BALTIMORE GAS AND ELECTRIC

CHARLES CENTER · P. O. BOX 1475 · BALTIMORE, MARYLAND 21203

June 30, 1981

ARTHUR E. LUNDVALL, JR.
VICE PRESIDENT
SUPPLY

Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

RECEIVED
JUL 06 1981
U.S. NUCLEAR REGULATORY COMMISSION

Attn: Mr. Robert A. Clark, Chief
Operating Reactors Branch #3
Division of Licensing

Subject: Calvert Cliffs Nuclear Power Plant
Units Nos. 1 & 2; Dockets Nos. 50-317 & 50-318
Auxiliary Feedwater System

Reference: Generic Letter No. 81-14, Seismic Qualification of Auxiliary Feedwater Systems, dated 10 February 1981.

Gentlemen:

The referenced letter requested information concerning the seismic qualification of the Calvert Cliffs Auxiliary Feedwater (AFW) Systems. Enclosed please find a report discussing the design of the seismic and non-seismic portions of the AFW systems.

BALTIMORE GAS AND ELECTRIC COMPANY

By: A. E. Lundvall Jr
Vice President, Supply

STATE OF MARYLAND:
: TO WIT:
CITY OF BALTIMORE:

Mr. A. E. Lundvall, Jr. being duly sworn, states that he is Vice President of the Baltimore Gas and Electric Company, a corporation of the State of Maryland; that he executed the foregoing submittal for the purposes therein set forth; that the statements made in said submittal are true and correct to the best of his knowledge, information and belief; and that he was authorized to execute the submittal on behalf of said corporation.

WITNESS my hand and Notarial Seal: Ruth H. Grese

My Commission Expires: July 1, 1982

A001
S/1

8107070385 810630
PDR ADOCK 05000317
P PDR

cc: J. A. Biddison, Esquire
G. F. Trowbridge, Esquire
Messrs. E. L. Conner, Jr. - NRC
J. C. Ventura - Bechtel
P. W. Kruse - CE
R. E. Arthitzel - Resident Inspector

CONTENTS

## I. Introduction and Conclusions

The Calvert Cliffs Auxiliary Feedwater System has been addressed in responses to NRC IE Bulletins 79-02, 79-04, 79-07, 79-14, and 80-11 and to IE Information Notice 80-21, which verified and evaluated the as-built characteristics of the system. This evaluation contains additional information requested by Generic Letter 81-14, Seismic Qualification of Auxiliary Feedwater Systems. Section II provides a brief system description. Section III discusses the criteria and methods used for the qualification of Seismic Class I components in the Calvert Cliffs non-Seismic Class I and addresses specifically items listed in Table 1 of Generic Letter 81-14.

This evaluation concludes that the Calvert Cliffs Auxiliary Feedwater Systems exhibit a high degree of inherent seismic resistance. The majority of the system's original design was accomplished using the seismic design criteria typical for other Calvert Cliffs Seismic Class I systems. For those few portions of the system which have been identified as non-seismic, the as-built configuration of the systems has been examined and it has been determined that the safe shutdown earthquake would not have a significant effect on the AFW system function as explained in Section IV.

## II. System Description

Overall Design - (See Attachment B for a schematic)

In general, each units AFWS is a auto/manual operated system that includes two steam turbine-driven pumps, each of which is sized to deliver 700 gpm at 1100 psia to the steam generators. The pumps' turbines can be supplied with steam from either the steam generators (SG) or the auxiliary boiler. Both pumps are located in a Seismic Class I auxiliary feedwater pump room. This room is designed as a separate, totally enclosed Class I structure located at the bottom elevation of the Turbine building. The normal water supply to each pump is from Condensate Storage Tank No. 12 (CST No. 12), via a common line feeding both units. Each unit's suction line splits and feeds the two AFWS pumps. Flow from each pump discharges into a common line which in turn branches to each of two SG. AFWS flow is controlled by regulating pump speed and by regulating flow through an air-operated throttle control valve in the feed line to each SG.

Water Supply

The primary water source for both units is CST No. 12 which has a 350,000 gallon capacity, 300,000 gallons of which are dedicated to the AFWS for both units. The normal supply path of AFWS water is from CST No. 12 through two locked open manually operated valves in a common line which branches to the two pumps. CST No. 12 is designed to seismic Class I requirements and is protected against tornado missiles.

The secondary water source (CST 11 and 21) feed lines each include two normally closed manually-operated valves, and are connected to the common header that feeds both auxiliary feedwater pumps. These sources of water are used for normal plant makeup and are not specifically dedicated to the AFWS. To supply the AFWS pumps with water from CST No. 11 or 21 would require an operator to go to the tank and open the valves. Specific procedures are provided for this operation. CST No. 12 is filled from the demineralized water system via a line containing a check valve and a normally shut manual valve. Filling CST No. 12 is performed locally by an operator at the tank, using approved procedures.

