May 1, 2006

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
ENTERGY NUCLEAR VERMONT YANKEE, LLC and ENTERGY NUCLEAR OPERATIONS, INC.	)	Docket No. 50-271-OLA
	)	ASLBP No. 04-832-02-OLA
(Vermont Yankee Nuclear Power Station)	)	

NRC STAFF'S ANSWER TO NEW ENGLAND COALITION'S
REQUEST FOR LEAVE TO FILE NEW CONTENTIONS

ATTACHMENT 3

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. ——229 TO FACILITY OPERATING LICENSE NO. DPR-28

ENTERGY NUCLEAR VERMONT YANKEE, LLC

AND ENTERGY NUCLEAR OPERATIONS, INC.

VERMONT YANKEE NUCLEAR POWER STATION

DOCKET NO. 50-271

~~DRAFT~~

~~Revision 1~~
~~November 2, 2005~~

Proprietary information pursuant to
Title 10 of the *Code of Federal Regulations* Section 2.390
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1.0 INTRODUCTION

1.1 Application

By application dated September 10, 2003, as supplemented by letters dated October 1, and October 28 (2 letters), 2003~~,~~; January 31 (2 letters), March 4, May 19, July 2, July 27, July 30, August 12, August 25, September 14, September 15, September 23, September 30 (2 letters), October 5, October 7 (2 letters), December 8, and December 9, 2004~~, and~~; February 24, March 10, March 24, March 31, April 5, April 22, June 2, August 1, August 4, September 10, September~~-~~ 14, September 18, September 28, October 17, October 21 (2 letters), October 26, ~~and~~ October 29, November 2, November 22, and December 2, 2005; January 10, and February 22, 2006 (References 1 through 4~~1~~6), Entergy Nuclear Vermont Yankee, LLC and Entergy Nuclear Operations, Inc. (Entergy or the licensee), requested changes to the Facility Operating License and Technical Specifications (TSs) for the Vermont Yankee Nuclear Power Station (VYNPS).

The proposed changes would increase the maximum steady-state reactor core power level from 1593 megawatts thermal (MWt) to 1912 MWt, which is an increase of approximately ~~20 percent~~20%. The proposed increase in power level is considered an extended power uprate (EPU).

1.2 Background

VYNPS is a boiling-water reactor (BWR) plant of the BWR/4 design with a Mark-I containment. The Nuclear Regulatory Commission (NRC or Commission) licensed VYNPS on February 28, 1973, for full-power operation at 1593 MWt (i.e., the current power level).

The VYNPS site is located in the town of Vernon, Vermont, on the west bank of the Connecticut River, on the pond formed by the Vernon Dam and Hydroelectric Station. As shown in VYNPS Updated Final Safety Analysis Report (UFSAR) Table 2.2.1 (Reference 50), in the year 2000, the population was estimated to be 9,919 within a ~~five-mile~~5-mile radius of the site, 23,954 within a ~~ten-mile~~
10-mile radius, and 193,746 within a 25-mile radius.

The construction permit for VYNPS was issued by the Atomic Energy Commission (AEC) on December 11, 1967. The plant was designed and constructed based on the proposed General Design Criteria (GDC) published by the AEC in the *Federal Register* (32 FR 10213) on July 11, 1967 (hereinafter referred to as "draft GDC"). The AEC published the final rule that added Appendix A to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "General Design Criteria for Nuclear Power Plants," in the *Federal Register* (36 FR 3255) on February 20, 1971 (hereinafter referred to as "final GDC").

Differences between the draft GDC and final GDC included a consolidation from 70 to 64 criteria. As discussed in the ~~U.S. Nuclear Regulatory Commission (~~NRC~~ or the Commission)~~ Staff Requirements Memorandum for SECY-92-223, dated September 18, 1992 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML003763736), the Commission decided not to apply the final GDC to plants with construction permits issued prior to May 21, 1971. At the time of promulgation of Appendix~~-~~ A to 10 CFR Part 50, the Commission stressed that the final GDC were not new requirements and were promulgated to

Attachment 2 to the March 26, 2003, letter states that for purposes of determining the P-T curves for the vessel core region material, VYNPS has elected to maintain the more conservative ART values previously used by VYNPS (89°F at the 1/4T point and 73°F at the 3/4T point). The licensee's submittal states that, based on RG 1.99, Revision 2, lower values of ART could have been used.

The NRC staff's assessment included an independent calculation of the ART values for both the 1/4T and 3/4T locations of the VYNPS reactor vessel beltline regions based on the revised 33 EFPY neutron fluence specified in the submittal for VYNPS for EPU conditions. The staff confirmed, using the methodology of RG 1.99, Revision 2, that the limiting beltline material was the reactor vessel plate 1-14 with an ART of 58°F at the 1/4T location and 53°F at the 3/4T location. Item 13 in Table 1, "Proposed OL and TS Changes," in Attachment 1 to Reference 1, indicates the analytical methods used in the March 26, 2003, letter are unchanged; however, the peak neutron fluence increased to 3.18×10^{17} n/cm^2. The neutron fluence methodology was determined to be consistent with the guidance in RG 1.190 as discussed in the NRC's SE for Amendment No. 218. Previously, the P-T limit curves were based on a peak vessel fluence value of 1.24×10^{18} n/cm^2 resulting in the limiting material (reactor vessel plate 1-14) having an ART of 89°F at the 1/4T location and 73°F at the 3/4T location. Since the staff has confirmed that the previous ART values bound the revised ART values for EPU conditions, the staff agrees that the P-T limit curves contained in the ~~Technical Specifications~~TSs remain bounding for EPU conditions.

Conclusion

The NRC staff has reviewed the licensee's evaluation of the effects of the proposed EPU on the USE values for the reactor vessel beltline materials and P-T limits for the plant. The staff concludes that the licensee has adequately addressed changes in neutron fluence and their effects on the USE values for VYNPS reactor vessel beltline materials and the P-T limits for the plant. The staff concludes that the VYNPS beltline materials will continue to have acceptable USE, as mandated by 10 CFR Part 50, Appendix G, through the expiration of the current operation license for the facility. The NRC staff further concludes that the licensee has demonstrated the validity of the proposed P-T limits for operation under the proposed EPU conditions. Based on this, the NRC staff concludes that the proposed P-T limits will continue to meet the requirements of 10 CFR Part 50, Appendix G, and 10 CFR 50.60 and will enable the licensee to comply with draft GDC-9, 33, 34, and 35 in this respect following implementation of the proposed EPU. Therefore, the NRC staff finds the proposed EPU acceptable with respect to the proposed P-T limits.

2.1.3 Reactor Internal and Core Support Materials

Regulatory Evaluation

The reactor internals and core supports include structures, systems, and components (SSCs) that perform safety functions or whose failure could affect safety functions performed by other SSCs. These safety functions include reactivity monitoring and control, core cooling, and fission product confinement (within both the fuel cladding and the reactor coolant system (RCS)). The NRC staff's review covered the materials' specifications and mechanical properties, welds, weld controls, nondestructive examination procedures, corrosion resistance, and susceptibility to degradation. The NRC's acceptance criteria for reactor internal and core

support materials are based on draft GDC-1 and 10 CFR 50.55a for material specifications, controls on welding, and inspection of reactor internals and core supports. Specific review criteria are contained in SRP Section 4.5.2 and ~~Boiling Water Reactor Vessel and Internals Project (BWRVIP)-26~~BWRVIP-26, and Matrix 1 of RS-001.

Technical Evaluation

Reactor internals and core support materials are subject to the following degradation:

- Crack initiation and growth due to stress-corrosion cracking (SCC), intergranular stress-corrosion cracking (IGSCC) and irradiation assisted stress-corrosion cracking (IASCC);
- Crack initiation and growth due to flow induced vibration;
- Cumulative fatigue damage; and
- Loss of fracture toughness due to thermal aging and neutron embrittlement.

Cumulative fatigue damage and crack initiation and growth due to flow induced vibration ~~is~~are discussed in Section 2.2.2 of this SE. Crack initiation and growth and loss of fracture toughness due to thermal aging and neutron embrittlement are managed through the inservice inspection program that conforms to the requirements of 10 CFR 50.-55a and the ~~Boiling Water Reactor Vessels and Internals Project (~~BWRVIP~~)~~ program. The BWRVIP inspection program supplements the inservice inspection program required by 10 CFR 50.55a. The BWRVIP program is reviewed and approved by the NRC. Section 10.7 of the Attachment 4 to Reference 1 indicates that VYNPS belongs to the BWRVIP organization, and implementation of the procedurally controlled program is consistent with the BWRVIP issued documents. The inspection strategies recommended by the BWRVIP consider the effects of fluence on the applicable components and are based on component configuration and field experience. To mitigate the potential~~s~~ for SCC, IGSCC and IASCC, VYNPS utilizes noble metals applications. Reactor water chemistry conditions are maintained consistent with ~~the Electric Power Research Institute (~~EPRI~~)~~, BWRVIP and established industry guidelines, except where technical justification in accordance with BWRVIP-94 ha~~ve~~s been documented. The licensee concludes that the current inspection program for the reactor internal components is adequate to manage any potential effects of EPU conditions because the increase in neutron fluence resulting from EPU conditions does not significantly increase the potential for degradation.

Since EPU conditions do not significantly increase the potential for degradation, the NRC staff concludes that the current inspection program is acceptable for all reactor vessel internals components except for the top guide and the steam dryer, which are discussed below.

Top Guide

Note 1 in Matrix 1 of Section 2.1 of RS-001 Revision 0 indicates that guidance on the neutron irradiation-related threshold for inspection for IASCC in BWRs is in BWRVIP report BWRVIP-26. The NRC staff's SE for BWRVIP-26 dated December 7, 2000, states that the threshold fluence level for IASCC is 5×10^{20} n/cm^2 (E > 1 million electron volts).

The licensee, in response to a staff RAI (Attachment 1 to Reference 6), indicated the following:

> Of the reactor vessel internal components, only the top guide's integrated flux will exceed 5×10^{20} n/cm^2. VY will commence inspection of critical top guide components in the refueling outage following power uprate. Enhanced Visual Testing (EVT)-1 of top guide grid beams will be performed in accordance with SIL 554 following the sample selection and inspection frequency of BWRVIP-47 for the CRD guide tubes. In other words, VY will perform inspection of 10% of the total population of cells within twelve years, with one-half (5%) to be completed within six years. The six-year intervals at Vermont Yankee will be defined to be the same as those for the CRD guide tubes. Selection of the cells will be biased to the highest fluence areas in the top guide. However, Vermont Yankee reserves the right to modify the above inspection program should BWRVIP-26 be revised in the future.

