May 20, 2004

Mr. Paul D. Hinnenkamp
Vice President - Operations
Entergy Operations, Inc.
River Bend Station
5485 US Highway 61N
St. Francisville, LA 70775

SUBJECT: RIVER BEND STATION, UNIT 1 - ISSUANCE OF AMENDMENT RE: HIGH ENERGY LINE BREAK ANALYSIS (TAC NO. MB5096)

Dear Mr. Hinnenkamp:

The Commission has issued the enclosed Amendment No. 139 to Facility Operating License No. NPF-47 for the River Bend Station, Unit 1. The amendment is in response to your application dated May 14, 2002, as supplemented by letters dated June 27, 2002, July 9, 2003, April 7, 2004, and May 12, 2004.

The amendment allows you to revise Updated Safety Analysis Report Appendix 3B and Sections 6.2.1.1.3.2.1, "Reactor Water Cleanup Break" and 6.2.1.2 "Containment Subcompartments" to change the method of analysis for high energy line breaks inside and outside of containment. The change will replace the current THREED code for room pressure-temperature analyses with GOTHIC (Generation of Thermal-Hydraulic Information for Containments).

A copy of our related Safety Evaluation is enclosed. The Notice of Issuance will be included in the Commission's next biweekly *Federal Register* notice.

Sincerely,

/RA/

Michael Webb, Senior Project Manager, Section 1
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-458

Enclosures: 1. Amendment No. 139 to NPF-47
2. Safety Evaluation

cc w/encls: See next page

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ENTERGY GULF STATES, INC. **

AND

ENTERGY OPERATIONS, INC.

DOCKET NO. 50-458

RIVER BEND STATION, UNIT 1

AMENDMENT TO FACILITY OPERATING LICENSE

Amendment No. 139
License No. NPF-47

1. The Nuclear Regulatory Commission (the Commission) has found that:

   A. The application for amendment by Entergy Gulf States, Inc.* (the licensee) dated May 14, 2002, as supplemented by letters dated June 27, 2002, July 9, 2003, and April 7 and May 12, 2004, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's rules and regulations set forth in 10 CFR Chapter I;

   B. The facility will operate in conformity with the application, as amended, the provisions of the Act, and the rules and regulations of the Commission;

   C. There is reasonable assurance (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations;

   D. The issuance of this license amendment will not be inimical to the common defense and security or to the health and safety of the public; and

---

* Entergy Operations, Inc. (EOI) is authorized to act as agent for Entergy Gulf States, Inc., and has exclusive responsibility and control over the physical construction, operation and maintenance of the facility.

**Entergy Gulf States, Inc., has merged with a wholly owned subsidiary of Entergy Corporation. Entergy Gulf States, Inc., was the surviving company in the merger.

E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

2. Accordingly, this license amendment authorizes changes to the Updated Safety Analysis Report (USAR) Appendix 3B and Sections 6.2.1.1.3.2.1 and 6.2.1.2. EOI shall update the USAR to reflect the revised licensing basis authorized by this amendment in accordance with 10 CFR 50.71(e).

3. The license amendment is effective as of its date of issuance and shall be implemented within 60 days from the date of issuance. Implementation of the amendment is the incorporation into the USAR of the changes to the method of analysis for high energy line breaks as described in the licensee's application dated May 14, 2002, as supplemented by letters dated June 27, 2002, July 9, 2003, and April 7 and May 12, 2004, and evaluated in the staff's Safety Evaluation enclosed to this amendment.

FOR THE NUCLEAR REGULATORY COMMISSION

/RA/

Robert A. Gramm, Chief, Section 1
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Date of Issuance: May 20, 2004

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 139 TO

FACILITY OPERATING LICENSE NO. NPF-47

ENTERGY OPERATIONS, INC.

