind velocity in mph (design wind velocity x gust factor).

The local pressure at any point on the surface of a building is equal to:

$q \times Cp$ where

Cp = Pressure coefficient

⑤

The total pressure on a building is equal to:

$q \times C_D$ where,

C_D = Shape coefficient.

The Susquehanna SES structures have sloping roofs with a pitch less than 20 degrees. The following are values for Cp and C_D: (See Reference 3.3-2, p. 1151 and Figure 7)

Cp for windward wall = 0.8 (pressure)

Cp for leeward wall = -0.5 (suction)

Cp for windward slope = 0

Cp for leeward slope = -0.6 (suction)

C_D = 1.3 (pressure).

Wind loads on structures are tabulated in Table 3.3-1.

Exposed tanks are designed to resist a minimum wind load of 30 psf on the vertical projection, based on Reference 3.3-3. For cylindrical tanks, wind is considered acting on six-tenths of the vertical projection. No increases in allowable working stresses are permitted for these structures for loading conditions involving wind.

3.3.2 TORNADO LOADINGS

Table 3.3-2 lists the systems that are protected against tornadoes and the enclosures which provide this protection. This table is based on NRC Regulatory Guide 1.117 (Reference 3.3-4).

3.3.2.1 Applicable Design Parameters

The following design parameters are used for the design of tornado-resistant structures and are based on Reference 3.3-5:

a) Dynamic Wind Loading (FOR STRUCTURES OTHER THAN DIESEL GENERATOR 'E' BUILDING)

Tangential speed: 300 mph

Translational speed: 60 mph

6

b) Pressure Differential Between the Inside and Outside of a Building (FOR STRUCTURES OTHER THAN DIESEL GENERATOR 'E' BUILDING

A pressure drop of 3 psi at the rate of 1 psi per second.

c) Tornado-Generated Missiles

These are discussed in Subsection 3.5.1.4.

→ INSERT 'A'

3.3.2.2 Determination of Forces on Structures

The following procedures are used to transform the tornado loadings into effective loads on structures:

a) Dynamic Wind Loading

A procedure the same as the one utilized to transform the wind velocity into an effective pressure, as described in Subsection 3.3.1.2, is used with the following exceptions:

1) Velocity and velocity pressure are assumed not to vary with height.

2) The gust factor is taken as unity.

As shown in Figure 5 of Reference 3.3-5, and as explained therein, the equivalent uniform tornado wind velocity on the building due to a tangential component of 300 mph and a translational component of 60 mph is 220 mph. On Susquehanna SES the pressure loads are calculated on the basis of a uniform 300 mph wind velocity and are as follows: FOR STRUCTURES OTHER THAN DIESEL GENERATOR 'E' BUILDING:

		FOR DG 'E' BLDG.
Windward pressure on walls:	185 psf	266 psf
Leeward suction on walls:	115 psf	166 psf
Total design pressure:	300 psf	432 psf
Suction (uplift) on roof:	140 psf.	199 psf

"The turbine building is designed to resist the tornado loading assuming 2/3 of the metal siding and the roof deck being blown away. However, all the frames are designed for the full tornado loading.

The metal siding and the roof deck of all structures are not designed to resist full tornado loading."

⑦

b) Differential Pressure Loading

Differential pressure loading is calculated using the following pressure-time function:

The differential pressure is assumed to vary from zero to 3 psi at the rate of 1 psi/sec, remain at 3 psi for 2 seconds and then return to zero at 1 psi/sec.

INSERT 'B'

Blowout panels are used as necessary on safety related structures to minimize differential pressure.

c) Tornado-Generated Missiles

Tornado-generated missiles are classified as given in Tables 3.5-4 AND 3.5-4a. The barrier design procedures are described in Subsection 3.5.3.

Loadings a), b), and c) are combined in the following manner to obtain the total tornado loading:

(i) W' = Ww

(ii) W' = Wp

(iii) W' = Wm

(iv) W' = Ww+0.5Wp

(v) W' = Ww+Wm

(vi) W' = Ww+0.5Wp+Wm

where,

W' = Total tornado load

Ww = Tornado wind load

Wp = Tornado differential pressure load, and

Wm = Tornado missile load

3.3.2.3 Effect of Failure of Structures or Components Not Designed for Tornado Loads

Structures not designed for tornado loads are checked to ensure that during a tornado they will not generate missiles that have more severe effects than those listed in Table 3.5-4.

The modes of failure of these structures are analyzed to verify that they will not collapse on safety related structures.

3.3.3 REFERENCES

3.3-1. H.C.S. Thom, "New Distributions of Extreme Winds in the United States", Journal of the Structural Division, ASCE (July 1968), pp 1787.

3.3-2. "Wind Forces on Structures", ASCE Paper No. 3269, Transactions, Volume 126, Part II (1961), p 1124.

3.3-3. "Steel Tanks, Standpipes, Reservoir, and Elevated Tanks for Water Storage", AWWA Standard, D100-73.

3.3-4. "Tornado Design Classification", US NRC Regulatory Guide 1.117, (June 1976).

3.3-5. J.A. Dunlap and Karl Wiedner, "Nuclear Power Plant Tornado Design Considerations", Journal of the Power Division, ASCE, (March 1971).

INSERT 'A'

d) Dynamic wind loading (for Diesel Generator 'E' Building).

Tangential Speed: 360 mph
Translational Speed: 70 mph

e) Pressure differential between the inside and outside of diesel generator 'E' building.

A pressure drop of 3 psi at the rate of 2 psi per second.

INSERT 'B'

The differential pressure is assumed to vary from zero to 3 psi at the rate of 2 psi/sec, remain at 3 psi for 2 seconds and then return to zero at 2 psi/second. (FOR DIESEL GENERATOR 'E' BUILDING)

⑩

TABLE 3.3-2

TORNADO WIND PROTECTED SYSTEMS AND TORNADO RESISTANT ENCLOSURES

	Protected System	Tornado Resistant Enclosure
1.	Reactor coolant pressure boundary	Reactor Building
2.	Reactor core and reactor vessel internals	Reactor Building
3.	Systems or portions of systems required for	
	a) Reactor shutdown	Reactor Building
	b) Residual Heat Removal	Reactor Building
	c) Cooling the spent fuel storage pool	Reactor Building
	d) Makeup water for primary system	Reactor Building
	e) Systems necessary to support service water, cooling water source, and component cooling	ESSW Pumphouse and Reactor Building
4.	Reactivity control systems	Reactor Building and Control Building
5.	Control room	Control Building
6.	Monitoring, actuating, and operating systems important to safety	Reactor Building and Control Building
7.	Electric and mechanical devices and circuitry between the process sensors and the input terminals of the actuator systems involved in generating signals that initiate protective action	Reactor Building, Diesel Generator Building, and ESSW Pumphouse

DIESEL GENERATOR 'E' BUILDING,

TABLE 3.3-2 (Continued)

	Protected System	Tornado Resistant Enclosure
8.	Long-term emergency core cooling system	Reactor Building, Diesel Generator Building, and ESSW Pumphouse DIESEL GENERATOR 'E' BUILDING
9.	Class 1E electric systems	All Seismic Category I structures

①

3.4 WATER LEVEL (FLOOD) DESIGN

As discussed in Section 2.4, all Seismic Category I structures are secure against flooding due to probable maximum flood (PMF) of the Susquehanna River or probable maximum precipitation (PMP) on the area surrounding the plant. Therefore, special flood protection measures are unnecessary. The Seismic Category I structures have, however, been designed for hydrostatic loads resulting from groundwater, as discussed in Section 3.8. The groundwater table is at elevation 665 MSL in the main plant area.

A postulated break in the cooling tower basins or of the water delivery pipes to the basin could result in a build-up of water against the walls of either or both of the ESSW pumphouse and the turbine building. In the event of such water build-up breaching the turbine building wall, water that would not be intercepted by the floor drains or grilles and thus would flow through the turbine building to the reactor building would be prevented from endangering equipment in the latter by means of watertight doors. Flood water building up against the ESSW pumphouse would also be prevented from entering the building by means of watertight doors. Impact forces and water pressure due to flood water will not endanger the integrity of the ESSW pumphouse.

All safety-related systems are located in the Reactor Building, Diesel Generator Building, Control Structure and the Engineered Safeguard Service Water (ESSW) Pumphouse. DIESEL GENERATOR 'E' BUILDING

Sufficient physical separation between these buildings is provided to prevent internal spreading of any floods from one building to another.

Redundant Engineered Safety Features, pumps and drives, heat exchangers and associated pipes, valves and instrumentation in the reactor building subject to potential flooding, are housed in separate watertight rooms, with the exception of HPCI and RCIC rooms in Unit 2. Seismic Category I level detectors trip alarms in the main control room when the water level in any room exceeds the set point. Isolation of the floor drainage lines from these rooms is provided by outside manual valves.

All other rooms in the reactor building and control structure containing safety related equipment which are subject to potential flooding by process fluid leakage or fire protection water are provided with at least one open floor drain.

Floods in excess of the approximately 80 gpm floor drain capacity increase the water level in the affected area and are released through the door-to-floor clearance of these rooms.

Refer to Subsection 9.3.3 for a detailed description of the reactor building and control structure drainage system.

The four diesel generator sets are housed in individual water tight compartments within the diesel generator building. Floor drain line branches from each of these compartments are equipped with check valves to prevent backflooding from the common sump.

The ESSW pumphouse is divided into two redundant compartments. Flooding from internal leakage would, therefore, only affect one of the redundant pump sets. The control and electrical panels are mounted on minimum 4 inch high concrete pads or structural supports. Operating floor openings allow drainage of any leakage to the ESSW pump suction space below or to a reserve sump space that could be emptied with a portable pump.

The HPCI and RCIC rooms in Unit 2 are interconnected through a vent plenum which leads to the common blowout panel. Flooding in either room could potentially spill over to the other via the vent path. The vent path is 10'-8" above the floor. A moderate energy pipe break in each room has been postulated and analyzed in consistence with BTP APCSB3-1. It is conservatively estimated, without taking credit for floor drain capacity, that it will take approximately 13 hours for the maximum moderate energy pipe crack leakage in the RCIC room to overflow into the HPCI room, and 5 hours from HPCI room to RCIC room. The maximum moderate energy pipe crack leakage that cannot be isolated from outside these pump rooms will take approximately 23 hours to overflow from RCIC room to the HPCI room and 6 hours to overflow from HPCI room to RCIC room. There is sufficient time to identify the pipe failure and take appropriate action to mitigate the consequence of pipe failure prior to overflow occurred between these two interconnected rooms.

IN THE CASE OF DIESEL GENERATOR 'E' BUILDING, FLOOR DRAINS AT EL. 656'-6" ARE EQUIPPED WITH CHECK VALVES TO PREVENT BACKFLOODING FROM THE BUILDING SUMP. ALL FLOORS OF THE DIESEL GENERATOR 'E' BUILDING WHICH ARE SUBJECT TO POTENTIAL FLOODING BY FIRE PROTECTION WATER ARE PROVIDED WITH FLOOR DRAINS.

3

Commercial Aircraft

In V-232   18,000 movements x 0.12 x 10^{-11}/mi^2 x .04 mi^2 = .09 x 10^{-8} per year.

In V-106   3,000 movements x 1.9 x 10^{-11}/mi^2 x .04 mi^2 = .23 x 10^{-8} per year.

The sum of these event probabilities at the Susquehanna SES site is about 9.3 x 10^{-8}.

3.5.2 SYSTEMS TO BE PROTECTED

3.5.2.1 Missile Protection Design Philosophy

Systems that are reviewed for missile protection are listed in Subsection 3.12.2.

For internally generated missiles, protection is provided through basic station component arrangement so that, if equipment failure occurs, the missile does not cause the failure of a Seismic Category I structure or any safety related system. Where it is impossible to provide protection through station layout, suitable physical barriers are provided whose function is either to isolate the missile or to shield the critical system or component. In addition, redundant Seismic Category I components are suitably protected so that a single missile cannot simultaneously damage a critical component and its backup system.

3.5.2.2 Structures Designed to Withstand Missile Effects

Seismic Category I structures are designed to withstand postulated external or internal missiles which may impact them. Table 3.3-2 is a list of the structures designed to withstand external tornado generated missiles, and the safety related equipment which they protect. The missiles are listed in TableS 3.5-4 AND 3.5-4a for Structures other than Diesel Generator 'E' BUILDING and the Diesel Generator 'E' BUILDING respectively.

3.5.3 BARRIER DESIGN PROCEDURES

The structures and barriers are designed in accordance with the procedures detailed in Reference 3.5-5. The procedures include:

④

a) Prediction of local damage (penetration, perforation, and spalling) in the impact area including estimation of the depth of penetration

b) Estimation of barrier thickness required to prevent perforation

c) Prediction of the overall structural response of the barrier and portions thereof to missile impact.

The use of a ductility ratio higher than 10 but less than the allowables given in Reference 3.5.5 will be governed by the following conditions:

(1) Reinforced concrete barriers

The allowable displacement of reinforced concrete flexure members can be based on an upper limit for plastic hinge rotation $r\theta$ as follows:

$$r\theta = 0.0065 \frac{d}{c} \leq 0.07$$

where

d = distance from compression face to centroid of tensile steel reinforcement (inch)

c = distance from compression face to the neutral axis at ultimate strength (inch)

This condition is given in section C.3.5 of Appendix C and commentary to Appendix C of ACI 349-~~76~~ 80

(2) Steel barriers

To insure the ability of a steel beam to sustain fully plastic behavior and thus to possess the assumed ductility at plastic hinge formation, it is necessary that the elements of the beam section meet minimum thickness requirements sufficient to prevent local buckling failure.

The conditions to preclude local buckling as given in AISC Manual are satisfied.

5

3.5.4 REFERENCES

3.5-1. GE Memo Report "Hypothetical Turbine Missile Data - 38 inch Last Stage Bucket Units" (March 16, 1973).

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3.5-16 U.S. NUCLEAR REGULATORY COMMISSION "STANDARD REVIEW PLAN 3.5.1.4 REV.2" NUREG-0800 (JULY 1981)

3.5-17 U.S. NUCLEAR REGULATORY COMMISSION "STANDARD REVIEW PLAN 3.5.3 REV.1" NUREG-0800 (JULY 1981)

TABLE 3.5-4a

Tornado-Generated Missile Parameters for Diesel Generator 'E' Building.

Missile	Weight (lb)	Impact Velocity (fps)
A) Wood plank, 4 in. x 12 in. x 12 ft., traveling end-on	108	440
B) Steel pipe, 3 in. dia., Schedule 40, 10 ft. long, traveling end-on	72	147
C) Steel pipe, 6 in. dia., Schedule 40, 15 ft. long	285	170
D) Steel pipe, 12 in. dia., SCHEDULE 40, 15 FT. long	750	155
E) Steel rod 1-inch dia. x 3 ft. long	8	317
F) Automobile flying through the air at not more than 25 ft. above the ground and having contact area of 20 sq. ft.	4000	195
G) Utility pole 13.5 in. dia, 35 ft. long	1490	211

Note:

The vertical velocities will be considered equal to 80 percent of the horizontal velocities mentioned above.

⑦

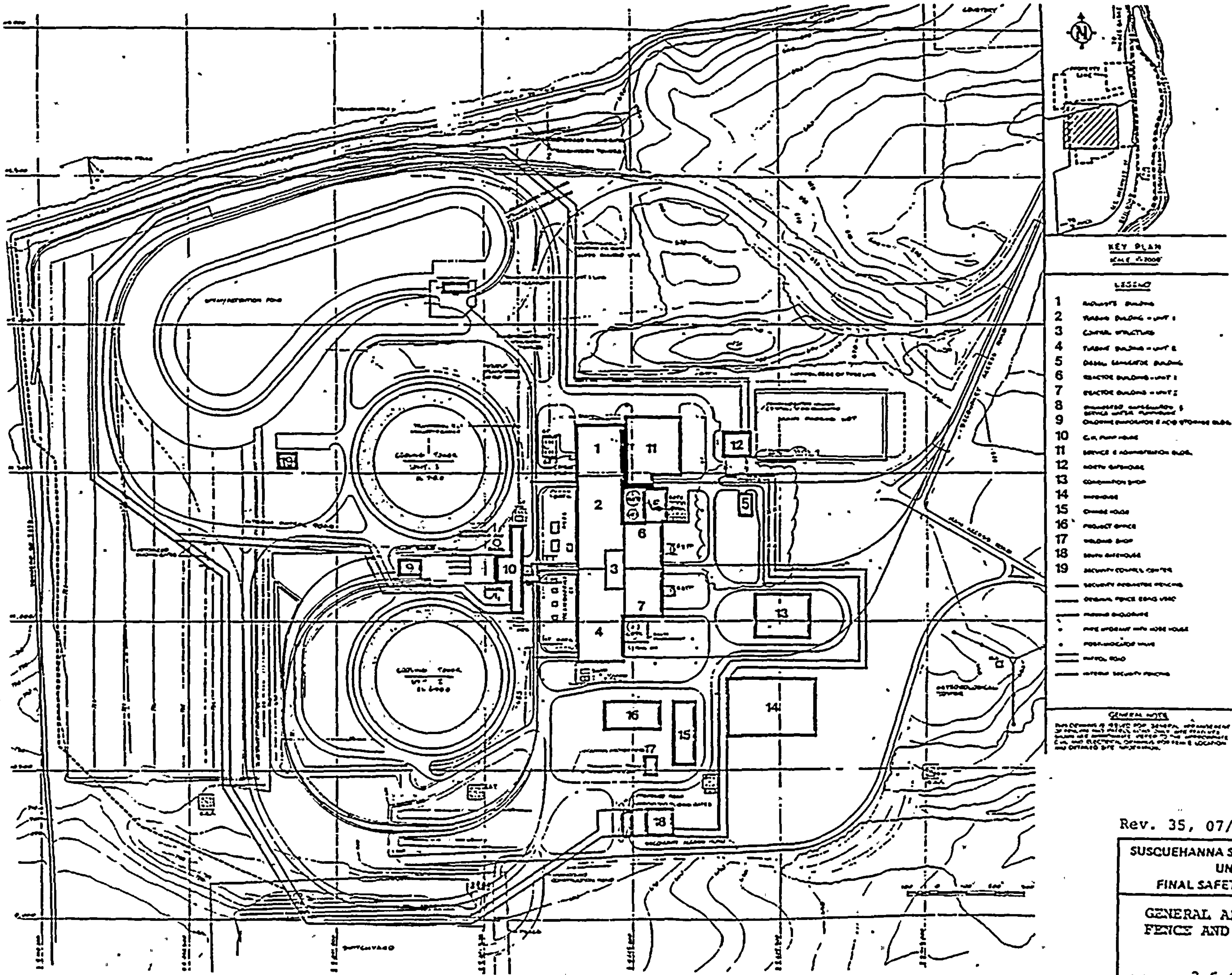
TABLE 3.5-4

TORNADO-GENERATED MISSILE PARAMETERS
(FOR STRUCTURES OTHER THAN DIESEL GENERATOR 'E' BUILDING)

Missile	Weight (lb)	Velocity (mph)
Wood plank, 4 in. x 12 in. x 12 ft, traveling end-on	108	300
Steel pipe, 3 in. dia., Schedule 40, 10 ft long, traveling end-on	76	100
Automobile flying through the air at not more than 25 ft above the ground and having contact area of 20 sq ft.	4000	50
Steel rod 1-inch diameter x 3 feet long	8	216
Utility pole 13-1/2 inch diameter, 35 feet long acting not more than 30 feet above the ground	1490	144

NOTE:

The vertical velocities will be considered equal to 80% of the horizontal velocities mentioned above.



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SUSQUEHANNA STEAM ELECTRIC STATION
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GENERAL ARRANGEMENT
FENCE AND PATROL ROAD

FIGURE 3.5-8

3.7b SEISMIC DESIGN

This section describes the seismic design requirements and methods used for Susquehanna SES and the seismic design and analysis of non-NSSS equipment. Seismic design of NSSS equipment is described in Section 3.7a.

For the DG "E" Facility, the site horizontal design response spectra have been scaled down from those given in Regulatory Guide 1.60, Rev. 1, refer to Figures 3.7b-102 through 3.7b-105.

3.7b.1 SEISMIC INPUT

3.7b.1.1 Design Response Spectra

The site design response spectra for rock founded structures except DG "E" Facility are illustrated on Figures 3.7b-1 and 3.7b-2 for the horizontal components of the Operating Basis Earthquake (OBE) and Safe Shutdown Earthquake (SSE) respectively. The design earthquake is assumed to be the free field motion at the base mat of the structure without the effect of the structure. For all Seismic Category I structures founded on rock the horizontal ground acceleration values are 5 and 10 percent of gravity for OBE and SSE respectively (refer to Subsections 2.5.2.6 and 2.5.2.7). However, Seismic Category I structures founded on soil, and the spray pond have been designed for ground accelerations of 8 percent (OBE) and 15 percent (SSE) of gravity. The maximum ground displacement is taken proportional to the maximum ground acceleration and is set at 40 in. (36 in. for the DG "E" Facility) for a ground acceleration of 1.0 gravity.

The base diagram of all design spectra consists of three parts: the maximum ground acceleration line on the left part, the maximum ground displacement line on the right part, and the middle part depends on the maximum pseudo-velocity.