The proposed top guide inspection program will inspect a sample of top guides in the highest fluence areas using a technique capable of detecting IASCC at a frequency consistent with industry recommendations. The NRC staff concludes that the proposed program is reasonable and provides an acceptable means to manage the potential for IASCC.

Steam Dryer

The NRC staff raised concerns during the review that the proposed EPU conditions could cause cracks left ~~inservice~~in service in the steam dryer, following refueling outage (RFO) 24 (spring 2004), to grow to a size that could ~~effect~~affect the integrity of the steam dryer and ~~could cause~~result in the generation of loose parts, which could ~~effect~~affect the function of other reactor internals components. In response to a staff RAI, the licensee, in Attachment 2 to Reference 9, reported that the flaws left ~~inservice~~in service were produced by IGSCC. The licensee quantitatively evaluated the largest flaw, which is located in the dryer drain channel. The crack is located in the heat-affected-zone adjacent to the weld, follows the grain boundary, and exhibits a jagged appearance typical of IGSCC. The crack is not straight and does not have characteristics of a fatigue crack.

The NRC staff's summary of the licensee's quantitative evaluation (contained in Attachment 2 to Reference 14) follows:

- IGSCC crack growth was assumed during future operation at a rate of 5×10^{-5} in/hr on each end, consistent with established BWRVIP growth rates (which is also consistent with the IGSCC rates given in NUREG-0313). This growth will be independent of any fluctuating loading since it is dependent only on the sustained loads, which in this case are the residual stresses from the dryer fabrication. The fuel cycle length at VYNPS (i.e., the time between refueling outages~~,~~) is nominally 18-months (13,140 hrs). The predicted IGSCC crack growth for the next fuel cycle is then ($5 \times 10^{-5} \times 13{,}140$) or 0.66 inch at each end of the indication. This translates into a projected increase in the crack length from 12.0 inches to 13.32~~-~~ inches.

- The next step was to evaluate the length at which fatigue crack growth could occur. It is well established that fatigue will only occur when the applied stress intensity factor range exceeds the threshold stress intensity factor (ΔK_{th}~~-) is exceeded~~. For stainless steel at 550°F, this value is conservatively assumed to be 5 ksi-in$^{1/2}$.

- Strain gage data from an overseas BWR measured on the drain channel was used to determine the magnitude of the peak alternating stresses that would be present. A conservative adjustment to this peak stress for use in conjunction with the VYNPS drain channel was performed by scaling the overseas plant stress to the ratio of the square of the steam line velocity at VYNPS at EPU conditions to the square of the steam velocity at the overseas plant. The use of square of the steam line velocity is consistent with the recommendations in Appendix N of the ASME Code, Section III that deals with the treatment of dynamic loads. Also, the exponent 2 is consistent with the average of the exponents obtained in the development of the generic fluctuating load definition.

- The results of this evaluation established that the flaw would be predicted to reach 13.32 inches after 18 months. The associated ΔK for this longer crack is below the critical ΔK_{th}. Only when the crack reached~~s~~ 15.6 inches would the crack reach the ΔK_{th} at which fatigue crack extension could take place. This would be predicted to occur after 32 months of operation (i.e., longer than the 18-month fuel cycle).

The licensee's conclusion that the flaws remaining ~~inservice~~in service will not cause loose parts is based on the premise that as long as the flaws are not subjected to crack growth resulting from fatigue, they will grow at a slow enough rate during each fuel cycle that crack growth can be monitored by inservice inspection. This conclusion is based on industry experience with IGSCC flaws in BWR steam dryers. The licensee has also performed a qualitative engineering assessment of all the flaws and determined that there is additional margin in the design of the components that will prevent their failure.

In Reference 33, Attachments 1 and 10, the licensee provided commitments regarding steam dryer inspections. During RFO 24 (spring 2004), the licensee performed a baseline visual inspection of all accessible, susceptible locations of the steam dryer consistent with GE~~-~~ Services Information Letter (SIL) No. 644, Revision 1, "BWR Steam Dryer Integrity," dated November 9, 2004. The licensee had originally planned to conduct visual inspection of all accessible, susceptible locations of the steam dryer during RFO 25 (fall 2005), RFO 26 (spring 2007), and RFO 27 (fall 2008). This plan was based on implementation of EPU prior to RFO 25. However, since the EPU will be implemented after RFO 25, the licensee committed to

perform visual inspection of all accessible susceptible locations of the steam dryer during RFO 26, RFO 27, and RFO 28 (spring 2010). During RFO 25, the licensee committed to perform a visual inspection of the steam dryer modifications, flaws left "as-is," and repairs made during RFO 24. ~~I~~New information on indications identified in previous inspections that were not repaired will be compared with the previous information to validate crack growth projections.

In Supplement 42 to its EPU license amendment request (Reference 43), the licensee documented the results of the steam dryer inspection during RFO 25 and its analysis of those results. In particular, the licensee found no indications in the recent steam dryer modifications (including the gussets or their weld connections) nor any changes in previous left-as-is indications. The licensee did identify about 50 new indications in the end plates used to separate the internal vane assemblies in the steam dryer. The end plates are fabricated from 3/16-inch thick Type 304 stainless steel, and are 48 inches high and 8 inches wide with a channel shape that has a 1.25-inch flange on each side. Most of the indications are tight horizontal IGSCC cracks that appear to be 1.25 inches long on the inlet flow side of the flange next to the dryer shell. The licensee did not identify any indications in the 48-inch vertical welds

that hold the end plates in place on both the inlet and outlet flow sides of the vane assemblies. The licensee identified six fatigue cracks in the fillet welds where the bottom of the end plates fit into the drain trough. In that the end plates are notched into the drain troughs, the end plate to trough welds do not perform a structural function for the assembly. The licensee also reported that the previously identified steam dryer indications (including those in the end plates) had not grown in size. The licensee believed that the enhanced inspection technique applied during RFO 25 might have resulted in the identification of the additional indications in the steam dryer. In evaluating the end plate indications, the licensee determined that there were no structural consequences from the steam dryer indications, nor was there a potential for the generation of loose parts if it is postulated that the end plate indications propagate across the entire 8-inch end plate width.

The NRC staff does not believe that IGSCC will arrest; however, the licensee can propose a revised frequency of examination based on observed crack growth. Based on the licensee's analysis, the industry experience with IGSCC, and the licensee's commitment to institute an inspection program as discussed above, the staff concludes that there is reasonable assurance that the steam dryer can be safely operated at EPU conditions with flaws discovered during the spring 2004 and fall 2005 outages.

With regard to steam dryer experience at other nuclear power plants, the NRC staff discussed with the licensee the identification of fatigue cracks in the steam dryers at Dresden Units 2 and 3 during their fall 2005 outages. The licensee reviewed the steam dryer damage that occurred in those plants at the connection between the gussets and lower cover plate. The licensee verified that the pressure loads had been properly evaluated for the gusset to cover plate connection in the steam dryer at VYNPS, and that those loads will not cause fatigue damage to its gussets or connections. Additional discussion of steam dryer modeling is provided in Section 2.2.6.2.1 of this SE.

Conclusion

The NRC staff has reviewed the licensee's evaluation of the effects of the proposed EPU on the susceptibility of reactor internal and core support materials to known degradation mechanisms and concludes that the licensee has identified appropriate degradation management programs to address the effects of changes in operating temperature and neutron fluence on the integrity of reactor internal and core support materials. The NRC staff further concludes that the licensee has demonstrated that the reactor internal and core support materials will continue to be acceptable and will continue to meet the requirements of draft GDC-1 and 10 CFR 50.55a with respect to material specifications, welding controls, and inspection following implementation of the proposed EPU. Therefore, the NRC staff finds the proposed EPU acceptable with respect to reactor internal and core support materials.

2.1.4 Reactor Coolant Pressure Boundary Materials

Regulatory Evaluation

The RCPB defines the boundary of systems and components containing the high-pressure fluids produced in the reactor. The NRC staff's review of RCPB materials covered their specifications, compatibility with the reactor coolant, fabrication and processing, susceptibility to degradation, and degradation management programs. The NRC's acceptance criteria for

2.2.5.2 Technical Evaluation-

The licensee evaluated equipment qualification for EPU conditions. The VYNPS plant-specific dynamic loads such as SRV discharge and LOCA loads (including pool swell, condensation oscillation, and chugging loads) that were used in the equipment design will remain unchanged as discussed in Section 4.1.2 of the PUSAR, since these loads are based on the range of test conditions for the design-basis analysis at VYNPS, which are bounding for EPU conditions.

Based on its review of the proposed EPU amendment, the NRC staff finds that the original seismic and dynamic qualification of safety-related mechanical and electrical equipment is not affected by the EPU conditions for the following reasons:

- The seismic loads are unaffected by the EPU;
- No new pipe break locations or pipe whip and jet impingement targets are postulated as a result of the EPU;
- Pipe whip and jet impingement loads do not increase for the EPU; and
- SRV and LOCA dynamic loads used in the original design basis analyses are bounding for the EPU.

2.2.5.3 Conclusion

The NRC staff has reviewed the licensee's evaluations of the effects of the proposed EPU on the qualification of mechanical and electrical equipment and concludes that the licensee has (1) adequately addressed the effects of the proposed EPU on this equipment; and (2) demonstrated that the equipment will continue to meet the requirements of draft GDC-1, 2, 9, 33, 34, 40, and 42, following implementation of the proposed EPU. Therefore, the NRC staff finds the proposed EPU acceptable with respect to the qualification of the mechanical and electrical equipment.

2.2.6 Additional Review Area - Potential Adverse Flow Effects

2.2.6.1 Regulatory Evaluation

Plant operation at EPU conditions can result in adverse flow effects on the MS, FW, and condensate systems and their components (including the steam dryer in BWR plants) from increased system flow and FIV. Some plant components, such as the steam dryer, do not perform a safety function, but must retain their structural integrity to avoid the generation of loose parts that might adversely impact the capability of other plant equipment to perform their safety functions. The NRC staff reviewed the licensee's consideration of potential adverse flow effects of the proposed EPU at VYNPS, including consideration of the design input parameters and the design-basis loads and load combinations for the VYNPS steam dryer for normal operation, upset, emergency, and faulted conditions. The NRC staff's review covered the analytical methodologies, assumptions, and computer programs used in the evaluation of the VYNPS steam dryer. The NRC staff's review also included a comparison of the resulting stresses against applicable limits. The NRC staff also reviewed the licensee's evaluation of other reactor, MS, FW, and condensate system components at VYNPS for potential

susceptibility to adverse flow effects from EPU operation. The NRC's acceptance criteria are based on (1) draft GDC-1, insofar as it requires those systems and components which are essential to the prevention of accidents which could affect the public health and safety or to mitigation of their consequences be designed, fabricated, erected, ~~constructed,~~ tested, and inspected to quality standards commensurate with the importance of the safety functions to be performed; (2) draft GDC-2, insofar as it requires that those systems and components which are essential to the prevention of accidents which could affect the public health and safety or to mitigation of their consequences be designed to withstand the effects of earthquakes combined with the effects of normal or accident conditions; and (3) draft GDC-40 and 42, insofar as they require that protection be provided for ESFs against the dynamic effects and missiles that might result from plant equipment failures, as well as the effects of a LOCA. Specific review criteria are contained in SRP Sections 3.9.1, 3.9.2, 3.9.3, and 3.9.5.

