5.6 OTHER STRUCTURES

5.6.1 AUXILIARY BUILDING

5.6.1.1 General Description

General plans at various elevation and sections through the Auxiliary Building are shown in Figures 1-5 through 1-16 in Chapter 1.

The Auxiliary Building is primarily a reinforced concrete structure and the mat foundation supports a structural steel and reinforced concrete frame which consists mainly of reinforced concrete walls and floors. On the top structure and over the fuel handling area is a secondary steel frame structure with missile resistant concrete walls and roof, which houses the Spent Fuel Cask Handling Crane.

Facilities related to the Nuclear Steam Supply System which are located in the Auxiliary Building include:

a. New and spent fuel handling, storage and shipment (spent fuel pool, bottom at el. 30'0" and new fuel racks at el. 69'0")
b. Control Room (Elevation 45'0")
c. Waste Processing System
d. Chemical Addition and Sampling System
e. Component Cooling System
f. Part of the Containment Structure Spray System
g. High and Low Pressure Injection Systems
h. Spent Fuel Cooling System
i. Electrical Distribution System
j. Chemical and Volume Control System

During the week of May 8, 1969, part of the concrete for the Auxiliary Building walls was pumped through aluminum pipe (Figure 5-17). During the week of August 15, 1969, 20% of concrete pour No. C-5.5a, i.e., for the base slab, Containment Structure, Unit 1, was also pumped through aluminum pipe. The area to which the concrete was pumped is shown in Figures 5-18 and 5-19.

Upon discovery, extensive tests were performed on the concrete, initially with the "Swiss Hammer," which indicated the average strength of the concrete to be above 5000 psi, for walls in the Auxiliary Building. The design strength of the concrete for the walls of interest in the Auxiliary Building and for the base slab in the Containment Structure is 4000 psi. Five cores were taken from the above walls for further testing. These tests indicated the minimum strength of concrete to be 4727 psi and maximum strength 5583 psi.

Since the actual calculated stresses in the concrete are well below allowable stresses, and since the tests on concrete pumped through aluminum pipe in the Auxiliary Building indicate that the strength of the concrete is well above the design strength of 4000 psi, it is evident that the concrete pumped through aluminum pipe, in the base slab of the Containment Structure Unit 1, and in the Auxiliary Building wall, is structurally adequate.

5.6.1.2 Design

The areas of the building housing the above facilities have been designed for the loads and conditions as shown in Table 5-6, the reinforced concrete design being in accordance with ACI 318-63 and the structural steel with AISC.

The spent fuel storage racks, located in the spent fuel pools, are designed for seismic loadings by considering the appropriate spectral acceleration for a 2% damping. The racks support the fuel element assemblies at the bottom, maintaining a center to center distance of 10.09". A 3/16", solid stainless steel liner plate was used on the inside face of both pools for leak tightness, and all of the field welds have leak-test channels welded to the outer side of the liner plates. The channels are grouped into 10 zones, each with its own detector pipe to localize leaks in the liner seams. Access from one pool to the other is provided by an opening in the central dividing wall, which may be closed by the use of stainless steel bulkhead gates.

5.6.1.3 Tornado Protection In Spent Fuel Area

In addition to all other loads including OBE and SSE, the steel-framed structure over the spent fuel pool is designed to resist tornadoes and horizontal missiles without partial or complete collapse, except for the west wall. A study indicates that the possibility of horizontal tornado missiles impacting the spent fuel pool from the west side is remote. Two foot thick concrete for missile protection is provided in the roof and the north, east, and south walls.

Since the steel-framed structure is designed to resist tornadoes with all other load combinations as listed in Table 5-6 and the cask handling crane is supported by the steel-framed structure, the cask handling crane will not be damaged during the tornado loading.