For various damping values, the numerical values of design displacements and accelerations for the horizontal component design response spectra are obtained by multiplying the values of the maximum ground displacement and acceleration by the corresponding factors given in Table 3.7b-1. For the DG "E" Facility the numerical values for corresponding horizontal component follow Regulatory Guide 1.60, Rev. 1

for all Seismic Category I Structures except the DG "E" Facility,

The acceleration lines of the design response spectra are drawn parallel to the maximum ground acceleration line between the frequency lines of 6.67 cps (control point B of Figures 3.7b-1 and 3.7b-2) and 2 cps (control point C). The acceleration lines converge at the junction of the maximum ground acceleration line and the 33 cps frequency line (control point A). For frequencies higher than 33 cps, the maximum ground acceleration line represents the design response spectra. The displacement lines

For the DG "E" Facility, since the design spectra are plotted against frequency instead of period, the maximum ground acceleration line is on the right hand side and the maximum ground displacement line is on the left hand side.

are drawn parallel to the maximum ground displacement line. The maximum pseudo-velocity is assumed to be constant. Lines were drawn parallel to the constant velocity lines connecting the acceleration lines at control point C and the displacement lines. For the DG "E" Facility, Regulatory Guide 1.60, Rev 1 is followed.

For all Seismic Category I structures except the Diesel Generator "E" facility

Design response spectra values for the vertical component of the earthquake are taken as 2/3 of the corresponding values of the horizontal component of the earthquake. For the DG "E" Facility, Regulatory Guide 1.60 Rev. 1 is followed. The vertical ground acceleration values are the same as the horizontal ground acceleration values described above.

For all Seismic Category I structures except the Diesel Generator "E" facility

The site design spectra deviate from those suggested in Regulatory Guide 1.60. Figures 3.7b-102 through 3.7b-105 provide comparison of the two. The damping values for the NRC spectra are those specified by Regulatory Guide 1.61 for reinforced concrete structures. For the DG "E" Facility, Regulatory Guides 1.60 Rev. 1 and 1.61, Rev. 0 are followed.

3.7b.1.2 Design Time History

A synthetic time history motion for all Seismic Category I structures except the DG "E" Facility, is generated by modifying the actual records of the 1952 Taft earthquake according to the techniques proposed in Reference 3.7b-1. Figure 3.7b-3 shows the normalized synthetic time history motion. The duration of the time history is 20 sec. The time interval of the time history is 0.005 sec.

Figures 3.7b-4 and 3.7b-5 show a comparison of the time history response spectra and the design response spectra for 2, 3, 5, and 7 percent damping values. The spectra are computed at the following frequency values (in cps):

0.2 to 1.0 (increment of 0.05)

1.0 to 10.0 (increment of 0.1)

10.0 to 30.0 (increment of 1.0)

Figure 3.7b-6 shows a comparison of the time history response spectra and the design response spectra for 2 and 5 percent damping values for a frequency range between 0.2 and 1.0 cps, with intervals of 0.0125 cps. All the above figures show that the time history response spectra envelop the design response spectra.

For the DG "E" Facility, the horizontal and vertical synthetic time history motions are shown in Figures 3.7b-107 and 3.7b-108, respectively. The duration of these time histories is 25 sec. The time interval of these time histories is 0.01 sec. Figures 3.7b-109 through 3.7b-~~118~~ 114 show a comparison of the time history response spectra and the design response spectra for ~~1~~, 2, 5, and 7 ~~and 10~~ percent damping values. The spectra are computed at the frequencies ~~as~~ suggested in Standard Review plan 3.7.1, ~~June 1975~~ July 1981. All of the above figures show that the time history response spectra meet the acceptance criterion described in the same Standard Review plan.

except for the DG "E" Facility.

3.7b.1.3 Critical Damping Values (Non-NSSS)

Table 3.7b-2 summarizes the damping values used on Susquehanna SES. They are expressed as a percentage of critical damping and are based on Reference 3.7b-2. For the DG "E" Facility, the damping values are summarized in Table 3.7b-7.

The ESSW pumphouse, piping to the reactor building ~~and~~ the spray pond, are the only Seismic Category I structures and systems founded on soil. The equivalent spring constants and the soil damping coefficients used in the analysis of the ESSW pumphouse are shown in Table 3.7b-3. These values are based on formulae contained in Table 3-2 of Reference 3.7b-3. A lumped representation of soil structure interaction was used.

and the diesel fuel tank for the Diesel Generator "E" facility

Soil structure interaction is also considered in the generation of the response spectra for the containment. As in the ESSW pumphouse, a lumped representation of the soil structure interaction is considered. Table 3.7b-3 shows the equivalent spring and damping coefficients used in the containment model.

3.7b.1.4 Supporting Media for Seismic Category I Structures

All Seismic Category I structures, with the exception of ESSW pumphouse and the spray pond, and its pipe supports are founded on rock. For the structural analysis of the rock based structures, soil structure interaction is considered to be negligible due to the high stiffness of the rock which has a modulus of elasticity of approximately 3.0×10^6 psi. However, the response spectra of the containment are derived from a model that considers the flexibility of the rock.

The properties of the rock and soil supporting the ESSW pumphouse are shown in Table 3.7b-4. Discussion of the embedment of structures in soil will be limited to the ESSW pumphouse, since all the other structures are founded on rock.

The ESSW pumphouse is 59 ft high and rests on a 64 ft x 112 ft reinforced concrete mat foundation. The embedment depth of the foundation is 29 ft. The depth of soil below the mat foundation varies from 35 to 60 ft. The soil is predominantly sand, gravel, cobbles, and boulders. Near the surface, the soil is primarily sand and sandy gravel. With increasing depth, the soil changes to more cobbles and boulders. Near bedrock, the soil is mostly cobbles and boulders.

The site geology is discussed in detail in Section 2.5.

4

3.7b.2 SEISMIC SYSTEM ANALYSIS

Section 3.2 identifies Seismic Category I structures, systems, and components. Seismic Category I structures are considered seismic systems and are discussed here. Seismic Category I systems and components are considered seismic subsystems and are discussed in Subsection 3.7b.3. Seismic systems are analyzed for both the OBE and SSE.

3.7b.2.1 Seismic Analysis Methods

The response spectrum method, as described in Section 4.2.1 of Reference 3.7b-3, is used for seismic analysis of Seismic Category I structures. Separate lateral and vertical analyses of structures are performed. The responses are then combined to predict the total response of the structure.

A time history analysis of the Seismic Category I structures is done to generate the response spectra at the various mass points of the model.

The mathematical models used for these analyses are lumped mass, stick models. The same models were used for both the response spectrum and time history analyses with the exception of containment. In this case, the time history analysis used the flexible base models shown in Figures 3.7b-7 and 3.7b-8, whereas the structural analysis used a fixed base model. The fixed base model differs from the flexible base only in that the soil springs and dampers are assumed to be infinitely rigid, which results in a fixed base. The equivalency of the two models determined by comparing their dynamic characteristics is discussed in answer to NRC Question 130.20 in Volume 16 of FSAR.

The mathematical models of the reactor and control building are shown on Figures 3.7b-9 through 3.7b-11.

For all models, the masses are located at elevations of mass concentrations, such as floors and roofs. However, in the case of the containment which is a structure of continuous mass distribution, masses are lumped at approximately 15 ft intervals along the containment shell and reactor pedestal. These methods of mass distribution are in accordance with the procedures of Section 3.2 of Reference 3.7b-3 to provide an adequate number of masses.

The reactor and control buildings act as a single structure due to the monolithic construction. The entire reactor and control

5

building structure is shown as a single unit in Figure 3.7b-12. Both the control building and the line 29 wall of the reactor building are connected to the P-line wall, which is common to both the reactor and control buildings. In the east-west direction, the control building and the line 29 wall are considered to respond as a single unit.

The horizontal mathematical models are shown on Figures 3.7b-9 and 3.7b-10. The sticks represent shear walls located at the base mat elevation in the reactor building in the direction of the earthquake motion. In the east-west model (Figure 3.7b-9), the control building is lumped entirely on the line 29 stick. The entire control building is considered to contribute to the stiffness of the line 29 stick. In the north-south direction, the control building has its own stick connected to the P-line wall by springs.

The springs between the sticks represent the flexibility of the floor slab connecting each stick. Since these springs act in the direction of the earthquake motion, the model allows relative displacement between sticks.

Figure 3.7b-11 shows the vertical earthquake model of the reactor and control buildings. The left stick represents the steel columns. The right stick represents the shear walls of both the reactor and control buildings. The floors are represented by lumped masses and beam elements with the appropriate stiffness to capture the out of plane flexural vibration. Vertical translational coupling springs are provided to represent the coupling stiffness of the floor slab between the wall and column sticks. Mass numbers 8, 55, and 57 represent the fuel pool girder masses. Mass numbers 34, 35, 41, 43, 44, 46, 53 and 54 represent the floors between the fuel pool girders and columns/walls. Figure 3.7b-13 shows the correlation between the model mass points and the actual structure.

To more accurately determine the dynamic characteristics of the mathematical models the modulus of elasticity for concrete used in the analysis, is determined based on test results of concrete samples obtained from the plant site. The modulus value used is 720,000 ksf.

insert A

The seismic analysis of the Seismic Category I structures considers all modes whose frequencies are less than 33 cps. However, if a structure has only one or two modes with a natural frequency below 33 cps, then the three lowest modes are used. If a structure has three or less degrees of freedom, then all modes are considered in the analysis.

For the DG "E" Building and its pedestal, all modes were considered.

(A)

The DG "E" Building was represented by a horizontal and a vertical model. (Figures 3.7b-119A and 3.7b-119B) to evaluate the seismic responses due to the horizontal and vertical seismic excitations, respectively. The horizontal model has four lumped masses, one at each floor elevation. The asymmetry in the building is accounted for by considering the eccentricity of each lumped mass location. The vertical model is the same as the horizontal model except that a vertical translational spring with a mass has been added at each mass location to account for the flexibility of each floor.

A finite element model consisting of beam and plate elements was generated for the DG "E" Building to evaluate its stiffness matrix at each lumped mass location.

The DG "E" Pedestal was represented by a stick model (Figure 3.7b-120) having three lumped masses, mass 1 located at CG of the the Diesel engine and generator assembly, mass 2 and 3 at top and mid-height of the pedestal, respectively.

The modulus of elasticity of 4000 psi Concrete used in the DG "E" Building analysis has been taken as 3.6×10^6 psi

The Seismic Category I structures are supported by continuous base mats; therefore, relative displacement of supports is not a consideration.

Nonlinear responses are not considered since the Seismic Category I structures are designed to remain elastic.

3.7b.2.2 Natural Frequencies and Response Loads

The natural frequencies of the containment and the reactor and control building below 33 cps are shown in Tables 3.7b-5 and 3.7b-6 respectively. The first seven frequencies of the reactor and control building in the east-west direction are dependent upon the location of the reactor building cranes.

The significant mode shapes of the containment and the reactor and control building are shown on Figures 3.7b-14 through 3.7b-43. The mode shapes for containment are for the horizontal and vertical directions. The reactor and control building mode shapes are for each of the three principal directions: east-west, north-south, and vertical. As with the frequencies, the first seven mode shapes of the reactor and control building in the east-west direction depend on the location of the cranes. Figures 3.7b-20 through 3.7b-26 show that it is the superstructure of the reactor building that is excited at these low frequencies. The location of the cranes is noted on the figures.

Figures 3.7b-44 through 3.7b-57 show the response (i.e., displacements, accelerations, shear forces, bending moments, and axial forces) of the containment for both OBE and SSE. The response of the reactor and control building is shown on Figures 3.7b-58 through 3.7b-79.

Response spectra at critical locations are shown on Figures 3.7b-80 through 3.7b-101. The curves are shown for each of the three principal directions at the damping values used for each design earthquake (see Subsection 3.7b.2.15 for further discussion of damping values). A brief description of the location of each series of curves is provided below with the corresponding figure numbers.

Figures 3.7b-80 through 3.7b-83	RPV Pedestal
Figures 3.7b-84 through 3.7b-89	Refueling Area
Figures 3.7b-90 through 3.7b-95	Diesel Generator "A-D" Pedestals,

Figures 3.7b-96 through 3.7b-101	Operating Floor of ESSW Pumphouse

Insert → (B)

3.7b.2.3 Procedure Used for Modeling

Seismic systems and subsystems were defined in Subsection 3.7b.2.

All equipment, components, and piping systems are lumped into the supporting structure mass except for the reactor vessel, which is analyzed using a coupled model of the containment structure and the reactor vessel (refer to Figures 3.7b-7 and 3.7b-8). See Section 3.2 of reference 3.7b-3 for the criteria of lumping the equipment, components and piping systems into the supporting structure mass.

Adequacy of the number of masses and degrees of freedom is discussed in Subsection 3.7b.2.1.

Each Seismic Category I structure is considered to be independent because of a gap between adjacent structures. For example, there is a 2 in. horizontal gap between the reactor and control building and the containment above the foundation mat.

To form these gaps rodofoam material (Ref. 3.7b-12) was used. Rodofoam was left in place in the following areas:

(1) Joints where the provided actual gap is 0-5 inch greater than that originally specified on the civil drawings.

(2) Joints where the interaction forces between structures due to presence of rodofoam cause insignificant effect on shear and moment.

3.7b.2.4 Soil Structure Interaction

All Seismic Category I structures, except the ESSW pumphouse and spray pond, are founded on rock. The seismic analysis of these structures is done assuming a fixed base. As stated in Subsection 3.7b.2.1, the containment response spectrum curves are generated from a flexible base model. The rock is assumed to be a homogeneous material comprising an entire elastic half-space. The soil springs and dampers used to represent the effect of the soil are discussed in Subsection 3.7b.1.3.

(B)

The natural frequencies and corresponding participation factors for the DG "E" Building and its Pedestal are shown in Tables 3.7b-8 and 3.7b-9, respectively.

The response spectra generated for all floor elevations of the DG "E" Building are given in Project Specification C-1041, Rev. 1. These curves were prepared for three orthogonal directions at damping values 1, 2, 3, 4, 5 and 7 percent for the SSE and 0.5, 1, 2, 3, 4 and 5 percent for the OBE.

The ESSW pumphouse is supported by natural soil formation; consequently, soil structure interaction has been considered in the analysis of the pumphouse. Information regarding soil characteristics, foundation embedment, etc., is contained in Subsection 3.7b.1.4. The soil structure interaction analysis is performed using the lumped spring approach. The soil is considered a homogeneous material. The equivalent spring constants and the soil damping coefficients are discussed in Subsection 3.7b.1.3.

The seismic analysis of the spray pond is discussed in Subsection 2.5.5.

3.7b.2.5 Development of Floor Response Spectra

A time history analysis is used to develop the floor response spectra. The mathematical models used for this analysis are discussed in Subsections 3.7b.2.1, 3.7b.2.3, and 3.7b.2.4.

The floor response spectra are calculated at the frequencies listed in Table 5-1 of Reference 3.7b-3. Structural frequencies up to 33 cps are used. For the DG "E" Facility, the floor response spectra were generated at the frequencies per Regulatory Guide 1.122, Rev. 1

3.7b.2.6 Three Components of Earthquake Motion

Independent analyses are done for the vertical and two horizontal (east-west and north-south) directions. For design purposes, the response value used is the maximum value obtained by adding the response due to vertical earthquake with the larger value of the response due to one of the horizontal earthquakes by the absolute sum method. For the DG "E" Facility, the responses due to three simultaneous orthogonal components of an earthquake are combined by the square root of the sum of the squares method per Regulatory Guide 1.92, Rev. 1.

3.7b.2.7 Combination of Modal Responses

The modal responses, i.e., shears, moments, deflections, accelerations, and inertia forces, are combined by either the sum of the absolute values method or by the square root of the sum of the squares method. When the latter method is used, the absolute values of closely spaced modes for each group are added first and then combined with the other modes or groups of closely spaced modes by the square root of the sum of the squares method. Two consecutive modes are defined as closely spaced when their frequences differ from each other by 0.5 cps or less.

Insert C →

(c)

For the DG "E" ~~Building~~ Facility, the total response is obtained by combining the absolute values of all closely spaced modal responses with the square root of the sum of squares of the remaining modal responses. Two consecutive modes are defined as closely spaced when their frequencies differ from each other by 10 percent or less.

3.7b.2.8 Interaction of Non-Category I Structures with Seismic Category I Structures

Non-Category I structures that are close to Seismic Category I structures, viz., the turbine and radwaste buildings, have been designed to withstand an SSE. Dynamic analyses of these structures were done by the response spectrum method.

The remaining non-Category I structures were designed for seismic loads according to the UBC (Ref. 3.7b-4). The collapse of any of these remaining non-Category I structures will not cause the failure of a Seismic Category I structure.

Structural separations have been provided to ensure that interaction between Category I and non-Category I structures does not occur. The minimum separation at any point is maintained at one and a half times the absolute sum of the predicted maximum displacements of the two structures.

The rodofoam material which was used to form the separation gaps was left in place in some areas as mentioned in Section 3.7b.2.3.

3.7b.2.9 Effects of Parameter Variations on Floor Response Spectra

To account for variations in the structural frequencies owing to uncertainties in the material properties of the structure and to approximations in the modeling techniques used in the seismic analysis, the computed floor response spectra are smoothed and peaks associated with each of the structural frequencies are broadened. The parameters, which are considered variable, are the masses, the modulus of elasticity of the material, and the cross-sectional properties of the members. In addition, variation in the structural frequency is also taken into account because the base of the structures may not be fully fixed as assumed in the analysis.

Let

nf	=	Natural frequency of the building at a peak value of the floor response spectra
Δnf	=	Total variation in nf
Δnf_m	=	Variation in nf due to variation in the mass
Δnf_e	=	Variation in nf due to variation in the modulus of elasticity of the material
Δnf_s	=	Variation in nf due to variation in the cross-sectional properties of the members

A factor of 0.05 is used to account for the decrease in nf due to the possibility that the base of the structures may not be fully fixed.

Since it is highly improbable that the maximum variations in the individual parameters would occur simultaneously, Δnf is determined by the square root of the sum of the squares of the individual variations as follows:

The maximum increase in nf is given by:

$$+\Delta nf = \left[(\Delta nf_m)^2 + (\Delta nf_e)^2 + (\Delta nf_s)^2\right]^{1/2}$$

$$-\Delta nf = \left[(\Delta nf_m)^2 + (\Delta nf_e)^2 + (\Delta nf_s)^2 + (0.05)^2\right]^{1/2}$$

For all seismic Category I structures, excluding the Diesel Generator "E" facility, ~~On Susquehanna~~ SES, the following values of $\pm\Delta nf$ are used:

$+\ \Delta nf = 0.12\ nf$

$-\ \Delta nf = -0.14\ nf$

3.7b.2.10 Use of Constant Vertical Static Factors

Constant vertical static factors are not used in the seismic design of Seismic Category I structures. The methodology used for the vertical seismic analysis is similar to the horizontal analysis.

For the DG "E" Facility, the computed floor response spectra were smoothed and peak width associated with each structural frequency was increased by ±15 percent.

3.7b.2.11 Methods Used To Account for Torsional Effects

Torsional effects for the diesel generator building and ESSW pumphouse are accounted as follows:

A static analysis was done to account for torsion on these two structures. For the ESSW pumphouse the eccentricity was determined by the distance between the center of mass and the center of rigidity of the structure. The inertia force from the response spectrum analysis was applied at the center of mass. The resulting torsional moment is equal to the inertial force times the eccentricity. The shear forces due to the torsional moment were then distributed to the walls. The torsional shear forces are distributed according to the method described in Section 3.4 of Reference 3.7b-5.

In the diesel generator building, torsion is considered due to the eccentricity caused by the difference in rigidities of the east and west shear walls. The torsional shear forces are assumed to be taken entirely by east and west walls only.

Torsional effects are negligible for the containment because of the symmetry of the structure.

The reactor/control building is modeled for horizontal dynamic analysis as multiple sticks coupled by springs representing the shear stiffness of the floor slabs. Each stick represents a major structural shear wall. The mass and stiffness distribution of the structural walls is such that torsional effects are properly represented in the dynamic analysis.

Torsional effects for the diesel generator building, ESSW pumphouse, and reactor/control building are also discussed in response to NRC questions 130.21 and 130.22.

Insert E →

3.7b.2.12 Comparison of Responses

Figures 3.7b-4 through 3.7b-6 show that the response spectra of the time history envelop~~e~~ the design response spectra at all frequencies. The time history has been used to generate response spectra in the structures but has not been used to calculate forces in the structures. Response in containment, a typical Category I Structure, obtained from the response spectrum analysis compare closely with those obtained from time history analysis based on studies comparing displacements and accelerations obtained by the two methods. For the DG "E" Building, the above two comparisons are shown in Figures 3.7b-109 through 3.7b-118.

(E)

For the DG "E" Building, the torsional effects due to its asymmetry are accounted for by lumping the floor masses at their respective CG's in the mathematical model of the building [illegible] discussed in Section 3.7b.2.1. The stiffness matrix is calculated at these mass points and thus reflects the actual asymmetrical building configuration including the various wall openings. To account for accident torsion, an additional torsional moment, produced by an eccentricity of ± 5 percent of the maximum building dimension, is added to the gross torsional moment obtained from the dynamic analysis of the above mathematical model.

For the DG "E" Building, the total accelerations at each floor elevation, due to an earthquake component resulting from the modal combination described in Subsection 3.7b.2.7 are used to compute the overturning moment. 16

3.7b.2.13 Methods for Seismic Analysis of Dams

Dams are not provided on Susquehanna SES.

3.7b.2.14 Determination of Seismic Category I Structure Overturning Moments

The overturning moments for Seismic Category I structures excluding the Diesel Generator E facility is the sum of the moments at the base of each stick of the mathematical model. For each stick, the moment at the base is determined by combining the modal overturning moments. The moments are combined by the methods described in Subsection 3.7b.2.7.

The components of the earthquake motion used are the same as those discussed in Subsection 3.7b.2.6.

Subsection 3.8.5 discusses the factor of safety against overturning for several loadings which include seismic loads.