2.2.6.2 Technical Evaluation

2.2.6.2.1 Steam Dryer

As indicated in Attachment 5 to Supplement 26 (March 31, 2005) of its EPU request, the licensee originally procured the steam dryer for VYNPS as a non-safety-related, non-Seismic I, non-ASME component. In response to damage experienced ~~to~~by steam dryers at other nuclear power plants under EPU conditions, Entergy modified the square-hood steam dryer at VYNPS to improve its capability to withstand potential adverse flow effects that could result from operation of the plant at EPU conditions. In Supplement 8 (July 2, 2004) of its EPU request, the licensee described the modifications to the VYNPS steam dryer as follows:

- outer vertical hood plates (61-inch high) on 90° and 270° sides replaced with 1-inch thick plate;
- 3 reinforcing gussets (55.5-inch high) welded to outer vertical hood plates and lower horizontal cover plates on 90° and 270° sides;
- lower horizontal cover plates on 90° and 270° sides replaced with 5/8-inch thick plate;
- 15-inch section of upper horizontal cover plates on 90° and 270° sides at intersection of outer vertical hood plates replaced with 1-inch thick plate;
- internal bracing brackets at outer vertical hood plates removed; and
- dryer bank tie bars replaced with new design.

During a technical audit at the GE office in San Jose, CA, from August 24 to 26, 2004, NRC staff members from the Office of Nuclear Reactor Regulation (NRR) and Office of Nuclear Regulatory Research (RES) with technical assistance by contractors from the Argonne National Laboratory reviewed the VYNPS steam dryer analysis initially provided as part of the licensee's EPU request. As discussed in the audit report dated September 14, 2004, the NRC staff concluded that the licensee's analysis was inadequate to demonstrate that the steam dryer at the VYNPS will be capable of maintaining its structural integrity under EPU conditions. For example, the licensee's analysis of the steam dryer as then submitted in support of its EPU request (1) had not adequately identified and verified the excitation sources for FIV

mechanisms that resulted in significant degradation of similar steam dryers at other BWR nuclear power plants operating at EPU conditions; (2) had not provided a technically justifiable load definition for the steam dryer for EPU conditions in light of several assumptions that had not been adequately justified; (3) had not justified the applied methodology as realistic in light of assumptions to account for uncertainties that resulted in apparent significant overestimation of predicted steam dryer stresses; (4) might be non-conservative based on assumptions for reducing the stress experienced by steam dryer parts and the creation of new potential fatigue failure locations as a result of modifications to the VYNPS steam dryer; and (5) had not validated the extrapolation of pressure peaks from original power levels to EPU conditions for the steam dryer at VYNPS. In the audit report, the NRC staff indicated that the licensee could submit a revised analysis of the steam dryer in support of its request to operate VYNPS at EPU conditions.

In Supplement 26 (March 31, 2005), Supplement 27 (April 5, 2005), and Supplement 29 (June 2, 2005) of its EPU request, Entergy provided a revised analysis of the capability of the modified VYNPS steam dryer to maintain its structural integrity under EPU conditions. NRC staff members from NRR and RES have reviewed the revised VYNPS steam dryer analysis with technical assistance by contractors from the Argonne National Laboratory (including a consultant from the Pennsylvania State University), and McMaster University in Canada. On June 15 and 16, 2005, the NRC staff with its contractors conducted a technical audit of the revised analysis of the VYNPS steam dryer at the GE office in Washington, DC. On July 27, 2005, the NRC staff provided a ~~finalized~~final RAI to Entergy on the revised analysis of the VYNPS steam dryer. On August 1 and 4, 2005, the licensee submitted a response to the RAI in Supplements 30 and 31 to its EPU request. On August 15 and 16, 2005, an NRC staff member and ~~one~~a contractor conducted an audit at the GE Scale Model Test (SMT) facility near San Jose, CA, to obtain information on the licensee's performance of tests to validate the specific application of the acoustic circuit model (ACM) used by the licensee to determine the pressure loads on the VYNPS steam dryer during EPU operation. From August 22 to 25, 2005, the NRC staff with its contractors conducted a technical audit at the GE office in Washington, DC, of the revised analysis of the VYNPS steam dryer. In Supplement 33 (September 14, 2005) of its EPU request, the licensee provided revised RAI responses to address the NRC staff's findings from the August 22-25, 2005, audit. In Supplement 34 (September 18, 2005) of its EPU request, the licensee provided, among other information, several figures inadvertently omitted from Supplement 33. On December 5, 2005, the NRC staff conducted a follow-up audit to the June and August 2005 audits with licensee personnel at the Excel Corporation office in Rockville, MD, to verify appropriate finite element modeling of the connection of the gussets to the cover plate in the VYNPS steam dryer for the determination of stress at the connection under EPU conditions.

As described in the applicable supplements to its EPU request, the licensee evaluated the pressure loads acting on the steam dryer during operation of VYNPS through computational fluid dynamics (CFD) and acoustic circuit model (ACM) analyses. The licensee used the CFD analysis of the VYNPS steam dryer to predict hydrodynamic pressure loads that would act on the steam dryer at low frequencies under CLTP and EPU conditions. The licensee used the ACM analysis to calculate the acoustic pressure loads acting at high frequencies on the VYNPS steam dryer at CLTP based on pressure fluctuations in the MSLs measured by pressure sensors installed on the MSL venturi lines and strain gages installed on the MSLs. The licensee performed transient and static stress analyses using an ANSYS finite element model (FEM) of the VYNPS steam dryer. The licensee calculated the stresses on the VYNPS steam

dryer resulting from the CFD and ACM analyses, and combined those stresses by the square-root-of-the-sum-of-squares (SRSS) methodology with applicable weld concentration factors. The licensee then compared the peak alternating stresses for specific steam dryer locations to the fatigue limits in the ASME ~~B&PV~~ Code and the primary plus secondary stresses to the applicable ASME Code Service Level limits.

In its review of the VYNPS steam dryer analysis, the NRC staff evaluated the licensee's validation of its CFD and ACM analyses, and the uncertainty of those analyses and their inputs. The staff reviewed the licensee's fundamental frequency and damping assumptions for the VYNPS steam dryer. The staff evaluated the licensee's calculational methodology to convert the design pressure loads obtained from the CFD and ACM analyses to the stress at various locations on the steam dryer, the combination of the calculated CFD and ACM stresses, the stress limits used in evaluating steam dryer integrity, and the margins to those limits. The staff also reviewed the information provided by the licensee for monitoring the loads exerted on the steam dryer during plant operation and overall dryer performance.

In its CFD analysis, the licensee conducted a Large Eddy Simulation (LES) of the upper portion of the VYNPS reactor pressure vessel (including the steam dryer) and MSLs. The licensee determined pressure loads from low frequencies up into the acoustic range based on CFD analyses. Upon filtering the CFD analysis based on frequency, the licensee predicted stresses of low magnitude in the VYNPS steam dryer due to hydrodynamic loads having a frequency content of less than 30 Hz. In Attachment 5 to Supplement 33 of its EPU request, the licensee indicated that it used the full CFD predicted stress (and not the filtered CFD stress) in the evaluation of the combined stress and the limit curve factors. The licensee estimated the uncertainty of the CFD analysis as 15% based on a previous analysis of a small pipe flow model, and used measurements of low frequency pressure loads on steam dryers at four other nuclear power plants to support this uncertainty estimate. The NRC staff reviewed the CFD analysis (including the electronic data file) of the fluid dynamic loads on the VYNPS steam dryer. The NRC staff determined that significant uncertainty surrounds the CFD predictions, and that the magnitude of this uncertainty was highly underestimated by the licensee. For example, the licensee did not perform sensitivity studies of the CFD analysis applied to VYNPS to obtain an understanding of the significance of specific assumptions in the analysis. The comparison of the Vermont Yankee CFD results to the measured low frequency pressure loads at four other nuclear power plants does not establish the uncertainty value for the VYNPS CFD analysis, because CFD analyses were not performed for those other plants and all but one of those plants contained a steam dryer with an improved design to reduce hydrodynamic loads. The plant with a similar design steam dryer to VYNPS provided one pressure measurement that was in the skirt area with low flow conditions. Based on its review at that point, the staff determined that the uncertainty assumed by the licensee in its determination of the loads from the CFD analysis of the VYNPS steam dryer ~~is~~was significantly underestimated. To address this concern, and to confirm the licensee's predictions regarding the hydrodynamic and acoustic loads on the steam dryer, a license condition will be added to the VYNPS Facility Operating License as shown in SE Section 3.17.3. The license condition provides requirements for monitoring, evaluating, and taking prompt action in response to potential adverse flow effects as a result of operation at EPU conditions.

The licensee applied two different methods in its effort to validate the ACM used to calculate the acoustic pressure loads at high frequencies on the VYNPS steam dryer. In one method, the licensee used air tests conducted at the GE SMT facility to compare pressure loads calculated

by the ACM from steam line data to pressure measurements from a scale model steam dryer. In the second method, the licensee compared pressure sensor data collected from the instrumented steam dryer at the Quad Cities Unit 2 nuclear power plant during its power ascension to pressure loads calculated by the version of the ACM selected for application to the VYNPS steam dryer. The NRC staff determined that a number of uncertainties exist regarding the use of the SMT facility to validate the specific application of the ACM for the VYNPS steam dryer (including the relatively low flow provided by the SMT facility and the substantial deviation of the ACM predictions to SMT measurements). As a result, the staff focused on the licensee's use of the pressure sensor data obtained from the Quad Cities Unit 2 instrumented steam dryer to validate the ACM for application to VYNPS.