5.6.1.4 Fuel Pool Floor Design Criteria

The following design criteria were used in the analysis of the fuel pool floor to withstand the effect of a fuel cask drop.

a.	Weight of the Cask in air	50 kips
b.	Length of the Cask	16' 1-1/2"
c.	Diameter of the Cask	2'0"
d.	Distance Traveled (During Accidental Drop)	
	1. Free Fall in air	3'6"
	2. In water	39'0"
e.	Water density	62.4 lbs/ft^3
f.	Strength of Concrete ($f_c{}'$) (based on cylinder tests)	4150 psi
g.	Modulus of Elasticity (Ec) ($3.1x10^6$ psi)	$4.46x10^5$ k.s.f.
h.	Maximum Acceleration	290 g's

Determining the striking velocity at collision involves evaluating the velocity change due to missile weight, geometry of the missile, the buoyant force, and the drag force. In the above determination, the drag coefficient (Cd) was assumed to be unity.

In the evaluation of a structure due to missile impact, both the penetration criteria and structural response characteristics must be reviewed. The penetration of the cask missile into the concrete pool floor was evaluated by the use of the Modified Petry Formula. The Ballistic Research formula was used to check against perforation. The dynamic response was evaluated by calculating the ductility ratio of the elastic-plastic system response to a triangular pulse impact force-time history.

5.6.1.5 Conclusion of The Cask Drop Analysis

Analysis of the floor of the fuel pool indicates that the spent fuel pool bottom is capable of safely withstanding the impact of the accidental drop of the cask. Cracks will be developed by diagonal tension near the support but they will be of microscopic type considering the shear stresses. The structural integrity of fuel pool bottom will not be impaired.

In 1980, a reanalysis of this accidental drop using more conservative parameters also indicated that the truck cask drop did not impair the structural integrity of the fuel pool bottom.

In 1992, the spent fuel cask handling crane was upgraded to single-failure proof to allow use of the NUHOMS transfer cask for transfer of spent fuel from the spent fuel pool to the Independent Spent Fuel Storage Installation dry storage facility. The single-failure-proof crane, designed to meet requirements of NUREG 0554, provides the primary plant protection against a cask drop accident.

In addition to the crane upgrade, an energy absorbing cask platform was installed in the cask pit area of Unit 1 for further protection against crane drive train failure. The structural integrity of the fuel pool bottom will not be impaired in the unlikely event of a crane drive train failure in the cask pit area.

5.6.1.6 Thermal Stresses in The Spent Fuel Pool Walls

The maximum thermal stresses developed in the spent fuel pool walls under the most adverse conditions will be in the range of 950 psi, compressive, and in the range of 7500 psi, tension, in the reinforcing steel. Reinforcing steel is provided in the floor and both faces of the fuel pool walls to accommodate these thermal stresses.

5.6.2 INTAKE STRUCTURE

5.6.2.1 General Description

The intake structure is situated to the east of the main plant and is primarily a reinforced concrete structure, founded on a slab varying in Elevation from -26'0" to -14'3". It houses 12 circulating water pumps supplying water from the Chesapeake Bay to the condensers, located under the turbine generators, and to 6 saltwater pumps. To protect the condensers from foreign bodies present in the Bay water, trash racks and traveling water screens are provided. Vertical guides are provided down the sides of each intake channel to receive stop-logs. Running the full length of the structure is a gantry crane having a lifting capacity of 35 tons. Design features and administrative controls are in place to minimize the probability of a load drop from the gantry crane. A description of our means of controlling heavy loads is presented in Section 5.7.

Water from the traveling water screens flows through a separate fish collection and holding structure/facility constructed to allow for environmental aquatic studies.

5.6.2.2 Design

The Intake Structure has been designed for the loads and conditions as shown in Table 5-7. The reinforced concrete structure is designed in accordance with ACI 318-63 and the structural steel with AISC. All of the structural concrete is a 4000 psi mix at 28 days, and the reinforcement is in accordance with ASTM A615, Grade 60. The total length of the structure is divided into three sections above the base slab by two expansion joints. The high level roof at Elevation 28'6" is comprised of a reinforced concrete slab supported on a structural steel frame. Within this roof are access covers to each of the saltwater and circulating water pumps. The concrete structure design conforms to Seismic Category I requirements.

To prevent wave runup overtopping of the pump room wall, an adverse slope was constructed at the top 5' of the structure (Section 2.8.3.6).

