**From:** Norman Cohen <ncohen12@home.com>
**To:** Robert Fretz <RXF@nrc.gov>
**Date:** Wed, Jan 9, 2002 5:53PM
**Subject:** [Fwd: Aircraft]

Attached are comments from David Lochbaum and excepts of the Salem SER's. Please add this to our 2.206 letter.

--
Coalition for Peace and Justice and the UNPLUG Salem Campaign; 321 Barr Ave., Linwood, NJ 08221; 609-601-8537 or 609-601-8583 (8583: fax, answermachine); ncohen12@home.com UNPLUG SALEM WEBSITE: http://www.unplugsalem.org/ COALITION FOR PEACE AND JUSTICE WEBSITE: http:/www.coalitionforpeaceandjustice.org The Coalition for Peace and Justice is a chapter of Peace Action.

"First they ignore you; Then they laugh at you; Then they fight you; Then you win. (Gandhi)
"Why walk when you can fly?" (Mary Chapin Carpenter)

**Mail Envelope Properties** (3C3CC9F5.CE0 : 16 : 36064)

**Subject:** [Fwd: Aircraft]
**Creation Date**: Wed, Jan 9, 2002 5:45PM
**From:** Norman Cohen <ncohen12@home.com>

**Created By:** ncohen12@home.com

**Recipients**
nrc.gov
owf4_po.OWFN_DO
RXF (Robert Fretz)

| **Post Office** | **Route** |
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| owf4_po.OWFN_DO | nrc.gov |

| **Files** | **Size** | **Date & Time** |
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| MESSAGE | 640 | Wednesday, January 9, 2002 5:45 PM |
| Mail | | |
| Mime.822 | 84947 | |

**Options**

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| **Expiration Date:** | None |
| **Priority:** | Standard |
| **Reply Requested:** | No |
| **Return Notification:** | None |
| **Concealed Subject:** | No |
| **Security:** | Standard |

**From:** "Dave Lochbaum" <dlochbaum@ucsusa.org>
**To:** <pgunter@nirs.org>
**Date:** Fri, Sep 14, 2001 12:34PM
**Subject:** Aircraft

From Section 2.2 fo the NRC's Safety Evaluation Report for the Salem Generating Station:

"The nearest commercial airport is The Greater Wilmington Airport which is located 21 miles north-northwest of the site. We have reviewed the matter of airport proximity to nuclear power plants in the Shoreham Nuclear facility licensing case. On the basis of this study, we have concluded that the Salem site is sufficiently far from an airport of significant size that the probability of a crash is essentially that associated with general overflights and that the Salem facility need not be designed or operated with special provisions to protect the facility against the effects of an aircraft crash."

From Section 3.5 of the NRC's Safety Evaluation Report for the Salem Generating Station:

"Safety related structures and equipment have been designed and constructed to withstand the effects of tornado generated missiles. Among these structures are the auxiliary building, the control room, the containment, and the fuel handling building.

"The critical missile assumed by the applicants in their design is a 40 foot, 12 inch diameter wooden utility pole weighing 50 pounds per cubic foot and moving with a velocity of 150 mph. The modified Petry formula was used to determine the minimum depth of reinforced concrete required.

"A spectrum of interior missiles has also been considered in the design of safety related equipment and structures. The applicants used the modified Petry formula to determine missile penetration.

"The criteria used in the design of Category I structures, to account for the loading due to specified missile impacts postulated to occur at the facility site, provide a conservative design basis for determining the forces on the structure to assure that such impact forces will not penetrate structures, shields and barriers beyond acceptable limits as governed by the strength and resistance offered by such structures, shields, and barriers. We have concluded that conformance with these design loading criteria is an acceptable basis for satisfying AEC General Design Criteria Nos. 2 and 4."

Soooo, the Salem plant is NOT protected from an airplane hit unless the airplane weighs less than 1,571 pounds and flies less than 150 miles per hour.

The Salem SER sections are attached.

Thanks,

Dave

**CC:** <ncohen12@home.com>

**Mail Envelope Properties** (3C3CC9F5.CE1 : 17 : 36065)

**Subject:** Aircraft
**Creation Date:** Fri, Sep 14, 2001 12:34PM
**From:** "Dave Lochbaum" <dlochbaum@ucsusa.org>

**Created By:** dlochbaum@ucsusa.org

**Recipients**
home.com
ncohen12 CC

nirs.org
pgunter

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| | nirs.org |

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|---|---|---|
| MESSAGE | 2337 | Friday, September 14, 2001 12:34 PM |
| 2-0.ASC | 27632 | |
| 3-0.ASC | 29949 | |
| Header | 1265 | |

**Options**
**Expiration Date:** None
**Priority:** Standard
**Reply Requested:** No
**Return Notification:** None

**Concealed Subject:** No
**Security:** Standard

xsec:

# 2.0 SITE CHARACTERISTICS

## 2.1 Geography and Demography

The Salem Nuclear Generating Station, Units 1 and 2 is situated on a 700 acre site adjacent to the proposed Hope Creek Generating Station, Units 1 and 2 on the southern part of land referred to as Artificial Island in lower Alloways Creek Township, Salem County, New Jersey. The site is located on the east bank of the Delaware River, approximately 18 miles south of Wilmington, Delaware, 30 miles southwest of Philadelphia, Pennsylvania, and 7-1/2 miles southwest of Salem, New Jersey.

The site for the Salem Generating Station is located on 1500 acres of relatively flat land, which was formerly a natural bar in the Delaware River, and which has been connected to the mainland of New Jersey by a strip of dredged fill. The site, with an average elevation of about nine feet mean sea level (MSL) and a maximum elevation of about 18 feet MSL is characterized as tidal marshlands and low-lying meadowlands; these features are typical of the adjacent southern region of the Delaware River. The Delaware side of the river, approximately 2.5 miles from the reactor site, is similar to the New Jersey side, except that the tidelands and marshes are not as extensive.