At VYNPS, the licensee applied a version of the ACM that was used by Exelon to assess the pressure loads on the steam dryer at Quad Cities Unit 2 at a power level of ~~790 MWe~~790 megawatts electric (MWe) during EPU restart in May 2005. At Quad Cities Unit 2, Exelon revised the 790 MWe version of the ACM based on additional pressure sensor data collected from its instrumented steam dryer at 930 MWe. For VYNPS, Entergy developed an uncertainty estimate for the "790 MWe-version" of the ACM based on a comparison of the pressure loads calculated by the ACM to the measured pressure at 27 locations on the Quad Cities Unit 2 steam dryer. From its evaluation, the licensee estimated the uncertainty of the ACM as 100% of the calculated steam dryer pressure load. The NRC staff reviewed the licensee's estimation of the uncertainty of the version of the ACM used at VYNPS, and determined the 100% uncertainty value to be insufficient to provide reasonable assurance in the calculation of the pressure loads on the VYNPS steam dryer. For example, Figure EMEB-B-18-1-6 on page 16 in Attachment 1 to Supplement 33 of the licensee's EPU request indicates that the root mean square (RMS) of the pressure load calculated by the ACM, combined with the 100% uncertainty estimate, underpredicts the measured RMS pressure at many of the 27 pressure sensor locations on the Quad Cities Unit 2 steam dryer. Further, Figures EMEB-B-18-4-1 to 27 indicate that the power spectral density (PSD) from the ACM-calculated loads, combined with the 100% uncertainty estimate, underpredicts the PSD from the measured pressure data at Quad Cities Unit 2 over a wide frequency range for many of the 27 pressure sensors. As a result, the NRC staff considers the uncertainty assumed by the licensee for the version of the ACM applied at VYNPS to be significantly underestimated. To address this concern, and to confirm the licensee's predictions regarding the hydrodynamic and acoustic pressure loads on the steam dryer, a license condition will be added to the VYNPS Facility Operating License as shown in SE Section 3.17.3. The license condition provides requirements for monitoring, evaluating, and taking prompt action in response to potential adverse flow effects as a result of operation at EPU conditions.

At VYNPS, the licensee currently uses data from the MSL venturi instrument lines and one strain gage on each MSL to provide input to the ACM. The long venturi instrument lines and the lack of an array of strain gages at each MSL measurement location at VYNPS can result in significant uncertainty (over 100%) in the pressure input to the ACM. The NRC staff questioned the reliability of the ACM in calculating steam dryer pressure loads based on the large uncertainty associated with the MSL input data. To address the concerns with the uncertainty of the current MSL data used as input to the ACM, the licensee stated in the cover letter for Supplement 33 of its EPU request that it would install 32 additional strain gages on the MSL piping during the fall 2005 refueling outage (RFO) and would enhance the data acquisition system prior to EPU operation to reduce the measurement uncertainty associated with the ACM input. During the August 22-25, 2005, audit, the licensee indicated that the 32 additional strain

gages ~~will~~would be installed as a set of four strain gages in a quadrant array at two locations on each MSL to provide 8 independent inputs to the VYNPS ACM.

In Attachment 5 to Supplement 26 of its EPU request, the licensee described its structural analysis of the VYNPS steam dryer for CFD and ACM pressure loads at CLTP conditions. In Attachment 5 to Supplement 33 of its EPU request, the licensee discussed its updated structural analysis of the steam dryer that includes the ACM results for CLTP conditions from Supplement 26 combined with CFD pressure loads predicted for EPU conditions at VYNPS. The ACM analysis uses MSL instrumentation to project the measured pressure fluctuations as pressure loads on the steam dryer for the specific power level at which the plant is operating, and does not predict steam dryer loads for higher power levels. The ANSYS FEM for the VYNPS steam dryer analysis included the dryer support ring, dryer hoods, end plates, cover plates, upper dryer banks, cross beams, bottom support plates, tie bars, and gussets. In early 2005, the licensee identified the need to revise the FEM to model more accurately the connection of the gussets to the lower cover plate. The FEM used to evaluate steam dryer stress from CFD loads was updated at that time. The licensee performed hand calculations to verify that the stress at the gusset to cover plate connection from the ACM loads was significantly less than the applicable stress limit. As part of determining the EPU steam dryer load definition, the licensee will update the FEM model used in the ACM analysis to reflect the as-built connection of the gussets to the cover plate.

The licensee evaluated the dynamic structural response of the steam dryer to applied pressure fluctuations from acoustic loading using a time history method with modal superposition. The licensee performed a sensitivity assessment by varying the time interval between the pressure time steps by 10% (equivalent to peak broadening in the response spectrum analysis method). The licensee assigned an uncertainty to the stress amplitude of 20% due to load/response frequency uncertainty based on these shifted frequency analyses. However, the licensee did not include potential increased stress resulting from peak loading frequencies aligning with the dryer resonance frequencies in its analysis. For the fatigue stress evaluation, the licensee determined the peak stress for various locations on the VYNPS steam dryer by combining the stresses calculated from the CFD and ACM analyses by the SRSS method, and then multiplying the combined stress by applicable weld concentration and size factors. The licensee applied the acoustic and CFD uncertainties to calculate an uncertainty value for the limit curve factor used to monitor steam dryer performance. For the ASME load case assessments, the licensee increased the acoustic loading stress by a 130% uncertainty value and the CFD loading stress by a 16% uncertainty value, and combined these stresses by the SRSS method. The licensee then compared the results of these stress analyses to the applicable ASME allowable stress limits to demonstrate available structural margin in the VYNPS steam dryer. In Attachment 2 to Supplement 33, the licensee provided the results of its analysis of the dryer skirt indicating low acoustic loading stress for that region of the VYNPS steam dryer.

Based on the ASME fatigue stress limit, the licensee calculated an allowable limit curve over the frequency spectra using the CFD analysis for low frequency loads and the ACM analysis for the high frequency loads with the current MSL data input, including the consideration of uncertainties. The NRC staff reviewed the method used by the licensee to calculate the stress at various locations on the VYNPS steam dryer based on the pressure loads predicted by the CFD and ACM analyses. As a result of the uncertainties associated with the CFD and ACM analyses and MSL input data, the NRC staff indicated during the audit on August 22-25, 2005,

that it was important to demonstrate that the structural integrity of the steam dryer would not be challenged if the actual loads on the steam dryer reached the limit curve. In Attachment 5 to Supplement 33 of its EPU request, the licensee provided its assessment of the limit curve relative to the fatigue stress limit to demonstrate that, if the limit curve is not exceeded, the structural integrity of the VYNPS steam dryer will be assured. In its assessment, the licensee calculated the most limiting stress location as the [[-]] with a stress of [[ ]] psi based on the CFD analysis at EPU conditions and a stress of [[ ]] psi based on the ACM analysis at CLTP conditions. As these stresses are associated with independent low and high frequency pressure loads, respectively, the combined peak stress for this location on the VYNPS steam dryer is calculated by the SRSS method to be [[ ]] psi. The licensee established a limit curve that would provide for an SRSS combination of CFD and ACM stress at the most limiting steam dryer location of 7393 psi. Therefore, the limit curve stress will provide considerable margin to the ASME fatigue limit stress of 13,600 psi. As discussed below, in accordance with the license condition discussed in SE Section 3.17.3, the licensee will provide its limit curve as part of the startup test procedure for VYNPS to the NRC staff prior to exceeding CLTP.

In Attachment 6 to Supplement 33 of its EPU request, the licensee describes its updated Steam Dryer Monitoring Plan (SDMP) for monitoring and evaluating the performance of the VYNPS steam dryer during power ascension testing and operation above CLTP to full EPU conditions to verify acceptable steam dryer performance. The licensee defines unacceptable steam dryer performance as a condition that could challenge steam dryer structural integrity and result in the generation of loose parts, cracks or tears in the dryer that result in excessive moisture carryover. The licensee proposed a license condition for steam dryer monitoring to require operational surveillances as well as visual inspections of the steam dryer at specific scheduled RFOs following achievement of full uprate conditions as shown in SE Section 3.17.3. The licensee state~~s~~d that power ascension above CLTP would be conducted in 2.5% power steps and 5% power plateaus. The power ascension will include hold points at each 2.5% step and 5% plateau. The licensee stated that the maximum power increase would not exceed a nominal 5% power in a 24-hour period. The SDMP specifies that moisture carryover will be determined every 24 hours; MSL pressure data from strain gages will be obtained hourly when initially increasing power above a previously attained level and at least once every 2.5% power step above CLTP; and MSL pressure data from pressure transducers will be collected at least once every 2.5% power step above CLTP and within 1 hour after achieving every 2.5% power step above CLTP. The SDMP allows relaxed monitoring if the surveillance requirements are met at a power step, but requires a power reduction if a surveillance is not accomplished within the specified time intervals. In addition, the SDMP indicates that plant data ~~that~~which may be indicative of off-normal dryer performance will be monitored during power ascension (e.g., steam flow, feed flow, etc.).

The SDMP establishes criteria for verifying acceptable steam dryer performance at VYNPS using moisture carryover and MSL pressure data. The performance criteria are specified as Level 2 based on maintaining less than (or equal to) 80% of the ASME allowable alternating stress at 10^{11} cycles (i.e., 10,880 psi) and Level 1 based on maintaining the ASME allowable alternating stress at 10^{11} cycles (i.e., 13,600 psi). The Level 2 steam dryer performance criteria are (1) moisture carryover exceeds 0.1%; (2) moisture carryover exceeds 0.1% and increases by more than 50% over the average of the three previous measurements taken at greater than 1593 MWt; and (3) pressure data exceed the Level 2 spectra. If any of the Level 2 steam dryer performance criteria are exceeded, the SDMP specifies that (1) reactor power ascension be

promptly suspended until an engineering evaluation concludes that further power ascension is justified; and (2) before resuming reactor power ascension, the steam dryer performance data shall be reviewed as part of an engineering evaluation to assess whether further power ascension can be made without exceeding the Level 1 criteria. The Level 1 steam dryer performance criteria are (1) moisture carryover exceeds 0.35%; and (2) pressure data exceed Level 1 spectra. If either of the Level 1 steam dryer performance criteria is exceeded, the SDMP specifies that the licensee will:

(1) Promptly initiate a reactor power reduction and achieve a previously acceptable power level (i.e., reduce power to a previous step level) within 2 hours, unless an engineering evaluation concludes that continued power operation or power ascension is acceptable.

(2) Within 24 hours, re-measure moisture carryover and perform an engineering evaluation of steam dryer structural integrity. If the results of the evaluation of dryer structural integrity do not support continued plant operation, the reactor shall be placed in a hot shutdown condition within the following 24 hours. If the results of the engineering evaluation support continued power operation, implement steps (3) and (4) below.