3.7b.2.15 Analysis Procedure for Damping

The structures consist of reinforced concrete and welded/bolted structural steel. Damping values for these materials are shown in Table 3.7b-2. However, in the seismic analysis of the structures, (except Diesel Generator E Facility) damping values of 2 and 5 percent are used for OBE and SSE respectively for reinforced concrete, as well as welded/bolted structural steel. Therefore, analysis of composite model damping is not necessary.

All Seismic Category I structures except the ESSW pumphouse and spray pond and its pipe supports are founded on rock. Consequently, soil damping values are calculated for the ESSW pumphouse as described in Appendix D of Reference 3.7b-3.

The interaction damping values for the time history analysis of the containment are also calculated by the method described in Appendix D of Reference 3.7b-3.

For the DG "E" Facility, the damping values for various materials are shown in Table 3.7b-7. For a structural system consisting of various components having different materials, composite modal damping is computed in accordance with Standard Review Plan, Rev. 1, sheet 3.7.2-11, equation (4).

For rigid equipment having a fundamental frequency greater than 33 Hz, the dynamic load consists of a static load obtained as the equipment's weight times the acceleration corresponding to 33Hz.

For structurally complex equipment, which cannot be classified as structurally simple or rigid, the equipment is idealized by a mathematical model and dynamic analysis is performed using standard analytical procedures. An alternative method used for verifying structural integrity of members physically similar to beams and columns is the static coefficient method. In this method no determination of natural frequency is made. Dynamic forces are calculated as product of the weight and peak acceleration of response spectra multiplied by a static coefficient of 1.5.

Damping values used are given in Table 3.7b-2~~9~~ and 3.7b-7.

3.7b.3.1.1.2 Dynamic Testing

Dynamic testing is performed when analysis is insufficient to determine either the structural or functional adequacy of the equipment or both. Typical test methods used are as follows:

a) Single frequency sine beat test

b) Single frequency dwell test

c) Multifrequency test

All seismic qualification tests subject the equipment to excitation for at least 30 seconds.

3.7b.3.1.1.3 Combination of Analysis and Dynamic Testing

Certain equipment is qualified by a combination of analysis and dynamic testing.

3.7b.3.1.2 Piping Systems

BP-TOP-1, Rev. 3 (Ref. 3.7b-6) describes the methods used for seismic analysis of piping systems. Reference 3.7b-6 is followed on Susquehanna SES with the following exceptions:

For rigid equipment having a fundamental frequency greater than 33 Hz, the dynamic load consists of a static load obtained as the equipment's weight times the acceleration corresponding to 33Hz.

For structurally complex equipment, which cannot be classified as structurally simple or rigid, the equipment is idealized by a mathematical model and dynamic analysis is performed using standard analytical procedures. An alternative method used for verifying structural integrity of members physically similar to beams and columns is the static coefficient method. In this method no determination of natural frequency is made. Dynamic forces are calculated as product of the weight and peak acceleration of response spectra multiplied by a static coefficient of 1.5.

Damping values used are given in Table 3.7b-2.

3.7b.3.1.1.2 Dynamic Testing

Dynamic testing is performed when analysis is insufficient to determine either the structural or functional adequacy of the equipment or both. Typical test methods used are as follows:

a) Single frequency sine beat test

b) Single frequency dwell test

c) Multifrequency test

All seismic qualification tests subject the equipment to excitation for at least 30 seconds.

3.7b.3.1.1.3 Combination of Analysis and Dynamic Testing

Certain equipment is qualified by a combination of analysis and dynamic testing.

3.7b.3.1.2 Piping Systems

Rev. 0
and ~~AEG-502,~~ (Ref. 3.7b-14)

BP-TOP-1, Rev. 3 (Ref. 3.7b-6) describes the methods used for seismic analysis of piping systems. Reference 3.7b-6 is followed on Susquehanna SES ~~with the following~~ exceptions:

found in all category I structures, excluding the Diesel Generator "E" Facility.

After Sec Subsection 3.7b.3.7

AEG-502, Rev. 0 (Ref. 3.7b-14) describes the methods used for seismic analysis of piping systems found in the Diesel Generator "E" Facility.

2-

In seismic analysis the modal responses are combined by SRSS and lower damping values than specified in Reference 3.7b-6 are used.

See Subsection 3.7b.3.7.

3.7b.3.1.3 Class IE Cable Trays

The cable trays are seismically qualified by the capacity evaluation method which consists of the following:

a) Calculation of the fundamental frequency of the cable tray based on the tray properties obtained from static tests

b) Seismic load computation based upon the tray frequency, the possible support frequencies and the design spectra

c) Calculation of the tray allowable capacity

d) Evaluation of the tray capacity by interaction formulae

Note: for the DG "E" facility, equivalent static analysis is used in lieu of steps (a) and (b).

3.7b.3.1.4 Supports for Seismic Category I HVAC Ducts

The supports of HVAC ducts are analyzed by the response spectrum method.

3.7b.3.1.5 Concrete Block Masonry Structures (Blockwalls)

The dynamic analysis of safety related concrete masonry blockwalls in Class I structures is performed by the response spectrum method. Response spectrum for the lower floor has been used for vertical motion and for walls, cantilevered from the floor. For horizontal motion, the acceleration of the lower floor or average of the lower and upper floor, whichever is greater, is used in determining inertia loads. Frequency calculations for blockwalls supporting class I attachments or located in areas of class I equipment are based on either cracked section, partially cracked section, or uncracked section properties; whichever represents the condition based upon the calculated loads.

Partially cracked section analysis is based on the following ACI 318 (Ref. 10A of Table 3.8-1) formula

$$I_e = (M_{cr}/M_a)^3 I_g + (1 - (M_{cr}/M_a)^3) I_{cr}$$

where,

I_e = effective moment of inertia of cracked Section

I_{cr} = moment of inertia of cracked Section

M_a = bending moment applied to the blockwall

I_g = Gross section moment of inertia (uncracked)

M_{cr} = cracking bending moment = $\frac{fr\ I_g}{yt}$

fr = modulus of rupture for masonry = 50 psi

modulus of rupture for concrete = 6 $\sqrt{f'c}$ psi

Y_t = distance from centroid axis of gross section to the extreme fiber in tension.

For assessing the effects of frequency variations on the responses, the variable items such as boundary conditions, mass, modulus of elasticity, cracking moment are considered. Damping values used are in accordance with Table 3.7b-2. The response of attachments to blockwalls is determined as described in Subsection 3.7b.3.1.1.1.

The three components of earthquake motion are combined in accordance with Subsection 3.7b.2.6.

3.7b.3.1.6 Supports of Seismic Category I Electrical Raceway Systems

This section defines the procedures used for the design of the supports of electrical raceway systems; i.e., cable tray, conduit, and wireway gutter systems, subject to the seismic and other applicable loads. The raceway support system usually consists of raceways, horizontal and vertical support members and lateral and longitudinal bracing members.

3.7b.3.1.6.1 Loading Combinations

In all Seismic Category I Structures, except the Diesel Generator "E" Facility, the adequacy of raceway systems to withstand seismic and other applicable static loads is determined according to the loading combinations and allowable responses given below:

Equation	Condition	Load Combination	Allowable Response
1	Normal	D + L	F - See note 4
2	Normal/Severe	D + L + E	See Notes 2 & 4
	(Equation 2 applies only to connections for fatigue considerations.)		
3	Abnormal/Extreme	D + E'	See Notes 2, 3, & 4

Notes:

1. For notations, see Table 3.8-2.

2. The following equation is applicable for bending in overhead connections:

$$\frac{5n_{EQ}}{N_{OBE}} + \frac{n_{EQ}}{N_{SSE}} \leq 1.0$$

where:

n_{EQ} = Total number of load/stress cycles per earthquake.

N_{OBE} = Allowable number of load/stress cycles per OBE event.

N_{SSE} = Allowable number of load/stress cycles per SSE event.

3. The following criteria are used for checking the members. In no case shall the allowable stress exceed 0.90F in bending, 0.85F in axial tension or compression, and 0.50F in shear. Where the design is governed by requirements of stability (local or lateral buckling), the actual stress shall not exceed 1.5F.

4. Allowable shear and normal loads in connections are determined from the manufacturers' data or from code allowable stresses whichever is applicable.

The allowable values are increased 50% for load combination equation 3.

→ INSERT 'G'

3.7b.3.1.6.2 Analytical Techniques

In all Seismic Category I structures, except the Diesel Generator "E" Facility, Either of two methods of analysis is used. Method 1 is a simplified method of analysis which determines the fundamental frequency of braced supports using two dimensional analysis. Frequencies are determined in each of three principal directions. Then loads are determined by taking the spectral accelerations times the weight; and stresses are determined from static analysis. All members and connections are checked using stress criteria.

Method 2 uses a three dimensional computer analysis and includes springs to represent joint stiffnesses. Response spectrum analyses are done to determine stresses and deformations. The number of stress cycles is determined by multiplying the time of maximum earthquake motion by the natural frequency of the system. The allowable number of cycles is taken from Reference 3.7b-8 for the joint rotations calculated. Only overhead connections are checked for fatigue since the test results (ref. 3.7b-8, pg. 7-19) demonstrate that failures occur only in overhead connections.

The basis for the design criteria and analysis method 2 is the "Cable Tray and Conduit Raceway Test Program" (references 3.7b-7 through 3.7-10).

→ INSERT 'H'

3.7b.3.1.6.3 Damping

In all Seismic Category I structures, except the Diesel Generator "E" Facility, Damping of 7% of the critical is used for the design of ~~all~~ raceway systems. The test program demonstrates that for cable tray systems damping is, in general, much higher than 7%. Reference 3.7b-7 recommends using 20% but values up to 50% are reported. The recommended damping values, developed from the test program and based on lower bound values, are shown in Figure 3.7b-106. Damping is amplitude dependent, i.e., it increases with increasing amplitude of input motion. For conduit systems the damping increases with increasing amplitude, but is much lower than for cable tray systems. This 7% is a realistic value for input motion exceeding 0.1g for conduit systems. Wireway gutters were not tested; however, the manner in which they are constructed - with more bolted connections and more cables than conduit - provides more damping mechanisms that are present in conduit systems so that 7% is a conservatively low damping value.

FOR DIESEL GENERATOR 'E' BUILDING A DAMPING VALUE OF 3% FOR OBE CONDITION AND 5% FOR SSE CONDITION IS USED FOR CABLE TRAY SUPPORTS. IN CASE OF CONDUIT SUPPORTS, 2% DAMPING IS USED FOR OBE CONDITION AND 3% DAMPING FOR SSE CONDITION, IN ORDER TO ENSURE THAT THE DESIGN IS CONSERVATIVE.

INSERT 'G'

DIESEL GENERATOR 'E' BUILDING.

The loading combinations and the allowable stresses for the design of cable tray supports in the Diesel Generator 'E' Building are as follows:

SERVICE LOAD.

1. $S = D + L$

2. $S = D + E$

FACTORED LOAD.

1. $1.6\ S = D + E'$

The definitions of terms S, D, L, E and E' are as per table 3.8-9a.

INSERT 'H'

DIESEL GENERATOR 'E' BUILDING.

Static coefficient method of analysis is used for the design of cable tray supports. In this method, the acceleration response of the cable tray is assumed to be the peak of the response spectrum at the damping values described in Section 3.7b.3.1.6.3 This response is then multiplied by a static coefficient of 1.5 to take into account the effects of both multifrequency excitation and multimode response.

(6)

3.7b.3.1.6.4 Operating Basis Earthquake (OBE) (EXCEPT DG 'E' BLDG.)

The OBE is considered in the load combinations only for the overhead connections which are checked for fatigue. The OBE stresses are not checked during design for two reasons: first, raceway systems do not fail in a brittle or catastrophic mode as demonstrated by the test program in which such failures did not occur and the electrical systems were able to continue to function in all cases. Thus, there is no need to limit the OBE stresses to the low levels usually used to preclude such failures. Second, the OBE stresses will always be less than the SSE stresses as demonstrated below.

In all cases the ZPA values are high enough to use 7% damping based on Figure 3.7B-106 since they all exceed 0.1g. A comparison of response spectra for corresponding damping values demonstrates that for all response spectra the OBE acceleration values are less than the corresponding SSE acceleration values. (See References 3.7b-8 and 3.7b-10) Thus, the OBE acceleration response and stresses are below the SSE acceleration response and stresses.

3.7b.3.2 Determination of Number of Earthquake Cycles

In general, the design of the equipment is not fatigue controlled because the equipment is elastic and the number of cycles in an earthquake is low.

Equipment that is qualified by analysis is designed to remain elastic during the earthquake. Any fatigue effects in tested equipment are accounted for by performing extended duration test on selected specimens. Consequently, the number of cycles of the earthquake has been accounted for.

In order to conduct a fatigue evaluation for nuclear Class I piping, the number of cycles for a given load set is obtained. This is done by considering ten maximum stress cycles per earthquake and five OBE's and one SSE to occur within the life of the plant.

3.7b.3.3 Procedure Used for Modeling

The models are developed to represent the equipment. Two or three dimensional models are used depending on the complexity of the equipment. The boundary conditions are modeled to reflect

the in-plant mounting conditions. The equipment is represented by lumped mass models. Massless elastic members are used to connect the masses.

Supports for HVAC ducts are modeled as two dimensional, lumped mass, plane frame models. The masses are lumped at the center of the ducts. The cable tray support analytical techniques are discussed in Subsection 3.7b.3.1.6.2. The cable tray properties are determined from the load deflection tests (see Reference 3.7b-11).

Sections 2.0 and 3.0 of Reference 3.7b-6 discuss the techniques and procedures used to model piping other than the buried type.

3.7b.3.4 Basis for Selection of Frequencies

The natural frequencies of components are calculated. If the natural frequency of the component falls within the broadened peak of the response spectrum curve, then it is designed to withstand the peak acceleration.

3.7b.3.5 Use of Equivalent Static Load Method of Analysis

The equivalent static load method of analysis is used when the natural frequency of the equipment is not determined. If the equipment can be adequately represented by a single degree of freedom system, then the applied inertia load is equal to the weight of the equipment times the peak value of the response spectrum curve. If the equipment requires more than one degree of freedom for an adequate representation, then a factor of 1.5 is applied to the peak of the response spectrum curve.

Section 2.3.2 and Appendix D of Reference 3.7b-6 discuss the use of equivalent static load method of analysis as applicable to piping.

3.7b.3.6 Three Components of Earthquake Motion

For equipment, cable trays, and supports for cable trays and HVAC ducts, the three spatial components of the earthquake are considered in the same manner as for structures (described in Subsection 3.7b.2.6).

The criteria used for combining the results of horizontal and vertical seismic responses for piping systems are described in Section 5.1 of Reference 3.7b-6.

3.7b.3.7 Combination of Modal Responses

The modal responses of equipment (excluding the equipment in the Diesel Generator "E" Building) are combined by the square root of the sum of the squares method. The absolute values of two closely spaced modes are added first before combining with the other modes by the square root of the sum of the squares method. Two consecutive modes are defined as closely spaced when their frequencies differ from each other by 10 percent or less. For equipment located in the Diesel Generator "E" Building, the modal responses are combined using the criteria presented in Regulatory Guide 1.92.

Procedures given in Regulatory Guide 1.92 for combining modal responses, when closely-spaced modes are present, are not complied with in the seismic response spectra analysis for piping, except for piping within the DG "E" facility. All modal responses are combined by square root of sum of squares (SRSS) in the response spectra method of modal analysis for seismic loading (OBE and SSE). Seismic response spectra used in the piping analysis corresponds to conservative damping values of 1/2% for OBE and 1% for SSE. The damping values used for the DG "E" facility correspond to those presented in Regulatory Guide 1.61.

The procedures used in evaluating the piping system for hydrodynamic loads (SRV and LOCA) by response spectra method is in compliance with Regulatory Guide 1.92. The modal responses in this case are combined in accordance with section 5.2 of BP-TOP-1, Rev. 3, which has been accepted by the NRC staff, per the letter dated September 29, 1976, from Karl Kniel, Chief Light Water Reactors Branch No. 2, Division of Project Management to Burton L. Lex, Bechtel Power Corporation.

The criteria used for piping systems are described in Sections 5.1 and 5.2 of Reference 3.7b-6

3.7b.3.8 Analytical Procedures for Piping

The design criteria and the analytical procedures applicable to piping systems are as described in Section 2.0 of Reference 3.7b-6. The methods used to consider differential piping support movements at different support points are as described in Section 4.0 of Reference 3.7b-6.

3.7b.3.9 Multiply Supported Equipment and Components with Distinct Inputs

For cable trays and ducts whose supports have two distinct inputs, a response spectrum curve is used that envelopes the curves at the two locations. Section 4.0 of Reference 3.7b-6 discusses the methods used for the analysis of multiple supported piping systems.

3.7b.3.10 Use of Constant Vertical Static Factors

Constant vertical static factors are not used in the seismic design of subsystems.

3.7b.3.11 Torsional Effects of Eccentric Masses

The torsional effects of valves and other eccentric masses are considered in the seismic analysis of piping by the techniques discussed in Section 3.2 of Reference 3.7b-6.

3.7b.3.12 Buried Seismic Category I Piping Systems and Tunnels

Buried Seismic Category I piping has been analyzed and designed for seismic effects in accordance with Section 6.0 of Reference 3.7b-35 and Reference 3.7b-13 for the DG "E" Facility.

The majority of the anticipated settlement due to static loading of the ESSW Pumphouse will have occurred prior to connecting the piping to the building. During a SSE event, the differential settlement between the pumphouse and the surrounding soil which supports the piping, will be less than one inch (see Subsection 2.5.4.7 for further discussion of settlements). This movement will be accommodated by the piping without exceeding code allowable stresses.

Tunnels on the Susquehanna SES are non-Seismic Category I.

3.7b-12 Rodofoam II manufactured by W. R. Grace & Co. or equivalent equal.

3.7b-13 M.A. Iqbal and E.C. Goodling, "Seismic Design of Burried Pipes," Presented at the 2nd ASCE Specialty Conference on Structural Design of Nuclear Plant Facilities at New Orleans, Louisiana December, 1975

3.7b-14 "Seismic Analysis of Piping Systems in Nuclear Power Plants", AEG-502, Rev. 0, Gibbs and Hill, Inc., New York, New York (June 1981)

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TABLE- 3.7b-7

DAMPING VALUES FOR NON-NSSS MATERIALS FOR DG "E" FACILITY

(Percent of Critical Damping)

Structure or Component[3]	Operating Basis Earthquake (OBE)[1]	Safe Shutdown Earthquake (SSE)
Equipment and large-diameter piping systems[2], pipe diameter greater than 12 in.	2	3
Small-diameter piping systems, diameter equal to or less than 12 in.	1	2
Welded steel structures . . .	2	4
Bolted steel structures . . .	4	7
Reinforced concrete structures	4	7

[1] In the dynamic analysis of active components as defined in U.S. NRC Regulatory Guide 1.48, these values should be used for the SSE.

[2] Include both material and structural damping. If the piping system consists of only one or two spans with little structural damping, use values for small-diameter piping.

[3] If the maximum combined stresses due to static, seismic, and other dynamic loading are significantly lower than the yield stress and 1/2 yield stress for SSE and OBE, respectively, in any structure or component, damping values lower than those specified above should be used for that structure or component to avoid underestimating the amplituide of variations or dynamic stresses.