SECURITY RELATED INFORMATION WITHHELD
UNDER 10 CFR 2.390

5.6.3 TURBINE BUILDING

5.6.3.1 General Description

The building, comprising the turbine generator bays and the heater bays, is an integrated steel structure, with metal siding, supported on reinforced concrete foundations. The circulating water intake and discharge conduits are incorporated into the spread footings. Turbine generator Units No. 1 and 2 are separated by expansion joints from their respective superstructures. Also, Unit Nos. 1 and 2 Turbine Building Superstructures are separated by an expansion joint.

5.6.3.2 Design

The building is a Seismic Category II structure designed as described in Appendix 5A, except that the auxiliary feedwater pump enclosure is Seismic Category I. All of the structural steel columns, beams, and roof trusses of the building have been designed as independent members and in accordance with the AISC "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings," 1963 Edition.

Two bridge cranes, a 200-ton unit and a 40-ton radio-controlled unit, are located in the turbine generator section of the building.

The two turbine generators are mounted on their own concrete pedestals which project up through the building to the operating deck at Elevation 45.0'.

5.6.4 SERVICE BUILDING

5.6.4.1 General Description

The building is situated between the Turbine Building and the intake structure and accommodates a warehouse, lube oil room and water treatment area at Elevation +12.0’ and office space and a machine shop at Elevation +45.0’. It is primarily a structural steel frame supporting a reinforced concrete floor slab. At Elevation 45', part of the warehouse is covered by a roadway and parking area. The structural steel columns are supported by reinforced concrete piers.

5.6.4.2 Design

The structural steel members are designed as a continuous frame across the width of the building in an east-west direction, all being fabricated from ASTM A36 steel. The floors are made with 3000 psi concrete and ASTM Grade 40 reinforcement.

The entire building falls into a Seismic Category II category for design as described in Appendix 5A.

5.6.5 SAFETY-RELATED DIESEL GENERATOR BUILDING

5.6.5.1 General Description

The safety-related Diesel Generator Building is a three-story, reinforced concrete structure approximately 75' by 97' in plan, excluding the east end entry ports. The corners of the building are beveled 15' to increase the available area on the east and west wall elevations. This increased area will allow wall surfaces to function as baffle areas for building ventilation and radiator cooling and as structural shear walls. Exhaust ducts were installed over the east baffle areas in order to direct radiator exhaust vertically. This prevents design winds (100 mph) from interfering with radiator fan performance. The building is about 60' in height and is supported on mat foundations at grade with a partial basement in the area of the diesel generator pedestal. In addition, a one-story structure is provided on the east side of the building as missile protection for the main building entry and diesel generator area exhaust louver.

Additional safety-related Diesel Generator Building description is provided in Reference 1.

5.6.5.2 Design

The safety-related Diesel Generator Building structure is classified as Seismic Category I.

The safety-related Diesel Generator Building structure is designed for wind loadings resulting from 100 mph winds at 33' above the ground. The vertical velocity profiles and gust factors used in the design of the Diesel Generator Building are in accordance with the Standard Building Code, Subsection 1205.2 and American Society of Civil Engineers 7-88.

The safety-related Diesel Generator Building structure is designed for tornado-induced forces in accordance with Regulatory Guide 1.76, Revision 1, Standard Review Plan (SRP) Section 3.8.4 and "Tornado and Extreme Wind Design Criteria for Nuclear Power Plants," BC-TOP-3-A (Reference 2).

The tornado loadings used in the design are simultaneously applied as follows:

a. The velocity components on the safety-related Diesel Generator Building are applied as a funnel of wind traveling at 70 mph with a maximum tangential velocity of 290 mph. Therefore, the maximum effective wind velocity on any structure is 360 mph.

b. The tornado-induced pressure differential is applied as a 3 psi positive pressure within the safety-related Diesel Generator Building occurring in 1.5 seconds (2 psi per second) followed by a calm for two seconds and then a repressurization to atmospheric pressure at a rate of 2 psi per second.

c. The safety-related Diesel Generator Building is designed for missile impingement as shown in Table 5-8. A vertical velocity of 70% of the postulated horizontal velocity shall be considered acceptable for all missiles except for steel rods. A steel rod missile's vertical velocity is assumed to be equal to the horizontal velocity.