RIVER BEND STATION, UNIT 1

DOCKET NO. 50-458

1.0 INTRODUCTION

By application dated May 14, 2002 (Accession No. ML021410482), as supplemented by letters dated June 27, 2002 (Accession No. ML021840463), July 9, 2003 (Accession No. ML031970054), April 7, 2004 (Accession No. ML041040749), and May 12, 2004, Entergy Operations, Inc. (the licensee or EOI), requested to make changes to the Updated Safety Analysis Report (USAR) for the River Bend Station, Unit 1 (RBS). The supplements dated June 27, 2002, July 9, 2003, April 7, 2004, and May 12, 2004, provided additional information that clarified the application, did not expand the scope of the application as originally noticed, and did not expand the scope of the original *Federal Register* notice or change the staff's original proposed no significant hazards consideration determination as published in the *Federal Register* on July 9, 2002 (67 FR 45563).

The licensee intends to modify the initiation logic for the temperature isolation of the high energy lines in the auxiliary building and the containment. Postulated high energy line breaks (HELBs) in these buildings are affected by the additional time delays which will be part of the new design. The proposed change involves revising the method of analysis of HELBs in subcompartments inside and outside containment. The current analyses, described in the RBS USAR, discusses the use of the THREED computer code for these analyses. The licensee has proposed to use the GOTHIC (Generation of Thermal-Hydraulic Information for Containments) computer code to justify the proposed change in design of the temperature isolation equipment. The licensee stated in its letter dated July 9, 2003, that the scope of this license amendment request is limited only to the application of GOTHIC to subcompartment analyses inside and outside containment (including environmental qualification considerations). The licensee has determined that the modification of the initiation logic itself does not require prior U.S. Nuclear Regulatory Commission (NRC) review and approval. However, in accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.59, "Changes, tests, and experiments," the change in analysis code from THREED to GOTHIC presents a departure from a method of evaluation described in the USAR; therefore, EOI is required to obtain a license amendment in order to implement the change. The proposed amendment would revise USAR Appendix 3B and Sections 6.2.1.1.3.2.1 and 6.2.1.2 to change the method of analysis for HELBs inside and outside of containment.

Section 6.2.1.2 of the Standard Review Plan (SRP) (NUREG-0800) provides guidance for reviewing HELBs inside containment. SRP Section 3.6.1 provides guidance for reviewing HELBs outside containment. SRP Section 6.2.1 defines a subcompartment as any fully or partially enclosed volume that houses high energy piping and would limit the flow of fluid to the main containment volume. A HELB in such a subcompartment would cause a short term pressure transient which produces a pressure differential across the walls of the subcompartment. This pressure differential reaches a maximum value within a short time after blowdown. It is necessary to determine that the walls of the subcompartment and any connected compartments remain structurally sound following the HELB.

USAR Section 3.6A describes the HELB locations outside containment analyzed for subcompartment pressurization. USAR Appendix 3B describes the design bases, design features, and the pressure response for postulated piping ruptures in the main steam tunnel and other subcompartments in the auxiliary building.

These analyses were done using the THREED computer program. The licensee states that THREED is similar to RELAP4 and will give the same results if similar options are chosen. The licensee proposes using GOTHIC rather than THREED for the revised HELB analyses.

2.0 REGULATORY EVALUATION

Commercial operation of RBS began on June 16, 1986. Therefore, the General Design Criteria (GDC) of 10 CFR Part 50 Appendix A and the SRP are applicable to RBS.

GDC-4, “Environmental and dynamic effects design bases,” requires, in part, that structures, systems, and components important to safety shall be designed to accommodate the effects of and to be compatible with the environmental conditions associated with postulated accidents, including loss-of-coolant accidents (LOCAs).

GDC-50, “Containment design basis,” requires, in part, that the containment be designed so that the containment structure and its internal compartments can accommodate a LOCA. In the context of this review, this implies that the pressure differentials across the walls of the subcompartments must be less than structural limits with some margin.

SRP Section 3.6.1, “Plant Design for Protection Against Postulated Piping Failures in Fluid Systems Outside Containment,” provides guidance to ensure that failures of piping systems will not cause the loss of needed functions of safety-related systems.

SRP Section 6.2.1.2, “Subcompartment Analysis,” provides guidance to ensure that containment internal structures and system components are designed to withstand the differential pressure loadings due to pipe breaks within containment subcompartments.