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TABLE 3.7b-8

MODAL FREQUENCIES AND PARTICIPATION FACTORS FOR DIESEL GENERATOR "E" BUILDING SEISMIC MODELS

Horizontal Model

Freq. (Hz)	γ_x	γ_z
7.17	−0.10	−15.36
9.75	−15.29	0.11
14.46	−0.05	0.94
22.28	−0.28	−7.06
22.70	1.80	−1.07
25.25	−6.79	−.0.04
30.80	0.05	−5.53
33.89	0.21	1.23
36.42	−1.52	0
38.13	−0.68	−0.02
38.34	−5.72	0.02
45.26	0.36	0.04
49.84	−0.90	0.01
52.85	−0.11	0.07
61.02	−0.13	0.03
62.85	−0.03	0.01
68.42	−0.49	−0.05
72.29	−0.07	0.42
75.26	−0.14	−0.14
77.85	−0.40	0
83.21	−0.02	−0.08
83.83	−0.03	−0.28
98.42	0.03	0.01
113.94	0	0.02

Vertical Model

Freq. (Hz)	γ_y
7.17	−0.04
9.75	0.41
13.93	−3.77
14.14	5.17
14.46	0.02
15.08	−3.10
22.29	−0.53
23.83	12.73
25.46	−6.41
30.80	0.14
33.89	0.23
36.17	3.35
38.11	0.60
38.27	0.57
43.78	1.65
45.26	0.04
49.85	−0.05
52.85	0.05
62.84	−0.28
65.02	5.47
68.99	−1.32
72.47	−0.52
77.43	4.02
78.72	0.96
83.70	1.19
84.01	0.82
103.20	−0.37
113.96	0

NOTE:

γ_x = PARTICIPATION FACTOR IN X (N-S) DIRECTION

γ_y = " " Y (VERTICAL) "

γ_z = " " Z (E-W) "

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TABLE 3.7b-9

FREQUENCIES AND MODAL PARTICIPATION FACTORS FOR DIESEL GENERATOR "E" PEDESTAL SEISMIC MODEL

Freq. (Hz)	γ_x	γ_y	γ_z
18.44	0	0	4.11
27.81	1.39	0	0
29.94*	0	0	0
32.24	0	3.14	0
37.72	0	0	-2.38
50.59	-4.78	0	0
77.36*	0	0	0
101.09	0	0	-2.45
129.49	-2.11	0	0
132.54	0	-4.35	0
150.07*	0	0	0
162.63	0	0	-0.71
183.03	-0.30	0	0
234.87	0	0	0.52
256.81	0	0	-0.12
304.22	0.17	0	0
317.88	0	-0.79	0
345.58	0.01	0	0

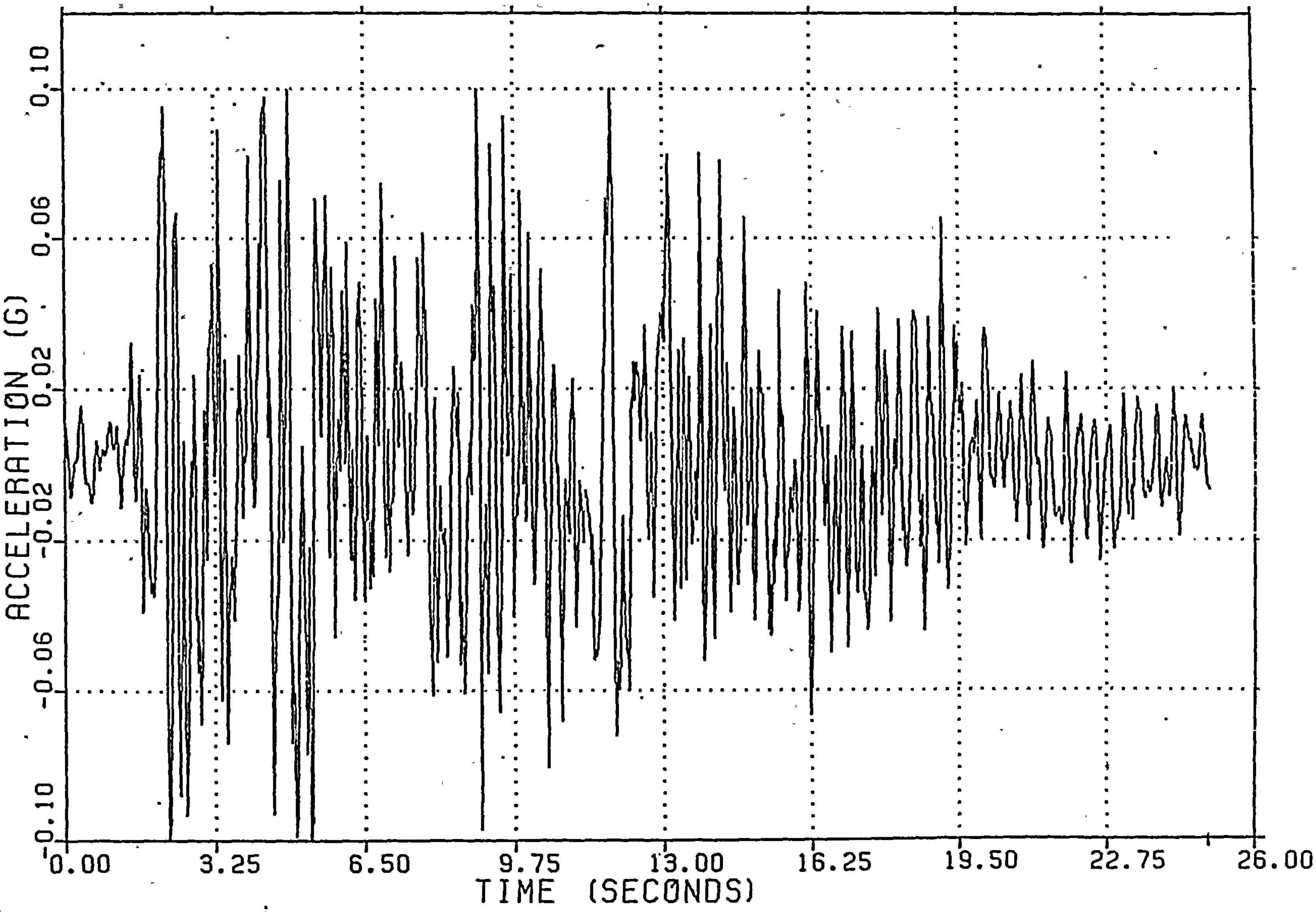
* Torsional mode

NOTE:

γ_x = PARTICIPATION FACTOR IN X (N-S) DIRECTION

γ_y = " " Y (VERTICAL) "

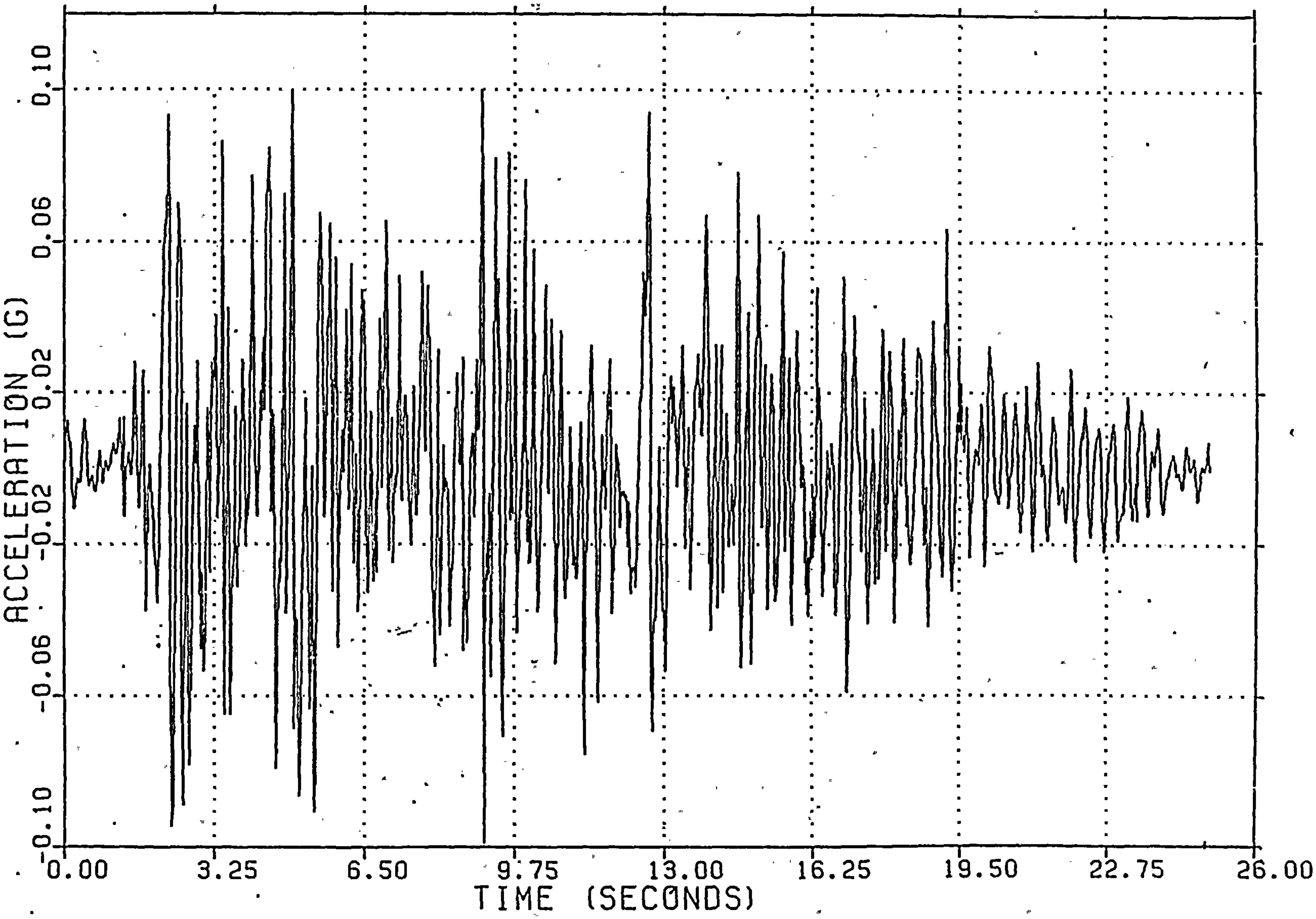
γ_z = " " Z (E-W) "



SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

DIESEL GENERATOR "E" FACILITY
HORIZONTAL SYNTHETIC TIME HISTORY NORMALIZED TO 0.1 G

FIGURE 3.7b-107



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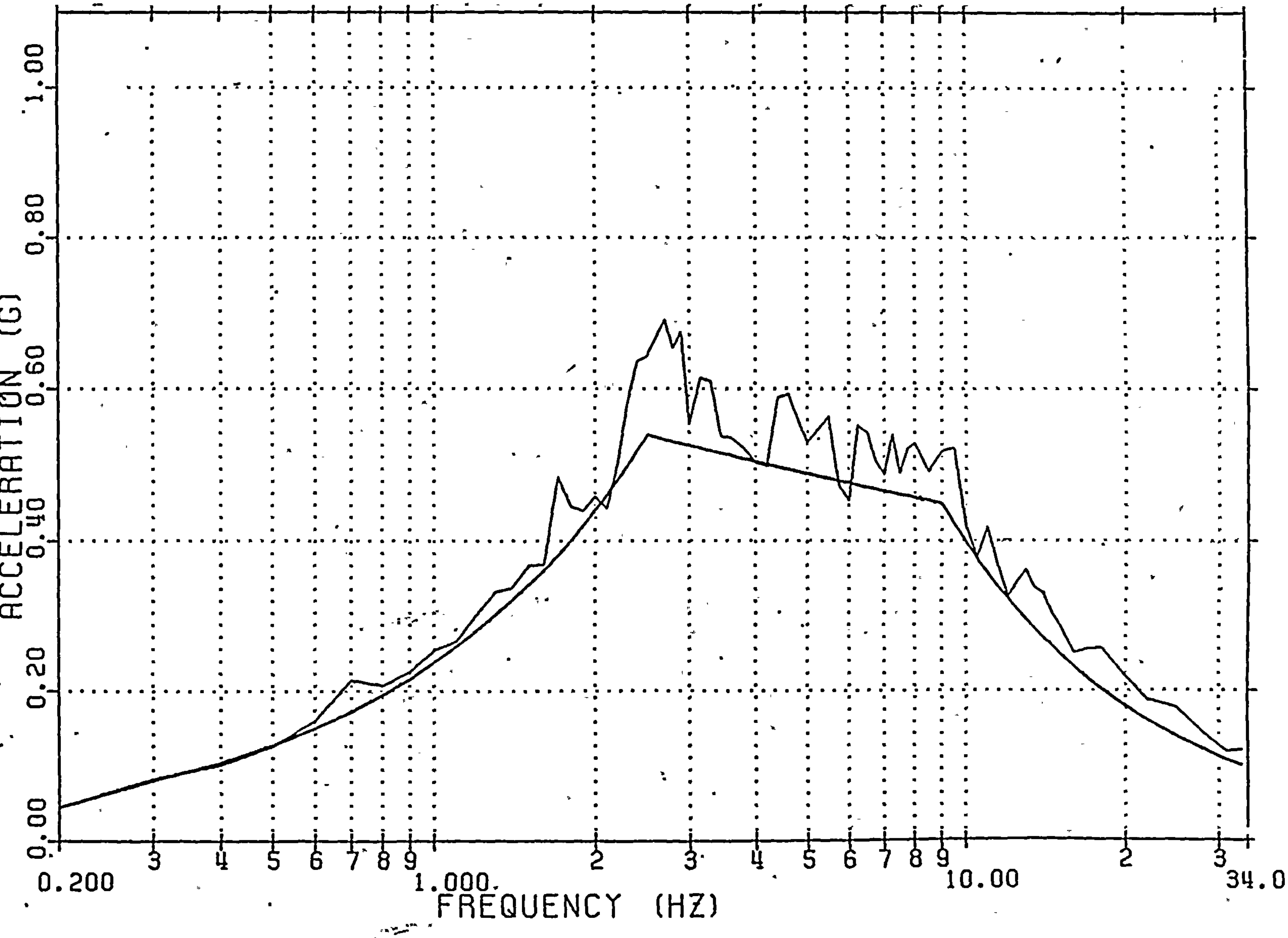
DIESEL GENERATOR "E" FACILITY
VERTICAL SYNTHETIC TIME
HISTORY NORMALIZED TO 0.1 g

FIGURE 3.7b-108



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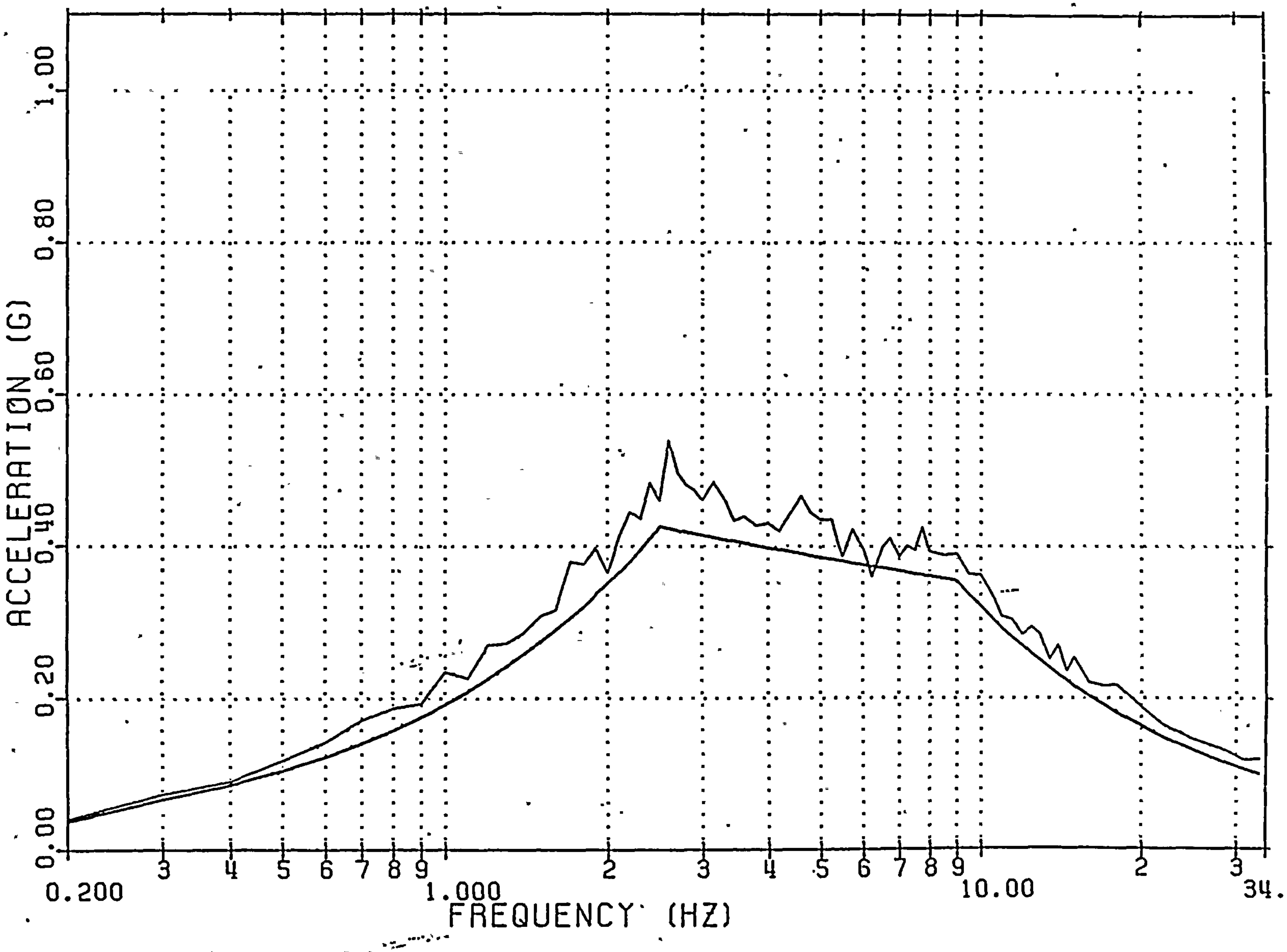
DIESEL GENERATOR "E" FACILITY
COMPARISON OF HORIZ. TIME HISTORY
RESPONSE SPECTRUM AND HORIZ. DESIGN
RESPONSE SPECTRUM — 1% DAMPING

FIGURE 3.7b-109



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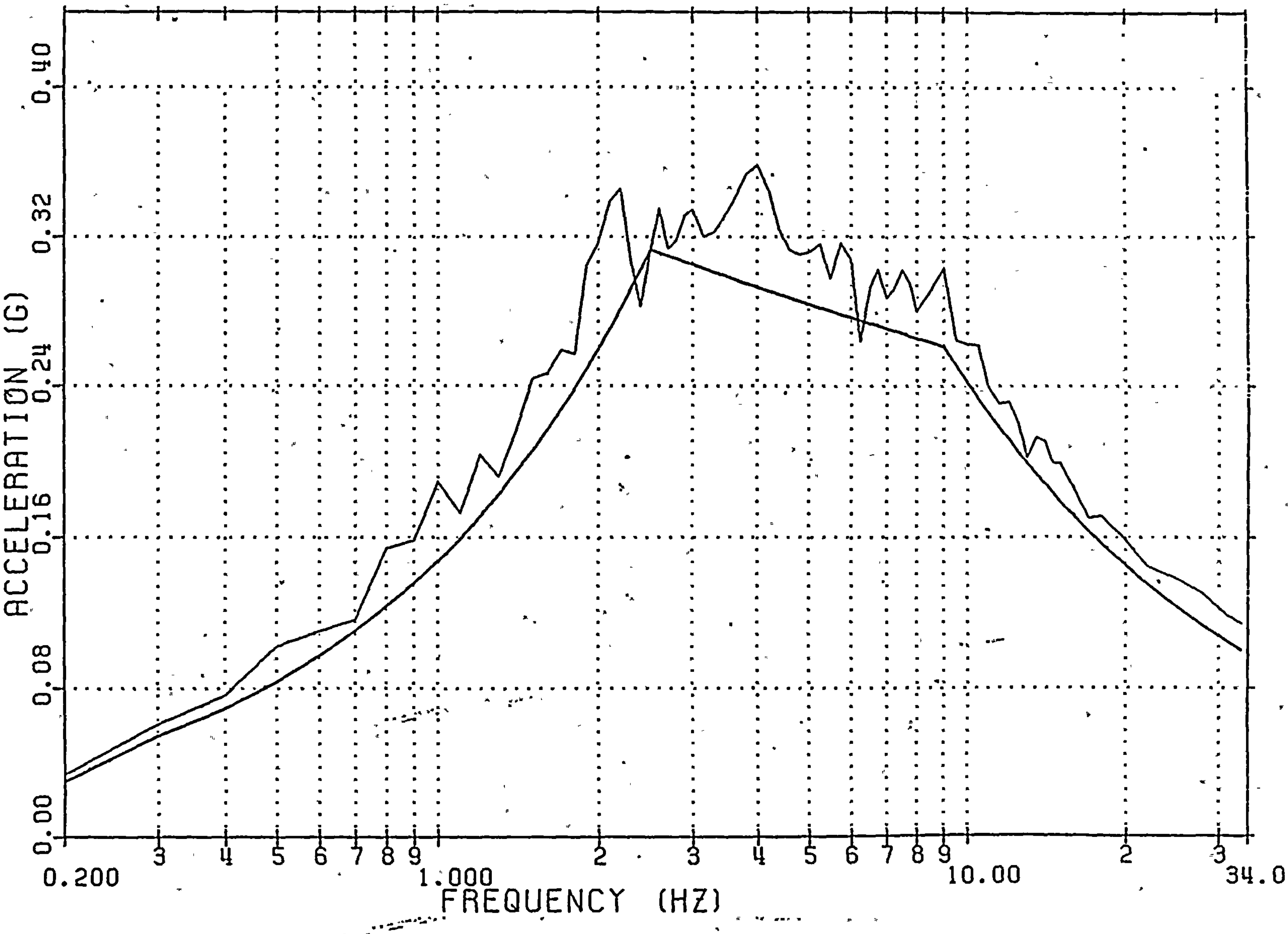
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

DIESEL GENERATOR "E" FACILITY
COMPARISON OF HORIZ. TIME HISTORY
RESPONSE SPECTRUM AND HORIZ. DESIGN
RESPONSE SPECTRUM — 2 % DAMPING