Steam Supply

Steam to drive the AFWS pump turbines is supplied by the steam generators. Each steam generator can supply steam to either or both turbines from its main steam line through a normally closed motor operated valve (MOV) which fails as-is or a normally closed manual bypass valve into a common header. Each AFW pump takes steam from the common header through a normally open manual valve, a check valve, a normally open stop valve (with a DC trip mechanism) and an air operated normally closed throttle valve. An alternative source of steam is the auxiliary boiler fired by oil. When operating, the auxiliary boiler supplies steam through a normally locked closed manual valve located between the check valve and stop valve on each turbine steam supply line.

Controls

The following controls are located in the Control Room:

1. Hand indicating controllers for:

   a. Turbine Control (throttle) Valve

      Air operated fail open valve; air supply is instrument air with no back-up; control circuit power supply is vital AC. For automatic start this valve is set to open all the way and the AFWS Regulating Valve is positioned accordingly to prevent excess flow. During normal operations the control room operator controls pump speed with this valve and repositions the AFWS Regulating valve to obtain optimum system performance. If during operation the throttle valve were to fail open there would be no adverse effects because the AFWS Regulating valve, as stated above, can handle this condition.

   b. AFWS Regulating Valve

      Air operated fail open valve; air supply is instrument air with back-up air accumulators, electrical supply is vital AC. To minimize the possibility of the AFWS Regulating Valve failing open, the back-up air accumulator has enough capacity to allow time for the operator to take local manual control. This valve can be bypassed by operating a normally closed manual valve.

2. Motor Operated Valves - Open/Close for Each MOV

The MOVs are powered from separate emergency AC buses. Only one is required to be opened for full AFWS demand. The MOVs can be bypassed using manually operated full flow bypass valves in the remote event that both AC power sources are lost.

3. Turbine Stop Valves (DC Trip)

The Turbine Stop Valves are powered from the DC buses and fail in the open position.

All controls except the motor operated valve controls are also located at the Remote Shutdown Panel/AFWS Pump Room. All control and instrumentation power is from emergency buses which can be energized from the diesel generators.

In accordance with NUREG 0578 and 0737, each AFWS has been modified to include a safety-related, automatic start system (AFAS). The AFAS consists of four redundant steam generator level monitoring subsystems and two redundant actuation subsystems for the AFW start (auto start of the AFWS pumps). The actuation system is qualified to the same criteria as the Engineered Safety Features Actuation System (ESFAS), as discussed in Attachment (A), and is installed in the ESFAS cabinets. The level transmitters are also seismically qualified as discussed in Attachment (A).

III. General Discussion of Seismic Methodology

Attachment A, except for loading combination, is excerpted from the Calvert Cliffs FSAR basic seismic criteria. These criteria were used to qualify the majority of both Units 1 and 2 Class I structures, equipment, and components. Specific items have been highlighted for ease of referencing. The applicable questions and answers from the FSAR Supplement are also included. The seismic criteria for those areas not included in Attachment A are presented below by discipline. Additional information is also presented on the criteria qualification methods.

Mechanical equipment which was qualified to the attached criteria was analyzed by the applicable supplier. No actual or type testing was performed. The supplier's calculations determined equipment rigidity and provides assurance that no failures will occur under the loading combinations specified. All pipe/supports within Class I structures were also designed and installed to the attached criteria. For field run 2-inch and smaller Class I piping, a field installation manual was utilized by field engineers to properly design and locate pipe supports.

Recent plant modifications have upgraded all electrical power supplies to Class 1E (seismic). Associated distribution panels, inverters, chargers, and batteries are qualified 1E as discussed in Attachment (A). Cable tray supports were originally installed to standard seismic installation details and guidelines and verified by engineering in the field.

All Class I instrumentation devices were qualified in accordance with the criteria presented in Attachment (A). Control valves and appurtenences were type-tested and/or analyzed to withstand a 3.0g load in any direction. Natural frequency of extended parts was designed to be greater than 20 hertz to be consistent with associated process pipe. Pump suction and discharge pressure switches initially were prototype shock tested to military standards to verify pressure integrity under impact loads. Integral pipe mounted devices are qualified with the piping. Instrument sensing lines were designed and installed to small pipe standard seismic installation details.

Instrument supports were designed and analyzed to ensure a natural frequency of greater than 33 hertz and to ensure integrity at 2g's. The instrument air supply to AFW throttle valves has recently been upgraded to the seismic Class I criteria for both the air source and the associated piping in accordance with the requirements for 2" and smaller pipe.