The proposed changes in analysis methods are discussed in the introduction to this safety evaluation (SE) and evaluated below in Section 3.0.

The licensee’s letter dated May 14, 2002, also states that EOI complies with the guidance of Generic Letter (GL) 83-11, Supplement 1, “Licensee Qualification for Performing Safety Analyses in Support of Licensing Actions.”

3.0 TECHNICAL EVALUATION

3.1 Overview

The NRC staff has reviewed the licensee's proposed use of GOTHIC. The review has concentrated on those features judged most significant to the type of analysis proposed by the licensee. The NRC staff is not making a judgment as to the overall acceptability of GOTHIC for licensing calculations. The NRC staff has performed independent analyses to assist with the assessment.

3.2 The GOTHIC Computer Code

GOTHIC 7.0[1] [2] [3] is a state-of-the-art general purpose thermal hydraulics computer program which solves the conservation equations for mass, energy, and momentum for multi-component, multi-phase flow. Interface models between phases allow for thermal nonequlibrium and unequal phase velocities.

GOTHIC is maintained by Numerical Applications, Inc. (NAI) for the Electric Power Research Institute (EPRI). The licensee states that GOTHIC is qualified under the NAI Quality Assurance (QA) program which conforms to the requirements of 10 CFR Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," with error reporting in accordance with 10 CFR Part 21, "Reporting of Defects and Noncompliance."

GOTHIC is widely used by the nuclear industry and applications of the GOTHIC code have been previously approved by the NRC.

GOTHIC has been successfully compared with a variety of data and analytic solutions. Therefore, the NRC staff's review of the RBS license amendment request concentrated on the GOTHIC models deemed to be significant for this application and assumptions made by the licensee in applying GOTHIC to HELB analyses.

In addition to reviewing the information supplied by the licensee, the NRC staff performed independent calculations using the NRC-developed CONTAIN 2.0 containment computer program[4].

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[1] GOTHIC 7.0 Containment Analysis Package Technical Manual NAI 8907-06 July 2001

[2] GOTHIC 7.0 Containment Analysis Package User Manual NAI 8907-02 July 2001

[3] GOTHIC 7.0 Containment Analysis Package Qualification Report NAI 8907-09 July 2001

[4] Code Manual for CONTAIN 2.0: A Computer Code for Nuclear reactor Containment Analysis, NUREG/CR-6533 June 1997

The licensee's letter dated May 14, 2002, contains a table comparing the modeling in GOTHIC and THREED. GOTHIC uses more detailed models for the phenomena occurring during a HELB as seen in the reproduced table below.

THREED (USAR Appendix 6B)	GOTHIC
Homogeneous flow unless the Moody choking option is chosen	Inter-phase mass, energy and momentum transfer rates obtained through constitutive relations
Thermodynamic equilibrium in each node	Separate mass equation solved for each fluid phase and gas component. Separate energy equation solved for each fluid phase.
Incompressible form of the momentum equation	Compressible flow for all fluid phases
Valves open or close instantaneously	Can model valve closure time
Water, if present, occupies the entire volume, i.e., a homogeneous mixture of vapor and liquid is assumed	Water in liquid phase can be accumulated at the bottom of a control volume
Air is assumed to be a perfect gas	Can model actual air properties. Air treated as an ideal gas for mixture calculations.
If air and liquid water are present, the water vapor is saturated (relative humidity = 100 percent)	Can have relative humidity values other than 0 or 100 percent.
If air is present, liquid water conditions are the saturated condition	Water in the vapor phase is dependent upon momentum, mass and energy equations.

GOTHIC, unlike THREED, models break flow as liquid or as drop flow. This is important for this application, as discussed below.

3.3 Assumptions and Analysis Model

The licensee has revised the discussion of USAR Section 6.2.1.2 for HELBs inside containment and Section 3.6A for HELBs outside containment to indicate the use of GOTHIC and to describe the updated analyses. The licensee stated that the break locations were not revised in the proposed analysis.