The minimum exclusion distance, as defined by the applicants, is 3823 feet (1165 meters). Figure 2.1 shows the exclusion radius for the Salem site. The nearest residence is 2-3/4 miles west-southwest of the site. The nearest population center of 25,000 or more is Wilmington, Delaware (1970 population of 80,386) located 18 miles north



SEE HARD COPY FOR FIGURE

SALEM NUCLEAR GENERATING STATION, UNITS 1 & 2 SITE

FIGURE 2.1

of the site. Bridgeton, New Jersey, located 15.5 miles east of the site had a 1970 census report population of about 20,000. The closest densely populated area to the reactor facility is Salem, New Jersey, at a distance of 7-1/2 miles and with a 1970 population of 7,560. The applicants have defined a low population zone (LPZ) distance of five miles (8045 meters).

The area within five miles of the site, defined by the applicants as the low population zone, has a population of about 1500 (1970 census data). There are no schools or hospitals within the low population zone. The Odessa Elementary School, with an enrollment of 154 students, is the nearest school located in New Castle County, Delaware, 6.5 miles west of the site. Figure 2.2 shows the 1970 and predicted year 2010 cumulative population data for the site.

At the present time, the land surrounding the Salem facility is undeveloped. The southern end of the site is uninhabited. Portions of the site are used for farming and grazing rodeo stock during the summer months. The remainder of the site is covered with marsh grasses. A strip of land about one mile east of the site and extending from Alloways Creek to Hope Creek is owned by the United States Government. This land consists entirely of tidal marshes. Approximately 3-1/2 miles east of the site, the land is at an elevation suitable for farming and grazing.

The Delaware River in the vicinity of the site is used for barge and freighter traffic, boating, fishing, crabbing, and oystering. Because of salt water intrusion, industrial use of the Delaware River water 25



SALEM NUCLEAR GENERATING STATION, UNITS 1 & 2

CUMULATIVE POPULATION DISTRIBUTION

FIGURE 2.2

SEE HARDCOPY FOR FIGURE

miles upstream from the site is limited to cooling water applications. Potable water supplies in Salem County, New Jersey are obtained from ground water with some inland areas using surface water sources. There are three State Parks, two boating access areas, and five wildlife areas within 10 miles of the site. The closest State Park is Reedy Island, 3.5 miles north-northwest of the site.

On the basis of the 10 CFR Part 100 definitions of the population center distance, the exclusion area, and low population zone distance, our analysis of the onsite meteorological data from which atmospheric dilution factors were calculated (Section 2.3 of this report), and the calculated potential radiological dose consequences of postulated design basis accidents discussed in Section 15.0 of this report, we have concluded that the exclusion area radius and the low population zone distance are acceptable. The site meets the requirements of 10 CFR Part 20 with respect to the restricted area.

## 2.2 Nearby Industrial, Transportation, and Military Facilities

The Salem site is accessible by the Alloways Creek Neck Road, a New Jersey state secondary highway from Hancocks Bridge, New Jersey. On the western side of the river, Delaware Route 9 runs parallel to the river at a distance of approximately three miles inland.

On the basis of information presented in the FSAR, we have determined that there are no manufacturing plants, railways or military installations located within five miles of the Salem facility. The



nearest military facility is Dover Air Force Base which is located 20 miles south-southwest of the site.

Three turf airstrips are located within 10.5 miles of the site, the nearest of which is Salem Airport eight miles north-northeast. The nearest commercial airport is The Greater Wilmington Airport which is located 21 miles north-northwest of the site. We have reviewed the matter of airport proximity to nuclear power plants in the Shoreham Nuclear facility licensing case. On the basis of this study, we have concluded that the Salem site is sufficiently far from an airport of significant size that the probability of a crash is essentially that associated with general overflights and that the Salem facility need not be designed or operated with special provisions to protect the facility against the effects of an aircraft crash.

An area on the Delaware River about 1.5 miles northwest of the Salem site had originally been designated as an anchorage for vessels containing explosive cargo. However, in the context of our review of the Hope Creek Generating Station (Docket Nos. 50-354 and 50-355) to be located adjacent to the Salem facility, the applicants indicated in their response to the Regulatory staff's interrogatories dated April 11, 1974 that the anchorage will be relocated from its present position to approximately eight miles south of the Salem site. We have concluded that since the anchorage will be approximately eight miles away from the Salem facility, accidents involving the anchorage should not adversely affect safe operation of the Salem facility.

Commercial barge or freighter traffic on the Delaware River channel (1.5 miles west of the Salem site) was approximately 4700 vessels in 1970. To accommodate the remote possibility of a derelict shipping barge damaging the service water intake structure, the applicants during the construction permit review, modified the arrangement of the service water pumps in the intake structure. As a result of this modification, three pumps for each reactor will remain operable following damage to half of the intake structure. Three pumps are adequate to maintain the cooling requirements for vital systems and components required to safely shutdown the facility. The applicants also installed rubber bumper guards on the front face of the screen wall. This design arrangement was considered acceptable for the construction permit review.

Through subsequent investigations, the applicants have determined that some hazardous material shipments occur along the Delaware River in the vicinity of the facility. These shipments include liquified gases and a small amount of explosives. Because the water depth in the vicinity of the facility is not shallow enough to preclude the possibility of a barge, carrying explosives, from impacting the intake structure, the applicants have been requested to provide, for our review, an analysis of the probability of such an accident. We will review the analysis and will report the results of our evaluation in a supplement to the Safety Evaluation Report. This issue will be resolved prior to a decision concerning issuance of an operating license for Salem Unit 1.