(3) If the results of the engineering evaluation support continued power operation, reduce further power ascension step and plateau levels to nominal increases of 1.25% and 2.5% of CLTP, respectively, for any additional power ascension.

(4) Within 30 days, use the transient pressure data to calculate the steam dryer fatigue usage to demonstrate that continued power operation is acceptable.

The SDMP also specifies that, if the steam dryer performance criteria are exceeded, the following actions will be taken depending on the criteria exceeded:

(1) Either suspend reactor power ascension (Level 2 Acceptance Criteria) or reduce reactor power (Level 1 Acceptance Criteria), initiate a Condition Report, and evaluate the cause of any exceedance of the performance criteria.

(2) Prior to increasing reactor thermal power to a level higher than any previously attained, the plant conditions relevant to steam dryer integrity and associated evaluation results shall be reviewed by the on-site safety review committee, and a recommendation shall be made to the General Manager, Plant Operations prior to increasing power for each 5% power plateau.

(3) Strain gage pressure and moisture carryover data collected at each 5% power plateau will be made available to the NRC through its resident inspector.

(4) Each initial increase in reactor thermal power to the next higher 5% power plateau above 100% CLTP must be authorized by the General Manager, Plant Operations.

In addition, the SDMP states that other reactor operational parameters that may be influenced by steam dryer integrity (e.g., steam flow distribution between the individual steam lines) will be

monitored with the intent of detecting structural degradation of the steam dryer during plant operation (e.g., flow distribution between individual MSLs). Plant procedures will control the enhanced monitoring of selected plant parameters.

The SDMP states that the results of visual inspections of the steam dryer conducted during the next three RFOs shall be reported to the NRC staff within 60 days following startup from the respective RFO. The SDMP also states that its results shall be submitted to the NRC staff in a report within 60 days following completion of all EPU power ascension testing. In addition, the final full EPU power performance criteria spectra (limit curve) will be submitted to the NRC staff within 120 days.

As long-term actions, the SDMP states that the VYNPS steam dryer will be inspected during RFOs scheduled for fall 2005, spring 2007, fall 2008, and spring 2010, according to the recommendations of GE Services Information Letter (SIL) No. 644, Revision 1 (November 9, 2004). The SDMP also indicates that, following completion of EPU power ascension testing, moisture carryover measurements will continue to be made periodically, and other plant operational parameters that may be affected by steam dryer structural integrity will continue to be monitored, in accordance with GE SIL 644 and plant procedures. The SDMP notes that temporarily installed pressure monitoring sensors and strain gages may be removed from service following achievement of one operating cycle after issuance of the EPU license amendment and satisfaction of the license condition requirements for steam dryer inspections.

In Attachment 1 to Supplement 32 to its EPU request, the licensee ~~updates~~modified its commitment to perform visual inspections of the steam dryer at VYNPS. In particular, the licensee describes its plan to perform a visual inspection during the fall 2005 RFO of the steam dryer modification, flaws left "as-is," and the repair made during the last RFO. The licensee indicates that this inspection plan satisfies recommendations A.1.c and A.1.d in GE SIL 644, Revision 1. The licensee also discusses its plan to conduct a visual inspection of all accessible, susceptible locations of the steam dryer during each of the three RFOs, beginning with RFO-26 (i.e., spring 2007) to satisfy recommendation B.2 in SIL 644, Revision 1. The licensee lists this steam dryer inspection plan as a regulatory commitment in Attachment 10 to Supplement 32.

In the cover letter for Supplement 33 of its EPU request, the licensee states that several actions will be taken with respect to providing confidence in the capability of the steam dryer at VYNPS to maintain its structural integrity under EPU conditions. In Attachment 1 to Supplement 36, Entergy specified those planned actions as part of a proposed license condition. The proposed license condition is shown in SE Section 3.17.3. The actions include:

(1) The licensee will install 32 additional strain gages on the main steam piping during the fall 2005 RFO and will enhance the data acquisition system prior to EPU operation in order to reduce the measurement uncertainty associated with the ACM.

(2) In the event that acoustic signals are identified that challenge the limit curve during EPU power ascension, the licensee will evaluate dryer loads and re-establish the limit curve based on the new strain gage data, and will perform a frequency specific assessment of ACM uncertainty at the acoustic signal frequency.

(3) After reaching 120% of CLTP, the licensee will obtain measurements from the MSL strain gages and establish the VYNPS dryer flow-induced vibration load fatigue margin, update the dryer stress report, and re-establish the SDMP limit curve with the updated ACM load definition and revised instrument uncertainty, which will be provided to the NRC staff.

(4) During power ascension, if an engineering evaluation is required in accordance with the SDMP, the licensee will perform the structural analysis to address frequency uncertainties up to ±10% and assure that peak responses that fall within this uncertainty band are addressed.

(5) The licensee will revise the SDMP to reflect long-term monitoring of plant parameters potentially indicative of a dryer failure; to reflect consistency of the VYNPS steam dryer inspection program with SIL 644, Revision 1; and to identify the NRR Project Manager for VYNPS as the point of contact for providing SDMP information during power ascension.

(6) The licensee will submit the final EPU VYNPS steam dryer load definition to the NRC upon completion of the power ascension test program.

(7) The licensee will submit the flow-induced vibration related portions of the EPU startup test procedure, including the methodology for updating the limit curve, prior to power ascension.

In Attachment 6 to Supplement 33 of its EPU request, the licensee proposed a license condition for implementation of the VYNPS SDMP. The proposed license condition was subsequently superceded by Supplement 36 of the EPU request. The proposed license condition is shown in SE Section 3.17.3.

The NRC staff has reviewed the information provided by the licensee in support of its analysis of the structural integrity of the VYNPS steam dryer under EPU conditions, and for monitoring steam dryer loads and performance during plant operation. Although significant uncertainty exists regarding the licensee's method for calculating specific stress values on the VYNPS steam dryer from its CFD and ACM analyses, the licensee's current MSL instrumentation suggests minimal excitation of the pressure frequency spectra in the MSLs at CLTP conditions. As a result, the staff finds that the licensee has demonstrated that the flow-induced stress imposed on the VYNPS steam dryer at CLTP conditions is within the fatigue stress limits provided in the ASME ~~B&PV~~ Code. However, the available margin to those stress limits is not readily verifiable.

~~The~~Therefore, the NRC staff considers the licensee's planned actions specified in Supplement 33 of its EPU request, and included in the proposed license condition in Supplement 36, to be an important part of the licensee's effort to provide confidence that the structural integrity of the steam dryer will be maintained during EPU operation. For example, the staff considers the use of the more accurate MSL strain gages to be installed for monitoring pressure fluctuations in the MSLs to be necessary in light of the large uncertainty in the current MSL instrumentation that provides input to the ACM analysis. The staff considers the selection of the new MSL instrumentation in terms of its sensitivity and signal-to-noise ratio to be important to its acceptability. The staff also considers it important to consider whether any acoustic sources

might exist between the MSL strain gage locations. Further, the staff agrees with the importance of evaluating the peak frequencies within the ±10% frequency range when the licensee re-evaluates the steam dryer loads if MSL strain gage data exceed the limit curve, or following achievement of EPU conditions, as part of establishing a new limit curve. During the licensee's evaluation of the results of the inspection of the VYNPS steam dryer to be conducted in the fall of 2005, the predictions of low stress (including in the skirt region) need to be compared to actual operating experience with the VYNPS steam dryer. The staff also considers the requirements specified by the licensee in the proposed license condition to be appropriate for establishing and implementing the SDMP at VYNPS.

In light of the large uncertainties in the CFD and ACM analyses and the fact that the ACM analysis has calculated the steam dryer pressure loads only at CLTP, the NRC staff determined that the licensee needs to closely monitor MSL strain gage data and other plant data as the reactor power is raised at VYNPS such that the ACM loads can be calculated at the increased power level to verify that the structural limits for the steam dryer are not reached. For example, the staff ~~believes~~concluded that the new 32 MSL strain gages need to be monitored frequently during power ascension above CLTP for increasing pressure fluctuations in the steam lines. Hold points need to be established at 105%, 110%, and 115% of CLTP to collect plant data, conduct plant inspections and walkdowns, and evaluate the plant data for steam dryer performance. The time period for each hold point will need to be sufficient to complete all activities specified in the startup test procedure for the applicable hold point. Sufficient information and time will need to be provided to the NRC staff to determine whether any safety concerns exist prior to increasing power above each hold point. If any frequency peak from the MSL strain gage data exceeds the limit curve established by the licensee prior to operation above CLTP, the unit needs to be returned to a power level where the limit curve is not exceeded. The licensee would then resolve the uncertainties in the steam dryer analysis prior to further increases in reactor power. In the subsequent engineering evaluation, peak responses that fall within the ±10% frequency uncertainty band need to be considered as part of an adequate structural analysis. Further, the potential effect of the skirt in the steam dryer FEM on the stresses in the steam dryer components needs to be addressed. In addition to evaluating the MSL strain gage data, reactor pressure vessel water level instrumentation or MSL piping accelerometers need to be monitored frequently to help identify any resonance frequencies not captured by the MSL strain gage data and ACM analysis. If resonance frequencies are identified as increasing significantly above nominal levels established at CLTP conditions, power ascension needs to be stopped until an evaluation of continued steam dryer integrity is performed to demonstrate that no safety concerns exist. Within a reasonable time period following issuance of the EPU license amendment, the uncertainties in the steam dryer analysis need to be resolved to avoid long-term fatigue concerns with the steam dryer. In response to an NRC letter dated October 12, 2005, Entergy submitted a proposed license condition in Attachment 1 to Supplement 36 of its EPU application that addresses the NRC staff findings discussed above. The proposed license condition is shown in SE Section 3.17.3.

