PSNH

SEABROOK STATION
Engineering Office

Public Service of New Hampshire

New Hampshire Yankee Division

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United States Nuclear Regulatory Commission
Washington, DC 20555

Attention: Mr. Vincent S. Noonan, Project Director
PWR Project Directorate No. 5

References: (a) Construction Permits CPPR-135 and CPPR-136, Docket Nos. 50-443 and 50-444

Subject: Integrated Leak Rate Testing

Dear Sir:

During the finalization of Seabrook Station's 10CFR50, Appendix J, Containment Leakage Testing plans, it was determined that the acceptance criteria for allowable leakage rates provided in FSAR Section 6.2 would be burdensome and costly to plant operation and maintenance of containment isolation valves. As a result thereof, we initiated a containment leakage optimization study. This study was to identify changes to containment leakage criteria which would be the most beneficial with respect to plant operations (e.g., shorter outages) and valve maintenance, but which would still leave acceptable safety margins between calculated doses and NRC acceptance criteria.

We have completed the optimization study and, as summarized in Attachment No. 1, have concluded that changes can be made in some of the leakage criteria and still provide adequate protection to both the public and plant personnel during a design basis accident. The proposed changes to leakage rate criteria in FSAR Section 6.2 are provided in Attachment No. 2. The revisions to the associated analyses in FSAR Chapter 15 are provided in Attachment No. 3.

Seabrook is in its final stages of Type B and C Appendix J testing and therefore, we request a decision regarding the acceptability of the enclosed by February 28, 1986.

The enclosed revised FSAR section will be incorporated by a future amendment following NRC approval. If the staff requires further information or clarification to support this review, do not hesitate to contact us.

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Very truly yours,

John DeVincentis

John DeVincentis, Director
Engineering and Licensing

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Attachments
cc: Atomic Safety and Licensing Board Service List

ATTACHMENT NO. 1

Optimization Study Summary

1. The Containment Leakage Study focused on two radiation analyses, "DBA-LOCA Dose Analysis and LOCA Control Room Habitability," which govern both on-site and off-site calculated dose rates.

2. For both analyses, the Seabrook Secondary Containment was assumed to be operational as designed, which provides significant benefits in limiting radiation dispersion.

3. The critical pathway for both analyses is the thyroid dose.

4. The study results were evaluated against the following limits:

   a. The zero to two-hour Exclusion Area Boundary (EAB) thyroid dose-300 rem.

   b. The zero to 30-day Low Population (LPZ) thyroid dose - 300 rem.

   c. The zero to 30-day Control Room thyroid dose - 30 rem.

5. The changes in containment leakage criteria proposed based on the optimization study are:

   a. Decrease the Primary Containment Integrated Leakage Rate (La) from 0.2 to 0.15 percent by weight of containment air per day.

   b. Decrease the combined leakage rate fraction for Appendix J, Type B and C, penetrations from 0.75La to 0.60La.

   c. Increase the combined bypass leakage rate fraction from 0.15La to 0.60La for all penetrations identified as secondary containment bypass leakage paths.

6. Our analysis shows that the above proposed changes in containment leakage acceptance criteria results in thyroid doses 3.8 times lower than the EAB and LPZ maximum allowable limits. For the Control Room habitability thyroid dose, the margin was determined to be two (2) times lower than the maximum limits.

7. The above margins indicate that both the public and plant personnel are adequately protected from hazardous radiation doses during a design basis accident.

8. The plant will benefit by proposed changes because of shorter outages and improvement in containment isolation valve maintenance requirements.

ATTACHMENT NO. 2

Revised FSAR Excerpts - Section 6.2
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containment atmosphere to within half of its calculated peak value in less than 24 hours following the containment design basis LOCA.

6. Containment Leakage Rate Bases

The containment is isolated from the outside environment following major accidents by the containment isolation system. The presence of the containment enclosure and the use of exhaust fans to produce a slightly sub-atmospheric pressure in the space between the containment enclosure and the containment structure reduce the direct leakage from the structure to the environment to zero. The containment design is such that the maximum rate of leakage from the containment structure to the containment enclosure following a coolant 0.15% pipe rupture is 0.2% of the containment air mass per day. 53 The containment heat removal systems are capable of reducing the containment pressure, within 24 hours following the accident, to such a value that the volumetric leakage rate is less than ½ of the maximum value. The use of HEPA and charcoal filters in the exhaust line from the containment enclosure reduces the discharge of radioactive iodine into the environment to the extent that offsite doses following an accident are within the guidelines of 10 CFR 100. The exhaust system is discussed in Subsection 6.2.3.

The periodic testing and surveillance program to assure the above containment leakage rate is discussed in Subsection 6.2.1.6 and in the Technical Specifications, Chapter 16.

7. Bases for Minimum Containment Pressure Analysis

Assumptions in the minimum pressure analysis for ECCS confirmatory studies are based upon maximizing the ESF heat removal capability and other heat removal mechanisms. They are discussed in Subsection 6.2.1.5.

b. Design Features

1. Containment Structure

The containment structure is a reinforced concrete cylinder with a hemispherical dome and a reinforced concrete foundation, keyed into the rock by the depression for the reactor cavity pit and by continuous bearing around the periphery of the foundation mat. A welded steel liner plate is anchored to the inside face of the concrete as a leaktight membrane. The liner plate on top of the foundation slab is protected by a 4-foot-thick concrete slab which serves to carry internal equipment loads and forms the floor of the containment. A detailed description of the containment structure is given into these areas from ~~either~~ the containment structure or equipment/systems located within the enclosure (ECCS).

c. Containment Enclosure Emergency Cleanup System

This system has two functions: 1) to produce a negative pressure post accident in the annular, cylindrical volume between the containment and the containment enclosure, and 2) to collect any hazardous materials that might leak ~~from the containment structure post-accident~~ into these areas from ~~either~~ the containment structure or equipment/systems located within the enclosure (ECCS), so that they may be disposed of in a controlled manner. Both these functions are performed by redundant filter trains, redundant fans, dampers and controls, and a common discharge ductwork system to the unit plant vent.