## 2.3 Meteorology

The climate of the extreme southwest portion of New Jersey, with warm, humid summers and relatively mild winters, is characteristic of temperate climates considerably influenced by the presence of large bodies of water. The predominant air mass type over the area during the colder months of the year is continental polar of Canadian origin. During the warmest portion of the year, maritime tropical air masses with origins over the Gulf of Mexico predominate over the region. The proximity of Delaware Bay tends to moderate the extreme temperatures. Precipitation is rather uniformly distributed throughout the year, occurring as thundershowers during the summer and mainly as rain or snow from storm systems moving northward along the Atlantic Coast during the other seasons. High air pollution potential (atmospheric stagnation) is expected to exist, on the average, on four days during the year.

High wind occurrences in the site area are associated with severe thunderstorms or tropical storms and hurricanes. During the period 1955-1967, nine tornadoes were reported within the one degree latitude-longitude square containing the site, giving a mean annual frequency of 0.7 and a computed recurrence interval of 1870 years.* The plant site lies within the potential probable maximum Atlantic Hurricane Track. The prevailing wind over the area is from the west-northwest.

* The recurrence interval is computed by the method in the paper by H. C. S. Thom, "Tornado Probabilities."

An onsite meteorological measurements program was initiated in June 1969. The program consisted of the installation of and measurements from a 300-foot tower constructed on the site, 2700 feet north of the reactor complex. Wind direction and speed measuring instruments were located at the 30, 150, and 300-foot levels on the tower and temperature measuring instruments were located at the 30, 85, 100, and 300-foot levels.

The applicants have submitted a two year period of data record (June 1969 - May 1971) in joint frequency form, similar to that recommended in AEC Regulatory Guide 1.23 to provide a basis for the staff's evaluation of atmospheric diffusion conditions. For evaluation of the expected building and vent releases, the joint frequency distribution of wind speed and direction measured at the 30-foot level and vertical temperature difference (delta-T) between 150 and 30-foot levels was used. The joint data recovery during the two year period of record was 93 percent.

Utilizing standard staff practices, we evaluated the meteorological diffusion characteristics of the site for both accident analysis and routine release analysis purposes.

The evaluation of the calculated offsite doses resulting from radioactive releases due to postulated accidents requires calculations of the relative concentration (X/Q) for the first 30 days following an assumed accident. The impact of routine radioactive releases requires calculations of an annual average X/Q. These relative concentrations were then incorporated into dose analyses.



Accident dose analyses utilize calculated X/Q values which vary with time. The staff uses its most conservative assumptions when calculating the X/Q values for the first eight hours following an assumed accident. Additional credit is given for diffusion and spread of the gaseous plume for time periods beyond the first eight hours.

In our evaluation of diffusion rates for short term (0-2 hours at the site boundary and 0-8 hours at the low population zone boundary) accidental releases from the buildings and vents, a ground level release with a building wake factor of 800 square meters was assumed.
Our calculated results are (1) the X/Q for 0-2 hours that is exceeded five percent of the time was found to be 2.4 x 10-4 seconds per cubic meter at the exclusion radius of 3823 feet. (This X/Q is equivalent to dispersion conditions produced by Pasquill Type F stability with a wind speed of 1.5 meters per second.) (2) The X/Q for 0-8 hours that is exceeded five percent of the time was found to be 2.2 x 10-5 seconds per cubic meter at the outer boundary of the low population zone (five miles). The calculated X/Q values (in seconds per cubic meter), at the low population zone boundary, used in our estimates of long term accidental releases were found to be 3.9 x 10-6 for the 8-24 hours period, 1.4 x 10-6 for the 1-4 day period, and 2.8 x 10-7 for the 4-30 day period.

We have calculated the dose at the minimum exclusion radius at the end of the first two hours and the thirty day dose at the low population zone (five miles) and have determined that they meet the guidelines of 10 CFR Part 100 (see Section 15.0 of this report).

The applicants' X/Q estimates for accidental releases were about 50 percent more conservative than those of the staff. This difference is due to the applicants' choice of using AEC Regulatory Guide 1.4 meteorological conditions (which are generally more conservative than the measured conditions) to describe the dispersion characteristics of the site. We have concluded that the diffusion rates used in our calculations, based on meteorological data collected at the site, are acceptably conservative.

In our evaluation of the diffusion associated with estimating routine effluent releases, we have determined that the highest offsite annual average X/Q of 2.2 x 10-6 seconds per cubic meter (for vent releases) would occur at the east-southeast boundary of the reactor complex. This calculated value is more conservative by a factor of two than that of the applicants. This difference is attributed to the applicants' use of data for only a one year period of record (June 1969 - May 1970) and to the applicants' use of a mathematical model different from that of the staff.

We have concluded that the meteorological data presented in the FSAR provide an acceptable basis for making conservative estimates of atmospheric diffusion rates for accidental and routine gaseous effluent releases from the Salem facility.



## 2.4 Hydrology

### 2.4.1 Hydrologic Description

As discussed in Section 2.1 of this report, the Salem site is located on a land mass (referred to as Artificial Island) on the New Jersey shore of the Delaware Estuary above Delaware Bay. Natural ground at the site averages about elevation nine feet, MSL (U.S. Coast and Geodetic Survey Datum), but facility grade has been raised to approximately elevation 10.5 feet, MSL for flood protection purposes. Additional flood protection is provided by rock armored earthen dikes and seawalls fronting much of the site.

The Delaware Estuary begins at Trenton and extends 86 miles downstream to Delaware Bay at Liston Point, about three miles south of the Salem site. Average annual fresh water inflow to the estuary is about 12,000 cubic feet per second (cfs), but a peak tidal flow has been measured at 400,000 cubic feet per second. The normal daily tide range in the vicinity of the site is about 5.8 feet.