## IV. Non-Seismic Class I Components

### General

Upgrading of Non-Seismic Class I electrical and controls components will be accomplished under our general AFW modification which is a result of the NRC Bulletins and Orders Task Force review of the Calvert Cliffs Auxiliary Feedwater System. Long term modifications are presently being engineered and have been described in previous correspondence with the NRC.

The following is a list of components which have been identified as presently being non-seismic Class I. Each item for which there are no plans to upgrade was walked-down in the field such that its as-built configuration could be evaluated to determine the degree of seismic resistance the engineering provided. The items are arranged in the order presented in Table 1 of Generic Letter 81-14, and the additional information as required by Enclosure 1, section C is provided.

1. Pumps/Motors

   The AFW pump turbine and the associated trip/throttle valve assembly presently does not carry a seismic certification from the manufacturer. However, inquiries have been made of other plants that have Terry turbines which are the same model of similar configuration. One of these plants has obtained seismic certification for their equipment with greater loading than required at Calvert Cliffs. These facts afford a high level of confidence that the Calvert Cliffs installation will withstand the stresses resulting from an SSE. The remainder of the pump turbine skid assembly carries a seismic certification from the manufacturer.

2. Piping

   a. AFW pump minimum flow recirculation piping

Each pair of AFW pumps has one common recirculation line routed through the non-seismic turbine building to the Condensate Storage Tank No. 12. These lines, to a point downstream of the second flow restriction orifice inside the AFW pump rooms, are seismic Class I. It has been determined that any failure of this line downstream of the first restriction orifice will not significantly affect system function. The minimum flow requirement for the AFW pumps is not an important safety parameter with respect to other one-time system functions under emergency conditions.

b. AFW Pump exhaust piping to atmosphere

The exhaust lines, one 10" pipe from each pump turbine, run out of the AFW pump room, through the non-seismic Class I turbine building to the roof where they are open to atmosphere. We consider these lines acceptable based on the following:

1. Approximately 90% of the lines in the turbine building are not located near or under any heavy equipment which could collapse and damage them.

2. The lines are generally supported from heavy turbine building crane columns not from secondary steel.

3. Those portions of the lines in the pump room are supported seismically.

4. Failure or rupture of these lines would not significantly affect AFW pump turbine operation.

5. Upon completion of the AFWS modifications required by the Bulletins and Orders Task Force, a third auxiliary feedwater pump will be in operation which does not require exhaust piping.

c. Chemical addition piping to the AFW system.

Each pair of AFW pumps has a chemical addition line which ties in to the common pump suction piping in the AFW pump room. The chemical addition equipment is located in the non-seismic turbine building. The chemical addition piping within the AFW pump room is non-seismic Class I, however, it can be isolated from the AFW system by using an existing manual valve in the pump room. We intend to change the position of this valve to normally shut. The portion of piping between the chemical addition isolation valve and the AFW system is very small, i.e., two welds. On Unit 1, an additional chemical addition line is installed by each AFW containment penetration room. These lines are not in use. We plan to cut and cap these lines as part of the general AFW modifications.

3. Valves

Manual valves, with the exception of penetration and CST No. 12 discharge valves, were purchased with no seismic qualification. These valves were

installed in seismic lines and analyzed with the system. However, we have determined that these valves are similar in material properties and construction to other valves which are seismically qualified, and they therefore would possess a substantial amount of inherent seismic resistance.

4. Power Supplies

All conduits required for circuits essential to the safe operation of the AFW system are installed per the standards and criteria discussed in section III and attachment (A). For certain selected conduits carrying circuits which are diagnostic only, such as AFW system temperature, vibration monitoring, and pressure, the installation is in accordance with the National Electrical Code Table 346-12 for rigid metallic conduit. For the AFW modification, all conduits carrying any circuit within the system boundaries, regardless of its nature, will be upgraded to Class 1E and will meet the intent of IE Bulletin 79-01B and NUREG-0588.

5. Primary Water and Supply Path

No non-seismic equipment.

6. Secondary Water Supply Path

Not applicable to Calvert Cliffs

7. Initiation and Control Systems

The non-qualified pressure indicators are the Bourdon tube type which are mounted and tubed to the seismic criteria used for 2" and smaller piping as discussed in this evaluation. The remote turbine trip hand-switches are not seismically qualified. These items are presently being upgraded under our general AFW modification and will meet the intent of IE Bulletin 79-01B and NUREG-0588.

The instrument air source for AFW pump turbine throttle is non-seismic plant instrument air. On failure of the air supply, the throttle valve fails to the full open position.