Each exhaust fan has a capacity, with a clean and dirty filter train, of ~~2200~~ 2275 scfm, and ~~1780~~ 2100 scfm, respectively. The purge flow rate will be equal to the inleakage rate of the containment enclosure at a negative pressure of at least -0.25" w.g. Subsection 6.2.3.3.a discusses the performance of the fans. The presence of the containment enclosure and the use of the exhaust fans to produce a slightly negative pressure between it and its external surroundings minimize the direct leakage from the containment structure to the environment. 56

The redundant filter trains contain moisture separators, upstream HEPA filters, carbon adsorber bank and a downstream HEPA filter bank. The use of HEPA and charcoal filters in the exhaust from the containment enclosure reduces the discharges of radioactive iodine to the extent that offsite doses following a LOCA are within the guidelines of 10CFR100. 56

All components of the containment enclosure emergency cleanup system required to operate following an accident are Safety Class 2, seismic Category I. The system does not have provision for recirculation flow. Additional details are presented in Subsections 6.5.1 and 6.5.3.

d. Containment Enclosure Bypass Leakage

The maximum allowable leakage from the containment structure following an accident is ~~[illegible]~~ 0.15% of the mass of its atmosphere per day. This would occur at maximum pressure. During the first 24 hours following a LOCA, the containment heat removal systems reduce the pressure, the driving force behind the leakage, to less than one half the maximum value. As discussed in the preceding section, the direct leakage to the environs of radioactive contaminants from the containment is within the guidelines of 10CFR100. 53

INSERT "A" 56

The containment enclosure system and the containment isolation system, as discussed in Subsection 6.2.4, virtually eliminate the bypass of the emergency cleanup system for accidents within the containment. In order to estimate the amount of leakage that could bypass the containment enclosure in the event of a LOCA, all 56

"INSERT "A"

Although, as discussed in the preceding section, a Containment Enclosure Emergency Cleanup System has bee. ovided to minimize leakage to the enviorns, a significant number of lines penet . the containment and terminate in areas not treated by this cleanup system. Therefore, all leakage attributed to penetrations and isolation valves, requiring Type B and Type C Test per 10CFR50, Appendix J, is conservatively assumed to bypass the cleanup system. The total allowable leakage for Type B and Type C Tests and for Combined Bypass Leakage is 0.60La. This is in accordance with Appendix J acceptance criteria.

Lines that penetrate the containment and terminate in areas not treated by the containment enclosure exhaust filter system are assumed to be potential paths for bypass leakage, unless these lines are filled with water, or are at a higher pressure than the primary system following a postulated LOCA, or comprise a closed system. The definition of a closed system, used as a leakage boundary to preclude bypass leakage, is provided in Subsection 6.2.3.2.e.

The main steam, feedwater and steam generator blowdown lines penetrate the containment and pass through the containment enclosure annulus. These lines have flued-head construction, and the containment enclosure boundary seals to the forged portion of the flued head. The containment boundary weld is included within the enclosure so that if one of these lines breaks within the containment no leakage bypass path exists. 56

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For the penetration of the lines terminating outside the secondary containment, as defined above, leakage is assumed to occur through the isolation valve with the greater seat diameter, with the other isolation valve failed open, allowing for a failure of an active component in each line. The potential sources of bypass leakage are listed in Table 6.2-83. 56

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The containment enclosure itself does not have outleakage, but would have inleakage from the environment. The fans are sized to maintain a negative pressure even with inleakage. 56 Details of the containment structure leakage testing, containment enclosure testing and the containment enclosure exhaust filter system testing are discussed in the Technical Specifications, Subsection 3/4.6. A leakage limit of 0.03% of containment mass per day for those penetrations identified in Table 6.2-83 which could result in bypassing the enclosure building will be included in the Technical Specifications. 41 53 56 The tests will be conducted as outlined in Subsection 6.2.6.

e. Closed Systems Precluding Bypass Leakage

In accordance with the Branch Technical Position CSB 6-3, Item B.9, closed systems (used as a leakage boundary to preclude bypass leakage) meet the following criteria.

1. Do not directly communicate with the containment atmosphere, or do not directly communicate with the environment following a LOCA.

2. Are classified as ASME Safety Class 2. (Exceptions to this criterion are outlined at the end of this subsection).

3. Meet seismic Category I design requirements. 56

4. Are designed to withstand temperatures and pressures at least equal to the containment design temperature and pressures.

5. Are protected against missiles and pipe whip.

6. Are tested for leakage, unless it can be shown that during normal plant operations the system integrity is maintained.

The following systems do not communicate with the containment atmosphere, and comply in full with the closed system criteria:

1. Main Steam
2. Feedwater
3. Blowdown
4. Primary Component Cooling Water (thermal barrier portion)

The following systems do not communicate with the environment and are Safety Class NNS:

1. Combustible Gas Control (H_2 analyzer portion).

2. Containment Air Handling (radiation monitoring portion).

The reasons for the exemptions are provided in the Subsection 6.2.6. 56

6.2.3.3 Design Evaluation

The containment enclosure system design is evaluated from two viewpoints. Subsection 6.2.3.3.a investigates the adequacy of the structure and associated equipment to achieve its functional goal, a negative pressure differential. Subsection 6.2.3.3.b considers the vulnerability of the system to damage from a high energy line rupture within the enclosure.

a. Containment Enclosure Analyses

In the event ~~of the occurrence~~ of a LOCA, the containment could experience an increase in volume on the order of 11,500 cubic feet because of thermal and pressure expansion. This is determined 56 using the data listed in Table 6.2-82, and considers the swelling of the containment structure due to the design pressure of 52 psig. This would result in a decrease in the free volume of the containment enclosure building of less than 1% with a similar, but temporary, corresponding rise in its pressure. The containment enclosure exhaust filter fans are calculated to be able to draw down the containment enclosure pressure below -0.25" w.g. in less than four minutes from the time of a design basis LOCA. This analysis takes into account the engineered safety feature actuation system signal delay time, delay time for the diesel generator to supply power in the event of simultaneous loss of offsite power, 8 seconds for the filter fan to come up to speed, and the rise in pressure due to 56

In addition Radiological dose analyses conservatively assume a draw down time of eight (8) minutes.

the increase in size of the containment structure. The ability to attain a negative pressure differential is maintained assuming any single failure in either of the redundant emergency cleanup system trains. Draw-down time is conservatively calculated using low air flow of ~~1700~~ 2025 scfm.