Although major precipitation-induced flooding occurs in the Delaware River Basin, maximum water level fluctuations in the vicinity of the site are caused by hurricanes from the southeast and by strong northwestern and northern winds. The highest tide recorded in the vicinity occurred in November 1955 and reached elevation 8.5 MSL. The lowest tide level is estimated to have reached elevation minus eight feet MSL and occurred an December 31, 1962.

2.4.2 Flood Potential

The potential for site flooding from precipitation events, hurricanes, and from combinations thereof has been investigated by the applicants and evaluated by the staff. Water levels at the site for a probable maximum flood (PMF), a probable maximum hurricane (PMH) surge, and coincident precipitation-type floods and hurricanes have been estimated. The applicants' evaluation of flooding events indicates that the most critical flood design basis for the site is the flooding that would occur as the result of a PMH. We have reviewed the applicants' evaluation of flooding events and concur with the applicants' conclusions.

The applicants estimated that the maximum stillwater resulting from a PMH is elevation 110.9 feet, Public Service Electric and Gas Company Datum (PSD), which is equivalent to elevation 21.9 feet MSL. We and our consultant, the Coastal Engineering Research Center (CERC) of the U. S. Army Corps of Engineers, did not consider this stillwater level to conservatively reflect PMH conditions. Our independent surge estimates, considering the complete range of PMH parameters coincident with the local high spring tide, resulted in an estimated maximum stillwater at elevation 113.8 feet, PSD (24.8 feet, MSL) with maximum wave runup to elevation 120.4 feet, PSD (31.4 feet, MSL). To assure operability of safety related equipment required to safely shut down the facility and maintain cold shutdown conditions, we required the applicants to provide flood protection from the static and dynamic effects for a water level up to 120.4 feet PSD (31.4 feet MSL).



Since the grade level elevation for all structures (except the facility intake structure) which are essential to facility safe shutdown will be at or above 99. feet, PSD (10.5 feet, MSL) and these structures would be inundated in the unlikely event of a PMH, the protection against the flooding of structures will be provided by administrative controls. The administrative controls will be specified in the Technical Specifications requiring protection procedures to be initiated prior to the water level reaching elevation 99.5 feet, PSD (10.5 feet, MSL) , and facility shutdown to be initiated when the water level reaches 100.5 feet, PSD (11.5 feet, MSL).

The intake structure is below grade but is designed with water tight compartments capable of withstanding a PMH.

We have concluded that the combination of the design of structures against the effects of flooding including dynamic effects, and the Technical Specification requirements on facility operation, result in acceptable conditions to protect the facility against flooding.

In our evaluation of the design criteria for armor stone on the dike that protects the facility from excessive wave action, we found the proposed rock size gradation would be inadequate. Consequently, at our request, the applicants will increase the size of the rock protection and will provide a more massive dike to assure that severe wave action cannot reach the containment and auxiliary structures.

The site drainage system was evaluated by the applicants at our request to determine if a local probable maximum precipitation (PMP) storm could adversely affect safety-related facilities. Although the design basis selected for site drainage by the applicants is substantially less severe than a local PMP storm, ground slopes in the area are away from safety-related structures, and runoff in excess of storm drainage inlet and piping capacity is not expected to cause water levels greater than a few inches above the ground surface. We have reviewed the applicants' evaluation of site drainage and have concluded that such levels should not constitute a flood threat to safety-related facilities.

Another potential source of facility flooding is associated with the failure of the roofs of buildings. We have reviewed the roof drainage system, and have concluded that the system will prevent rainfall accumulations from exceeding the structural design bases of the roofs of safety-related buildings during storms as severe as a local PMP storm and is acceptable.

### 2.4.3 Safety-Related Water Supply

Cooling water for vital facility systems, which must remain operable in the event of an accident, will be supplied by the service water system. This system will draw up to 10,000 gallons per minute (gpm) of estuary water by pumps located in the service water intake structure. The Delaware Estuary serves as the ultimate heat sink, i.e., it is the source of water under all normal operating conditions and accident conditions.



The service water intake structure is designed to remain operable for high and low water conditions as severe as those that could result from a probable maximum hurricane (PMH). The flood design bases for the structure is discussed in Section 2.4.2 of this report. For the low water design bases, a PMH was assumed to persist at the most critical location for developing low water levels at the site. For this condition to exist, the center of a PMH would be located east-northeast of Delaware Bay in a location which will develop maximum sustained northwesterly winds along the axis of the Delaware Bay. The applicants' analysis of this condition indicated a probable minimum low water elevation of 77.9 feet, PSD (minus 11.1 feet, MSL). Our independent evaluation of this probable minimum low water level indicated that the applicants' estimate is conservative. Since the applicants have stated that the minimum submergence level of the service water pumps to assure their operation is elevation 76 feet, PSD (minus 13.0 feet, MSL), we have concluded that acceptable margin has been provided between the probable minimum low water level and the submergence level of the service water pumps. However, as discussed in Section 2.2 of this report, the applicants have been requested to provide an analysis of the probability of a barge carrying explosives impacting the intake structure. We will review the analysis and will report the results of our evaluation in a supplement to the Safety Evaluation Report.

We have also evaluated the effects of ice buildup at the service water intake structure. Since the applicants have provided ice barriers in front of the intake structure to prevent buildup, we have concluded that ice would not adversely affect the ability of the service water pumps to perform their necessary functions.

On the bases of our evaluation, and subject to the results of our evaluation regarding the probability of a barge carrying explosives impacting the intake structures, we have concluded that acceptable design measures have been provided to assure an adequate source of cooling water for normal and accident conditions.