As discussed in Section II (under Controls), this does not affect system safety, therefore, there are no plans to upgrade this air supply.

8. Structures

All structures housing AFW system items are seismically Class I designed.

Attachment (A)

Comprising:

F.S.A.R. Section 5-A - Structural Design Bases (5 pages)

F.S.A.R. Questions (7 pages)

Loading Combinations (1 page)

## APPENDIX 5-A

## 5A STRUCTURAL DESIGN BASES

### 5A.1 GENERAL

The design bases for structures for normal operating conditions are governed by the applicable building design codes. The design bases for specific systems and equipment are stated in the appropriate FSAR Section. The design basis for the maximum loss-of-coolant incident and seismic conditions is that there be no loss-of-function if that function is related to public safety.

### 5A.2 CLASSES OF STRUCTURES, SYSTEMS AND EQUIPMENT

#### 5A.2.1 CLASS 1

Class 1 structures, systems, and equipment are those whose failure could cause uncontrolled release of radioactivity or those essential for immediate and long-term operation following a loss-of-coolant incident. When a system as a whole is referred to as Class 1, portions not associated with loss-of-function of the system may be designated as Class 2.

The following are typical Class 1 structures:

Containment structure shell

The auxiliary building below elevation 69'-0"

Enclosures for the critical service water pumps, critical salt water pumps, and auxiliary feedwater pumps

Supports for Class 1 system components.

Typical Class 1 equipment and systems are:

Reactor vessel and internals including control rods and control rod drives

Other primary coolant system components (steam generators, pressurizer, pumps, etc.,) and piping, including vent and drain piping inside the containment

Containment penetrations up to and including the first isolation valve outside the containment

Atmospheric dump and main steam safety valves and associated piping from main steam headers

Penetration room ventilation ducting.

Spent fuel storage racks

Auxiliary feedwater pump, condensate storage tank, and associated piping

Main emergency generator including fuel supply

Control boards, switchgear, load centers, batteries, and cable runs serving Class 1 equipment

Critical service water system

Critical salt water system

Containment structure spray system, including refueling water tank

Containment structure air cooling system

Low-pressure safety injection and shutdown cooling system

High-pressure safety injection system

Chemical and volume control system

Safety injection tanks and piping

Spent fuel pool purification system

All equipment in the radioactive waste processing systems except the reactor coolant and miscellaneous waste evaporators. (Failure of the evaporators has been assumed, and the resultant offsite dose was calculated. The dose was shown to be well below Part 100 limits with accident meteorology. Consequently, in accordance with Safety Guide 29, the evaporators are not required to be Seismic Class I.) 23|24

5.A.2.2 CLASS 2

Class 2 structures, systems, and equipment are those whose failure would not result in the release of radioactivity and would not prevent reactor shutdown. The failure of Class 2 structures, systems, and equipment may interrupt power generation.

## 5A.3 DESIGN BASES

### 5A.3.1 CLASS 1 STRUCTURE DESIGN

#### 5A.3.1.1 Normal Operation

For loads to be encountered during normal plant operation (including operating basis earthquake loads), Class 1 structures are designed in accordance with design methods of accepted standards and codes insofar as they are applicable.

#### 5A.3.1.2 LOCI, Seismic and Tornado Loads

The Class 1 structures are in general proportioned to maintain elastic behavior when subjected to various combinations of dead loads, thermal loads, LOCI loads, seismic and tornado loads. The upper limit of elastic behavior is considered to be the yield strength of the effective load-carrying structural materials. The yield

strength (Y) for reinforced concrete structures is considered to be the ultimate resisting capacity as calculated from the "Ultimate Strength Design" portion of the ACI-318-63 code when $\phi$ is taken as unity. Reinforced concrete structures are designed for ductile behavior whenever possible, i.e., with steel stresses controlling the design.

The final design of Class 1 structures (except the Containment Structure) satisfies the most severe of the following load combination equations.

$$Y \geq 1/\phi\ (1.25D + 1.0R + 1.25E)$$

$$Y \geq 1/\phi\ (1.25D + 1.25H + 1.25E)$$

$$Y \geq 1/\phi\ (1.0D + 1.0R + 1.0E')$$

$$Y \geq 1/\phi\ (1.0D + 1.0H + 1.0E')$$

The final design of the Containment Structure satisfies the following load combinations and factors (factored load cases):

$$Y \geq 1/\phi\ (1.05D + 1.5P + 1.0T_A + 1.0F)$$

$$Y \geq 1/\phi\ (1.05D + 1.25P + 1.0T_A + 1.25H + 1.25E + 1.0F)$$

$$Y \geq 1/\phi\ (1.05D + 1.25H + 1.0R + 1.0F + 1.25E + 1.0T_o)$$

$$Y \geq 1/\phi\ (1.05D + 1.25H + 1.0F + 1.25W + 1.0\,T_o)$$

$$Y \geq 1/\phi\ (1.0D + 1.0P + 1.0T_A + 1.0H + 1.0E' + 1.0F)$$

$$Y \geq 1/\phi\ (1.0D + 1.0H + 1.0R + 1.0E' + 1.0F + 1.0T_o)$$

(Wind, W, is to replace earthquake, E, in the above formulae where wind stresses control)

(0.90 D is used where dead load subtracts from critical stress in the above equations.)