Test or sampling connections in lines penetrating both the containment and containment enclosure are protected by either two isolation valves or by a locked-closed valve and one isolation valve so that no single failure can compromise the ability to achieve negative pressure by allowing a source of suction fluid to the exhaust fans other than the atmosphere of the containment enclosure. By assuming the existence of the design pressure of -0.25" w.g. therein, the total calculated maximum inleakage for all areas is ~~[illegible]~~ 620 cfm.

The analyses of the pressure/temperature response of the containment to a LOCA, performed for Subsection 6.2.1, have demonstrated that there is never any significant change in the temperature on the outside of the containment wall. Accordingly, the temperature in the containment enclosure is determined by the heat generated by the equipment present inside it and energy removal by the containment enclosure cooling units which function both during normal plant operations and in the event of a LOCA. The cooling coils have the been sized ~~for the ability~~ to continuously maintain ~~design~~ temperatures ~~atures of 104°F and 148°F for normal and accident conditions, respectively,~~ in the areas to be cooled, for normal, abnormal and accident conditions as discussed in Section 3.11 (B).

b. High Energy Line Rupture

The main steam, feedwater, and steam generator blowdown lines pass through the containment enclosure, but not directly. The enclosure boundary terminates on the flued portion of the penetration for these pipes on main steam tunnel sides. The residual heat removal line also passes through the containment enclosure, but is classified as a moderate energy line because of its short operational period. Therefore, ruptures of these lines within the containment enclosure are not considered.

Failure of a high energy line would result in pressurization of the containment enclosure due to the mass and energy release. The high energy lines that penetrate the containment and traverse the enclosure building without guard pipes are:

1. Sample lines from the pressurizer

2. Sample lines from reactor coolant loops

3. Excess letdown line

4. Letdown line

The testing program will include a complete series of Type B and Type C tests as presented in Subsections 6.2.6.2 and 6.2.6.3, prior to fuel loading. During plant operation, each penetration requiring testing will be tested at least once every two years to ensure continued compliance with leakage limits. If maintenance must be performed on a penetration because of suspected excessive leakage, it will be done upon completion of an initial leakage rate measurement. A second leakage measurement will be made upon completion of this maintenance to determine the "as left condition". 44 47

6.2.6.1 Containment Integrated Leakage Rate Test - Type A Test

The initial containment integrated leakage rate test (Type A test) will be performed after completion of construction of the containment structure and prior to initial fuel loading. The maximum allowable integrated leakage 0.15 rate, La, at the calculated peak accident pressure, Pa, is ~~0.2~~ weight percent per 24 hours. The calculated peak accident pressure, Pa, is 46.1 psig. To 53 allow some margin for deterioration between Type A tests, the acceptance criteria for the Type A test conducted at the calculated peak accident pressure (Pa) is that the upper 95% confidence limit of the measured leakage rate, Lm, be less than 0.75 La.

All penetrations will be installed and all systems penetrating the containment will be complete, up to and including all automatic isolation valves external to the containment prior to the conduct of the initial Type A test. Deviations from this schedule will be documented and properly considered when reporting final leakage rate test results.

If the structural integrity test (SIT) precedes the initial Type A test, a minimum of 24 hours will elapse from the time the containment was in excess of 85% Pa for the SIT and the commencement of a Type A test, to assure sufficient time for outgassing from the internal structure.

Prior to the conduct of a Type A test, a general inspection of the accessible interior and exterior surfaces of the containment structure and components will be performed to uncover any evidence which may affect either the structural integrity or leak-tightness. If evidence of structural deterioration is noted, the Type A test will not be performed until corrective action has been completed in accordance with applicable repair procedures and tests specified in the applicable codes specified in 10CFR50.55a. Such structural deterioration and corrective actions will be reported as part of the subsequent required test report.

In order that test results from the initial test be comparable to results obtained from future tests, all systems within the containment will be, as closely as is practical, in the condition they would normally be during future tests. Where possible, those systems which would be exposed to the containment atmosphere during post-accident conditions will be drained and vented to containment atmosphere within the containment on the inboard side of isolation valves, and drained and vented to atmosphere outside the containment on the outboard side of the outboard isolation valves. Systems that are required to maintain the plant in a safe condition during the test will be operable in their normal mode, and will not be vented. Systems that are normally filled with water and operating under post-accident conditions, such as the containment heat removal system, will not be drained and vented. Valves will be closed by normal operation without any adjustments or exercising for the purpose of improving leakage performance. Table 6.2-90 lists systems vented prior to and during the conduct of the Type A test. Table 6.2-91 lists those systems not scheduled to be vented and the justification thereof. Those systems which are not vented and drained, and which could become exposed to containment atmosphere under postulated accident conditions, will be evaluated separately and their leakage contribution added to the measured Type A test results. 56 47

To perform the test, the containment will be pressurized with reasonably clean air which will be run through a cooler prior to admission to the containment, to assure that atmospheric stability will be obtained prior to the start of the test. Internal fan coolers will assure air mixing and temperature control during the conduct of the test. When the temperature is stable, the pressure and humidity will also be stable. The temperature will be considered stable when the rate of change of the weighted average contained air temperature averaged over the last hour does not deviate by more than 0.5°F/hr from the average rate of change of the weighted average contained air temperature averaged over the last four hours. 56

The containment leakage rate will be determined by the absolute method, utilizing a series of dry bulb temperatures, relative humidity measurements, (dew point temperatures) and the containment absolute pressure. Based upon the Perfect Gas Law, calculations of the contained mass of air with respect to time will be made. The test data will be plotted and a least-squares fit of the data will be performed. The slope of this least-square line will be calculated to determine the leakage rate. A statistical analysis will determine the acceptability of the measured results. The instrumentation sensitivity will be verified by a supplemental test upon successful completion of a Type A test. A controlled, metered leak will be established out of containment. This superimposed leak rate will be added to the existing containment leak rate and the composite leakage used to verify satisfactory response of the Type "A" instrumentation. 56

Type A test acceptance criteria require that the upper 95% confidence limit (UCL) of the measured test result, 0.11% conducted at a pressure of Pa (46.1 psig), be less than 0.75 La (~~0.15%~~/24 hrs). For Type B and C tests, the acceptance criteria require that the combined total B and C leakage, including the upper error limit, be less than ~~0.75 La~~ 0.60 (~~0.15%~~ 0.09%/24 hrs). 53 ~~Exclusions may be granted under specified conditions, for isolation valves or penetrations sealed with a fluid from a seal system.~~ 53

These acceptance criteria are in accordance with Appendix J.