FIGURE 3.7b-110



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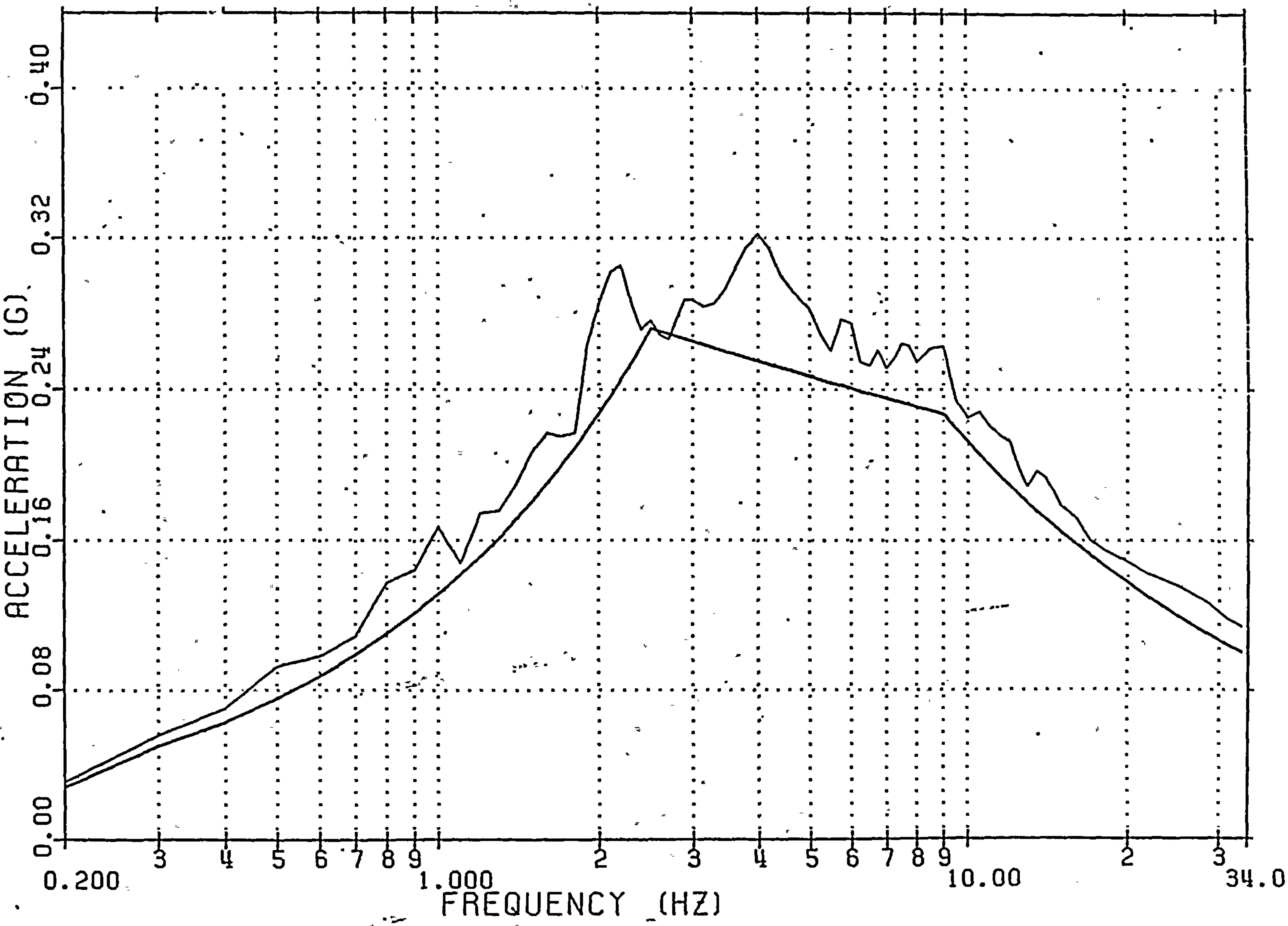
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

DIESEL GENERATOR "E" FACILITY
COMPARISON OF HORIZ. TIME HISTORY RESPONSE SPECTRUM AND HORIZ. DESIGN RESPONSE SPECTRUM — 5% DAMPING

FIGURE 3.7b-111



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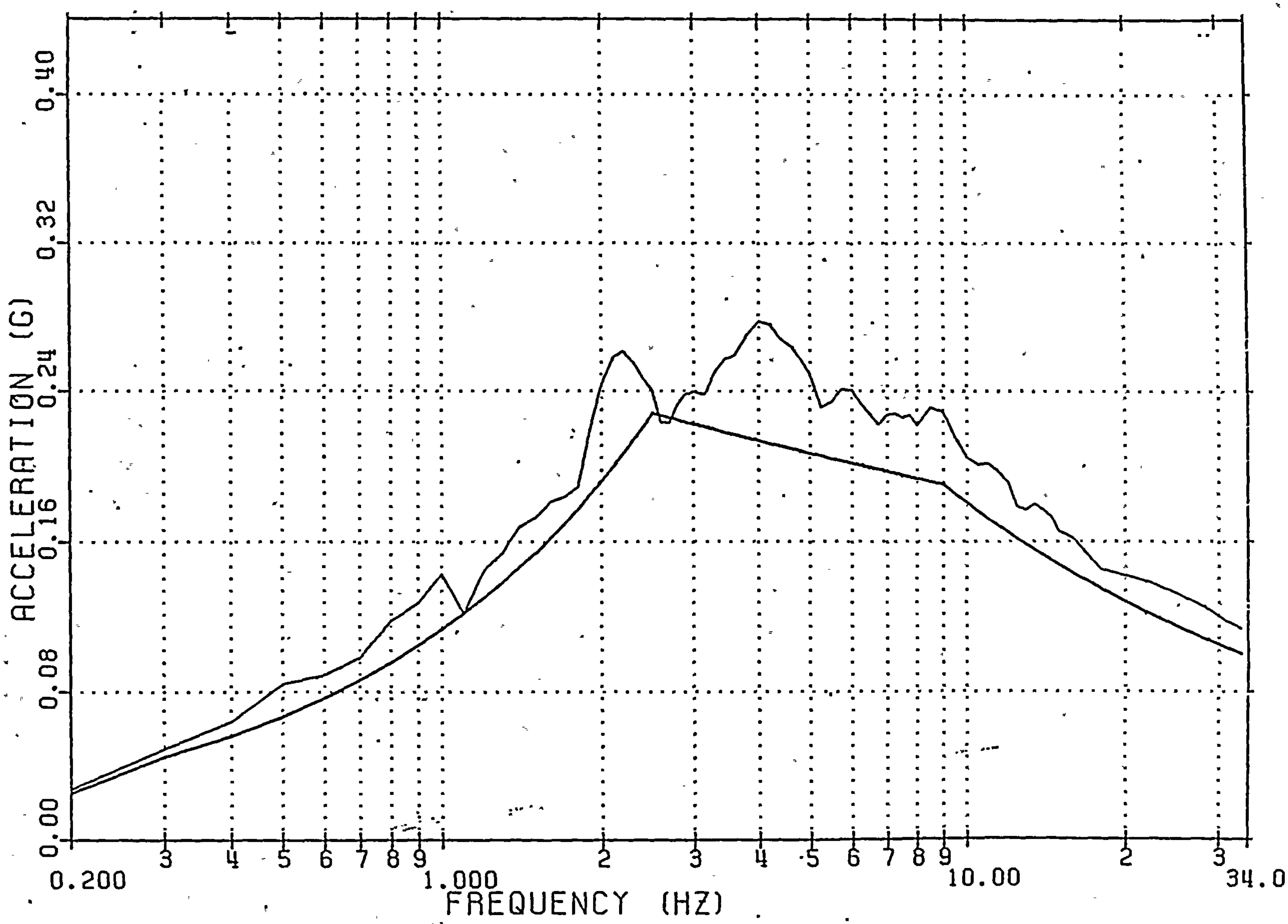
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

DIESEL GENERATOR "E" FACILITY
COMPARISON OF HORIZ. TIME HISTORY RESPONSE SPECTRUM AND HORIZ. DESIGN RESPONSE SPECTRUM — 7% DAMPING

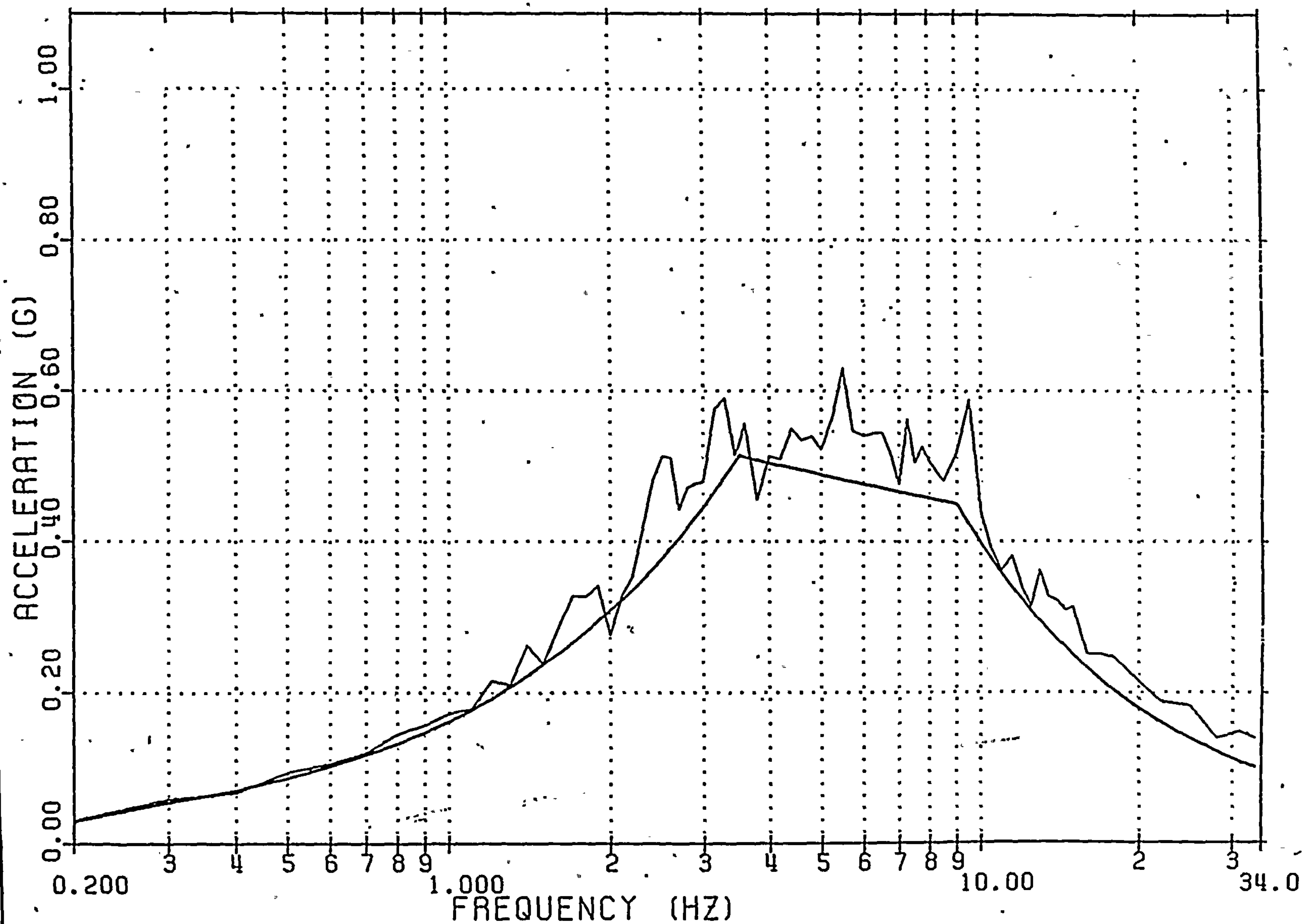
FIGURE 3.7b-112



SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

DIESEL GENERATOR "E" FACILITY
COMPARISON OF HORIZ. TIME HISTORY RESPONSE SPECTRUM AND HORIZ. DESIGN RESPONSE SPECTRUM — 10% DAMPING

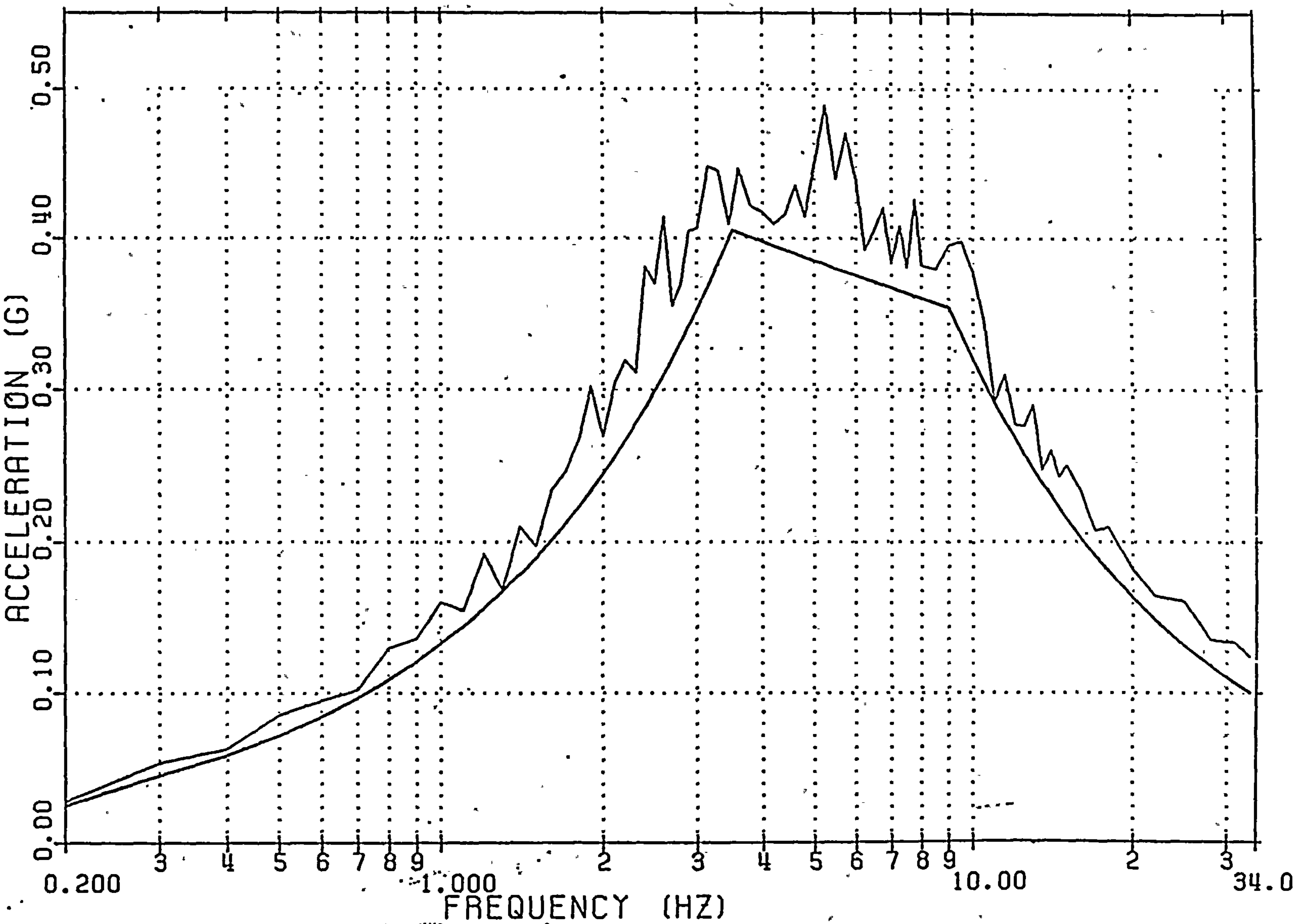
FIGURE 3.7b-113



SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

DIESEL GENERATOR "E" FACILITY
COMPARISON OF VERT. TIME HISTORY RESPONSE SPECTRUM AND VERT. DESIGN RESPONSE SPECTRUM — 1% DAMPING

FIGURE 3.7b-114



SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

DIESEL GENERATOR "E" FACILITY
COMPARISON OF VERT. TIME HISTORY
RESPONSE SPECTRUM AND VERT. DESIGN
RESPONSE SPECTRUM — 2% DAMPING
FIGURE 3.7b-115

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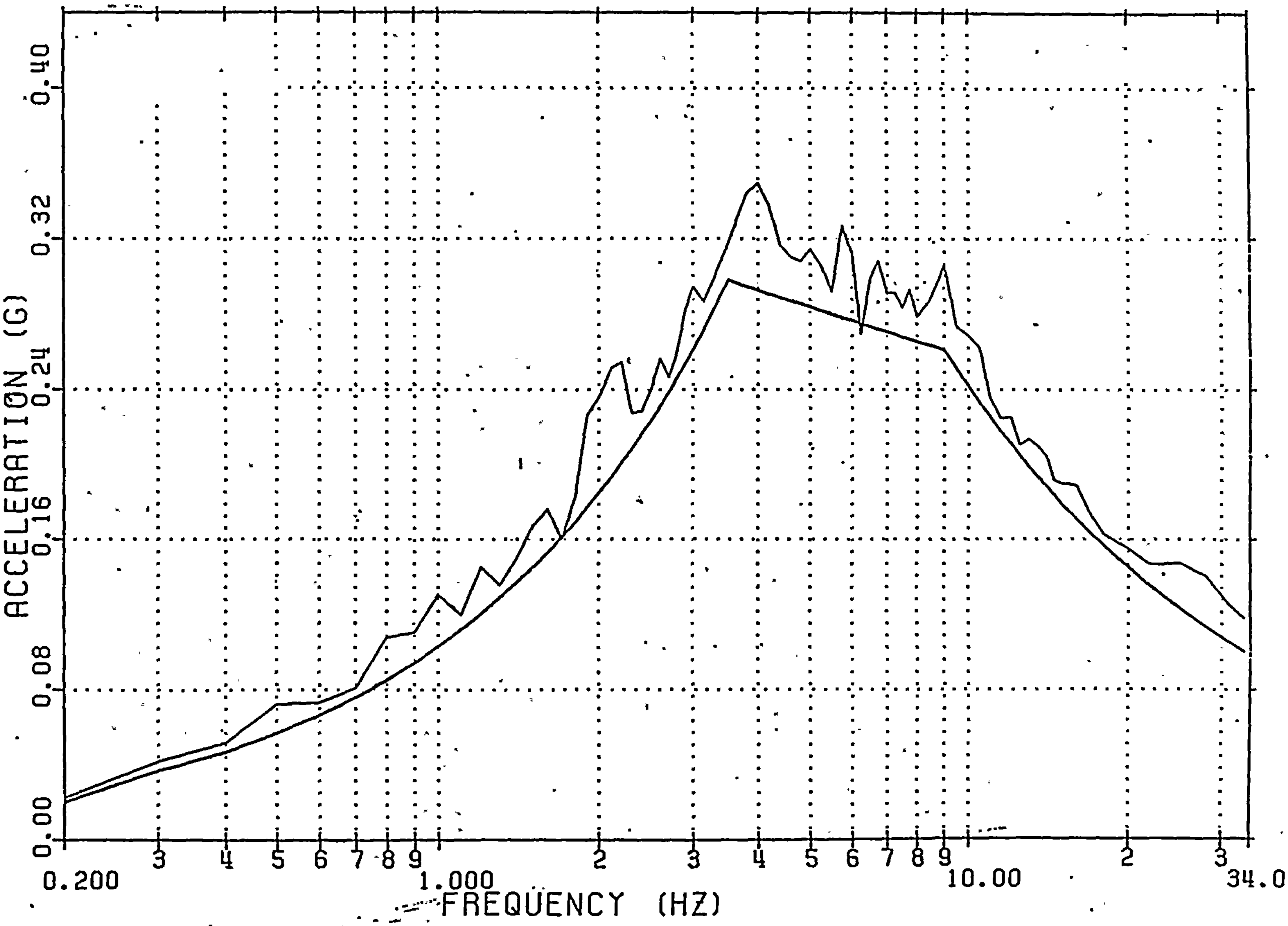
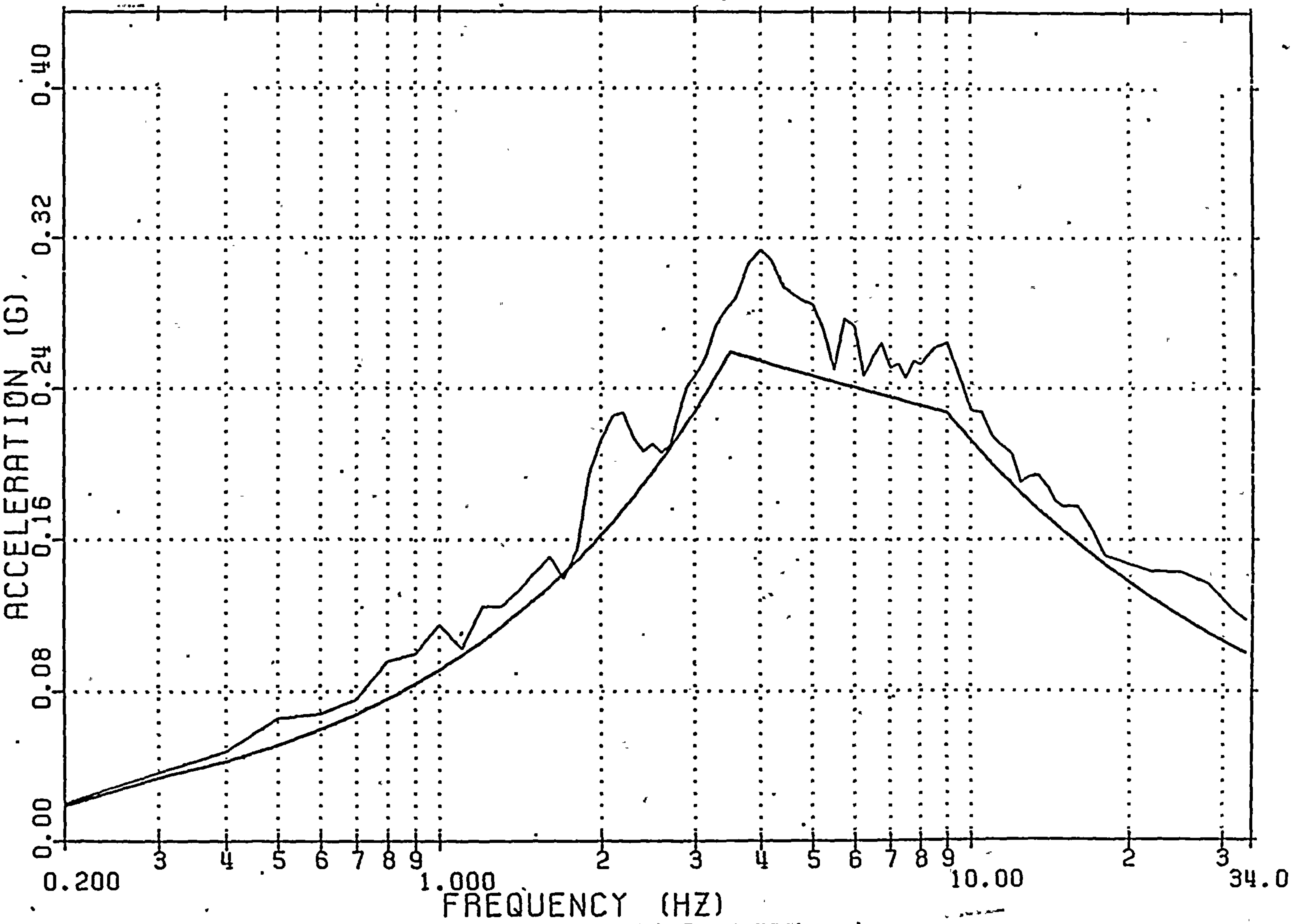


SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

DIESEL GENERATOR "E" FACILITY
COMPARISON OF VERT. TIME HISTORY
RESPONSE SPECTRUM AND VERT. DESIGN
RESPONSE SPECTRUM — 5% DAMPING

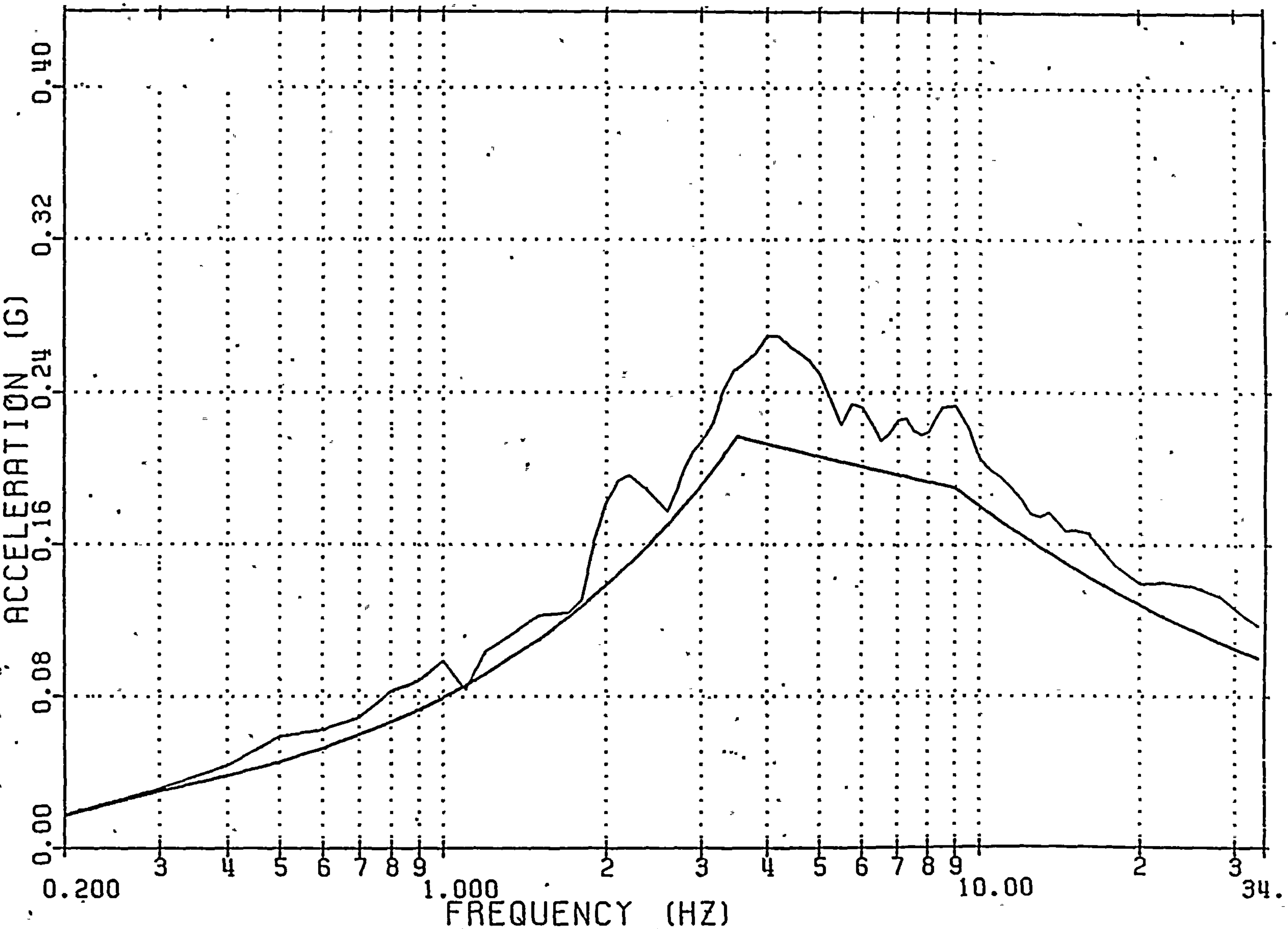
FIGURE 3.7b-116



SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

DIESEL GENERATOR "E" FACILITY
COMPARISON OF VERT. TIME HISTORY
RESPONSE SPECTRUM AND VERT. DESIGN
RESPONSE SPECTRUM — 7% DAMPING

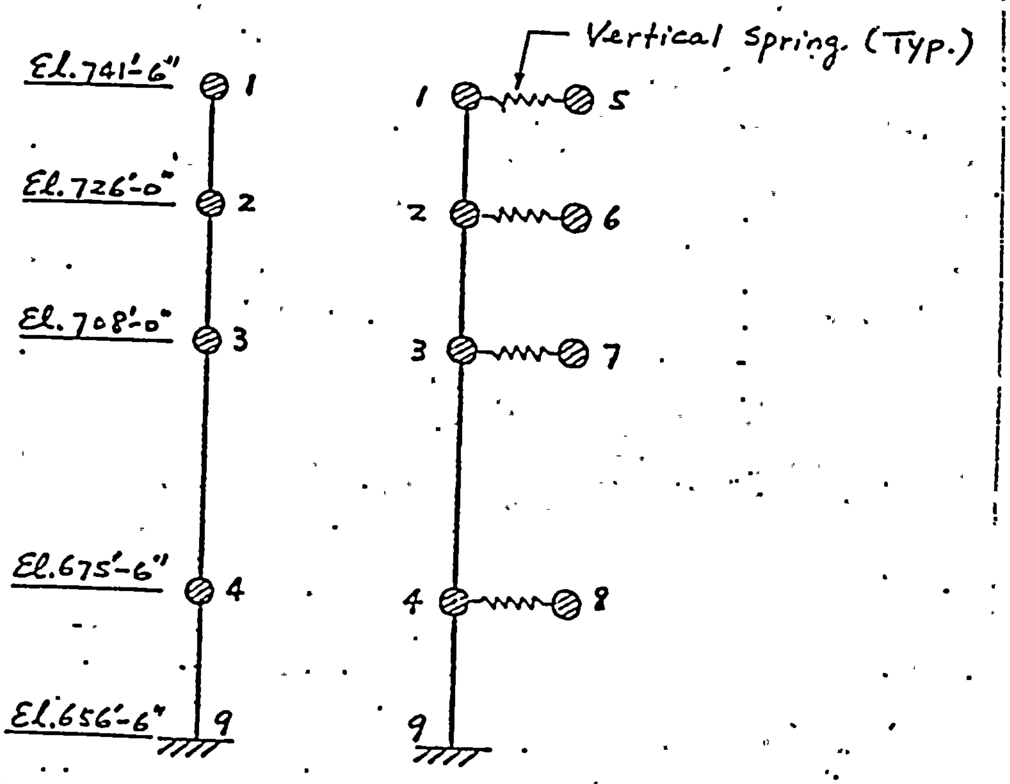
FIGURE 3.7b-117



SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

DIESEL GENERATOR "E" FACILITY
COMPARISON OF VERT. TIME HISTORY
RESPONSE SPECTRUM AND VERT. DESIGN
RESPONSE SPECTRUM—10% DAMPING

FIGURE 3.7b-118



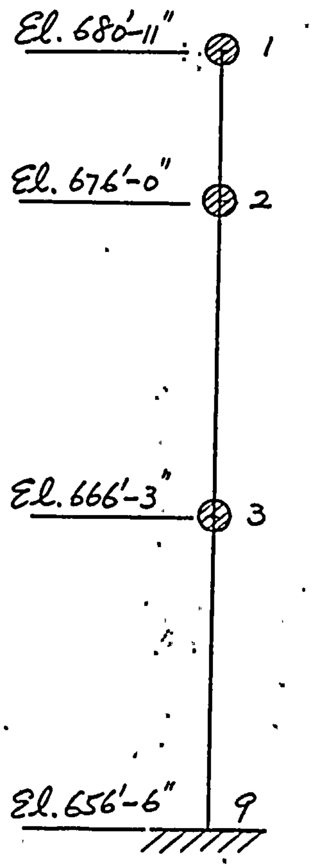
A. HORIZONTAL (N-S AND E-W) MODEL

B. VERTICAL MODEL

SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

DIESEL GENERATOR "E" BUILDING
HORIZONTAL AND VERTICAL SEISMIC MODELS

FIGURE 3.7b-119



SUSQUEHANNA STEAM ELECTRIC STATION
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FINAL SAFETY ANALYSIS REPORT

DIESEL GENERATOR "E" PEDESTAL SEISMIC MODEL

FIGURE 3.7b-120

3.8.3.6.5.2 Welding and Nondestructive Examination of Welds

Welding and nondestructive examination is performed in accordance with AWS D1.1.

3.8.3.6.5.3 Erection Tolerances

Erection tolerances for the drywell platforms are in accordance with AISC Specification (Ref. 2H of Table 3.8-1)

3.8.3.6.6 Quality Control

Quality control requirements for construction are discussed in Appendix D and amendments to the PSAR.

3.8.3.7 Testing and In-service Inspection Requirements

3.8.3.7.1 Preoperational Testing

3.8.3.7.1.1 Structural Acceptance Test

The drywell floor is tested to 1.15 times the design downward differential pressure. See Subsection 3.8.1.7.1.1 for a description of the structural acceptance tests.

Deflections and strains of the drywell floor measured during the Unit 1 test were less than the predicted values. Thus, the design of the drywell floor provides an adequate safety margin against internal pressure. Figure 3.8-79 shows a comparison between measured and predicted deflections for the drywell floor at peak differential pressure.

3.8.3.7.1.2 Leak Rate Testing

Preoperational leak rate testing is discussed in Subsection 6.2.6.

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3.8.3.7.2 In-service Leak Rate Testing

In-service leak rate testing is discussed in Subsection 6.2.6.

3.8.4 OTHER SEISMIC CATEGORY I STRUCTURES

This section gives information on all Seismic Category I structures except the primary containment and its internals. It also describes safety related non-Seismic Category I structures. The structures included in this section are as follows:

Seismic Category I Structures

Reactor Building

Control Building

Diesel Generator Building

Engineered Safeguards Service Water Pumphouse

Spray Pond
DIESEL GENERATOR 'E' BUILDING

Non-Seismic Category I, Safety Related Structures

Turbine Building

Radwaste Building

The general arrangement of these structures is shown on Figures 3.8-80 through 3.8-103. AND 3.8-105 THROUGH 3.8-106.

3.8.4.1 Description of the Structures

Reactor Building

Refer to Figures 3.8-80 through 3.8-89.

The reactor building encloses the primary containment, and provides secondary containment when the primary containment is in service during power operation. It also serves as containment during reactor refueling and maintenance operations, when the primary containment is open. It houses the auxiliary systems of the nuclear steam supply system, new fuel storage vaults, the refueling facility, and equipment essential to the safe shutdown of the reactor.

The reactor building, up to and including the operating floor, is of reinforced concrete on a mat foundation. The bearing walls are of reinforced concrete and are designed as shear walls to resist lateral loads. The floors are of reinforced concrete supported by a steel beam and column framing system and are designed as diaphragms to resist lateral load. The framing runs in both east-west and north-south directions, with the exterior ends of the beams supported by either the bearing walls or steel columns. The steel columns are supported by base plates on the mat foundation. The reinforced concrete walls and floors meet structural as well as radiation shielding requirements. Where structurally permissible, concrete block masonry walls are used at certain locations to provide better access for erection and installation of equipment. The block walls also meet the radiation shielding requirements.

The reactor building superstructure above the operating floor is a steel structure. The structural steel framing supports the roof, metal siding, and overhead cranes. The framing consists of a series of rigid frames connected by roof and wall bracing systems. The roof consists of built-up roofing on metal deck.

The refueling facility is located above the containment structure. It consists of spent fuel pool, fuel shipping cask storage pool, steam dryer and separator storage pool, reactor cavity, skimmer surge tank vault, and load center room. The facility is supported by two reinforced concrete girders running north-south, spanning over the containment. The girders are supported at the ends by concrete walls and at intermediate points by steel box columns. A gap is provided between the bottom of the girders and the top of the containment to ensure that loads from the refueling facility are not transferred to the containment. The walls and slabs of the spent fuel pool, the fuel shipping cask storage pool, the reactor cavity, and the steam dryer and separator storage pool are lined on the inside with a stainless steel liner plate. The facility meets the radiation shielding requirements.

The reactor building is separated from the primary containment by a gap, except at the foundation level, where a cold joint is provided between the two mats. A gap is also provided at the interface of the reactor building with the diesel generator and turbine buildings.

Control Building

Refer to Figures 3.8-80 through 3.8-88.

The control building houses the control room, the cable spreading rooms, computer and relay room, the battery room, H&V equipment room, off-gas treatment room, and the visitors' gallery for the control room.

The control building is structurally integrated with the reactor building. It is a reinforced concrete structure on a mat foundation. The bearing walls are of reinforced concrete and are designed as shear walls to resist lateral loads. The floors and roof are of reinforced concrete supported by steel beams, and are designed as diaphragms to resist lateral loads. The beams span in the east-west direction and are supported by the bearing walls at the ends. The reinforced concrete walls and floors meet structural as well as radiation shielding requirements. Where structurally permissible, concrete block masonry walls are used at certain locations to provide better access for erection and installation of equipment. The block walls also meet the radiation shielding requirements.

The control building is separated from the turbine building by a gap, except at the foundation level, where a cold joint is provided between the two mats.

Diesel Generator Building

Refer to Figures 3.8-92 and 3.8-93.

The diesel generator building houses the diesel generators essential for safe shutdown of the plant.

The diesel generators are separated from each other by concrete walls. A concrete overhang on the east side of the building serves as an air intake plenum. A concrete plenum for diesel exhaust is located on the roof.

It is a reinforced concrete structure on a mat foundation. The bearing walls are of reinforced concrete and are designed as shear walls to resist lateral loads. The floors and roof are of reinforced concrete supported by steel beams, and are designed as diaphragms to resist lateral loads. The south side of the building interfaces with the reactor building; there, a reinforced concrete wall is provided from foundation up to the design high water table level and then a steel frame is provided up to the roof. Where structurally permissible, concrete block masonry walls are used at certain locations to provide better access for erection and installation of equipment.

The diesel generators are supported by reinforced concrete pedestals. The pedestals are separated from the operating floor by a gap to allow for their independent vibration.

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Engineered Safeguards Service Water (ESSW) Pumphouse

Refer to Figure 3.8-94.

The ESSW Pumphouse contains the emergency service water (ESW) and residual heat removal (RHR) pumps and the weir and discharge conduit for the spray pond.

It is a two-story reinforced concrete structure on a mat foundation. The bearing walls are of reinforced concrete and are designed as shear walls to resist lateral loads. The operating floor and roof are of reinforced concrete supported by steel beams and are designed as diaphragms to resist lateral loads. A mezzanine floor composed of grating over steel beams is provided to support the heating and ventilating equipment.

Spray Pond

Refer to Figures 3.8-95 through 3.8-98.

The spray pond is a reservoir, free form in shape, which holds approximately 25 million gal of water during normal operation. The water surface area is approximately eight acres and has a depth of approximately 10 ft 6 in. It is designed so that normal operating water is retained in excavation alone, ie, not by constructed embankments. Embankments are provided to ensure a minimum freeboard of 3 ft and to direct flood water away from safety related facilities in a controlled manner.

The ESSW pumphouse is located at the southeast corner of the spray pond. A reinforced concrete liner covers the entire spray pond and is integrated with the outer walls of the ESSW pumphouse.

The water level in the pond is controlled by a weir housed in the ESSW pumphouse. During normal operation, excess water is discharged into the Susquehanna river via a conduit from the ESSW pumphouse.

An emergency spillway is provided at the east end of the pond. The only anticipated use of this spillway will be either during a malfunction of the discharge conduit leading out of the ESSW pumphouse or during certain postulated flood conditions. This is discussed in Subsection 2.4.8.

The ESSW and RHR pipes enter the south side of the pond and traverse to the spray bank areas buried in 18 in. of concrete, provided as missile protection. Concrete columns support the riser pipes in the spray bank areas.

Turbine Building

Refer to Figures 3.8-80 through 3.8-84, 3.8-88, 3.8-90, and 3.8-91.

The turbine building is divided into two units with an expansion joint separating the two units. It houses two in-line turbine generator units and auxiliary equipment including condensers, condensate pumps, moisture separators, air ejectors, feedwater heaters, reactor feed pumps, motor-generator sets for reactor recirculating pumps, recombiners, interconnecting piping and valves, and switchgears.

Two 220-ton overhead cranes are provided above the operating floor for service of both turbine generator units. Two reinforced concrete tunnels, one for each unit, are provided for the off-gas pipelines at the foundation level between the recombiners and the radwaste building. Reinforced concrete tunnels are also provided for the main steam lines below the operating floor from the reactor building to the condenser areas of the turbine generators.

The turbine building rests on a reinforced concrete mat foundation. The superstructure is framed with structural steel and reinforced concrete. Rigid steel frames support the two 220-ton cranes. They also resist all transverse (east-west) lateral loads. Steel bracings resist longitudinal (north-south) lateral loads above the operating floor. Below this level, reinforced concrete shear walls transfer all lateral loads to the foundations.

A seismic separation gap, also serving as an expansion joint, is provided near the center of the building between the two units. Seismic separation gaps are also provided at the interface of turbine building with the reactor, control, and radwaste buildings.

The floors of the turbine building are of reinforced concrete on structural steel beams. They are designed as diaphragms for lateral load transfer to the shear walls. The roof is built-up roofing on metal decking.

Exterior walls are precast reinforced concrete panels except for the upper 30 ft, which are metal siding.

Interior walls required for radiation shielding or fire protection are constructed of reinforced concrete block. These walls are not used as elements of the load resistant system.

The turbine generator units are supported on freestanding reinforced concrete pedestals. The mat foundations for the pedestals are founded on rock at the same level as the base mat

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for the turbine building. Separation joints are provided between the pedestals and the turbine building floors and walls to prevent transfer of vibration to the building. The operating floor of the building is supported on vibration damping pads at the top edge of the pedestal.

Radwaste Building

Refer to Figures 3.8-99 through 3.8-103.

The radwaste building houses systems for receiving, processing, and temporarily storing the radioactive waste products generated during the operation of the plant.

It is a reinforced concrete structure on a mat foundation. The bearing walls are of reinforced concrete and are designed as shear walls to resist lateral loads. The floors and roof are of reinforced concrete supported by a beam and column framing system and are designed as diaphragms to resist lateral loads. The columns are supported by base plates on the mat foundation. The reinforced concrete walls and floor meet structural as well as radiation shielding requirements. Where structurally permissible, concrete block masonry walls are used at certain locations to provide better access for erection and installation of equipment. The block walls also meet the radiation shielding requirements.

The radwaste building is separated from the turbine building by a gap.

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3.8.4.2 Applicable Codes, Standards, and Specifications

The codes, standards, and specifications used in the design, fabrication, and construction of the structures listed in Subsection 3.8.4 are shown in Table 3.8-1 and include reference numbers 10A, 12A, 1B, 1H, 2H, 3H, 1J, 2K, 3K, and 1L.

3.8.4.3 Loads and Load Combinations

The following loads and load combinations are considered in the design of Seismic Category I structures (other than the containment).

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3.8.4.3.1 Description of Loads

For a general description of loads, see Subsection 3.8.1.3.2.

3.8.4.3.2 Load Combinations

Table 3.8-8 describes the load combinations applicable to the reactor building. Tables 3.8-9 AND 3.8-9a contain~~s~~ the load combinations applicable to Seismic Category I structures other than the reactor building. Table 3.8-10 describes the load combinations used in the design of the turbine and the radwaste buildings.

3.8.4.4 Design and Analysis Procedures

The structures described in Subsection 3.8.4.1 are designed to maintain elastic behavior under various loads and their combinations. The loads and the load combinations are fully described in Subsection 3.8.4.3. All reinforced concrete components of the structure are designed by the strength method per ACI 318 AND ACI 349 (Refs. 10A AND 12A of Table 3.8-1). All structural steel components are designed by the working stress method per AISC specification (Ref 1H of Table 3.8-1).

Determination of wind and tornado loads is described in Section 3.3.

Seismic design of structures is described in Section 3.7. The buildings are analyzed dynamically.

Design of structure for missile protection is covered in Subsection 3.5.3.

Computer programs STRESS and ICES STRUDL-II (Ref 1 and 2 respectively of Subsection 3.8.4.8) are used to analyze structural steel framing.

The refueling facility of the reactor building is designed based on finite element analysis by use of computer program MRI/STARDYNE 3 (Ref 3 of Subsection 3.8.4.8).

The spray pond is basically a concrete-lined soil structure. Its design is discussed in Subsection 2.5.5.