SRP Section 6.2.1.2 contains acceptance criteria for the functional capability of subcompartments in the primary containment. SRP Section 6.2.1.2.II.B.1 states that the initial atmospheric conditions should be selected to maximize the resultant differential pressure. The licensee's letter dated July 9, 2003, states that this guidance is satisfied and the initial conditions are those specified in the original licensing bases calculations. The NRC staff finds this to be acceptable.

SRP Section 6.2.1.2.II.B.2 states that the nodalization should be chosen such that there is no substantial pressure gradient within a node. The licensee's letter dated July 9, 2003, states that the noding schemes were kept almost the same as the original noding scheme and sensitivity studies were done for the original noding scheme. For the auxiliary building, the licensee stated

that the number of nodes was chosen so that there are no substantial pressure gradients. The NRC staff agrees, based on independent NRC staff calculations, that there is no substantial pressure gradient for the case reviewed.

It is not uncommon for a subcompartment to be connected to another room by openings in the separating wall. These openings are the paths for relieving pressure in the break room. The SRP refers to these openings as vents. These openings may contain ducts that completely or partially block the opening. SRP Section 6.2.1.2II.B.3 provides several guidelines to be followed if these vent paths are credited as a fluid flow path to enable mass to leave the subcompartment and thus reduce the peak pressure in that subcompartment. In vents which are not open prior to the pressurization, the collapse of the duct which opens or further opens the area of the flow path should be based on a dynamic analysis of the subcompartment pressure response to the pipe rupture and this analysis should be supported by experimental data.

The licensee has considered duct collapse in the subcompartment analyses. This is described in the licensee's letter dated July 9, 2003. The licensee uses the terms "duct destruction," (DD) and "nonduct destruction," (NDD) for the cases of duct collapse and no duct collapse, respectively. The DD case removes the ducting from the opening, allowing free flow of the fluid from one room to the adjacent room. This assumption results in the highest pressure in the adjacent room and lower pressures in the break room. The NDD case credits vent paths directly connecting the break room with rooms not adjacent to the break room. This results in more limiting conditions in those rooms.

The licensee's modeling included duct destruction in a conservative way, thus, obviating the need for supporting experimental data. Both complete DD and NDD cases were simulated for each case in the auxiliary building and the worst case was used. Since the licensee has considered the extreme possible cases and is using the most conservative case, this is acceptable.

SRP Section 6.2.1.2II.B.4 states that the vent critical flow should be conservative compared to available experimental data. The licensee uses the homogeneous equilibrium mode which is conservative for this application. This model is applied correctly and is therefore acceptable for this application. Section 6.2.1.2.II.B.4 also states that 100 percent water entrainment should be assumed. The licensee's letter dated July 9, 2003, states that 100 percent entrainment was assumed. Sensitivity studies performed by the NRC staff during this review have shown that the SRP guidance to assume 100 percent entrainment and homogeneous equilibrium flow are not conservative for certain conditions. This is discussed below in Section 3.6 of this SE. The licensee's final position is conservative relative to this finding.

GOTHIC permits calculating the heat transfer to structures in several different ways. The licensee's letter dated July 9, 2003, states that the Uchida condensation heat transfer correlation was used which is consistent with the current RBS licensing basis. This correlation is used frequently in licensing calculations and is acceptable for this application.

The licensee's letter dated July 9, 2003, discusses additional conservative assumptions included in the proposed use of GOTHIC for subcompartment analyses. Among these are:

a. A minimal number of vent paths from the break have been modeled and some potential vent paths were not modeled.

b. Initial conditions were taken as the most limiting conditions from the Environmental Design Criteria.

3.4 Mass and Energy Release

SRP Section 6.2.1.3, "Mass and Energy Release Analysis for Postulated Loss-of-Coolant Accidents," Subsection 6.2.1.3.II.3.a states that the analytical approach used to compute the mass and energy release for subcompartment analysis will be accepted if both the computer program and the volume noding of the piping system are similar to those of an approved emergency core cooling system analysis.

As an alternative, this SRP section states that it is acceptable to assume a constant blowdown using the initial conditions with an acceptable choked flow correlation. The licensee has chosen the latter approach. The system pressure for each calculation was assumed to be the maximum operating pressure, not the nominal pressure, and to remain constant during the blowdown. Likewise, the temperatures were assumed higher than the actual operating temperatures.