6.2.6.2 Containment Penetration Leakage Rate Test - Type B Test

Type B tests are required on all containment penetrations with resilient seals, gaskets, or expansion bellows. These include, but are not limited to, air lock door seals, piping penetrations with expansion bellows and electrical seals. Those penetrations which are seal-welded are exempt from this testing requirement. Table 6.2-92 lists all containment penetrations falling into this category. 56

All penetrations requiring Type B testing will be tested at a frequency not to exceed two years at a test pressure not less than Pa. This is in accordance with Appendix J of 10CFR50. 56

Air locks will be tested at Pa prior to initial criticality and at six-month intervals. Air locks opened during periods when containment integrity is not required will have their seals tested at Pa at the end of such period. Air locks opened during periods when containment integrity is required will have their seals tested at Pa within three days of being opened. When multiple openings are required, the door seals will be tested at Pa at three-day intervals during the period of frequent use.

Other penetrations will be tested at intervals not exceeding two years, except where sealing surfaces are disturbed by removal or opening. In such cases, seal testing will be performed upon installation or closure. This applies to components like electrical penetrations or the equipment hatch. The deviation from Appendix J will ensure that any seal damage affecting containment integrity, will not be unnoticed.

Any test method capable of measuring the expected low leakage rates is acceptable. An example of one acceptable method is by pressure decay with respect to time, whereby a known or measured volume between double seals is pressurized to Pa with nitrogen or air and isolated. Application of the Perfect Gas Law permits conversion of any measured pressure drop with respect to time to mass leakage. Any measured leakage, even if only one seal of a double seal leaks, is assumed to be containment leakage.

The test acceptance criteria require that the combined leakage rate for all Type B and lines penetrating containment (Type C tests), including the upper error limit, be less than ~~0.75~~ 0.60 La. ~~The Appendix J criteria of 0.60 La is based upon the assumption that 60% of the leakage will be through penetrations (Type B and C tests) and 15% of the leakage will be through the inner plate (Type A test), and that each type test is independent of the others. In reality, nearly all leakage will be through penetrations with almost none through the liner. By venting most systems, the Type A test will include most of the Type B and Type C leakage. A value of 0.75 was chosen as the same conservative fraction used for the Type A test to allow for potential deterioration.~~ The test interval will be less than two years, and by testing during the interval, only minimal deterioration of the overall leakage rate is expected. In addition to the overall leakage limit of ~~0.75~~ 0.60 La, no individual penetration will be allowed to exceed 5% of the total allowed 53

~~In addition, as stated in Subsection 6.2.3.2.d, a leakage limit of 0.02% of containment mass per day for those penetrations identified in Table 6.2-83, which could result in bypassing the containment enclosure building, will be included in the Technical Specifications.~~ 53 41

Type C tests will be performed during each reactor shutdown for refueling, but in no case at intervals greater than two years. Valves requiring Type C testing will be tested at a pressure not less than Pa. Liquid-filled systems that have an assured 30-day water supply following the postulated accident may be liquid leakage tested. For valves tested in this manner, a radiological assessment will be made to establish the leakage limits. This form of testing meets the intent of 10CFR50, Appendix J (III.C.2), and no exemption is noted. 56 56

Acceptable methods of testing include the pressure decay method described in Subsection 6.2.6.2 and the following:

a. Make-Up Flow Method

A series of calibrated flow meters and a source of pressure regulated air or nitrogen is used. The flow meters measure the flow necessary to maintain the pressure between an isolation valve under test and a test barrier. After a stabilization period, the inflow is assumed to balance the outflow and, unless there is data to the contrary, the measured flow is assumed to be the leakage of the valve under test. A variation of this method is to measure the outflow through a vent or appropriate test tap downstream of a valve under pressure, Pa.

b. Water Collection

The variation above can be utilized to collect water from a liquid system as a measure of leakage. These valves will have their own liquid leakage limits based upon radiological considerations. 56

The test acceptance criteria for both Type B and Type C testing require that the total combined leakage be less than ~~0.75~~ 0.60 La~~, as explained in Subsection 6.2.6.2.~~ Type C tests are intended to measure leakage rates through piping penetrations. 56 A literal interpretation of the Appendix J acceptance criteria requires the summation of individual isolation valves, even those in series. An exception to this interpretation has been taken, and refers to Type C tests on lines penetrating the containment, and bases penetration leakage upon the test configuration having the highest leakage rate. Thus, if two valves in series are tested, the single failure criterion assumes that the tighter of the two valves fails in the open position and the leakage value assigned to the penetration is the higher value of the two valves tested. This, it is believed, is the intent of Appendix J, rather than sum the leakages of all valves tested and call the total the Type C leakage.

As with Type B tests, no individual penetration will be allowed to equal or exceed 5% of the total allowed leakage of all penetrations, as was explained in Subsection 6.2.6.2. Repair of valves leaking less than 5% of the total will be optional. 56

6.2.6.4 Scheduling and Reporting of Periodic Tests

One Type A test will be performed following the structural integrity test and prior to fuel loading (Preoperation Leakage Rate Test). A second Type A test will be performed within three years of the preop test, and subsequent tests will be conducted at intervals no greater than five years.

A major test report will be prepared and submitted to the NRC following the completion of a Type A test. This report will include a description, including test results, of all containment testing that has occurred since the previous Type A test. Where penetrations or valves have required repair, a description of the event, along with corrective action taken, will be included in the report.

6.2.6.5 Special Testing Requirements

This section addresses the special requirements associated with the secondary containment surrounding the primary containment. The maximum allowable leakage rate and in-leakage limits are discussed in Subsection 6.2.3.3(a) and Technical Specification 3/4.6.5.2. 53

6.2.7 References

1. "CONTRAST-S MOD1 - A Digital Computer Program to Predict Containment Pressure-Temperature Response," UEC-TR-006-SUP, June 1979, A Supplement to UE&C Topical Report UEC-TR-006-0, March 1976.