The safety-related Diesel Generator Building roof load was conservatively estimated using the Probable Maximum Snowfall saturated with residual rainfall. Therefore, based on the absence of parapets on the east and west sides of the Diesel Generator Building roof and a roof slope of 2%, the design roof loading due to the 100-year snow pack and the Probable Maximum Snowfall with residual rainfall was estimated as 70 psf.

The concrete structures and components are designed in accordance with the strength design methods of ACI-318 and ACI-349, using the load combinations specified in Reference 1. The structural steel design is based upon the AISC "Specification for Structural Steel Buildings, Allowable Stress Design and Plastic Design." Welding of structural steel was performed in accordance with the Structural Welding Code AWS D.1.1.

Regulatory Guide 1.60, Revision 1, design response spectra, anchored at the high frequency end at 0.15 g and 0.10 g for the SSE horizontal and vertical design motions, respectively, and at 0.080 g and 0.053 g for the OBE horizontal and vertical design motions, respectively, have been adopted for the design of the safety-related Diesel Generator Building. The peak horizontal ground acceleration for the OBE and SSE are 0.08 g and 0.15 g, respectively. The maximum vertical acceleration is defined as two-thirds of the maximum ground acceleration. The three synthetic time histories, developed for each of the three components of the earthquake, comply with the SRP acceptance criteria for total duration, strong motion duration, power spectral density enveloping, and response spectra enveloping.

The damping values used in the seismic analysis of the Diesel Generator Building and associated structures, systems, and components are provided in Table 5-9. Damping values given in Table 5-9 are in compliance with Regulatory Guide 1.61 with the following exceptions:

a. When cable trays are loaded to 100% of their maximum capacity, their damping value is 15%.
b. A damping value of 7% of critical is assumed for conduit at 100% maximum capacity.

These values were justified based on the testing of cable tray and conduit systems. Testing of these systems (Reference 3), demonstrated that a substantial amount of energy was dissipated by friction between cables and by friction between cables and the cable tray.

c. In lieu of damping values for piping identified in Table 5-9, ASME, B&PV Code, Section III, Division I, Code Class 3 piping systems, ASME Code Case N-411 damping values may be used. This method, which is preferred in most cases, permits the use of Code Case N-411 variable damping with a three dimensional spectra input (two horizontal and one vertical earthquake responses combined by the SRSS method). If this method is adopted, the spectra curves are enveloped curves with 15%

peak broadening. In addition, the modal combinations specified in Regulatory Guide 1.92, Revision 1, will also be used. Furthermore, the zero period acceleration effects shall be combined with inertia effects by the SRSS or CMSRS method. Use of the multiple zone response spectra is prohibited when Code Case N-411 damping is used. The use of Code Case N-411 damping was restricted as specified in Regulatory Guide 1.84 (Reference 4).

The loads considered during the design of the safety-related Diesel Generator Building are normal loads, severe environmental loads, extreme environmental loads and abnormal loads. Cumulative loads from the heating, ventilation and air conditioning system, conduit, cable trays, and pipe supports are considered in the design of major structural components.

Normal Loads

Normal loads are those loads encountered during normal plant operation and shutdown. These loads include:

Dead Loads or their related internal moments and forces, including any permanent equipment loads. Vertical and lateral fluid loads imposed upon the fuel oil tank enclosure, due to a tank rupture, shall be treated as a dead load.

Required section strength to resist design loads based on the strength design methods of ACI 318 and ACI 349.

Required section strength based on elastic design methods and allowable stresses defined in Part 1 of the AISC "Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings."

Live loads or their related internal moments and forces, including any movable equipment loads or other loads which vary with intensity and occurrence, such as soil pressure. Seismic or tornado load cases containing L substitute the operating live load term L_o, which is defined as the live load expected during normal plant operations. The term L_o is taken as 0.25 L or the actual weight of the equipment spread on the floor, whichever is larger. In laydown areas, the actual weight of the equipment spread out on the floor shall be considered as L_o. Snow loads were also considered as live loads in the design of the Diesel Generator Building. No reduction in live load (L_o) is taken for snow loads.