Concrete masonry blockwalls in all Seismic Category I structures have been analyzed dynamically as described in Section 3.7b.3.1.5. They are designed for out-of-plane and in-plane inertia forces generated by the mass of the blockwall and

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DIESEL GENERATOR 'E' BUILDING

Refer to Figures 3.8-105 and 3.8-106

The diesel generator 'E' building houses the diesel generator 'E' which will be used as a replacement for any one of the four existing diesel generators. The main purpose of the diesel generator 'E' is to allow maintenance to be performed on any one of the four existing diesel generators without the necessity for a unit outage.

The diesel generator 'E' building is a two-story structure with a basement consisting primarily of reinforced concrete. A gap is provided between the pedestal and the floor slab at grade level so that no vibrations from the diesel generator are transmitted to the building.

The outer reinforced concrete walls and roof of the diesel generator 'E' building are designed to resist effects of tornado missiles. A portion of the outer wall is removable to facilitate diesel generator installation and/or emergency removal and maintenance operation. This removable wall portion is also designed to resist the effects of tornado missiles.

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attachment loads, combined with other loads as described in Tables 3.8-8 and 3.8-9. Walls in the turbine and radwaste buildings have been designed for seismic loads per UBC (Ref. 1L of Table 3.8-1).

3.8.4.5 Structural Acceptance Criteria

Reinforced Concrete

AND ACI 349

The reinforced concrete structural components are designed by the strength method per ACI 318 (Refs.10A of Table 3.8-1) for loads and load combinations described in Subsection 3.8.4.3.

AND 12A

Structural Steel

The structural steel components are designed by the working stress method per AISC specification (Ref 1H of Table 3.8-1) for loads and load combinations described in Section 3.8.4.3. The allowable stresses for different load combinations are indicated therein.

Concrete Block Masonry Walls

All masonry blockwalls are reinforced walls and do not act as shear walls. Masonry blockwalls are designed by the working stress method per UBC (Ref. 1L of Table 3.8-1). The allowable loads per UBC Tables 24-B or 24-H (special inspection) are modified as described in Tables 3.8-8, 3.8-9 and 3.8-12, except as noted below.

For double wythe walls designed as composite sections and having concrete or grout infill thickness of 8 inches or more, the allowable shear or tension between masonry block and infill is 1.1 f' i.e. 43 p.s.i. However, the actual design stress does not exceed 15 p.s.i. For other double wythe walls, allowable shear/tension stress is assumed to be zero at the interface.

3.8.4.6 Materials, Quality Control, and Special Construction Techniques

3.8.4.6.1 Concrete and Reinforcing Steel

The concrete and reinforcing steel materials are discussed in Appendix 3.8B. Concrete design compressive strengths are given in Table 3.8-11. Materials for concrete block masonry walls are discussed in Appendix 3.8C.

3.8.4.6.2 Structural Steel

3.8.4.6.2.1 Materials

The various structural steel components conform to the following specifications:

Item	Specification
Beams, girder, and plates	ASTM A36 and ASTM A588
Box columns including base plates and cap plates	ASTM A588
Structural tubing	ASTM A500 and ASTM A501
High strength bolts	ASTM A325 and ASTM A490
Studs	AWS D1.1

3.8.4.6.2.2 Welding and Nondestructive Testing

Welding and nondestructive testing is performed in accordance with either AWS D1.1 (Ref. 1B of Table 3.8-1) or Section IX of the ASME Code (Ref. 1J of Table 3.8-1).

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3.8.4.6.2.3 Fabrication and Erection

The fabrication and erection of structural steel conforms to the AISC specification (Ref. 1H, 2H and 3H of Table 3.8-1).

3.8.4.6.2.4 Quality Control

Quality control of structural steel for the construction phase is discussed in Appendix D of the PSAR and amendments to the PSAR.

3.8.4.6.3 Special Construction Techniques

Techniques involved in the construction of Seismic Category I structures are standard construction procedures.

3.8.4.7 Testing and In-service Inspection Requirements

Testing and in-service inspection are not required for Seismic Category I structures (other than the containment).

3.8.4.8 Computer Programs Used in the Design and Analysis of Other Seismic Category I Structures

1) STRESS, Department of Civil Engineering, Massachusetts Institute of Technology

2) ICES STRUDL-II, Department of Civil Engineering, Massachusetts Institute of Technology

3) MRI/STARDYNE (Version 3), Control Data Corporation.

For other computer programs refer to Subsection 2.5.5 and Section 3.7

3.8.5 FOUNDATIONS

This subsection describes foundations for all Seismic Category I structures except the spray pond. The spray pond is basically a soil structure and its design is discussed in Subsection 2.5.5. Descriptions of foundations for safety related non-Seismic

Category I structures, such as the turbine building and the radwaste building, are also included in this section.

3.8.5.1 Description of the Foundations

Typical details of the foundations for various structures are shown on Figure 3.8-104.

Reinforced concrete mat foundations have been provided for all structures. The mats rest on sound rock except the ESSW pumphouse mat is supported by natural soil.

All bearing walls of the structures are rigidly connected to the foundation mat. Where steel columns are provided, they are attached to the mat by base plates and anchor bolts. The bearing walls and the steel columns carry all the vertical loads from the structure to the mat. Horizontal shears due to wind, tornado, and seismic loads are transferred to the shear walls by the roof and floor diaphragms. The shear walls transfer the horizontal shears to the foundation mat and from there to the foundation medium through friction. Also, as shown on Figure 3.8-104, the sides of the base mats of all the structures except the ESSW pumphouse are keyed to the foundation rock all around by poured concrete, which helps in transferring the horizontal shears to the foundation rock. The edges of the ESSW pumphouse base mat are poured directly against the excavated slopes of the natural soil formation.

A mudmat (unreinforced concrete layer) is provided between the base of the foundation mat and the foundation medium. Except for the ESSW pumphouse, a waterproofing membrane is provided in the mudmat and on the outside face of peripheral subterranean walls. Perforated pipes are provided around the periphery of the buildings to collect groundwater seepage and drain it to the sumps. Waterproofing membrane under the ESSW pumphouse foundation mat is not considered necessary as the predicted groundwater table at the pumphouse site is well below the foundation mat (refer to Subsection 2.5.5).

Peripheral subterranean walls are designed to resist lateral pressures due to backfill, groundwater, and surcharge loads, in addition to dead loads, live loads, and seismic loads.

Containment: The containment foundation is described in Subsection 3.8.1.

Reactor Building and Control Building: The foundation mats of the reactor and control buildings are poured monolithically.

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The reactor building foundation mat is approximately 4 ft 9 in. thick and is reinforced typically with #11 bars at 12 in. centers at top and bottom in both the north-south and east-west directions. The mat surrounds the containment mat, with a cold joint separating the two.

The control building foundation mat is about 2 ft 6 in. thick and is reinforced typically with #8 bars at 12 in. centers at top and bottom in the north-south direction and #11 bars at 12 in. centers at top and #8 bars at 12 in. centers at bottom in the east-west direction. A cold joint is provided between the control and the turbine building mats.

Diesel Generator Building: The foundation mat of the diesel generator building is approximately 2 ft 6 in. thick and is reinforced typically with #9 bars at 12 in. centers at top and bottom in both the north-south and east-west directions. A cold joint is provided between the diesel generator pedestal mat and the diesel generator building

ESSW Pumphouse: The foundation mat of the ESSW pumphouse is about 3 ft thick and is reinforced typically with #9 bars at 12 in. centers at top and bottom in both the north-south and east-west directions.

Turbine Building: The turbine building mat is approximately 2 ft 6 in. thick and is reinforced typically with #6 bars at 12 in. centers at top and bottom in both the north-south and east-west directions. A cold joint is provided between the turbine pedestal mat and the turbine building mat.

Radwaste Building: The radwaste building mat is about 3 ft thick and is reinforced typically with #9 bars at 12 in. centers at top and bottom in both the north-south and east-west directions.

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3.8.5.2 Applicable Codes, Standards, and Specifications

The codes, standards, and specifications used in the design, fabrication, and construction of foundations of structures are listed in Table 3.8-1.

3.8.5.3 Loads and Load Combinations

The loads and load combinations used in the design of the containment foundation are described in Subsection 3.8.1.3. The loads and load combinations used in the design of foundations of other Seismic Category I structures are discussed in Subsection 3.8.4.3. In addition, the following load combinations are

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considered to determine the factors of safety against sliding and overturning due to winds, tornadoes, and seismic loads, and against flotation due to groundwater pressure:

a) D+H+W

b) D+H+W' OR D+H+ W_{MS}

c) D+H+E

d) D+H+E'

e) D+F

where:

D, W, W', E, and E' are as described in Subsections 3.8.1.3 and 3.8.4.3 and H and F are as follows:

H = Lateral earth pressure

F = Buoyant force due to groundwater pressure.

3.8.5.4 Design and Analysis Procedures

The foundations are generally designed to maintain elastic behavior under different loads and their combinations. The loads and the load combinations are described in Subsection 3.8.5.3. The design and analysis of the reinforced concrete mat foundations have been carried out in accordance with ACI 318 AND ACI 349 (Refs.10A AND 12A of Table 3.8-1).

The bearing walls and the steel columns carry all the vertical loads from the structure to the foundation mat. The lateral loads are transferred to the shear walls by the roof and floor diaphragms, which then transmit them to the foundation mat. Determination of overturning moment due to seismic loads is discussed in Subsection 3.7.$_b$2.14.

Except for ESSW pumphouse, settlement of the foundations of Seismic Category I structures is considered negligible as the foundations are supported by sound rock. The settlement of the ESSW pumphouse mat is considered in the design and is discussed in Subsection 2.5.4.

As explained in Subsection 3.8.5.1 and shown in Figure 3.8-104, the sides of the foundation mats (except for the ESSW pumphouse) are keyed to the rock by poured concrete, which resists sliding of the mats. Stability against sliding for the ESSW pumphouse is

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DIESEL GENERATOR 'E' BUILDING

The foundation MAT of the diesel generator 'E' building is approximately 3'-10" thick and is reinforced typically with #9 bars at 12 in. centers at top and bottom in both the north-south and east-west directions.

maintained by the friction on the underside of the basemat and passive resistance of the soil against the edge of the mat.

Detailed description of the foundation rock and soil is contained in Subsections 2.5.4 and 2.5.5. For design purposes, the allowable bearing pressures of rock and soil are 40 and 2.5 tons/sq ft respectively. The calculated bearing pressures for loads and load combinations described in Subsection 3.8.5.3 do not exceed these allowable values.

The design and analysis of the containment foundation mat are discussed in detail in Subsection 3.8.1.4.

3.8.5.5 Structural Acceptance Criteria

The foundations of all Seismic Category I structures are designed to meet the same structural acceptance criteria as the structures themselves. These criteria are discussed in Subsections 3.8.1.5 and 3.8.4.5. In addition, for the additional load combinations delineated in Subsection 3.8.5.3, the minimum allowable factors of safety against overturning, sliding, and flotation are as follows:

Minimum Factors of Safety

Load Combination	Overturning	Sliding	Floatation
a) D+H+W	1.5	1.5	-
b) D+H+W' OR D+H+W_{HS}	1.1	1.1	-
c) D+H+E	1.5	1.5	-
d) D+H+E'	1.1	1.1	-
e) D+F	-	-	1.1

The calculated factors of safety exceed the above minimum factor of safety.

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3.8.5.6 Materials, Quality Control, and Special Construction Techniques

The foundations of Seismic Category I structures are constructed of reinforced concrete. The concrete and reinforcing steel materials are discussed in Appendix 3.8B. Concrete design compressive strengths are given in Table 3.8-11. Techniques involved in the construction of these foundations are standard construction procedures.

3.8.5.7 Testing and In-service Inspection Requirements

The containment foundation is load tested during the structural acceptance test as described in Subsection 3.8.1.7. An in-service surveillance program to monitor the settlement of the ESSW pumphouse foundation has been instituted. Detailed discussion of the program is contained in Subsection 2.5.4. Testing and in-service inspection is not necessary for foundations of all other Seismic Category I structures.

TABLE 3.8-1

LIST OF APPLICABLE CODES, STANDARDS, RECOMMENDATIONS, AND SPECIFICATIONS

Reference Number	Designation	Title	Edition*	DG 'E' BLDG.
(A) American Concrete Institute				
1A	ACI 211.1	Recommended Practice for Selecting Proportions for Normal and Heavyweight Concrete	1970	1981
2A	ACI 214	Recommended Practice for Evaluation of Compression Test Results of Field Concrete	1965	1977
3A	ACI 301	Specifications for Structural Concrete for Buildings	1972	1981
4A	ACI 304	Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete	1973	1978
5A	ACI 305	Recommended Practice for Hot Weather Concreting	1972	1977
6A	ACI 306	Recommended Practice for Cold Weather Concreting	1966 (1972)	1978
7A	ACI 307	Specification for the Design and Construction of Reinforced Concrete Chimneys	1969	
8A	ACI 308	Recommended Practice for Curing Concrete	1971	1981
9A	ACI 309	Recommended Practice for Consolidation of Concrete	1972	
10A	ACI 318	Building Code Requirements for Reinforced Concrete	1971	1977
11A	ACI 347	Recommended Practice for Concrete Formwork	1968	1978
12A	ACI 349	Criteria for Reinforced Concrete Nuclear Power Containment Structures (included in ACI Manual of Standard Practice, Part 2, 1973)	-	1980
13A	ACI SP2	Manual of Concrete Inspection	1975	1981
(B) American Welding Society				
1B	AWS D1.1	Structural Welding Code	1972 (Generally all work) 1975, 1980, 1981 (Some work after June 1975)	1983
2B	AWS D12.1	Recommended Practice for Welding Reinforcing Steel and Connections in Reinforced Concrete Construction	1961	

*Principal ~~le~~ ~~ed~~ Editions used are listed; later ~~ed~~ Editions may be applied for specific cases, SUCH AS DIESEL GENERATOR 'E' BUILDING.

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TABLE 3.8-1 (Continued)

Reference Number	Designation	Title	Edition*	DG 'E' BLDG.
(C)	**US Nuclear Regulatory Commission**			
1C	RG 1.10	Mechanical (Cadweld) Splices in Reinforcing Bars of Category I Concrete Structures	Revision 1 Jan. 1973	
2C	RG 1.15	Testing of Reinforcing Bars for Category I Concrete Structures	Revision 1 Dec. 1972	
3C	RG 1.18	Structural Acceptance Test for Concrete Primary Reactor Containments	Revision 1 Dec. 1972	
4C	RG 1.19	Nondestructive Examination of Primary Containment Liner Welds	Revision 1 Aug. 1972	
5C	RG 1.54	Quality Assurance Requirements for Protective Coatings Applied to Water-Cooled Power Plants	June 1973	
6C	RG 1.55	Concrete Placement in Category I Structures	June 1973	
7C	RG 1.57	Design Limits and Loading Combinations for Metal Primary Reactor Containment System Components	June 1973	
8C	RG 1.58	Qualification of Nuclear Power Plant Inspection, Examination, and Testing Personnel	Aug. 1973	
9C	RG 1.69	Concrete Radiation Shields for Nuclear Power Plants	Dec. 1973	
10C	RG 1.94	Quality Assurance Requirements for Installation, Inspection, and Testing of Structural Concrete and Structural Steel During the Construction Phase of Nuclear Power Plants	Apr. 1975	APR. 1976
SEE INSERT 'E'				
(D)	**American Society for Testing and Materials**			
1D	ASTM A519	Seamless Carbon and Alloy Steel Mechanical Tubing	1971, 1974, 1975	
2D	ASTM A615	Deformed and Plain Billet Steel Bars for Concrete Reinforcement	1972, 1974, 1975	
3D	ASTM C29	Unit Weight of Aggregate	1971	
4D	ASTM C31	Making and Curing Concrete Test Specimens in the Field	1969	1983

*Principal ~~ly~~ A ~~ed~~ Editions used are listed; later ~~ed~~ Editions may be applied for specific cases, SUCH AS DIESEL GENERATOR 'E' BUILDING.

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TABLE 3.8-1 (Continued)

Reference Number	Designation	Title	Edition*	DG 'E' BLDG.
5D	ASTM C33	Concrete Aggregates	1971, 1974	1982
6D	ASTM C39	Compressive Strength of Cylindrical Concrete Specimens	1972	1981
7D	ASTM C40	Organic Impurities in Sands for Concrete	1966, 1973	1979
8D	ASTM C87	Effect of Organic Impurities in Fine Aggregate on Strength of Mortar	1969	
9D	ASTM C88	Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate	1971, 1973	1976
10D	ASTM C94	Ready-Mixed Concrete	1973, 1974	1983
11D	ASTM C109	Compressive Strength of Hydraulic Cement Mortars	1973, 1975	1980
12D	ASTM C117	Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing	1969	1980
13D	ASTM C123	Lightweight Pieces in Aggregate	1969	1983
14D	ASTM C127	Specific Gravity and Absorption of Coarse Aggregate	1968, 1973	1981
15D	ASTM C128	Specific Gravity and Absorption of Fine Aggregate	1968, 1973	1979
16D	ASTM C131	Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine	1969	1981
17D	ASTM C136	Sieve or Screen Analysis of Fine and Coarse Aggregates	1971	1983
18D	ASTM C138	Unit Weight, Yield, and Air Content of Concrete	1973, 1974, 1975	1981
19D	ASTM C142	Clay Lumps and Friable Particles in Aggregates	1971	1978
20D	ASTM C143	Slump of Portland Cement Concrete	1971, 1974	1978
21D	ASTM C150	Portland Cement	1973, 1974, 1976, 1978, 1980	1983a
22D	ASTM C215	Fundamental Transverse, Longitudinal, and Torsional Frequencies of Concrete Specimens	1960	
23D	ASTM C231	Air Content of Freshly Mixed Concrete by the Pressure Method	1973, 1974, 1975	1982

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*Principal Editions used are listed; later Editions may be applied for specific cases, SUCH AS DIESEL GENERATOR 'E' BUILDING.

Reference Number	Designation	Title	Edition*	DG 'E' BLDG.
24D	ASTM C235	Scratch Hardness of Coarse Aggregate Particles	1968	
25D	ASTM C260	Air Entraining Admixtures for Concrete	1973, 1974	1977
26D	ASTM C289	Potential Reactivity of Aggregates	1971	1981
27D	ASTM C295	Petrographic Examination of Aggregates for Concrete	1965	1979
28D	ASTM C311	Sampling and Testing Fly Ash for Use as an Admixture in Portland Cement Concrete	1968	
29D	ASTM C330	Lightweight Aggregates for Structural Concrete	1969, 1975	
30D	ASTM C469	Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression	1965	1981
31D	ASTM C494	Chemical Admixtures for Concrete	1971	1982
32D	ASTM C566	Total Moisture Content of Aggregate by Drying	1967	1978
33D	ASTM C618	Fly Ash and Raw or Calcined Natural Pozzolans for Use in Portland Cement Concrete	1973	
34D	ASTM C637	Aggregates for Radiation Shielding Concrete	1973	
(E)	American Association of State Highway and Transportation Officials			
1E	AASHTO T26	Quality of Water to be Used in Concrete	1970	
2E	AASHTO T150	Percentage of Particles of Less Than 1.95 Specific Gravity in Coarse Aggregate	1949	
3E	AASHTO T161	Resistance of Concrete Specimens to Rapid Freezing and Thawing in Water	1970	
(F)	US Army Corps of Engineers			
1F	CRD C36	Test for Thermal Diffusivity of Concrete	1973	
2F	CRD C39	Test for Coefficient of Linear Thermal Expansion of Concrete	1955	
3F	CRD C119	Test for Flat and Elongated Particles in Coarse Aggregate	1953	1963
4F	CRD C572	SPECIFICATION FOR POLYVINYLCHLORIDE WATERSTOP	1974	

*Principle additions used are listed; later additions may be applied for specific cases, SUCH AS DIESEL GENERATOR 'E' BUILDING. 2

TABLE 3.8-1 (Continued)

Reference Number	Designation	Title	Edition*	DG 'E' BLDG.
(G)	American National Standards Institute			
1G	ANSI N45.2.5	Supplementary QA Requirements for Installation, Inspection and Testing of Structural Concrete and Structural Steel During the Construction Phase of Nuclear Power Plants.	1972	1974'
INSERT 'F' 2G	ANSI N101.6	Concrete Radiation Shields	1972	
(H)	American Institute of Steel Construction			
1H	AISC	Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings and Supplement Nos. 1, 2 and 3	1969	1978
2H	AISC	Code of Standard Practice for Steel Buildings and Bridges	1970 (Some work before) 1972 (Generally all work) 1976 (Some work after Sept. 1976)	1976
3H	AISC	Specification for Structural Joints Using ASTM A325 or A490 Bolts	1966, 1972 and 1976	1978
4H	AISC	Specification for the design, fabrication and erection of Structural Steel for buildings	1978 (Some work after July 1977)	
(J)	American Society of Mechanical Engineers			
1J	ASME	ASME Boiler and Pressure Vessel Code, Sections II, III, V, VIII, and IX	1971 with Addenda through Summer 1972	
(K)	Bechtel Power Corporation, San Francisco, California, Topical Reports			
1K	BC-TOP-1	Containment Building liner Plate Design Report	Revision 1 Dec. 1972	
2K	BC-TOP-4-A	Seismic Analyses of Structures and Equipment for Nuclear Power Plants	Revision 3 Nov. 1974	
3K	BC-TOP-9A	Design of Structures for Missile Impact	Revision 2 Sept. 1974	
(L)	International Conference of Building Officials			

*Principle Additions used are listed; later Additions may be applied for specific cases, SUCH AS DIESEL GENERATOR 'E' BUILDING.

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TABLE 3.8-1 (Continued)

Reference Number	Designation	Title	Edition*
1L	UBC	Uniform Building Code	1973, 1976

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*Principal editions used are listed; later editions may be applied for specific cases, SUCH AS DIESEL GENERATOR 'E' BUILDING.