ATTACHMENT NO. 3

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which assumes the remaining portion of the containment free air volume is not reached by the spray. The mathematical model used to represent a two compartment spray model with feedback is described in Appendix 15B.

4. Fission Product Release

(a) Conservative Analysis

The radiological assumptions for the conservative case are based on Regulatory Guide 1.4, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss-of-Coolant Accident for PWR's".

Twenty-five percent of the core iodine inventory given in Table 15.0-7 is assumed to be available for leakage from the containment structure. Ninety-one percent of this is in the elemental form, 4% in organic form and 5% in particulate form. The removal of iodine by the containment spray system is discussed in the previous subsection.

One hundred percent of the core noble gas inventory in Table 15.0-7 is assumed to be available for leakage from the containment structure.

The primary containment structure is assumed to leak at 0.15% ~~0.2%~~/day of its volume for the first day following the accident and ~~0.1%~~ 0.075%/day thereafter.

Primary containment leakage (with the exception of the 60% bypass fraction) is to the annulus region between the primary containment and the containment enclosure (secondary containment). The containment enclosure emergency exhaust filter system is described in Subsection 6.5.1 and in Appendix 15B.

The activity released to the environment as a result of this phase of the accident is shown in Table 15.6-16.

(b) Realistic Analysis

In the realistic analysis, it is assumed that 50% of the gap iodine inventory given in Table 15.0-7 is available for leakage from the containment structure. Of this total available for leakage, it is assumed that 91% is in elemental form, 4% in organic form, and 5% in particulate form. This is a conservative assumption, as it is expected that no more than 1-.2% of the iodine will exist as organic iodine. The removal of iodines by the spray system is discussed in the previous subsection.

One hundred percent of the gap noble gas inventory shown in Table 15.0-7 is assumed to be available for leakage from the containment structure.

The containment structure is assumed to leak at 0.1%/day of its volume for the first day of the accident and 0.05% thereafter. Leakage is to the primary-secondary annulus region and released to the environment through the containment enclosure emergency exhaust filters. The filter efficiencies are given in Appendix 15B.

The activity released to the environment as a result of this portion of the accident analysis is shown in Table 15.6-16.

5. Dose Analysis

The doses from this phase of the loss-of-coolant accident are presented in Table 15.6-20. These doses are based on the releases given in Table 15.6-16 and the meteorological and dose conversion assumptions of Appendices 15A and 15B.

b. Fission Product Release Due to On-Line Purge System Operation at the St--t of a LOCA

1. Conservative Analysis

The on-line purge system is described in Subsection 9.4.5, and is designed in conformance with NRC Branch Technical Position CSB 6-4. The fission product release and off-site dose contribution from this aspect of the accident are based on the following assumptions:

(a) The on-line purge system is in operation at the time of the LOCA.

(b) The purge system supply and exhaust isolation valves fully close within five seconds of receiving a containment isolation signal.

(c) The containment airborne fission product inventory available for release is based on ~~50%~~ 100% of the total primary coolant iodine inventory at the pre-existing iodine spike level of 60 μCi/gm dose equivalent I-131 and 100% of the primary coolant noble gas inventory, based on a total coolant activity level of 100/$\bar{E}$ μCi/gm.

The fission products available for release are assumed to be the same as described for the conservative case LOCA (above).

The efficiency of the hydrogen purge filter system is assumed to be as follows:

Elemental Iodine	-	95%
Organic Iodine	-	~~90%~~ 85%
Particulate Iodine	-	95%

Containment venting is assumed to start ~~50~~ 22 days after the LOCA with a vent rate of ~~1%~~ 2%/day of the containment volume (~~≃19 cfm~~ ≃38 cfm), (see Section 6.2.5). This will assure that the hydrogen concentration in the containment will ~~never~~ not exceed 4 v/o.

The activity released to the environment as a result of this venting is shown in Table 15.6-18.

(b) Realistic Analysis

The fission products available for release are assumed to be the same as described for the realistic analysis of the LOCA (above).

The efficiency of the hydrogen purge filter system is assumed to be as follows:

Elemental Iodine	-	99%
Organic Iodine	-	95%
Particulate Iodine	-	99%

The activity released to the environment as a result of this venting is shown in Table 15.6-18.

2. Dose Analysis

The doses from containment venting for post-accident hydrogen control are presented in Table 15.6-22. They are based on the releases shown in Table 15.6-18, the 30 day X/Q's listed in Appendix 15B, and the dose conversion assumptions in Appendix 15A.

d. Potential Leakage from Engineered Safety Features (ESF) During a Design Basis LOCA

The engineered safety features considered are the residual heat removal (RHR) system and containment spray systems. Ventilation and filtration of the ESF area is provided by the containment enclosure emergency exhaust filters.

1. Conservative Analysis

The following parameters were included in the analysis:

(a) The concentration ($\mu Ci/cc$) of iodine in the primary containment sump water following a LOCA would be:

$^{131}I - 4.38 \times 10^4$
$^{132}I - 6.13 \times 10^4$
$^{133}I - 9.19 \times 10^4$
$^{134}I - 1.01 \times 10^5$
$^{135}I - 8.75 \times 10^4$

These concentrations assume the source terms specified in Regulatory Guide 1.7 of 50% core halogens and 0% core noble gases in a sump volume of 301,821 gallons.

(b) The temperature vs. time curve for water being circulated through the ECCS pumps following a LOCA is the same as the primary containment sump temperature (DEPS-G) curve, Figure 6.2-6.

(c) The maximum expected leak rate (cc/hr) through pump seals, flanges and valves is 24 gpd. ~~In addition, a passive failure of 50 gpm is assumed to occur after 24 hours, and persists for 30 minutes~~.

(d) The partition factor for inorganic iodine is sufficiently large that only the organic form will contribute to the dose. A 10% fraction of the total source is used for the organic iodine contribution.

(e) The filtration efficiency of the filter train used on the exhaust system for the engineered safety features area is ~~90%~~ 86% for organic halogens.

(f) The total amount of leakage that could occur prior to isolation of failed equipment outside containment is 1,500 gallons.

The activity released to the environment is shown in Table 15.6-19.