2.4.4 Groundwater

The soils at the site are primarily hydraulic fill overlaying Pleistocene sand. The Pleistocene sand is about 30 feet deep and extends over most of the site. The Pleistocene sand is underlain with the Kirkwood Formation which, due to its relative impermeability, is classified as an aquitard. The piezometric surface at the site is relatively flat. The horizontal component of ground-water movement is quite slow, due to the low hydraulic gradient and relatively low formation permeabilities. The regional direction of ground-water movement is toward the Delaware River; however, temporary reversals in direction could occur due to high water conditions in the Delaware River.

Potable water supplies in the area are obtained primarily from groundwater. Municipalities in the area that utilize groundwater generally use deep wells, since adequate yields cannot be obtained from the shallower formations. The closest domestic well is a shallow well located about three miles up-gradient from the site.

The groundwater design bases water level is elevation 96.0 feet, PSD (7.0 feet, MSL), and all facility structures are designed to withstand



the hydrostatic forces associated with this level. In addition, the underground portion of the containment structure is waterproofed to avoid seepage of ground water through cracks in the concrete. The waterproofing consists of an impervious membrane that extends above facility grade.

On the basis of our review, we find (1) that accidental spills or leaks of radioactive liquids on or into the surficial soils would travel very slowly (due to the low hydraulic gradient and permeabilities) to the Delaware River and (2) there are no potable water supplies that could be affected (the river is saline at this point) from accidental spills and leaks. We have concluded that the groundwater design bases are acceptable and that groundwater in the vicinity will not be adversely affected by operation of the Salem facility.

2.5 Geology and Seismology

We and our consultants, the U.S. Geological Survey, the U.S. Coast and Geodetic Survey and Nathan M. Newmark Consulting Engineering Service reviewed the geology and seismology including soils engineering of the Salem site with respect to foundation conditions and intensity of potential earthquakes at the construction permit stage of our review and found them to be acceptable. A horizontal ground acceleration of 0.10 g was used for the operational basis earthquake (OBE) and an acceleration of 0.20 g for the safe shutdown earthquake (SSE).

During our review of the Hope Creek Station, which is proposed to be located adjacent to the Salem site, we required the applicants perform additional sampling of the soil to confirm that previously



obtained samples are representative of the Vincentown formation. We will consider the results of this investigation in conjunction with the Hope Creek application and also to further assess our previous conclusions regarding the foundations at the Salem site. We will report the results of our review in a supplement to the Safety Evaluation Report prior to a decision concerning issuance of an operating license for Salem  Unit 1.

xsec:

## 3.0 DESIGN CRITERIA - STRUCTURES, COMPONENTS, EQUIPMENT AND SYSTEMS

### 3.1 Conformance with AEC General Design Criteria

The Salem facility was designed and is being constructed on the basis of the proposed General Design Criteria, published for comment July 11, 1967. Design and construction were thus initiated and proceeded to a significant extent based upon the criteria proposed in 1967. Since February 20, 1971, when the Atomic Energy Commission published the General Design Criteria for Nuclear Power Plants, the applicants have attempted to comply with the intent of the newer criteria to the extent practical, recognizing previous design commitments. As a result, our technical review assessed the plant against the General Design Criteria now in effect, and we have concluded that the facility design conforms to the intent of these newer criteria.

### 3.2 Classification of Structures, Components and Systems

The applicants have classified the seismic design of plant structures, components and systems into three principal categories. Class I* includes (1) those structures and components, including instruments and controls, whose failure might cause or increase the severity of a loss-of-coolant accident or result in an uncontrolled release of excessive amounts of radioactivity, and (2) those structures and components vital to safe shutdown and isolation of the reactor.

*In this Safety Evaluation Report, the staff utilizes the words Category I as equivalent to the applicants' seismic Class I notation.



Class II includes those structures and components which are important to reactor operation but not essential to safe shutdown and isolation of the reactor and whose failure could not result in the release of substantial amounts of radioactivity. Class III includes those structures and components which are not related to reactor operation or containment.

We find these classifications to be acceptable and we have concluded that the applicants placed all safety-related structures, components and systems in their appropriate category.

### 3.3 Wind and Tornado Criteria

The applicants have considered the effects of tornado loads in the design of Category I structures. Tornado wind loading was taken as a 300 mph tangential wind traveling with a translational velocity of 60 mph. Also considered was a three psig atmospheric pressure differential as part of the ultimate loading combination.

The wind loading and pressure drop parameters are consistent with the generally accepted criteria used for nuclear power plants. Parameters given approximate those recommended in the American Society of Civil Engineers (ASCE) Paper No. 3269 "Wind Forces on Structures" to determine the loads resulting from these wind and tornado effects.

Structures were arranged on the facility site (or protected) in such a manner that a collapse of structures not designed for a tornado will not affect those designed for tornadoes.

The criteria used in the design of Category I structures to account for the loadings due to specific winds and tornadoes postulated to occur



at the site and the method used in determining those loads provide a conservative basis for the facility design. The use of these loading criteria provides reasonable assurance that, in the event of wind or tornadoes, the structural integrity and safety function of Seismic Category I structures will not be impaired by the specified environmental forces.

We have concluded that conformance with these criteria is an acceptable basis for satisfying the requirements of Criterion 2 of the AEC General Design Criteria.

### 3.4 Water Level (Flood) Design Criteria

All Category I structures and equipment are designed to withstand a localized probable maximum precipitation storm (PMP) storm. In addition, the intake structure housing the service water pumps is flood protected to a probable maximum hurricane (PMH) elevation of 120.4 feet, Public Service Electric and Gas Company Datum (31.4 feet mean sea level, U. S. Coast and Geodetic Survey Datum) as discussed in Section 2.4.2 of this report. Since the facility grade will be inundated in the unlikely event of a probable maximum hurricane (see Section 2.4.2 of this report), the Technical Specifications will require that flood protection procedures will be initiated prior to the water level reaching facility grade. Category I structures and buildings have been designed for hydrostatic and buoyancy forces appropriate for the site.