INSERT 'E'

11C	NUREG 0800	STANDARD REVIEW PLAN FOR THE REVIEW OF SAFETY ANALYSIS REPORTS FOR NUCLEAR POWER PLANTS	
12C	1.28	Quality Assurance Program Requirements (Design and Construction)	2/79
~~13C~~	~~1.29 Rev. 3~~	~~Seismic Design Classification~~	~~9/78~~
13C	1.60 Rev. 1	Design Response Spectra for Seismic Design of Nuclear Power Plants	12/73
14C	1.61 Rev. 0	Damping Values for Seismic Design of Nuclear Power Plants	10/73
15C	1.76 Rev. 0	Design Basis Tornado for Nuclear Power Plants	4/74
16C	1.92 Rev. 1	Combining Modal Responses and Spatial Components in Seismic Response Analysis	2/76
17C	1.117 Rev. 1	Tornado Design Classification	4/78
18C	1.132 Rev. 1	Site Investigations for Foundations of Nuclear Power Plants	3/79
19C	1.142 Rev. 1	Safety-Related Concrete Structures for Nuclear Power Plants (other than Reactor Vessels and Containments)	10/81

INSERT 'F'

REFERENCE NO.	DESIGNATION	TITLE	EDITION*
3G	ANSI N45.2	Quality Assurance Program Requirements for Nuclear Facilities, [redacted]	1977
4G	ANSI N45.2.2	Packaging, Shipping, Receiving, Storage and Handling of Items for Nuclear Power Plants, [redacted]	1978
	~~ANSI N45.2.5~~	~~Supplementary Quality Assurance Requirements for Installation, Inspection and Testing of Structural Concrete and Structural Steel During the Construction Phase of Nuclear Power Plants, 1974~~	
5G	ANSI N45.2.6	Qualifications of Inspection, Examination and Testing Personnel for the Construction Phase of Nuclear Power Plants, [redacted]	1978
6G	ANSI N45.2.9	Requirements for Collection, Storage, and Maintenance of Quality Assurance Records for Nuclear Power Plants, [redacted]	1974
7G	ANSI N45.2.10	Quality Assurance Terms and Definitions, [redacted]	1973
8G	ANSI N45.2.11	Quality Assurance Requirements for the Design of Nuclear Power Plants, [redacted]	1974
9G	ANSI N45.2.12	Requirements for Auditing of Quality Assurance Programs for Nuclear Power Plants, [redacted]	1977
10G	ANSI N45.2.13	Quality Assurance Requirements for Control of Procurement of Items and Services for Nuclear Power Plants, [redacted]	1976
11G	ANSI N45.2.23	Qualifications of Quality Assurance Program Audit Personnel for Nuclear Power Plants, [redacted]	1978

* EDITIONS ARE USED FOR DIESEL GENERATOR 'E' BUILDING

TABLE 3.8-8 (pg 1 of 4)

LOAD COMBINATIONS APPLICABLE TO REACTOR BUILDING

Notations W_{MS} = SITE PROXIMITY MISSILE LOAD

W = Wind load
W' = Tornado wind load
fs = Calculated stress in structural steel
Fs = Allowable stress for structural steel
Fy = Yield strength of structural steel
H_o = Force on structure due to thermal expansion of pipes under operating conditions
H_a = Force on structure due to thermal expansion of pipes under accident conditions
D_s = Force on blockwall due to story drift under Operating Basis Earthquake Loading
D'_s = Force on blockwall due to story drift under Safe Shutdown Earthquake Loading
S_m = Allowable stress for reinforced concrete masonry per UBC, Table 24-H (special inspection) for global wall analysis; or allowable stress for unreinforced concrete masonry per UBC Table 24-B (special inspection) for local wall analysis as a result of attachments.
f_s = Allowable working stress in tension for reinforcing steel (as specified in UBC).
f_y = Yield strength of reinforcing steel.

For all other notations, see Table 3.8-2.

A. Reinforced Concrete

Normal operating loads:

$$U = 1.4D+1.7L+1.0T_o+1.25\,H_o$$

Normal operating loads with Severe environmental loads:

$$U = 0.75[1.4D+1.7L+1.7(1.1)E]+1.0T_o+1.25\,H_H$$
$$U = 0.75(1.4D+1.7L+1.7W)+1.0T_o+1.25\,H_o$$

Where overturning forces cause net tension in the absence of live load, the following load combinations are considered:

$$U = 0.9D+1.3(1.1)E+1.0T_o+1.25\,H_o$$
$$U = 0.9D+1.3W+1.0T_o+1.25\,H_o$$

TABLE 3.8-8 (Continued) (pg 2 of 4)

For structural shear walls carrying seismic forces, the following load combination is also considered:

$$U = 1.0D+1.0L+1.8E+1.0T_o + 1.25\ H_o$$

Normal operating loads with Extreme environmental loads:

$$U = 1.0D+1.0L+1.0T_o +1.0W' + 1.0\ H_o$$

Normal operating loads with Abnormal loads:

$$U = 1.05D+1.05L+1.0(T_o+T_a)+1.0R+1.5P + 1.0\ H_o$$

Normal operating loads with Severe environmental and Abnormal loads:

$$U = 1.05D+1.05L+1.0(T_o+T_a)+1.0R+1.25P+1.25E + 1.0\ H_o$$

Where overturning forces cause net tension in the absence of live load, the following load combination is considered:

$$U = 0.95D+1.25E+1.0(T_o+T_a)+1.0R + 1.0\ H_o$$

Normal operating loads with Extreme environmental and Abnormal loads:

$$U = 1.0D+1.0L+1.0(T_o+T_a)+1.0E'+1.0P+1.0R + 1.0\ H_a$$
$$U = 1.0D+1.0L+1.0T_o+1.0E'+1.0R + 1.25\ H_a$$

TABLE 3.8-8 (Continued) (pg 3 of 4)

B. Structural Steel

Condition	Load Combination	Allowable Stress Increase
Normal operating loads:	$D + L + T_o + H_o$	Fs
Normal operating loads with Severe environmental loads:	$D + L + T_o + E + H_o$ $D + L + T_o + W + H_o$	1.25 Fs 1.33 Fs
Normal operating loads with Extreme environmental loads:	$D + L + T_o + W' + H_o$	See note below
Normal operating loads with Extreme environmental and Abnormal loads:	$D+L+R+T_o+E'+P+H$ $D + L + R + (T_o + T_a) + P + E' + H_a$	See note below See note below

Note: The allowable stress in structural steel does not exceed 0.9 Fy in bending, 0.85 Fy in axial tension or compression, and 0.5 Fy in shear. Where Fs is governed by requirements of stability (local or lateral buckling), fs does not exceed 1.5 Fs.

TABLE 3.8-8 (Continued) (pg 4 of 4)

C. Concrete Masonry Structures (Blockwalls)

Safety related blockwalls in category I structures other than the reactor building are designed for the following load combinations and allowable stress increase. The load combinations apply to out-of-plane loading as well as in-plane loading. Acceptance criteria is in accordance with Subsection 3.8.4.5.

Condition	Load Combination	Allowable Stres Increase
Normal	$D + L + T_o + H_a$	No increase
Normal/Severe	$D + L + T_o + H_o + E + D_s$	No increase
Normal/Extreme	$D + L + T_o + H_o + W'$	See Table 3.8
Abnormal	$D + L + (T_o + T_a) + R + H_a$	See Table 3.8
Abnormal/Severe	$D+L+(T_o + T_a)+R+H_a+1.25E+D_s$	See Table 3.8
Abnormal/Extreme	$D+L+(T_o+T_a)+R+H_a+E'+D'_s$	See Table 3.8

TABLE 3.8-9 (pg 1 of 3)

LOAD COMBINATIONS APPLICABLE TO SEISMIC CATEGORY I STRUCTURES OTHER THAN CONTAINMENT, ~~AND~~ REACTOR BUILDING AND DIESEL GENERATOR 'E' BUILDING.

Notations: See Tables 3.8-2 and 3.8-8

A. Reinforced Concrete

Normal operating loads:

$$U = 1.4D+1.7L+1.0T_o+ 1.25\ H_o$$

Normal operating loads with Severe environmental loads:

$$U = 0.75(1.4D+1.7L+1.7(1.1E))+1.0T_o+ 1.25\ H_o$$

$$U = 0.75(1.4D+1.7L+1.7W)+1.0T_o+ 1.25\ H_o$$

Where overturning forces cause net tension in the absence of live load, the following load combinations are considered:

$$U = 0.9D+1.3(1.1E)+1.0T_o +1.25\ H_o$$

$$U = 0.9D+1.3W+1.0T_o+1.25\ H_o$$

For structural elements carrying mainly seismic forces:

$$U = 1.0D+1.0L+1.8E+1.0T_o+ 1.25\ H_o$$

Normal operating loads with Extreme environmental loads:

$$U = 1.0D+1.0L+1.0W'+1.0T_o+ 1.0\ H_o$$

Normal operating loads with Severe environmental and Abnormal loads:

$$U = 1.05D+1.05L+1.25E+1.0(T_o+T_a)+1.0R + 1.0\ H_a$$

Where overturning forces cause net tension in the absence of live load, the following load combination is considered:

$$U = 0.95D+1.25E+1.0(T_o+T_a)+1.0R + 1.0\ H_a$$

Normal operating loads with Extreme environmental and Abnormal loads:

$$U = 1.0D+1.0L+1.0E'+1.0T_o +1.0R + 1.25\ H_o$$

$$U = 1.0D+1.0L+1.0E'+1.0(T_o+T_a)+1.0R + 1.0\ H_a$$

TABLE 3.8-9 (Continued) (pg. 2 of 3)

B. Structural Steel

Condition	Load Combination	Allowable Stress
Normal operating loads:	$D+L+T_o+H_o$	Fs
Normal operating loads with Severe environmental loads:	$D+L+T_o+E+H_o$ $D+L+T_o+W+H_o$	1.25 Fs 1.33 Fs
Normal operating loads with Extreme environmental loads:	$D+L+T_o+W'+H_o$	See note below
Normal operating loads with Extreme environmental and Abnormal loads:	$D+L+R+T_o+E'+H_o$ $D+L+R+T_o+T_a+E'+H_a$	See note below See note below

Note: The allowable stress in structural steel does not exceed 0.9 Fy in bending, 0.85 Fy in axial tension or compression, and 0.5 Fy in shear. Where Fs is governed by requirements of stability (local or lateral buckling), fs does not exceed 1.5 Fs.

TABLE 3.8-9 (Continued) (pg. 3 of 3)

C. Concrete Masonry Structures (Blockwalls)

Safety related blockwalls in the reactor building are designed for the following load combinations and allowable stress increase. The load combinations apply to out-of-plane loading as well as in-plane loading. Acceptance criteria is in accordance with Subsection 3.8.4.5.

Condition	Load Combination	Allowable Stress Increase
Normal	$D + L + T_o + H_o$	No increase
Normal/Severe	$D + L + T_o + H_o + E + D_s$	No increase
Normal/Extreme	$D + L + T_o + H_o + W'$	See Table 3.8-12
Abnormal	$D + L + (T_o + T_a) + R + 1.25P + H_a$	See Table 3.8-12
Abnormal/Severe	$D + L + (T_o + T_a) + R + 1.25P + H_a + 1.25E + D_s$	See Table 3.8-12
Abnormal/Extreme	$D + L + (T_o + T_a) + R + P + H_a + D'_s + E'$	See Table 3.8-12

TABLE 3.8-9a

Load Combinations for Diesel Generator 'E' Building

(See tables 3.8-2 and 3.8-8 for definitions of loads and other notations)

The Diesel Generator 'E' Building is designed for the following load combinations:

A. Reinforced Concrete

Service Load Combinations:

a. $U = 1.4D + 1.7L$

b. $U = 1.4D + 1.7L + 1.9E$

c. $U = 1.4D + 1.7L + 1.7W$

d. $U = 1.2D + 1.9E$

e. $U = 1.2D + 1.7W$

Where soil or hydrostatic pressures are present and have been included in L and D, in addition to all the preceding combinations, the requirements of Sections 9.2.4 and 9.2.5 of ACI 318.77 have been satisfied.

Factored Load Combinations:

a. $U = 1.0D + 1.0L + 1.0E'$

b. $U = 1.0D + 1.0L + 1.0W_t$

c. $U = 1.0D + 1.0L + 1.0W_{ms}$

Regarding preceding loads which are variable, the full range of variation has been considered in order to determine the most critical combination of loading.

B. Structural Steel

The following combinations of loadings have been considered in the design of structural steel seismic Category I structures. S is the required section strength based on the elastic design methods and the allowable stresses defined in Part I of American Institute of Steel Construction (AISC) Specification for the Design, Fabrication and Erection of Structural Steel for Buildings, November, 1978, except that the 33-percent increase in allowable stresses for seismic or wind loadings has not been permitted. In determining the most critical loading condition to be used in design, the absence of a load or loads has been considered as appropriate.

Service Load Combinations

a. $S = D + L$

b. $S = D + L + E$

c. $S = D + L + W$

Factored Load Combinations

a. $1.6S = D+L+E'$

b. $1.6S = D+L+W_t$

c. $1.6S = D+L+W_{ms}$

TABLE 3.8-11

CONCRETE DESIGN COMPRESSIVE STRENGTHS

Structure	Concrete Design Compressive Strength, f'c (psi)
Turbine generator pedestal	3000
All other Seismic Category I and safety-related, non-Seismic Category I structures and their associated foundation mats including: a) Containment (including its internal structures) b) Reactor Building c) Control Building d) Diesel Generator Building e) ESSW Pumphouse f) Spray Pond g) Turbine Building h) Radwaste Building i) DIESEL GENERATOR 'E' BUILDING.	4000

APPENDIX 3.8B

CONCRETE, CONCRETE MATERIALS, QUALITY CONTROL, AND SPECIAL CONSTRUCTION TECHNIQUES

Materials, workmanship, and quality control are based on the codes, standards, recommendations and specifications listed in Table 3.8-1. These documents are modified as required to suit the particular conditions associated with nuclear power plant design and construction while maintaining structural adequacy. Extent of application and principal exceptions are indicated herein, and as follows:

ACI 301-72

a) Provisions of ACI 301-72, Chapter 12, Curing and Protection, shall be modified as follows:

i) Paragraph 12.2.1 shall be revised to read as follows:

"For concrete surfaces not in contact with forms, one of the following procedures shall be applied immediately after completion of placement and finishing except that the curing process may be interrupted as necessary not to exceed 8 hours providing requirements for weather protection are maintained. Such curing process may not be interrupted more than twice with a minimum of 8 hours elapsing between interruptions. If the curing is interrupted for up to 8 hours, the curing time shall be extended to provide a total of 7 days curing.

ii) Paragraph 12.2.3 shall be revised to read as follows:

"Curing in accordance with Section 12.2-1 and 12.2.2 shall be contained for at least 7 days in the case of all concrete except high-early-strength concrete for which the period shall be at least 3 days. Alternatively, if tests are made of cylinders kept adjacent to the structure and cured by the same methods, moisture retention measures may be terminated prior to 7 days when test results indicate that the average compressive strength, has reached 70 percent of the specified strength, f'c. Required period of initial curing need not be greater than the lesser of the two periods. If one of the curing procedures of Section 12.2.1.1 through 12.2.1.4 is used initially, it may be replaced by one of the other

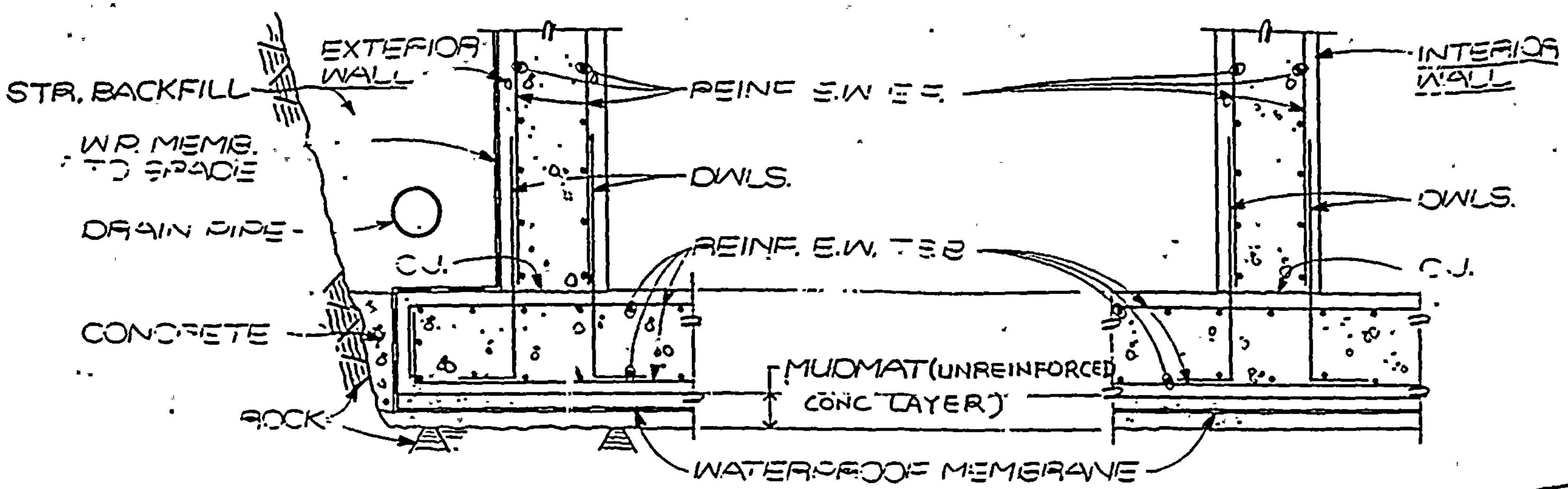
interpretation of these detail drawings in erecting the reinforcing steel. While this is also true of Bechtel field operation, we do have the additional help and guidance of the field engineers both during the installation phase and finally at the inspection phase prior to final sign-off on the report card.

e) The field engineers have the added benefit of being able to plan and witness the actual installation and can, therefore, better foresee any difficulties in meeting the intended design requirements. Their assessment of the situation is further assisted by regular telephone communication with the design engineers who also periodically visit the jobsite.

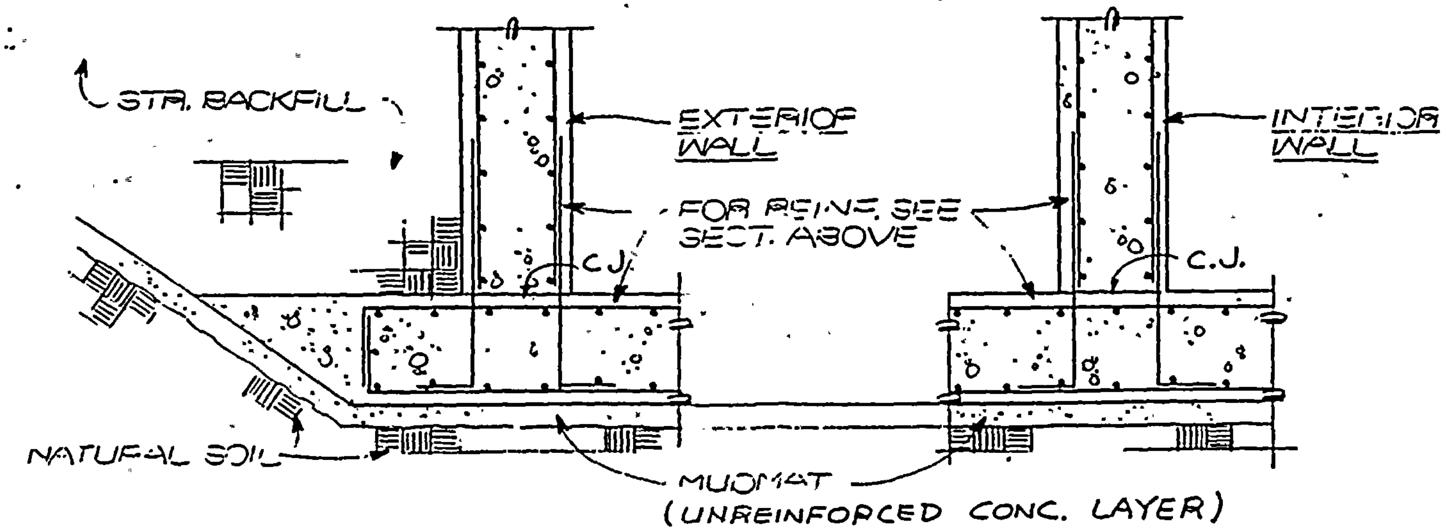
The above procedure of delegation of the design engineering office's responsibility to the field personnel and periodic monitoring by the engineering office ensures correctness and conformance of the shop drawings to the design drawings and therefore meets the intent of Regulatory Guide 1.55.

DIESEL GENERATOR 'E' BUILDING

MATERIALS, WORKMANSHIP AND QUALITY CONTROL FOR DIESEL GENERATOR 'E' BUILDING ARE IN ACCORDANCE WITH THE CODES, STANDARDS, SPECIFICATIONS, USNRC REGULATORY GUIDES AND ANSI DOCUMENTS LISTED IN TABLE 3.8-1.



TYPICAL FOUNDATION DETAIL
REACTOR, CONTROL, DIESEL GENERATOR, DIESEL GENERATOR 'E'
RADWASTE & TURBINE BUILDING



FOUNDATION DETAIL
ESSW PUMPHOUSE

Rev. 35, 07/84

SUSQUEHANNA STEAM ELEC
UNITS 1 AND 2
FINAL SAFETY ANALYSI

FOUNDATION DE

FIGURE 3.8-104