The NRC staff considers the development of an adequate EPU startup test procedure to be a significant action in confirming the safe operation of VYNPS during EPU conditions. The staff has determined that the EPU startup test procedure needs to include (a) the stress limit curve to be applied for evaluating steam dryer performance; (b) specific hold points and their duration during EPU power ascension; (c) activities to be accomplished during hold points; (d) plant parameters to be monitored; (e) inspections and walkdowns to be conducted for steam, FW, and condensate systems and components during the hold points; (f) methods to be used to

trend plant parameters; (g) acceptance criteria for monitoring and trending plant parameters, and conducting the walkdowns and inspections; (h) actions to be taken if acceptance criteria are not satisfied; and (i) verification of the completion of commitments and planned actions specified in the EPU application and all supplements to the application in support of the EPU request prior to power increase above CLTP. While the licensee indicates that plant parameters will be monitored to provide information on steam dryer ~~failure~~performance, the staff also considers it important for additional steam dryer loading information to be obtained for qualitative evaluation from the reactor pressure vessel water level instrumentation or MSL piping accelerometers in light of the inadequacy of the ACM in calculating low frequency pressure loads on the steam dryer. While the SDMP indicates that other plant parameters (such as steam flow distribution between MSLs) will be monitored, the staff also considers it important for the frequency of such monitoring, acceptance criteria, and actions if those criteria are not satisfied, to be specified in the startup test procedure. In response to an NRC letter dated October 12, 2005, Entergy submitted a proposed license condition in Attachment 1 to Supplement 36 of its EPU application. The staff has determined that this proposed license condition addresses the NRC staff findings discussed above. The proposed license condition is shown in SE Section 3.17.3.

Prior to power ascension above CLTP and during the power ascension, the NRC staff has determined that sufficient time needs to be available during the hold points to allow the licensee to present plant information on potential adverse flow effects on the steam dryer (and other plant equipment) to the NRC staff for a determination of whether any safety concerns exist with power ascension. In Attachment ~~1~~2 to Supplement 36 of its EPU request, Entergy submitted a regulatory commitment that addresses the NRC staff findings discussed above. As shown in SE Section 4.0 (Item No. 25), Entergy will provide information on plant data, evaluations, walkdowns, inspections, and procedures associated with the individual requirements of the license condition (pertaining to potential adverse flow effects) to the NRC staff prior to increasing power above 1593 MWt or each specified hold point, as applicable. If any safety concerns are identified during the NRC staff review of the provided information, Entergy will not increase power above 1593 MWt or the applicable hold point, and the specific requirements in the license condition will not be satisfied. The NRC staff considers that this commitment ~~to~~ provides appropriate interaction between the licensee and the staff prior to and during power ascension above CLTP conditions.

2.2.6.2.2 Steam, Feedwater, and Condensate Systems and Components

In Attachment 1 to Supplement 15 (September 23, 2004) of its EPU request, the licensee stated that the VYNPS piping steady state vibration program for EPU power ascension testing follows the guidance in Part 3 of the ASME OM-S/G-2000 standard (ASME OM-3). The program assesses the FIV levels of selected piping systems that are expected to experience increased flow during EPU conditions. The licensee stated that vibration data will be taken at approximately 2.5% power increments above CLTP and will be evaluated for acceptability. For example, the MS and FW piping located in the drywell which is inaccessible during plant operation will be monitored for vibration levels using direct mounted accelerometers with acceptance criteria based on guidance in ASME OM-3. The FW regulator valves and attached FW piping located downstream of the reactor feed pumps will be monitored with a hand-held vibration meter. If vibration levels for these components increase significantly, the licensee will further evaluate the affected components.

Also in Attachment 1 to Supplement 15 of its EPU request, the licensee states~~s~~d that it will employ visual monitoring during EPU power ascension testing to determine if significant vibration is occurring in MS, FW, and condensate piping located in the turbine building heater bay. If visual observations indicate significant increased vibration, the licensee will further monitor this piping with a hand-held device. The licensee will also monitor system components determined to have FIV vulnerabilities based on plant-specific experience~~;~~, industry operating experience~~;~~, identification of FIV through plant inspections and walkdowns~~;~~, and additional evaluation of components potentially susceptible to FIV at increased system flow. The licensee did not identify any components requiring FIV monitoring based on its own plant-specific experience. However, based on industry experience, the licensee will monitor the MS safety/relief valves using accelerometers on the MS piping; MS low point drain lines using accelerometers; and FW heater level control valves by means of inspections and walkdowns.

The licensee performed baseline inspections and walkdowns of the condensate, FW, and MS systems at VYNPS to identify systems and components with elevated vibration during CLTP operations. The licensee will compare the results of inspections and walkdowns performed during EPU power ascension testing, along with available vibration measurement data, to the baseline results. The licensee will enter components with significant increases in vibration into the VYNPS corrective action program and will evaluate those components for acceptability and additional action. The licensee stated that it ~~would~~will evaluate additional system components that might be susceptible to FIV at EPU conditions. The licensee indicated that it had identified condensate, FW, MS piping for cantilevered piping configurations as potentially susceptible to FIV, and that those components ~~would~~will be monitored if found susceptible. In its list of commitments attached to Supplement 15, the licensee states~~s~~d that, during EPU power ascension testing, it will implement FIV and steam dryer monitoring, including associated evaluation as necessary during EPU power ascension testing as described in Entergy letter BVY 04-100 (Supplement 15 to its EPU request).

In Attachment 2 to Supplement 32 of its EPU request, the licensee ~~has~~ determined, since the submittal of Supplement 15, that isokinetic sample probes are used in the MS, FW, and condensate systems at VYNPS. Those sample probes are subject to the effects of FIV. The licensee evaluated the susceptibility of the sample probes to high cycle fatigue failure. The licensee states~~s~~d that the four susceptible probes (SP-26, 27, 30, and 31) in the FW and condensate systems ~~will~~needed to be modified~~ during the upcoming RFO~~ to address the failure vulnerability. The licensee specifies~~s~~d its plan to modify the four susceptible isokinetic sample probes in the FW and condensate systems during the fall 2005 RFO as a regulatory commitment in Attachment 10 to Supplement 32. This commitment was satisfied as documented in Reference 74.

The NRC staff has reviewed the information submitted by the licensee on the monitoring of MS, FW, and condensate systems and components during EPU power ascension testing. The licensee indicates~~s~~d that significant vibration monitoring and walkdown/inspection activity will be conducted during the power ascension above CLTP. However, the power ascension test plan described in Supplement 15 does not specify the frequency of the vibration data collection, or the walkdowns and inspections with respect to the power ascension hold points discussed in the SDMP. For example, it is not apparent whether the vibration monitoring and walkdown/inspection activities can be accomplished within the hold points specified in the SDMP. While some acceptance criteria for vibration monitoring are provided, actions to be taken with respect to the power ascension in the event of failed acceptance criteria for the

vibration monitoring and walkdown/inspection activities are not clearly indicated. Therefore, the NRC staff considers it important for the licensee to provide the relevant sections of its EPU startup test procedure to the NRC prior to plant operation above CLTP. This requirement is included in the license condition shown in SE Section 3.17.3.

2.2.6.3 Conclusion

The NRC staff has reviewed the licensee's consideration of potential adverse flow effects on the MS, FW, and condensate systems and their components (including the steam dryer) for operation of VYNPS at EPU conditions. The staff concludes that the licensee has provided reasonable assurance that the flow-induced effects on the steam dryer and other plant equipment are within the structural limits at CLTP conditions. The staff further concludes that the licensee has demonstrated that the MS, FW, and condensate systems and their components (including the steam dryer) will continue to meet the requirements of draft GDC-1, 2, 40, and 42 following implementation of the proposed EPU at VYNPS, subject to the license condition discussed above. Therefore, the staff finds the proposed license amendment to operate VYNPS at EPU conditions to be acceptable with respect to potential adverse flow effects.

As noted in the technical evaluation, a license condition will be added to the VYNPS Facility Operating License as shown in SE Section 3.17.3. The license condition provides requirements for monitoring, evaluating, and taking prompt action in response to potential adverse flow effects as a result of operation at EPU conditions. The intent of the license condition is to (1) confirm the licensee's predictions regarding the hydrodynamic loads on the steam dryer; (2) confirm the licensee's predictions regarding the acoustic pressure loads on the steam dryer; and (3) confirm the safe operation of VYNPS during power ascension above CLTP.

2.3 Electrical Engineering

2.3.1 Environmental Qualification of Electrical Equipment

Regulatory Evaluation

Environmental qualification (EQ) of electrical equipment involves demonstrating that the equipment is capable of performing its safety function under significant environmental stresses which could result from design-basis accidents (DBAs). The NRC staff's review focused on the effects of the proposed EPU on the environmental conditions that the electrical equipment will be exposed to during normal operation, anticipated operational occurrences, and accidents. The NRC staff's review was conducted to ensure that the electrical equipment will continue to be capable of performing its safety functions following implementation of the proposed EPU. The NRC's acceptance criteria for EQ of electrical equipment are based on 10 CFR 50.49, which sets forth requirements for the qualification of electrical equipment important to safety that is located in a harsh environment. Specific review criteria are contained in SRP Section 3.11.

Technical Evaluation

2.7 Habitability, Filtration, and Ventilation

2.7.1 Control Room Habitability System

Regulatory Evaluation

The NRC staff reviewed the control room habitability system and control building layout and structures to ensure that plant operators are adequately protected from the effects of accidental releases of toxic and radioactive gases. A further objective of the NRC staff's review was to ensure that the control room can be maintained as the backup center from which technical support center personnel can safely operate in the case of an accident. The NRC staff's review focused on the effects of the proposed EPU on radiation doses, toxic gas concentrations, and estimates of dispersion of airborne contamination. The NRC's acceptance criteria for the control room habitability system are based on (1) draft GDC-40 and 42, insofar as they require that protection be provided for engineered safety features (ESFs) against the dynamic effects that might result from plant equipment failures, as well as the effects of a LOCA; and (2) draft GDC-11 and 10 CFR 50.67, insofar as they require that adequate radiation protection be provided to permit access and occupancy of the control room under accident conditions without personnel receiving radiation exposures in excess of 5 rem Total Effective Dose Equivalent (TEDE) for the duration of the accident. Specific review criteria are contained in SRP Section 6.4 and other guidance provided in Matrix 7 of RS-001.

Technical Evaluation

For control room habitability, the NRC staff reviewed the control room ventilation system and control building layout and structures, as described in the VYNPS UFSAR and the analysis provided by the licensee in support of VYNPS Amendment No. 223, dated March 29, 2005 (Reference 57), which incorporated a full-scope application of an ~~alternative source term (~~AST~~)~~ methodology in accordance with 10 CFR 50.67. In support of the AST amendment, the licensee re-analyzed the following DBAs: LOCA, main steam line break accident, fuel-handling accident, and control rod drop accident. The licensee performed the AST radiological analyses assuming a reactor power equal to 1950 MWt (i.e., ~~102 percent~~102% of the proposed EPU power level of 1912 ~~Mw~~MWt). As discussed in PUSAR Section 4.4, and summarized in PUSAR Table 4-4, the results of these analyses demonstrate that the EPU dose to control room occupants will be less than the 30-day 5 rem TEDE dose for the limiting DBA LOCA. As discussed in the NRC staff's SE for Amendment No. 223, the staff found, with reasonable assurance, that the licensee's estimates of control room doses due to postulated DBAs will comply with the guidance in 10 CFR 50.67. Based on the power levels used in the AST analyses, the NRC staff concludes that the AST analysis is bounding for the proposed EPU and, therefore, is acceptable with respect to radioactive gases. The NRC staff did not identify any aspects of the proposed EPU that would affect control room habitability with respect to toxic gases (e.g., no new system operation or creation of additional chemical sources).