We have concluded that the combination of the design of structures against the effects of flooding including dynamic effects, and the Technical Specification requirements on facility operation, result in acceptable conditions to protect the facility against flooding.

## 3.5 Missile Protection Criteria

Safety related structures and equipment have been designed and constructed to withstand the effects of tornado generated missiles. Among these structures are the auxiliary building, the control room, the containment, and the fuel handling building.

The critical missile assumed by the applicants in their design is a 40 foot, 12 inch diameter wooden utility pole weighing 50 pounds per cubic foot and moving with a velocity of 150 mph. The modified Petry formula was used to determine the minimum depth of reinforced concrete required.

A spectrum of interior missiles has also been considered in the design of safety related equipment and structures. The applicants used the modified Petry formula to determine missile penetration.

The criteria used in the design of Category I structures, to account for the loading due to specified missile impacts postulated to occur at the facility site, provide a conservative design basis for determining the forces on the structure to assure that such impact forces will not penetrate structures, shields and barriers beyond acceptable limits as governed by the strength and resistance offered by such structures, shields, and barriers. We have concluded that conformance with these design loading criteria is an acceptable basis for satisfying AEC General Design Criteria Nos. 2 and 4.



## 3.6 Protection Against Dynamic Effects Associated with the Postulated Rupture of Piping

### 3.6.1 Criteria for Protection Against Dynamic Effects Associated with a Loss-of-Coolant Accident

The design criteria used for identifying high energy fluid piping and for postulating pipe break locations, break orientations and break flow areas inside containment are consistent with the criteria set forth in AEC Regulatory Guide 1.46.

These provisions for protection against the dynamic effects associated with pipe ruptures and the resulting discharging coolant provide acceptable assurance that, in the event of the occurrence of the combined loadings imposed by an earthquake of the magnitude specified for the Safe Shutdown Earthquake and a concurrent single pipe break of the largest pipe at one of the design basis break locations, the following conditions and safety functions will be accommodated and assured.

(1) The magnitude of the design basis loss-of-coolant accident can not be aggravated by potentially multiple failures of piping.

(2) The reactor emergency core cooling systems can be expected to perform their intended function.

Pipe motion subsequent to rupture and the pipe restraint dynamic interaction was analyzed by the use of an elastic-plastic lumped mass beam element model sufficiently detailed to reflect the structural characteristics of the piping system.

On the basis of our review, we have concluded that the criteria used for the identification, design and analysis of piping systems where



postulated breaks may occur constitute an acceptable design basis in meeting the applicable requirements of AEC General Design Criteria Nos. 1, 2, 4, 14 and 15 and are consistent with recent Regulatory staff positions.

3.6.2 Criteria for Protection Against Dynamic Effects Associated with a Rupture of High-Energy Piping Outside Containment

The applicants submitted in Amendment No. 27 to the FSAR an analysis of postulated high-energy line ruptures outside containment. In general, to perform the evaluation, the applicants first determined the locations for postulated piping ruptures in accordance with our requirements. The equipment required to bring the facility to a safe shutdown condition, given each of the postulated breaks, was identified, then assessed in terms of potential damage due to any pipe whipping. jet impingement, adverse environmental conditions, and high compartment differential pressures that might result from the postulated break. Wherever it was determined that unacceptable damage might occur, appropriate facility modifications will be made.

The applicants identified seven areas where design modifications were required. These areas are (1) the piping penetration area (elevation 100 feet), (2) the waste evaporator room, (3) Piping penetration area (elevation 78 feet), (4) the pipe alley, (5) the safety injection pump room, (6) the auxiliary feedpump turbine room, and (7) the letdown heat exchanger room. Modifications required in these areas are described in Sections 14.5.1.6, 14.5.2, and 14.5.3 of the FSAR.

we have reviewed the high-energy lines in the Salem facility and have concluded that the applicants have identified the areas where modifications were necessary to mitigate the consequences of a postulated high-energy line failure.

To accommodate the consequences of a steam line or feedwater line break in the penetration room, several structural changes were required. The applicants had originally specified a wall thickness of 1.5 inches for the main steam line from the containment up to the main steam stop valves. They also specified a Schedule 120 pipe for the feedwater lines from the containment to the isolation valves. These pipe thicknesses are more conservative than those required by the applicable piping codes. A restraint system was also provided to prevent unacceptable pipewhip and fluid impingement.

To further reduce the potential of adverse consequences of a high-energy line rupture in this area, the applicants have thickened the pipe wall of the main steam lines and feedwater lines throughout the penetration area and have increased the penetration vent area from 100 square feet to 650 square feet. Certain penetration area walls and floors were sealed in order to confine the environmental effects of the postulated breaks and some localized impingement protection was added in order to accommodate the effects of impingement.

In the event of a postulated steam line rupture in the penetration area, the applicants have calculated a maximum peak pressure of 5.8 psig.



Using an approximate calculational model, we checked the applicants' analyses and are satisfied that their analyses are conservative. The applicants have stated that the penetration area has the capability of withstanding an internal pressure of 7.6 psi.

The auxiliary feedwater pump room is also an area where extensive modifications were made since a postulated failure of the high-energy steam line leading to the turbine driven auxiliary feedwater pump could possibly damage vital equipment in this area. To prevent pipe whip and to limit the two phase water/steam flow rates in the event of a postulated steam line rupture, the line was encapsulated and restrained at postulated break locations. The turbine driven auxiliary feedwater pump was enclosed in a steel plate sub-room with a drop ceiling to preclude environmental damage to the pump motors of the electrically driven auxiliary feedwater pumps and adjacent vital control centers. The steam line was lowered several inches in order to facilitate installation of the new ceiling below presently installed vital piping and equipment.