Thermal effects and loads during normal operating or shutdown conditions, based on the most critical transient or steady state condition.

Pipe reactions during normal operating or shutdown conditions, based on the most critical transient or steady state condition.

Severe Environmental Loads

Severe environmental loads are those loads infrequently encountered during plant life. Included in this category are:

Loads generated by the OBE. These include associated hydrodynamic and dynamic incremental soil pressures.

Loads generated by the design wind specified for the structure.

Extreme Environmental Loads

Extreme environmental loads are those loads that are credible but highly improbable. These loads include:

Loads generated by diesel engine/generator set missiles.

Loads generated by the safe shutdown earthquake.

Loads generated by the design tornado. Tornado loads include loads due to the tornado wind pressure (W_w), the tornado-created differential pressure (W_p), and tornado-generated missiles (W_m).

Abnormal Loads

Abnormal loads are those loads generated by a postulated high- or moderate-energy pipe break accident within the building. High- and moderate-energy pipe breaks are defined by Branch Technical Position SPLB 3-1, SRP 3.6.1 and SRP 3.6.2. The Diesel Generator Building structure provides physical separation of high- and moderate-energy systems and components of the redundant diesel generator train.

5.6.6 STATION BLACKOUT DIESEL GENERATOR BUILDING

5.6.6.1 General Description

The Station Blackout (SBO) Diesel Generator Building is a two-story structure with a basement and a penthouse. The building measures approximately 70’ by 75’ and is about 40’ high. Reinforced concrete is used for the foundation mat, diesel generator pedestal, and basement walls. Structural steel is used for the columns, floor beams, and other supporting members. A composite slab is used for the floor framing. Metal decking is used for the roof, and insulated metal siding is used for exterior walls.

5.6.6.2 Design

A requirement by NUMARC 87-00 is that alternate AC power systems and components and required subsystems must be located within a structure meeting, as a minimum, the Uniform Building Code (UBC) requirements. The UBC equivalent design code of record for the plant area is the Standard Building Code. As required by the Standard Building Code, likely weather-related external events are considered in the design of the SBO Diesel Building. The SBO building is designed with roof metal decking and metal wall siding that will deform or blow out to reduce the potential for high-pressure buildup due to a sudden pressure drop as a result of a tornado. Miscellaneous equipment related to the SBO Diesel Generator mounted outdoors, or on the roof of the SBO Diesel Generator Building, which could exceed the parameters for a Spectrum II tornado missile (as defined by SRP 3.5.1.4, Revision 2) is anchored to resist tornado wind loads. By these means, the potential for large missiles is greatly mitigated, and no tornado missile originating from the SBO Diesel Building will threaten the integrity of the adjacent safety-related Diesel Generator Building.

The acceptance criteria of SRP Section 3.7.2 require interfaces between Category I and non-Category I structures to be designed for dynamic loads and displacement produced by both the Category I and non-Category I structures. In order to prevent a structural failure and impact on the adjacent Safety-related Diesel Generator Building, the main girders, columns, and bracing for the SBO Diesel Generator Building have been analyzed to demonstrate that the building will not collapse under design basis earthquake loads. The seismic displacements of both the Category I Diesel Generator Building and the SBO Diesel Generator Building were calculated, and a seismic gap was sized to prevent structure-to-structure interaction between the buildings. Additional information regarding the design of the SBO Diesel Generator Building is provided in Reference 5.