However, limited yielding or erosion of barriers is allowable under load conditions including the design basis earthquake (E') and under jet or missile forces, provided the deflection is checked to ensure that the affected Class 1 systems and equipment do not suffer loss-of-function and the structure retains its required integrity.

Y = required yield strength of the structure.
D = dead load of structure and equipment plus any other permanent loads contributing stress, such as soil or hydrostatic loads. In addition, a portion of "live load" is added when such load is expected to be present when the plant is operating. An allowance is also made for future permanent loads.

R = force and/or pressure on structure due to rupture of any one pipe. 16
H = force on structure due to thermal expansion of restrained pipes under operating conditions.
E = operating basis earthquake load.
E'= design basis earthquake load.
W = tornado wind load.
P = LOCI pressure load.
F = final prestress load.
$T_A$ = thermal load due to the incident temperature gradient through the wall and expansion of the liner. It is based on a temperature corresponding to the factored LOCI pressure.
$T_o$ = thermal load due to the normal operating temperature gradient through the walls.

$\phi$ = yield capacity reduction factor as follows:

0.90 for reinforced concrete in flexure.

0.85 for tension, shear, bond, and anchorage in reinforced concrete.

0.75 for spirally reinforced concrete compression members.

0.70 for tied compression members.

0.90 for fabricated structural steel.

0.90 for unprestressed reinforcing steel in direct tension.

0.95 for prestressed tendons in direct tension.

The Containment Structure and engineered safety systems components are protected by barriers from all credible missiles which might be generated from the primary system during a LOCI.

The final design of the missile barrier and equipment support structures inside the containment were reviewed to assure that they can withstand applicable pressure loads, jet forces, pipe reactions and earthquake loads without loss-of-function. The deflections or deformations of structures and supports were checked to assure that the functions of the containment and engineered safety features are not impaired.

5A.3.1.3 Tornado Forces

Class 1 structures are designed to resist the effects of a tornado. These structures are analyzed for tornado loading (not coincident with LOCI or earthquake) on the following basis:

a. Differential bursting pressure between the inside and outside of the containment structure is assumed to be 3 pounds per square inch positive pressure.

(Rev. 10/20/72)

b. Lateral force is assumed as the force caused by a tornado funnel having a peripheral tangential velocity of 300 mph and a forward progression of 60 mph. The applicable portions of wind design methods described in ASCE Paper 3269 are used, particularly for shape factors. The provisions for gust factors and variation of wind velocity with height do not apply.

c. Torsion on the containment structure is computed from the drag on a cylinder resulting from a 300 mph rotary wind centered over the structure.

d. A tornado driven missile equivalent to a 4000 pound automobile flying through the air at 50 mph and at not more than 25 feet above the ground or a 4 inch by 12 inch by 12 ft. long piece of wood traveling end-on at 300 mph at any height.

Except for local crushing at the missile impact area, the allowable stresses to resist the effects of tornadoes are 90 percent of the yield of the reinforcing steel and 85 percent of the ultimate strength of the concrete.

5A.3.1.4 Seismic Forces (E and E')

AEC publication TID 7024, "Nuclear Reactors and Earthquakes," is used as the basic design guide for seismic analysis.

The "operating basis earthquake" used for this plant is a maximum ground acceleration of 0.08g horizontally and 0.053g vertically, acting simultaneously. The "design basis earthquake" is a ground acceleration of 0.15g horizontally and 0.10g vertically, acting simultaneously. The maximum stresses at a particular location resulting from the simultaneously occurring vertical and horizontal accelerations are added directly with stresses developed from other load conditions.

Seismic loads on structures, systems, and equipment are determined by realistic evaluation of dynamic properties and the accelerations from the acceleration spectrum curves in Section 2.

| | % Critical Damping (translational) | |
|---|---|---|
| | "Operating Basis Earthquake" (E) | "Design Basis Earthquake" (E') |
| Welded steel plate assemblies | 1 | 1 |
| Welded steel framed structures | 2 | 2 |
| Bolted or riveted steel framed structures | 2.5 | 2.5 |
| Reinforced concrete equipment supports | 2 | 3 |
| Reinforced concrete frames and buildings | 3 | 5 |
| Prestressed concrete structures | 2 | 5 |
| Steel piping | 0.5 | 0.5 |
| Soil | 2 | 3 |

4.28 QUESTION

Identify the method of seismic analysis (modal analysis, response spectra, modal analysis time history, equivalent static load, or empirical test analysis) that was employed in the design of Class I (seismic) system, components and structures other than the Containment Structure.