The applicants have presented evidence of a thorough and vigorous consideration of the potential for damage to essential equipment from the postulated failure of high-energy lines outside containment in accordance with our requirements. We have concluded on the basis of our review that with the program for plant modifications which the applicants have committed to, there is reasonable assurance that the facility could withstand the failure of high-energy lines outside containment and retain the capability to safely place the facility in a cold shutdown condition.

## 3.7 Seismic Design

We and our consultant, Nathan M. Newmark Consulting Engineering Services, have reviewed and evaluated the seismic design input criteria employed by the applicants with reference to structures, systems and components. The seismic loads are based on horizontal ground accelerations of 0.10 g for the operating basis earthquake and 0.20 g for the safe shutdown earthquake with vertical accelerations equal to two-thirds the horizontal ground accelerations. The consultant's report is attached as Appendix B.

The seismic design response spectra were presented in the application for a construction permit and found acceptable. The modified earthquake time-histories used for equipment design were adjusted in amplitude and frequency content to envelope the design response spectra specified for the site. We and our seismic design consultant concluded that the seismic input criteria used by the applicants provide an acceptable basis for the seismic design of safety related structures, systems and components.

The modal response multi-degree-of-freedom method and the normal mode-time history method were used for the analysis of all Category I structures, systems and components. The vibratory motions and the associated mathematical models account for the soil-structure interaction and the coupling of all coupled Category I structures and facility equipment. Governing modal response parameters have been combined by the square root of the square root of the sum of the squares to obtain the total maximum response when the modal response spectrum method is used.



The absolute sum of modal responses is however used for modes with closely spaced frequencies. Horizontal and vertical floor spectra inputs used for design and test verification of structures, systems and components were generated by the normal mode-time history method. Torsional loads have been adequately accounted for in the seismic analysis of Category I structures. Vertical maximum ground accelerations were assumed to be 2/3 of the horizontal ground accelerations and the horizontal and vertical effects were combined simultaneously. Constant vertical load factors were employed only where analysis showed sufficient vertical rigidity to preclude significant vertical amplification in the seismic system being analyzed.

We and our consultant have reviewed the information provided by the applicants and have concluded that the seismic system and subsystem dynamic analysis methods and procedures used by the applicants are acceptable.

The type, number, location, and utilization of strong motion accelerographs to record seismic events and to provide data on the frequency, amplitude, and phase relationship of the seismic response of the containment structure, correspond to the recommendations of AEC Regulatory Guide 1.12. Supporting instrumentation will be installed on Category I structures, systems, and components to provide data for the verification of the seismic responses as determined analytically for such Category I items. Also, a plan for the utilization of any acquired seismic data has been developed.

We have concluded that the applicants' seismic instrumentation program conforms to the recommendations of AEC Regulatory Guide 1.12 and is therefore acceptable.

## 3.8 Design of Category I Structures

### 3.8.1 Design of Concrete Containment

The containment structure is a soil supported reinforced concrete containment in the form of a right vertical cylinder with a hemispherical dome and a flat slab base mat. The inside surface of the containment is steel-lined in order to form a leak-tight barrier membrane.

The design of the concrete containment has been based on the ultimate strength provisions of the American Concrete Institute (ACI) 318-63 Code. The steel liner has been designed on the basis of allowable stresses using the criteria given in Section III of the ASHE Boiler and Pressure Vessel Code, 1968 edition.

The loading combinations that were utilized in checking the design of the structure under various conditions included: (1) one and one-half times the accident pressure, the coincident accident temperature, and the other normal loads, (2) the normal loads, the accident loads and the safe shutdown earthquake loading, and (3) the normal loads and 1.25 times both the accident loads and the operating basis earthquake loads. Wind, tornado and flood loads were also considered in appropriate combinations with other loads.



The internal structures such as the reactor cavity have been designed for load combinations that also include the effect of local pressure buildup resulting from postulated pipe breaks.

The static analysis for the containment shell was based on thin shell theory with elastic material behavior. As a check, a more sophisticated finite element analysis of the containment was also performed. Stress tabulations provided by the applicants indicate that the resultant stresses have been kept to acceptably low values.

As a result of our review and evaluation of the criteria and procedures used in the design and construction of the concrete containment, we have concluded that these criteria and procedures constitute an acceptable basis for satisfying the applicable requirements of AEC General Design Criteria Nos. 2, 4, 16 and 50.

### 3.8.2 Design of Other Category I Structures

Our review and evaluation of other seismic Category I structures included the auxiliary building, fuel handling building and service water screen well. These structures were built as composites of structural steel and reinforced concrete members. In general, the structures have been designed as continuous systems. The various structural components that were integrated into the continuous structure consist of slabs, walls, beams and columns.

The design methods for reinforced concrete included ACI 318-63 Code working stress design for normal loads in combination with an operating basis earthquake and wind load. ACI 318-63 Code ultimate strength design procedures have been implemented for normal loads in combination with the safe shutdown earthquake and tornado load.

The design methods for structural steel seismic Category I structures follow the procedures of the American Institute of Steel Construction (AISC) Code. Stress levels on structural steel elements have been kept in the working stress range for load combinations that include operating basis earthquake load and below yield for load combinations that include the safe shutdown earthquake loading.

As a result of our review and evaluation of the criteria and procedures used in the design and construction of seismic Category I structures, other than the containment structure, we have concluded that these criteria and procedures constitute an acceptable basis for satisfying the applicable requirements of AEC General Design Criteria Nos. 2 and 4.