Conclusion

The NRC staff has reviewed the effects of the proposed EPU on the ability of the control room habitability system to protect plant operators against the effects of accidental releases of toxic and radioactive gases. The NRC staff concludes that the control room habitability system will continue to provide the required protection following implementation of the proposed EPU. Based on this, the NRC staff concludes that the control room habitability system will continue to meet the requirements of draft GDC-11, 40, and 42, and 10 CFR 50.67. Therefore, the NRC staff finds the proposed EPU acceptable with respect to the control room habitability system.

2.7.2 Engineered Safety Feature Atmosphere Cleanup

Regulatory Evaluation

ESF atmosphere cleanup systems are designed for fission product removal in post-accident environments. These systems generally include primary systems (e.g., in-containment recirculation) and secondary systems (e.g., standby gas treatment systems and emergency or post-accident air-cleaning systems) for the fuel-handling building, control room, shield building, and areas containing ESF components. For each ESF atmosphere cleanup system, the NRC staff's review focused on the effects of the proposed EPU on system functional design, environmental design, and provisions to preclude temperatures in the adsorber section from exceeding design limits. The NRC's acceptance criteria for ESF atmosphere cleanup systems are based on (1) draft GDC-11 and 10 CFR 50.67, insofar as they require that adequate radiation protection be provided to permit access and occupancy of the control room under accident conditions without personnel receiving radiation exposures in excess of 5 rem TEDE for the duration of the accident; (2) ~~draft~~ draft GDC-67, 68, and 69, insofar as they require that systems that may contain radioactivity be designed to assure adequate safety under normal and postulated accident conditions; and (4) draft GDC-17, insofar as it requires that means be provided for monitoring effluent discharge paths and the plant environs for radioactivity that may be released from normal operations, including anticipated operational occurrences (AOOs), and postulated accidents. Specific review criteria are contained in SRP Section 6.5.1.

Technical Evaluation

The function of the ESF atmosphere cleanup system is to mitigate the consequences of postulated accidents by removing from the atmosphere radioactive material that may be released in the event of an accident. ESF atmosphere cleanup systems should be designed so that they can operate after a design-basis accident (DBA) and can retrain radioactive material after a DBA. The system should have provisions to prefilter air, remove moisture and meet the guidance in RG 1.52 for charcoal adsorption.

The ESF atmosphere cleanup system at VYNPS is the standby gas treatment system (SGTS). As discussed in Section 4.5 of the PUSAR, the acceptability of the SGTS at VYNPS

2.9 Source Terms and Radiological Consequences Analyses

2.9.1 Source Terms for Radwaste Systems Analyses

Regulatory Evaluation

The NRC staff reviewed the radioactive source term associated with EPUs to ensure the adequacy of the sources of radioactivity used by the licensee as input to calculations to verify that the radioactive waste management systems have adequate capacity for the treatment of radioactive liquid and gaseous wastes. The NRC staff's review included the parameters used to determine (1) the concentration of each radionuclide in the reactor coolant, (2) the fraction of fission product activity released to the reactor coolant, (3) concentrations of all radionuclides other than fission products in the reactor coolant, (4) leakage rates and associated fluid activity of all potentially radioactive water and steam systems, and (5) potential sources of radioactive materials in effluents that are not considered in the plant's UFSAR related to liquid waste management systems and gaseous waste management systems. The NRC's acceptance criteria for source terms are based on (1) 10 CFR Part 20, insofar as it establishes requirements for radioactivity in liquid and gaseous effluents released to unrestricted areas; (2) ~~10~~ 10 CFR Part 50, Appendix I, insofar as it establishes numerical guides for design objectives and limiting conditions for operation to meet the "as low as is reasonably achievable" criterion; and (3) draft GDC-70, insofar as it requires that the plant design include means to control the release of radioactive effluents. Specific review criteria are contained in SRP Section 11.1.

Technical Evaluation

In support of the subject license amendment request, the licensee provided analyses of the impact of the proposed EPU on the radiological consequences of DBAs in a separate license amendment request submittal which proposed a full-scope implementation of an alternative source term (AST) pursuant to 10 CFR 50.67. The NRC staff's evaluation of the licensee's calculated EPU radiological source term was performed as part of the review of the AST license amendment request ~~submittal as documented in an SE dated~~. The AST amendment was approved on March 29, 2005 (Reference 57).

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In Section 8 of the PUSAR, the licensee discussed the impact of operation at the proposed EPU power level on the source term for radioactive waste management systems. The licensee used either plant-specific evaluations or verified the applicability of the generic CLTR evaluations to VYNPS. As discussed in Section 2.5.5 of this SE, the NRC staff found that, for the proposed EPU, radioactive waste management systems would continue to control the release of radioactive materials consistent with the VYNPS licensing basis. As discussed in Section 2.10 of this SE, the NRC staff found that, for the proposed EPU, any increases in doses would remain ALARA and that the requirements in 10 CFR Part 20 would continue to be met.

Conclusion

The NRC staff has reviewed the radioactive source term associated with the proposed EPU and concludes that the proposed parameters and resultant composition and quantity of radionuclides are appropriate for the evaluation of the radioactive waste management systems. The NRC staff further concludes that the proposed radioactive source term ~~meets~~is appropriate for use in evaluating whether the requirements of 10 CFR Part 20, 10 CFR Part 50, Appendix I, and draft GDC-70 are met. Therefore, the NRC staff finds the proposed EPU acceptable with respect to source terms.

2.9.2 Radiological Consequences Analyses Using Alternative Source Terms

Regulatory Evaluation

The NRC staff evaluation included reviewed of the DBA radiological consequences analyses. The radiological consequences analyses reviewed are the LOCA, fuel-handling accident (FHA), control rod drop accident (CRDA), and main steamlinesteam line break (MSLB). The NRC staff's review for each accident analysis included (1) the sequence of events; and (2) models, assumptions, and values of parameter inputs used by the licensee for the calculation of the total effective dose equivalent (TEDE). The NRC's acceptance criteria for radiological consequences analyses using an alternative source term are based on 10 CFR 50.67, insofar as it sets standards for radiological consequences of a postulated accident. Specific review criteria are contained in SRP Section 15.0.1.

Technical Evaluation

In support of the subject licensea separate amendment request, the licensee provided analyses of the impact of the proposed EPU on the radiological consequences of DBAs in a separate license amendment request submittal which proposed a full-scope implementation of an alternative source term (AST) for VYNPS pursuant to 10 CFR 50.67. The AST amendment request assumed operation at the proposed EPU power level. The AST amendment was approved on March 29, 2005 (Reference 57). The NRC staff's evaluation of the licensee's calculated EPU radiological source term was performed as part of the review of the AST license amendment request submittal as documented in an SE dated March 29, 2005 (Reference 57). Within the AST review, as documented in the associated SE dated March 29, 2005, the NRC staff determined that the licensee has shown that the proposed changes, including uprated power, are acceptable with respect to the radiological consequences of all applicable DBAs. The licensee's dose analyses show that the dose criteria of 10 CFR 50.67, as further clarified in SRP 15.0.1, are met for the uprated power and changes made to the dose analysis methodologyEPU. As a result of the AST license amendment review, the staff found acceptable the licensee's dose analysis methodology, assumptions and inputs to be acceptable. As part of the AST review, the staff also performed independent dose analyses which confirmed the licensee's dose results.

Conclusion

As part of the evaluation of the full-scope implementation of an AST at VYNPS, the NRC staff has evaluated the licensee's revised accident analyses performed in support of the proposed EPU and concludesd that the licensee has adequately accounted for the effects of the proposed EPU. In its review of the proposed full-scope implementation of an AST at VYNPS, the NRC staff further concludesd that the plant site and the dose-mitigating ESFs remain acceptable with respect to the radiological consequences of postulated DBAs since, the calculated total effective dose equivalent (TEDE) at the exclusion area boundary (EAB), at the low population zone (LPZ) outer boundary, and in the control room, meet the exposure

guideline values specified in 10 CFR 50.67, as well as applicable acceptance criteria denoted in SRP Section 15.0.1. Therefore, based on the issuance of the full-scope implementation AST license amendment and its accompanying SE, the NRC staff finds the licensee's proposed EPU acceptable with respect to the radiological consequences of DBAs.–

2.10 Health Physics

2.10.1 Occupational and Public Radiation Doses

Regulatory Evaluation

The NRC staff conducted its review in this area to ascertain what overall effects the proposed EPU will have on both occupational and public radiation doses and to determine ~~that~~whether the licensee has taken the necessary steps to ensure that any dose increases will be maintained within applicable regulatory limits and as low as is reasonably achievable (ALARA). The NRC staff's review included an evaluation of any increases in radiation sources and how this may affect plant area dose rates, plant radiation zones, and plant area accessibility. The NRC staff evaluated how doses for personnel ~~doses~~ needed to access plant vital areas following an accident are affected. The NRC staff considered the effects of the proposed EPU on nitrogen-16 (N-16) levels in the plant and any effects this increase may have on radiation doses outside the plant and at the site boundary from skyshine. The NRC staff also considered the effects of the proposed EPU on plant effluent levels and any effect this increase may have on radiation doses at the site boundary. The NRC's acceptance criteria for occupational and public radiation doses are based on 10 CFR Part 20, 10 CFR 50.67, and draft GDC-11. Specific review criteria are contained in SRP Sections 12.2, 12.3,12.4, and 12.5, and other guidance provided in Matrix 10 of RS-001.

Technical Evaluation

Source Terms

In general, the production of radiation and radioactive material (either fission or activation products) in the reactor core are directly dependent on the neutron flux and power level of the reactor. Therefore, as a first order approximation, a 20% increase in power level is expected to result in a proportional increase in the direct (i.e., from the reactor fuel) and indirect (i.e., from the reactor coolant) radiation source terms. However, due to the physical and chemical properties of the different radioactive materials that reside in the reactor coolant, and the various processes that transport them to locations in the plant outside the reactor, several radiation sources encountered in the balance of plant are not expected to change in direct proportion to the increased reactor power. The most significant of these are:

1. The concentration of noble gas and other volatile fission products in the main steam line will not change. The increased production rate (20%) of these materials is offset by the corresponding increase in steam flow (20%). Although the concentration of these materials

in the steam line remains constant, the increased steam flow results in a 20% increase in the rate these materials are introduced into the main condenser and offgas systems.