ANSWER

1. Class I (seismic) structures:

A complete dynamic analysis, including soil structure interaction, similar to the containment structure, was performed on each Class I (seismic) structure. The method used to determine the seismic response resulting from the Operating Basis and Design Basis Earthquake is described in Sections 2.6.5 and 5.1.3.2.b of FSAR. | 9

2. Equipment, systems and components:

The analysis of Class I (seismic) equipment, systems and components located at various levels of the structures, were performed by modal analysis floor response spectra method.

The floor response spectra curves were generated by subjecting the building model to the selected base excitation, then determining the maximum response of a single degree of freedom system, of varying natural period of vibration and for several values of damping, at each floor elevation.

Rev. 4/25/72

4.33 QUESTION

With respect to seismic design criteria for piping and equipment, the use of static coefficients alone may not adequately account for structural amplification and the response of flexible components. Provide the bases for the value chosen and justification for the use of static design analysis by demonstrating the results thus obtained are conservative when compared with the results delivered by the application of an appropriate multi-degree-of-freedom system analysis.

ANSWER

For the design of Class I (seismic) piping and equipment, coefficients were based on the floor response spectrum curves. These curves were generated using the time history technique for both horizontal and vertical direction, for various damping values, and at designated floor elevations in the Class I (seismic) structures. This time-history method is based on a dynamic analysis of muti-degree-of-freedom system.

The use of these curves for Class I (seismic) piping and equipment is explained in our response to Questions 4.34.1 through 4.34.3.

4.34 QUESTION

Submit the basis for the method used to determine the possible combined horizontal and vertical amplified response loadings for the seismic design of structures, systems and components including the following:

4.34.1 The possible combined horizontal and vertical response loading for seismic design of the structure and floors.

ANSWER

The response of the structure and floors to the design basis and operating basis earthquake was computed using the response spectrum technique. This method, described in Section 5.1.3.2b of FSAR, computes the horizontal response in the direction that will give maximum stresses.

For the response of the structure in vertical direction, the structure was reduced into one-degree system.

The responses (shears, moments, and inertia forces) in both vertical and horizontal direction were combined to produce maximum loading on the structures or portions of the structures.

A multi-mass and multi-degree of freedom analysis was the original intent for determining the response of Class I structures in the vertical direction. However, the thick concrete members of the Class I structures produced a large extensional stiffness of the members in the vertical direction, with respect 9 to the relatively lower soil stiffness, hence resulting in a singular flexibility matrix for such a multi-degree of freedom system. An investigation showed that the vertical degrees of freedom were constrained, that is, they moved approximately the same amount at the same time. Thus all the constrained vertical degrees of freedom were reduced into one independent vertical degree of freedom for the structure.

4.34.2 QUESTION 6

The possible combined horizontal and vertical amplified response loading for the seismic design of equipment and components, including the effect of the seismic response of the structures and floors.

ANSWER

The spectrum response curves, for Class I (seismic) equipment and components, were generated using the time-history technique of seismic analysis. 6 These curves were generated for two horizontal directions (North-South and East-West) and for the vertical direction, using various damping values at designated floor elevations in the structures.

The following was included in the analysis of all Class I (seismic) 10 equipment for their seismic design:

a. Determine which response curve is applicable, using information from the specification concerning equipment location, and the appropriate damping value.

b. Evaluate the natural frequency (frequencies) of the equipment in both horizontal and vertical directions. The horizontal frequency (frequencies) shall be computed in the direction that will give the highest stresses.

c. Utilizing the natural frequency (frequencies) enter the applicable spectrum response curve to read the maximum response acceleration.

d. For equipment and systems modeled as multi-degree systems, the acceleration per mode shall be combined by the normal mode method. We have examined the effect of adding closely spaced modes linearly and find that allowable stress levels are not 12 exceeded.

e. The horizontal and vertical seismic forces are equal to the mass of the equipment times the respective spectrum acceleration.

f. Both horizontal and vertical forces shall be applied simultaneously at the center of gravity of the equipment or at lumped mass point.

g. Seismic stresses shall be computed and combined with all other stresses that might exist in critical components.

h. Stresses from the Operating Basis Earthquake, when combined with normal operating stresses, shall be kept at or below the applicable code allowable stresses.

i. Stresses from the Design Basis Earthquake, when combined with normal operating stresses, shall be kept at or below yield strength of the material provided that no-loss-of function can occur.

j. For equipment, where analysis is not reliable, vibration tests shall be employed to verify the seismic adequacy of the equipment. The test procedure shall be submitted for approval.