The Moody critical flow model is used for saturated critical break flow. For subcooled critical break flow the Henry-Fauske model is used. The licensee included the effect of pipe friction in calculating the mass and energy release for some breaks according to the analytical methods developed for the Mark III containment[5]. Some current break cases also include pipe friction. Pipe friction reduces the mass flow rate from the break when compared to the same calculation without friction. These methods have been previously approved for RBS, as described in USAR Appendix 3B.

3.5 GOTHIC Drop Liquid Conversion Model

The licensee's letter dated May 14, 2002, reported the results of benchmarking of the GOTHIC code against calculations previous performed with THREED and described in the RBS USAR. The NRC staff questioned the calculations for the 8-inch Reactor Water Cleanup (RWCU) line break in the RWCU filter demineralizer room. The RWCU filter demineralizer room is a small, closed room except for several small vents and two concrete plugs, which cover the whole ceiling with air spaces along the periphery. The licensee conservatively does not credit these air spaces for pressure relief. The current calculation reported in USAR Figure 6.2-54 shows a peak calculated pressure of 35.42 psia at 27.6 seconds. The GOTHIC-calculated peak pressure is 24.97 psia at 30.4 seconds.

The NRC staff requested that the licensee explain the difference between the current results and those reported in the EOI letter dated May 14, 2002.

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[5] NEDO 20533, Mark III Containment System Analytical Model, Appendix B, Pipe Inventory Blowdown, June 1974

The licensee stated that the difference was due to crediting pipe friction in the mass and energy release calculations and using the GOTHIC drop liquid conversion model. The licensee stated that the drop liquid conversion model was only used for the 8-inch line break in the RWCU filter demineralizer room. Using the drop liquid conversion model results in an entrainment fraction less than 100 percent, as specified in the SRP. The licensee assumed thermodynamic equilibrium between phases for these calculations.

The description of GOTHIC drop modeling is found in Section 8.7 of the GOTHIC Technical Manual. It includes the mechanisms of entrainment, deposition, and agglomeration. The drop liquid conversion model reduces the drop phase fraction in the lumped parameter volume and allows liquid to pool on the control volume floor. This is significant for the 8-inch RWCU line break since, for this break, the initial temperature of the blowdown fluid is relatively low.

Because of the importance of the drop liquid conversion model to the RWCU filter demineralizer room calculation, the NRC staff examined the components of this model and its qualification in some detail.

The NRC staff concluded that the validation of the GOTHIC drop liquid conversion model, as described in the GOTHIC Qualification Report, is not sufficiently comprehensive to support its use for subcompartment HELB licensing calculations. However, its use for these calculations, when modeling a subcooled break flow, such as that in the RWCU filter demineralizer room, combined with the nonequlibrium modeling option of GOTHIC, is acceptable since this results in conservative temperatures and pressures as discussed in Section 3.6 below.

3.6 RWCU Filter Demineralizer Room Line Break and Identified SRP Nonconservatism

The RWCU 8-inch line break in the filter demineralizer room was of particular interest for this review since the licensee used this calculation as a benchmark, and because of the unique features of this room including its small volume, limited vent flow area, the (subcooled) nature of the break flow and the use of the drop liquid conversion model. RBS USAR Section 6.2.1.1.3.2.1 provides a description of the RWCU system pipe break event.

The NRC staff examined the applicable GOTHIC models and performed sensitivity studies using the NRC containment computer code CONTAIN 2.0. The staff found that the 100 percent entrainment assumption with thermodynamic equilibrium between the phases, as specified by SRP Section 6.2.1.2, is not conservative for a subcooled break flow. The NRC staff calculations using CONTAIN 2.0 show that, making the reasonable assumption that the subcooled liquid in the break flow (which will not flash) drops to the floor, the remaining flow, assuming no (0 percent) entrainment, yields the highest room pressure. The small size of the vents in the RWCU filter demineralizer room also plays a role in this conclusion. (These vents are much smaller than those in the RWCU filter demineralizer rooms of the other BWR/6 reactors with Mark III containments.)