2. Realistic Analysis

The parameters used for the realistic analysis are the same as given for the conservative analysis, with the following exceptions:

(a) The concentration (μCi/cc) of iodine in the primary containment sump water following a LOCA is estimated to be:

^{131}I - 4.37×10^3
^{132}I - 6.12×10^3
^{133}I - 9.18×10^3
^{134}I - 1.01×10^4
^{135}I - 8.75×10^3

These concentrations assume 50% gap halogens and 0% noble gases in a sump volume of 301,821 gallons.

(b) The filtration efficiency of the filter train used on the exhaust system for the ESF area is ~~95%~~ 85% for organic halogens.

(c) The activity released to the environment from this phase of the accident is presented in Table 15.6-19.

3. Dose Analysis

The doses from this phase of the loss-of-coolant accident are presented in Table 15.6-23. These doses are based on the releases given in Table 15.6-19 and the meteorological and dose conversion assumptions of Appendices 15A and 15B.

e. Control Room Dose Analysis

The Seabrook Station control room operates on a dual, remote air intake system concept (See Section 6.4).

Control room doses are calculated for a ~~90~~ 30 day period following the LOCA. Both conservative and realistic values have been determined for the four release phases of the accident and are presented in Tables 15.6-20, 15.6-21, 15.6-22 and 15.6-23. These doses are based on the releases given in Tables 15.6-16, 15.6-17, 15.6-18 and 15.6-19, and the dispersion coefficients (X/Q's) discussed in Appendix 15B. The reported doses are comprised of the submersion dose from the passing cloud, the intake dose from the air makeup intake of contaminated air, and the direct radiation dose from the containment. The control room dose analysis is based on the following conservative and realistic parameters:

		Conservative	Realistic
1.	Control room volume (ft^3)	254,000	254,000
2.	Control room makeup air flow rate (cfm)	800	800
3.	Time makeup air intakes are effected (hrs/day)	0.5	0.5
4.	Makeup air filter efficiencies		
	- Elemental iodine	N/A	0.99
	- Organic iodine	N/A	~~0.95~~ 0.85
	- Particulate iodine	N/A	0.99
	- Air particulates	N/A	0.9997
5.	Minimum distance from release to control room (meters)	30	30

15.6.5.5 Conclusions

The analyses of both large break and small break accidents have demonstrated margin to all the Acceptance Criteria limits of 10CFR50.46.

15.6.6 BWR Transients

Not applicable to Seabrook.

15.6.7 References

1. Letter from T. M. Anderson of Westinghouse Electric Corporation to John Stolz of the Nuclear Regulatory Commission, letter number NS-TMA-2030, January 1979.

2. "Acceptance Criteria for Emergency Core Cooling Systems for Light Water Cooled Nuclear Power Reactors," 10CFR50.46 and Appendix K of 10CFR50. Federal Register, Volume 39, Number 3, January 4, 1974.

3. "Reactor Safety Study -- An Assessment of Accident Risks in U. S. Commercial Nuclear Power Plants," WASH-1400, NUREG-75/014, October 1975.

4. Bordelon, F. M., Massie, H. W. and Zordan, T. A., "Westinghouse ECCS Evaluation Model -- Summary," WCAP-8339, July 1974.

TABLE 15.6-16

ENVIRONMENTAL RELEASES FROM THE
LOSS-OF-COOLANT ACCIDENT - CONTAINMENT LEAKAGE PHASE

	Curies Released			
	Conservative Analysis		Realistic Analysis	
Radionuclide	0-2 hours	0-30 days	0-2 hours	0-30 days
I-131	4.14 ~~2.58~~E+02*	1.20 ~~4.03~~E+03	9.91E+00	2.33E+02
I-132	4.94 ~~3.21~~E+02	7.30 ~~4.31~~E+02	1.20E+01	1.83E+01
I-133	8.50 ~~5.35~~E+02	4.70 ~~2.10~~E+03	2.05E+01	1.15E+02
I-134	6.60 ~~4.56~~E+02	7.20 ~~4.06~~E+0[illegible]	1.64E+01	1.79E+01
I-135	7.80 ~~4.94~~E+02	2.09 ~~1.08~~E+03	1.88E+01	5.38E+01
Kr-83M	1.05 ~~1.40~~E+03	2.01 ~~2.68~~E+03	7.01E+01	1.35E+02
Kr-85M	3.01 ~~4.01~~E+03	1.14 ~~1.52~~E+04	2.01E+02	7.68E+02
Kr-85	8.50 E+01 ~~1.13E+02~~	1.56 ~~2.07~~E+04	1.67E+01	3.07E+03
Kr-87	3.81 ~~5.08~~E+03	5.79 ~~7.72~~E+03	2.54E+02	3.88E+02
Kr-88	7.12 ~~9.49~~E+03	1.87 ~~2.50~~E+04	4.75E+02	1.26E+03
Kr-89	4.24 ~~5.66~~E+02	4.24 ~~5.66~~E+02	2.83E+01	2.83E+01
Xe-131M	9.01 E+01 ~~1.20E+02~~	1.42 ~~1.90~~E+04	6.01E+00	9.79E+02
Xe-133M	3.71E+03 ~~4.95E+03~~	9.85E+04 ~~1.31E+05~~	2.48E+02	6.68E+03
Xe-133	2.49 ~~3.32~~E+04	1.55 ~~2.07~~E+06	1.67E+03	1.06E+05
Xe-135M	3.83 ~~5.33~~E+03	1.88 ~~2.53~~E+04	2.58E+02	1.32E+03
Xe-135	6.74 ~~9.05~~E+03	1.32 ~~1.78~~E+05	4.59E+02	9.22E+03
Xe-138	3.4 ~~4.53~~E+03	3.41 ~~4.54~~E+03	6.14E+01	6.14E+01
TOTAL	~~7.99~~E+04 6.15	~~2.51~~E+06 1.89	3.83E+03	1.30E+05