5.6.7 REFERENCES

1. Letter from R. E. Denton (BGE) to NRC Document Control Desk, dated December 18, 1992, Emergency Diesel Generator Project-Civil Engineering Design Report

2. Topical Report, BC-TOP-3A, Revision 3, Tornado and Extreme Wind Design Criteria for Nuclear Power Plants, Bechtel Power Corporation, San Francisco, California, August 1974

3. Anco Engineers, Inc., Cable Tray and Cable Raceway Seismic Test Program, Release 4 (Report 1053-21.1-4), dated December 15, 1978

4. Regulatory Guide 1.84, Design and Fabrication Code Case Acceptability – ASME Section III, Division 1, Revision 30, October 1994

5. Letter from R. E. Denton (BGE) to NRC Document Control Desk, dated March 7, 1994, AAC Power Source Design Report

TABLE 5-6

AUXILIARY BUILDING LOADS AND CONDITIONS

AREA	CLASS
Control Room	A.B.C.D.E.
Cable Spreading Room	A.B.C.D.E.
Electrical Equipment Rooms	A.B.C.D.E.
Spent Fuel Pool	A.D.
Spent Fuel Storage Racks	D.F.
Spent Fuel Cask Handling Crane	A.B.D.
Piping Penetration Room Frames	A.D.
Hot Machine Shop	A.D.

Key

A. All normal dead, equipment, live, and wind loads due to 90 mph wind.

B. Normal dead, equipment, live, and tornado wind load due to 300 mph wind.

C. Horizontal tornado missiles of (1) a 4000 lb automobile traveling at 50 mph up to a height of 25' in the air and (2) a wooden plank 4"x12"x12' long traveling end on at a velocity of 300 mph at any height.

D. Normal dead and equipment loads, plus SSE loads.

E. Turbine generator missile.

F. Normal dead load, live load, and equipment loads.

TABLE 5-7

INTAKE STRUCTURE LOADS AND CONDITIONS

CLASSIFICATION

	Seismic Category
Circulating Water Pumps	II
Saltwater Pumps	I
Concrete Structure	I

LOADING CONDITIONS

Area Description	Loading Designation
Floors - Slab @ E1 +10'0"	D.E.F.
Slab @ E1 +28'6"	D.E.
Well Walls	D.F.
Pump Room Walls	A.B.C.D.F.

Key

A. All normal dead, equipment, live, and wind loads due to a 90 mph wind.

B. Normal dead, equipment, live, and tornado wind load due to 300 mph wind.

C. Horizontal tornado missiles of (1) 4000 lb automobile traveling at 50 mph up to a height of 25' in the air, and (2) wooden plank 4"x12"x12' long traveling end on with a velocity of 300 mph at any height.

D. Normal dead and equipment loads plus SSE loads.

E. Normal dead load, live load and equipment loads.

F. Live loads from wave run-up.

TABLE 5-8

DESIGN BASIS TORNADO MISSILES

MISSILE	MASS (Kg)	DIMENSIONS (m)	VELOCITY (m/s)
Wood Plank	52	0.092 x 0.289 x 3.66	83
6” Schedule 40 pipe	130	0.168D x 4.58	52
1” Steel Rod	4	0.0254D x 0.915	51
Utility Pole	510	0.343D x 10.68	55
12” Schedule 40 pipe	340	0.32D x 4.58	47
Automobile	1,810	5 x 2 x 1.3	59

TABLE 5-9

DAMPING VALUES FOR THE 1A DIESEL GENERATOR SEISMIC CATEGORY I STRUCTURES, SYSTEMS, AND COMPONENTS

(Percent of Critical Damping)[(a)]

STRUCTURE OR COMPONENT	OBE	SSE
Equipment and large-diameter piping systems[(b)(c)] (pipe diameter > 12 inches)	2	3
Small-diameter piping systems[(c)] (pipe diameter ≤ 12 inches)	1	2
Welded steel structures	2	4
Bolted steel structures	4	7
Reinforced concrete structures	4	7
Electrical cable trays, conduits and supports	15 for Cable Tray 7 for Conduit	15 for Cable Tray 7 for Conduit
Sloshing fluid[(d)]	0.5	0.5

(a) Damping values for foundation material and for foundation structure interaction analysis are not included in this table.

(b) This includes both material and structural damping. If the piping system consists of only one or two spans with little structural damping, the values for small diameter piping are used.

(c) In lieu of these values, for ASME B&PV Code, Section III, Division I, Code Class 3 piping systems, the damping values provided in the Civil Design Report for the Emergency Diesel Generator Project may be used per Code Case N-411.

(d) These damping values are applicable to the horizontal sloshing of oil in the fuel oil storage tank.