However, the licensee did not assume 100 percent entrainment for the 8-inch RWCU line break calculation. The licensee used the drop liquid conversion model and the GOTHIC default option of "forced equilibrium." The latter assumption applies thermodynamic equilibrium to the calculation. Following discussions of the NRC staff's findings with the licensee, the licensee determined that it is more conservative and closer to the NRC staff's findings to use the GOTHIC drop liquid conversion model with the default option of "forced equilibrium" disabled.

In its place the licensee uses the GOTHIC "hydraulic non-equilibrium model." This closer approximates the CONTAIN 2.0 calculation in which the subcooled portion of the break flow is assumed to accumulate on the room floor and the portion of the break flow which is not subcooled pressurizes the room. The NRC staff considers the use of the drop liquid conversion model with the hydraulic non-equilibrium option to be acceptable since it approximates the NRC staff's conservative calculation in a more realistic but still conservative way.

The licensee's letter dated April 7, 2004, documents the licensee's approach and provides the following commitment:

> In performing high energy line break analyses, RBS will assume homogeneous equilibrium conditions and 100% water entrainment for all breaks unless it is more conservative to not employ these assumptions as in the case of breaks involving fluid which is highly subcooled. This analysis will be accomplished by disabling the forced equilibrium (i.e., enabling thermal hydraulic non-equilibrium model) and enabling the drop-liquid conversion model in GOTHIC.

The licensee's letter dated May 12, 2004, documents that EOI will include the commitment in the USAR, thereby placing any changes to these additional conservatisms under the requirements of 10 CFR 50.59. Accordingly, these changes will be subject to appropriate regulatory control.

Furthermore, the NRC staff and the licensee have concluded that, when using the reasonably conservative assumptions of the licensee's commitment for the 8-inch line break in the RWCU filter demineralizer room described above, the pressure in the filter demineralizer room would exceed the design pressure. This issue has been discussed with the licensee during a March 10, 2004, conference call. The licensee is resolving this issue in accordance with the guidance of GL 91-18[6]. Since the scope of the license amendment request was the acceptability of GOTHIC for performing HELB calculations within and outside containment, the resolution of the overpressure in the filter demineralizer room is not discussed further in this SE. It will be resolved in accordance with the licensee's corrective action program.

3.7 Technical Conclusion

The NRC staff finds EOI's proposed use of GOTHIC for HELBs inside and outside containment to be acceptable as discussed above (i.e., the guidance of SRP Section 6.2.1.2 will be followed, as discussed in the licensee's letters dated May 14 and June 27, 2002, July 9, 2003, and April 7 and May 12, 2004, including the assumption of homogeneous equilibrium flow through vent paths and 100 percent entrainment except where it is more conservative not to employ these assumptions as specified in the licensee's USAR modification).

With these restrictions, the NRC staff finds the licensee's proposed use of GOTHIC to be acceptable for HELB analysis.

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[6] NRC Generic letter 91-18 Revision 1, "Information to Licensees Regarding NRC Inspection Manual Section on Resolution of Degraded and Nonconforming Conditions," October 8, 1997

4.0 STATE CONSULTATION

In accordance with the Commission's regulations, the Louisiana State official was notified of the proposed issuance of the amendment. The State official had no comments.

5.0 ENVIRONMENTAL CONSIDERATION

The amendments change a requirement with respect to installation or use of a facility component located within the restricted area as defined in 10 CFR Part 20. The NRC staff has determined that the amendments involve no significant increase in the amounts, and no significant change in the types, of any effluents that may be released offsite, and that there is no significant increase in individual or cumulative occupational radiation exposure. The Commission has previously issued a proposed finding that the amendments involve no significant hazards consideration, and there has been no public comment on such finding (67 FR 45563 dated July 9, 2002). Accordingly, the amendments meet the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b) no environmental impact statement or environmental assessment need be prepared in connection with the issuance of the amendments.

6.0 CONCLUSION

The Commission has concluded, based on the considerations discussed above, that: (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendments will not be inimical to the common defense and security or to the health and safety of the public.

Principal Contributor: R. Lobel

Date: May 20, 2004

cc:

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