* 4.14 ~~2.58~~E+02 = 4.14 ~~2.58~~ x 10^2 = 414 ~~258~~

TABLE 15.6-17

ENVIRONMENTAL RELEASES FROM THE LOSS-OF-COOLANT ACCIDENT - DURING ON-LINE PURGE OPERATION

	Curies Released	
Radionuclide	Conservative Analysis 0-5 sec	Realistic Analysis 0-5 sec
I-131	3.9 ~~2.0~~E+00*	5.1E-05
I-132	1.4 ~~7.1~~E-~~01~~00	1.9E-05
I-133	6.2 ~~3.1~~E+00	7.5E-05
I-134	9.0 ~~4.5~~E-01	8.8E-06
I-135	3.4 ~~1.7~~E+00	3.6E-05
Kr-83M	1.9E-01	7.5E-06
Kr-85M	7.4E-01	3.2E-05
Kr-85	5.7E-02	7.5E-07
Kr-87	5.7E-01	2.3E-05
Kr-88	1.5E+00	6.7E-05
Kr-89	-	2.2E-06
Xe-131M	2.9E-02	2.0E-06
Xe-133M	2.5E-01	1.4E-05
Xe-133	1.1E+01	6.0E-04
Xe-135M	3.6E-01	5.6E-06
Xe-135	1.4E+00	7.6E-05
Xe-137	7.3E-02	3.9E-06
Xe-138	3.1E-01	1.9E-05
TOTAL	3.2 ~~2.4~~E+01	1.0E-03

* 3.9 ~~2.0~~E+00 = 3.9 ~~2.0~~ x 10^0 = 3.9 ~~2.0~~

TABLE 15.6-18

ENVIRONMENTAL RELEASES FROM THE LOSS-OF-COOLANT ACCIDENT - HYDROGEN PURGE PHASE

	Curies Released							
	Conservative Analysis				Realistic Analysis			
Radionuclide	0-30	~~50-80~~ days	0-90	~~50-140~~ days	0-30	~~50-80~~ days	0-90	~~50-140~~ days
I-131	2.7E+03	~~1.7E+02*~~	4.7E+03	~~1.8E+02~~	2.3E+02	~~2.3E+01~~	4.4E+02	~~2.4E+01~~
I-132		-		-		-		-
I-133		-		-		-		-
I-134		-		-		-		-
I-135		-		-		-		-
Kr-83M		-		-		-		-
Kr-85M		-		-		-		-
Kr-85	1.0	~~1.0~~E+05	5.1	~~4.0~~E+05	3.0	~~5.2~~E+04	1.6	~~1.2~~E+05
Kr-87		-		-		-		-
Kr-88		-		-		-		-
Kr-89		-		-		-		-
Xe-131M	6.4	~~2.0~~E+04	1.6	~~2.3~~E+04	6.9	~~2.0~~E+03	1.8E+04	~~2.4E+03~~
Xe-133M	2.2E+03	~~2.9E-01~~	2.4E+03	~~2.9E-01~~	4.8E+02	~~2.9E-02~~	5.3E+02	~~2.9E-02~~
Xe-133	1.6E+06	~~3.4E+04~~	2.1E+06	~~3.5E+04~~	3.0E+04	~~3.4E+03~~	4.5E+04	~~3.5E+03~~
Xe-135M		-		-		-		-
Xe-135		-		-		-		-
Xe-138		-		-		-		-
TOTAL		~~2.3E+05~~		~~4.6E+05~~		~~5.7E+04~~		~~1.2E+05~~
		1.6E+06		2.8E+06		2.4E+05		4.9E+05

* $2.7E+03 = 2.7 \times 10^3 = 2700$

~~* $1.7E+02 = 1.7 \times 10^2 = 170$~~

(- (dash) = negligible)

TABLE 15.6-19

ENVIRONMENTAL RELEASES FROM THE LOSS-OF-COOLANT ACCIDENT - ESF LEAKAGE PHASE

	Curies Released			
	Conservative Analysis		Realistic Analysis	
Radionuclide	0-2 hours	0-30 days	0-2 hours	0-30 days
I-131	6.8 E+00 ~~1.1E+00*~~	6.4E+02 ~~4.6E+03~~	1.1E-02	4.6E+01
I-132	7.8 E+00 ~~1.1E+00~~	1.4E+01 ~~7.8E+00~~	1.1E-02	7.8E-02
I-133	1.4 E+01 ~~2.3E+00~~	1.6 E+02 ~~4.1E+03~~	2.3E-02	4.1E+01
I-134	9.8E+00 ~~9.8E-01~~	1.1E+01 ~~1.9E+00~~	9.8E-03	1.9E-02
I-135	1.3E+01 ~~2.0E+00~~	5.1E+01 ~~5.4E+02~~	2.2E-02	5.4E+00
Kr-83M	N/A	N/A	N/A	N/A
Kr-85M	N/A	N/A	N/A	N/A
Kr-85	N/A	N/A	N/A	N/A
Kr-87	N/A	N/A	N/A	N/A
Kr-88	N/A	N/A	N/A	N/A
Kr-89	N/A	N/A	N/A	N/A
Xe-131M	1.5 E-03 ~~6.7E-04~~	5.3E+01 ~~4.5E+02~~	1.4E-05	9.5E+00
Xe-133M	4.4E-02 ~~2.5E-02~~	4.0 E+01 ~~1.7E+03~~	5.1E-04	3.4E+01
Xe-133	6.3 E-01 ~~6.1E-01~~	1.2E+03 ~~4.5E+04~~	1.3E-02	9.4E+02
Xe-135M	2.5 E+01 ~~3.1E+00~~	1.1 E+03 ~~1.6E+03~~	6.2E-02	3.3E+01
Xe-135	7.0 E+00 ~~2.9E+00~~	4.8 E+02 ~~2.1E+04~~	6.0E-02	4.2E+02
Xe-138	-	-	-	-
TOTAL	~~1.4E+01~~ 8.4 E+01	~~7.9E+04~~ 3.7E+03	2.1E-01	1.5E+03

$6.8 E+00 = 6.8 \times 10^0 = 6.8$

* ~~1.1E+00 = 1.1 x 10^0 = 1.1~~

N/A = Not applicable

TABLE 15.6-20

DOSES FROM LOSS-OF-COOLANT ACCIDENT
CONTAINMENT LEAKAGE PHASE (REM)

	Conservative Analysis			Realistic Analysis		
Location	Thyroid	Whole Body	Skin	Thyroid	Whole Body	Skin
Exclusion Area Boundary (0-2 Hours)	7.7 ~~4.9~~E+01*	1.7 ~~2.2~~E+00	2.8 ~~3.7~~E+00	5.5E-02	1.3E-02	1.7E-02
Low Population Zone (0-30 days)	6.9 ~~3.7~~E+01	1.4 ~~1.7~~E+00	2.4 ~~3.0~~E+00	9.7E-02	1.4E-02	1.9E-02
Control Room Occupants (0-90 days)	1.4E+01 ~~6.0E+00~~	4.0 ~~4.5~~E-03	4.0 ~~9.9~~E-02	2.0E-02	4.0E-04	1.9E-02