4.34.3 QUESTION

The possible combined horizontal and vertical response loading for seismic design of piping, instrumentation, including the effect of the seismic response of the building, floors, supports, equipment, and components.

ANSWER

A multi-mass, response spectrum, modal analysis method was employed in the seismic analysis of Class I (seismic) piping including support systems and instrumentation. The natural frequencies and mode shape for the system were calculated, and the maximum response accelerations were determined using the appropriate spectrum response curves in the horizontal and vertical direction. The spectrum response curves are generated using the time-history of the floor, which includes the seismic response of the building. The horizontal and vertical seismic forces were applied simultaneously. Shear stresses, moments, and deflections were determined for the piping system and restraints. The load and stresses due to seismic loadings were assumed to be acting simultaneously with operating weights and longitudinal pressure loads. 6

4.34.3 QUESTION

The possible combined horizontal and vertical response loading for seismic design of piping, instrumentation, including the effect of the seismic response of the building, floors, supports, equipment, and components.

ANSWER

A multi-mass response spectrum model analysis method was employed in the seismic analysis of Class I (seismic) piping including support systems and instrumentation. The natural frequencies and mode shape for the system were calculated, and the maximum response accelerations were determined using the appropriate spectrum response curves in the horizontal and vertical direction. The spectrum response curves are generated using the time-history of the floor, which includes the seismic response of the building. The horizontal and vertical seismic forces were applied simultaneously. Shear stresses, moments, and deflections were determined for the piping system and restraints. The load and stresses due to seismic loadings were assumed to be acting simultaneously with operating weights and longitudinal pressure loads.

Used For AFW

LOADING COMBINATIONS
($2\frac{1}{2}$-inch and Larger Pipe)

| System Operating Condition | Loading Condition For Piping | Design Limits for Pipe Supports | Design Limits for Piping |
|---|---|---|---|
| Design | PD | ---- | $\frac{2SE\ (t_m - A)}{Do - 2y\ (t_m - A)}$ |
| Normal | a. PO + DW | AISC | $S_h$ |
| Upset | a. PO + DW + RVC<br>b. PO + DW + OBE + RVO | AISC | 1.2 $S_h$ |
| Faulted | a. PO + DW + SSE<br>b. PO + DW + SSE + RVO | AISC | $S_y$ |
| Thermal | $(S_E + E_Q)$ | ---- | $S_a$ |

Where:

PD = Design Pressure

PO = Operating Pressure

W = Piping Weight

OBE = Operational Basis Earthquake

SSE = Safe Shutdown Earthquake

RVC = Relief valve-closed system (transient)

$S_E$ = Thermal Expansion

$E_Q$ = Anchor Point Displacements

RVO = Relief Valve-Open System (Sustained)

$S_h$ = Allowable Stress @ operating temperature (B31.1.0, 1967)

$S_c$ = Allowable Stress @ ambient temperature (B31.1.0, 1967)

$S_a$ = (1.25Sc + 0.25Sh) (B31.1.0, 1967)