2. For the very short lived activities, most significantly N-16, -the decreased transit (and decay time) in the main steam line, and the increased mass flow of the steam results in a larger increase in these activities in the major turbine building components. For N-16, with its 7.13 second half-life, the licensee estimates a 26% increase in activity in the turbine building.

3. The concentrations of non-volatile fission products, actinides, and corrosion and wear products in the reactor coolant are expected to increase proportionally with the power increase. However, the increased steam flow is expected to result in an increased moisture carryover in the steam, resulting in an increased transport of these activities to the balance of the plant. The licensee has calculated that the 20% increase in steam flow will double the moisture carry-over (from 0.04% to 0.08%) resulting in an overall increase in the condensate system by a factor of 2.4. The radiation from these non-volatile radioactive materials provides only a small contribution to the dose rates around balance of plant systems during normal power operations.

Radiation Protection Design Features

1. Occupational and onsite radiation exposures.

The radiation sources in the core are expected to increase in proportion to the increase in power. This increase, however, is bounded by the existing safety margins of the plant design. Due to the design of the shielding and containment surrounding the reactor vessel, and since the reactor vessel is inaccessible to plant personnel during operation, a 20% increase in the radiation sources in the reactor core will have no ~~affect~~effect on occupational worker personnel doses during power operations. Similarly, the radiation shielding provided in the balance of plant (i.e., around rad-waste systems, main steam lines, the main turbine, etc.) is conservatively sized such that the increased source terms discussed above are not expected to significantly increase the dose rates in the normally occupied areas of the plant. The existing radiation zoning design (e.g., the maximum designed dose rates for each area of the plant) will not change as a result of the increased dose rates associated with th~~is~~e EPU.

Operating at a 20% higher power level will result in an increased core inventory of radioactive material that is available for release during postulated accident conditions. The plant shielding design must be sufficient to provide control room habitability, per Draft GDC 11, and operator access to vital areas of the plant, per NUREG-0737, item II.B.2, during the accident. As part of a recent change to the VYNPS design basis, the licensee recalculated the radiological consequences of the postulated design basis accidents using the ~~an~~ AST in accordance with the provisions in 10 CFR 50.67. The AST, which was approved in VYNPS Amendment No. 223, issued on March 29, 2005 (Reference 57). ~~The AST~~, provides more realistic assumptions, than the previous VYNPS design basis source term, on the timing and mechanisms of radioactive material release from the core during postulated accident conditions. The licensee's reevaluation of the DBAs included an evaluation of control room habitability, and ~~the~~ post

accident vital areas access, at the proposed EPU power level of 1912 MWt. The NRC staff~~has~~ reviewed this design basis change and concluded~~s~~ that licensee continues to meet the applicable requirements.

Therefore, following implementation of th~~is~~e EPU, VYNPS will continue to meet its design basis in terms of radiation shielding, in accordance with the criteria in SRP ~~s~~Section 12.4, ~~D~~draft GDC 11, and NUREG-0737, item II.B.2.

2. Public and offsite radiation exposures.

There are two factors~~,~~ associated with th~~is~~e EPU that may impact public and offsite radiation exposures during plant operations. These are the possible increases in gaseous and liquid effluents released from the site, and the increase in direct radiation exposure from radioactive plant components and solid wastes stored onsite. As described above, ~~this~~the proposed EPU will result in a 20% increase in gaseous effluents released from the plant during operations. This increase is a minor contribution to the radiation exposure of the public. The nominal annual public dose from plant gaseous effluents for the VYNPS station is about ~~one~~1 mrem. A 20% increase in this nominal dose is still well within the design criteria of 10 CFR ~~20~~Part 50, Appendix I.

~~This~~The proposed EPU will also result in increased generation of liquid and solid radioactive waste. The increased condensate feed flow associated with th~~is~~e EPU results in faster loading of the condensate demineralizers. Similarly, the higher feed flow introduces more impurities into the reactor resulting in faster loading of the reactor water cleanup (RWCU) system demineralizers. Therefore, the demineralizers in both of these systems will require more frequent backwashing to maintain them. The licensee has estimated that these more frequent backwashes will increase the volume of liquid waste~~,~~ that will need processing~~,~~ by 1.2%, and an increase in processed solid radioactive waste by 17.8%. These increases are well within the processing capacity of the VYNPS radwaste system and are not expected to noticeably increase the liquid effluents or solid radioactive waste released from the plant. Therefore, these increases will have a negligible impact on occupational or public radiation exposure.

The most significant increase in ~~offsite-doses~~offsite doses, from ~~this~~the proposed EPU~~,~~ will be due to increased N-16 skyshine and the direct exposure to radiation from miscellaneous radioactive waste stored on site. Based on measurements, the licensee has determined that the west boundary of the facility has the highest direct offsite radiation dose, nominally 15 mrem per year. The licensee has estimated that almost 90% of this dose, 13.4 mrem per year, is due to N-16 skyshine from the turbine building components. Skyshine is a physical phenomenon where gamma radiation that is released skyward during radioactive decay interacts with air molecules and, in this case, is scattered back down to the ground where it can expose members of the public. Since there is significantly less radiation shielding above the steam components in the turbine building, than there is to the sides of these components, skyshine from N-16 ~~gammas~~gamma radiation is a significant contributor to offsite dose rates. As discussed above, the licensee has estimated that plant operations at th~~is~~e EPU power level will increase the N-16 activity in the turbine building by 26%. Therefore, the gamma dose rate from

N-16 skyshine at the west site boundary will likely increase to a nominal value of 16.9 mrem per year. Increases in the solid radioactive waste resulting from this EPU, which are stored on site, can also increase the direct radiation dose rate offsite. However, the licensee has committed to administratively control the contribution to offsite dose rates from these miscellaneous radioactive wastes. The maximum dose rate contribution, for the highest offsite location (west boundary), from radioactive waste stored onsite will be 1.74 mrem per year. Therefore, the projected maximum offsite dose rate from direct radiation exposure following this EPU is estimated to be about 18.6 mrem per year. This annual dose is within the applicable 40 CFR Part 190 annual limit of 25 mrem to an actual member of the public, as referenced by 10 CFR ~~20 paragraph~~ 20.1301(e).

As indicated in Attachment 3 of the licensee's application dated September 10, 2003 (Reference 1), the licensee plans to perform radiation surveys as part of the EPU power ascension testing. The surveys will be conducted at approximately 100%, 105%, 110%, 115%, and 120% of CLTP. In fall 2005, as part of the NRC's baseline inspection process, NRC Region I staff, with support from NRC Headquarters staff, initiated an inspection of the direct dose calculation methodology described in the VYNPS Offsite Dose Calculation Manual (ODCM). The calculation methodology described in Section 6.11.1 of the ODCM is used by the licensee to ensure compliance with the offsite dose requirement in 10 CFR 20.1301(e). As part of the ODCM methodology inspection effort, the NRC staff plans to review the results of the licensee's power ascension radiation surveys to confirm that the dose to a member of the public continues to meet the annual limit under EPU conditions.

Operational Radiation Protection Programs

The increased production of non-volatile fission products, actinides, and corrosion and wear products in the reactor coolant may result in proportionally higher plate-out of these materials on the surfaces of, and low flow areas in, reactor systems. The corresponding increase in dose rates associated with these deposited materials will be an additional source of occupational exposure during the repair and maintenance of these systems. However, the current ALARA program practices at VYNPS (i.e., work planning, source term minimization, etc.), coupled with existing radiation exposure procedural controls, will be able to compensate for the anticipated increases in dose rates associated with this EPU. Therefore, the increased radiation sources resulting from this proposed EPU, as discussed above, will not adversely impact the licensee's ability to maintain occupational and public radiation doses resulting from plant operation ~~to~~ within the applicable limits in 10 CFR Part 20 and ~~as low as is reasonably achievable~~ALARA.

Conclusion

The NRC staff has reviewed the licensee's assessment of the effects of the proposed EPU on radiation source terms and plant radiation levels. The NRC staff concludes that the licensee has taken the necessary steps to ensure that any increases in radiation doses will be maintained ALARA. The NRC staff further concludes that the proposed EPU meets the requirements of 10 CFR Part 20 and draft GDC-11. Therefore, the NRC staff finds the

licensee's proposed EPU acceptable with respect to radiation protection and ensuring that occupational radiation exposures will be maintained ALARA.

2.11 Human Performance

2.11.1 Human Factors

Regulatory Evaluation

The area of human factors deals with programs, procedures, training, and plant design features related to operator performance during normal and accident conditions. The NRC staff's human factors evaluation was conducted to ensure that operator performance is not adversely affected as a result of system changes made to implement the proposed EPU. The NRC staff's review covered changes to operator actions, human-system interfaces, and procedures and training needed for the proposed EPU. The NRC's acceptance criteria for human factors are based on draft GDC-11, 10 CFR 50.120, 10 CFR Part 55, and the guidance in GL 82-33. Specific review criteria are contained in SRP Sections 13.2.1, 13.2.2, 13.5.2.1, and 18.0.

Technical Evaluation

Changes in Emergency and Abnormal Operating Procedures

The licensee indicated that the Emergency Operating Procedures (EOPs)/Severe Accident Management Guidelines (SAMGs) should remain unchanged in most aspects, with slight modifications required for some parameter thresholds and graphs which depend on the power and decay heat levels. These modifications would require changes in some values in the EOPs and the supporting documentation, but the adjustments would not affect the accident mitigation philosophy. Additionally, any change in scenario timings would be minor and would not significantly change the Human Error Probabilities (HEPs) in the risk assessments. The licensee will review the EOPs for any required changes, implementing those changes, and providing training to operators on the procedures.

For the Abnormal Operating Procedures (AOPs), the licensee indicated that some operator actions may be influenced by plant modifications required for supporting the increase in rated thermal power. The increased power level may require modifications to the AOPs and the supporting documentation. The licensee will review the AOPs to identify any effects of the EPU, including modifications to equipment and changes in setpoints to implement any changes to the AOPs, equipment, and setpoints necessary as a result of ~~the~~ those effects, and to ~~providing~~provide training to operators on the AOPs, equipment modifications, and setpoint changes.

Because no new procedures would be required, necessary changes to EOPs/SAMGs/AOPs, equipment and setpoints will be implemented, and training to address these changes will be provided, the NRC staff finds the licensee's proposed ~~changes~~actions in this area to be acceptable.