* 7.7 ~~4.9~~E+01 = 7.7 ~~4.9~~ x 10^1 = 77 ~~49~~

TABLE 15.6-21

DOSES FROM LOSS-OF-COOLANT ACCIDENT ON-LINE PURGE SYSTEM RELEASE PHASE (REM)

Location	Conservative Analysis			Realistic Analysis		
	Thyroid	Whole Body	Skin	Thyroid	Whole Body	Skin
Exclusion Area Boundary (0-2 hours)	7.4 ~~4.3~~E-01*	1.4 ~~1.1~~E-03	2.3 ~~1.7~~E-03	2.3E-07	3.6E-09	4.6E-09
Low Population Zone (0-30 days)	3.0 ~~1.5~~E-01	6.0 ~~4.2~~E-04	1.0E-03 ~~6.8E-04~~	7.9E-08	1.7E-09	2.2E-09
Control Room Occupants (0-~~90~~ 30 days)	1.6E-03 ~~2.2E-02~~	4.0E-07 ~~2.6E-06~~	5.0E-06 ~~2.7E-05~~	-	-	-

* 7.4 ~~4.3~~E-01 = 7.4 ~~4.3~~ x 10^{-1} = 0.74 ~~0.43~~

TABLE 15.6-22

DOSES FROM LOSS-OF-COOLANT ACCIDENT POST LOCA HYDROGEN VENTING PHASE (REM)

	Conservative Analysis			Realistic Analysis		
Location	Thyroid	Whole Body	Skin	Thyroid	Whole Body	Skin
Low Population Zone (Duration of Accident)	2.1E+00 ~~3.5E-01~~*	3.2E-02 ~~2.9E-03~~	8.7E-02 ~~5.5E-02~~	4.0E-02 ~~4.2E-03~~	2.6E-03 ~~1.3E-04~~	5.1E-03 ~~2.7E-03~~
Control Room Occupants (50-140 days)	9.0 ~~1.6~~E-01	1.3E-03 ~~2.7E-04~~	1.7E-02 ~~3.0E-01~~	-	-	-

---

$2.1E+00 = 2.1 \times 10^{0} = 2.1$

* ~~3.5E-01 = 3.5 x 10^-1 = 0.35~~

TABLE 15.6-23

DOSES FROM LOSS-OF-COOLANT ACCIDENT ENGINEERED SAFETY FEATURE COMPONENT LEAKAGE (REM)

	Conservative Analysis			Realistic Analysis		
Location	Thyroid	Whole Body	Skin	Thyroid	Whole Body	Skin
Exclusion Area Boundary (0-2 hours)	1.2E+00 ~~1.7E-01~~*	5.0E-03 ~~5.9E-04~~	7.0E-03 ~~9.0E-04~~	3.3E-04	2.7E-07	7.7E-07
Low Population Zone (0-30 days)	2.6 ~~8.4~~E+00	1.0 ~~1.4~~E-02	2.0 ~~2.8~~E-02	3.2E-02	3.4E-05	1.1E-04
Control Room Occupants (0-90 days)	2.0E-01 ~~3.3E+00~~	1.0E-05 ~~2.3E-04~~	1.0E-04 ~~3.3E-03~~	-	-	-

$1.2E{+}00 = 1.2\times10^{0} = 1.2$

* ~~1.7E-01 = 1.7 x 10-1 = 0.17~~

evenly among the four steam generators. See FSAR Table 11.1-4.

11. Data and assumptions used to estimate activity released

A. Primary Containment Volume and Leak Rate

Containment Free Air Volume is 2.704×10^6 ft^3

Conservative Case Leak Rate

0.15% ~~0.2%~~ of contained volume per day for first 24 hours and ~~0.1%~~ 0.075% of contained volume per day thereafter.

Realistic Case Leak Rate

0.1% of contained volume per day for first 24 hours and 0.05% of contained volume per day thereafter.

B. Secondary Containment Volume and Leak Rate

Total Free Volume Serviced By Emergency Exhaust Filters is 8.861×10^5 ft^3

Conservative Case Leak Rate

Ventilation exhaust rate of 2,000 cfm; no mixing.

Realistic Case Leak Rate

Ventilation exhaust rate of 2,000 cfm; 50% mixing.

C. Valve Movement Times

Discussed in applicable accident analyses.

D. Adsorption and Filtration Efficiencies

1. Containment Enclosure Emergency Exhaust Filter Efficiencies:

Conservative Analysis

Elemental Iodine - 95%

Organic Iodine - 90%

Particulate Iodine - 95%

Realistic Analysis

Elemental Iodine - 99%

Organic Iodine - 95%

Particulate Iodine - 99%

Note: No credit for filters (Filter Efficiency = 0) for the first ~~4~~ 8 minutes following the accident. No credit for mixing within the annulus region for the conservative analysis and 50% mixing credit for the realistic analysis. 56

Containment Enclosure Emergency Exhaust Filter By-Pass Fractions:

Conservative Analysis = ~~0.15 (0 < t ≤ 24 hrs)~~ 0.60La

~~Conservative Analysis = 0.075 (t > 24 hrs)~~

0.075La

Realistic Analysis = ~~0.075 (0 ≤ t ≤ 24 hrs)~~

~~Realistic Analysis = 0.0375 (t > 24 hrs)~~

2. Fuel Storage Building Exhaust Filter Efficiencies:

Same as given above for Containment Enclosure Filters.

3. Control Room Makeup Air Intake Filter Efficiencies:

Conservative Analysis, not applicable.

Realistic Analysis

Elemental Iodine - 99%

Organic Iodine - ~~95%~~ 85%

Particulate Iodine - 99%

E. Recirculation System Parameters

Not applicable.

F. Containment Spray Parameters (Refer to Section 6.2.2 for details)

<u>Conservative Case</u>

λ(elemental) = 10.0 hr^{-1}

λ(organic) = 0.0 hr^{-1}

λ(particulate) = 0.45 hr^{-1}