$t_m$ = Minimum required wall thickness in inches

$D_o$ = Outside diameter of pipe in inches

SE = Maximum allowable stress in material

A = Additional thickness to provide for mechanical strength of the pipe

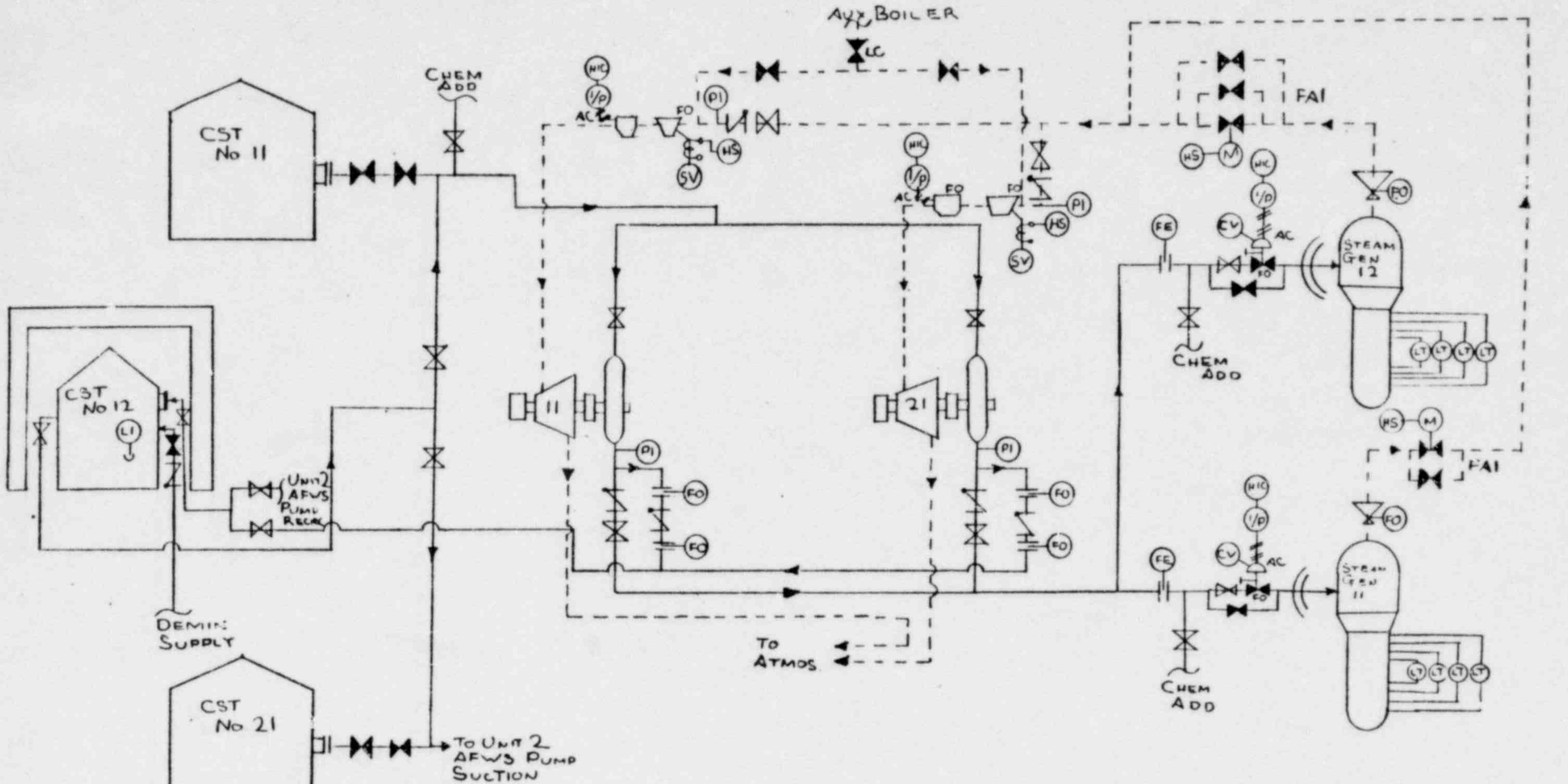
y = a coefficient having values given table 104.1.2(a)2 of B31.1.0, 1967

Attachment (B)

Comprising:

Auxiliary Feedwater System Schematic (1 page)

Key to Schematic (1 page)




KEY
— CONDENSATE LINE
-- STEAM LINE

NOTE: UNIT 2 SIMILAR

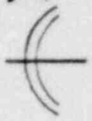
AUXILIARY FEEDWATER
SYSTEM SCHEMATIC, UNIT 1
(LEGEND ATTACHED)
CALVERT CLIFFS NUCLEAR
POWER PLANT

SHEET 1 OF 2 6/18/81

CST - CONDENSATE STORAGE TANK

 - NORMALLY OPEN VALVE

 - NORMALLY CLOSED VALVE

 - CONTAINMENT BUILDING PENETRATION

(PI) - PRESSURE INDIC TOR

(FO) - FLOW RESTRICTION

(FE) - FLOW NOZZLE

(I/P) - CURRENT TO PNEUMATIC

(HIC) - HAND INDICATOR CONTROL

(CV) - CONTROL VALVE

(M) - MOTOR

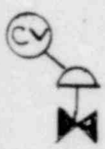
(HS) - HAND SWITCH

(LI) - LEVEL INDICATOR

(LT) - LEVEL TRANSMITTER

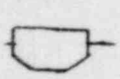
(SV) - SOLENOID VALVE

 - CHECK VALVE



- NORMALLY CLOSED ACTUATED CONTROL VALVE

 - TRAP

 - TURBINE CONTROL VALVE

FO - FAIL OPEN
FAI - FAIL AS IS
AC - AIR CLOSED

 - FLOW NOZZLE

AFWS SCHEMATIC
LEGEND, UNIT 1
CALVERT CLIFFS
NUCLEAR POWER
PLANT

SHEET 2 OF 2 6/18/81