## 3.9 Mechanical Systems and Components

### 3.9.1 Dynamic System Analysis and Testing

The consequences of vibration in piping systems within the reactor coolant pressure boundary have been considered by the staff. In accordance with the provisions of ASA B31.1, "Code for Pressure Piping," a vibration operational test program will be performed during startup and initial operations. This test program will verify that the piping and piping restraints within the reactor coolant pressure boundary have been designed to withstand the dynamic effects of valve closures, pump trips and other anticipated events which could cause significant vibrations. These tests



will stimulate transients that are expected to be experienced during reactor operation and will demonstrate that the provisions of ASA B31.1 to minimize vibrations have been met.

We have concluded that compliance with this test program constitutes an acceptable basis for satisfying the related requirements of AEC General Design Criteria Nos. 1 and 14.

### 3.9.2 Category I Components Outside of the Reactor Coolant Pressure Boundary

All Category I systems, components and equipment outside of the reactor coolant pressure boundary which are comparable to ASME Code Class 2 and 3 components have been designed to sustain normal loads, anticipated transients, the operating basis earthquake, and the safe shutdown earthquake within design limits which are consistent with those outlined in AEC Regulatory Guide 1.48.

The specified design basis combinations of loading as applied to the design of safety-related components which are comparable to ASME Code Class 2 and 3 components in systems classified as seismic Category I provide reasonable assurance that in the event (1) an earthquake should occur at the site, or (2) other upset, emergency or faulted plant transients should occur during normal plant operation, the resulting combined stresses imposed on the system components may be expected not to exceed the allowable design stress and strain limits for the materials of construction. Limiting the stresses under such loading combinations provides a conservative basis for the design of the system components to withstand the most adverse combinations of loading events without gross loss of structural integrity.

The applicants’ design load combinations and associated stress and deformation limits specified for all components which are comparable to ASME Code Class 2 and 3 components constitute an acceptable basis for design in satisfying AEC General Design Criteria Nos. 1, 2 and 4 and are consistent with recent Regulatory staff positions.

The design and installation criteria for pressure relief device comparable to ASME Code Class 2 are consistent with the rules of the USAS B31.1.0 "Power Piping Code." In the case of open safety or relief valves mounted on a common header and full discharge occurring concurrently, the additional stresses induced in the header will be combined with previously computed local and primary membrane stresses to obtain the maximum stress intensity.

The criteria used in developing the design and mounting of these safety and relief valves provide acceptable assurance that, under discharging conditions, the resulting stresses are expected not to exceed the allowable design stress and strain limits for the materials of construction. Limiting the stresses under the loading combinations associated with the actuation of these pressure relief devices provides a conservative basis for the design of the system components to withstand these loads without loss of structural integrity and impairment of the overpressure protection function.

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We have concluded that the use of the criteria for the design and installation of overpressure relief devices comparable to ASME Code Class 2 constitute an acceptable design basis in meeting the applicable requirements of AEC General Design Criteria Nos. 1, 14 and 15 and are consistent with recent Regulatory positions.

## 3.10 Seismic Qualification of Category I Instrumentation and Electrical Equipment

Instrumentation and electrical components required to perform a safety function have been designed to meet Category I design criteria. Seismic requirements established by the seismic system analysis have been incorporated into equipment specifications to assure that the equipment purchased or designed meets seismic requirements equal to or in excess of the requirements for Category I components, either by appropriate analysis or by qualification testing.

A seismic qualification program was implemented to confirm that (1) all category I instrumentation and electrical equipment will function properly when subjected to the excitation and vibratory forces imposed by a safe shutdown earthquake and the conditions following the accident, and (2) their support structures are adequately designed to withstand the seismic disturbance. The operability of the instrumentation and electrical equipment were ensured by testing, with the exception of the Solid State Output Test and Interface Cabinets. With respect to these latter components, the applicants have stated that additional seismic qualification testing will be performed and that the results of these tests will be submitted in a future Amendment to the FSAR. In addition, the results of the seismic qualification tests of the Safeguards Equipment Controllers will be submitted. We will review the results of the seismic qualification tests and will report the results of our review in a supplement to the Safety Evaluation Report. This issue will be resolved prior to a decision concerning issuance of an operating license for Salem Unit 1. The design adequacy of the supports for the instrumentation and electrical equipment were verified by either analysis or testing.

The applicants have referenced Westinghouse Topical Report WCAP-7397-L, "Seismic Testing of Electrical and Control Equipment" and supplement thereto. The final evaluation of this report has been completed. We find it to be acceptable and applicable to Salem Units I and 2. This program meets the intent of IEEE Std. 344-1971, "Seismic Qualification for Class I Electric Equipment for Nuclear Power Generating Stations".

Subject to the completion of the qualification program and verification of the test results as described above, the above program constitutes an acceptable basis for satisfying the staff requirements and the applicable requirements of Criterion No. 2 of the AEC General Design Criteria.

### 3.11 Environmental Design of Engineered Safety Features Equipment

Prototypes of all vital instruments, motors, cables, and penetrations associated with engineered safety features located within the containment have been tested, where required, under simulated loss-of-coolant conditions of combined pressure, temperature, and spray. Further, resistance



to radiation damage has been verified up to at least 108 rads, consistent with requirements for equipment qualified for service in a radiation environment. The applicants have described these tests, summarized the test results, and identified the test documentation. We have concluded that the foregoing is acceptable.

Those electrical systems and components vital to plant safety and located outside containment are designed so that their integrity will not be impaired by wind storms, floods, or disturbances on the external electrical system.

Power, control and instrumentation cabling, motors and other electrical equipment required for operation of the engineered safety features are suitably protected, as applicable, against the effects of a nuclear system accident and from external environmental phenomena in order to assure a high degree of confidence in the operability of such components.

On the basis of the information provided with regard to the environmental qualifications and design of engineered safety features equipment, we have concluded that the engineered safety features equipment installed in the Salem facility will be adequately protected against combined environmental effects and therefore is acceptable.