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Ken Peters
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W3F1-2004-0076

September 1, 2004

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

SUBJECT: Supplement 2 to Amendment Request NPF-38-256,
Alternate Source Term
Waterford Steam Electric Station, Unit 3
Docket No. 50-382
License No. NPF-38

REFERENCES:
1. Entergy Letter dated July 15, 2004, "License Amendment Request NPF-38-256, Alternate Source Term"
2. Entergy Letter dated August 19, 2004, "License Amendment Request NPF-38-256, Alternate Source Term"

Dear Sir or Madam:

Entergy Operations, Inc. (Entergy) requested approval of an amendment for Waterford Steam Electric Station, Unit 3 (Waterford 3) to revise its licensing basis source term in Reference 1 and supplemented this request via Reference 2. Entergy has proposed to implement an Alternate Source Term (AST) as permitted by 10 CFR 50.67 for calculating accident offsite doses and doses to control room personnel.

In Reference 2, Entergy committed to provide additional information regarding control room shine due to a Large Break Loss of Coolant Accident (LBLOCA). This additional information is contained in Attachment 1.

Reference 1 contained the calculated dose results for the LBLOCA event. This event has been reanalyzed and the revised results are also included in Attachment 1. The LBLOCA event was reanalyzed assuming reduced control room unfiltered in-leakage to show acceptable results when combined with the control room shine dose.

The proposed change to implement the alternative source term was evaluated in accordance with 10 CFR 50.91(a)(1) using criteria in 10 CFR 50.92(c) and it was determined that the change involved no significant hazards considerations. The bases for this determination are not affected by the attached additional information.

This submittal includes a new commitment as summarized in Attachment 2. If you have any questions or require additional information, please contact Jerry Burford at 601-368-5755.

A001

I declare under penalty of perjury that the foregoing is true and correct. Executed on September 1, 2004.

Sincerely,

KJP/DBM/cbh

Attachments:
1. Supplemental Licensing Report for the Radiological Consequences of Accidents for the Waterford Steam Electric Station, Unit 3 Using Alternative Source Term Methodology
2. List of Regulatory Commitments

cc: Dr. Bruce S. Mallett
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Attachment 1

W3F1-2004-0076

Supplemental Licensing Report for the Radiological Consequences of Accidents for the Waterford Steam Electric Station, Unit 3 Using Alternative Source Term Methodology

Licensing Report for the Radiological Consequences of Accidents for the Waterford Steam Electric Station, Unit 3 Using Alternative Source Term Methodology

August 31, 2004

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1.0 RADIOLOGICAL CONSEQUENCES UTILIZING NUREG-1465 SOURCE TERMS

1.1. Introduction

Reference 1 submitted a license amendment request to implement an Alternate Source Term (AST) as permitted by 10CFR50.67 for calculating accident offsite doses and doses to control room personnel for Waterford 3. That submittal provided dose consequence analyses for events expected to be limiting, and noted that a second AST submittal, Reference 2, would be made to provide the results of additional analyses. This final submittal provides the following:

- An amendment to Reference 1, Section 5.0, Large Break Loss of Coolant Accident (LBLOCA), and
- LBLOCA shine calculations.

LBLOCA is being amended to correct a conservative error in RADTRAD Version 3.02 and to specify a new unfiltered in-leakage value. Results listed in this submittal for LBLOCA supercede those listed in Reference 1. LBLOCA shine calculations have been contingent on the LBLOCA calculation and are being presented here for the first time.

1.2. Common Analysis Inputs and Assumptions

Common analysis inputs and assumptions are described in Section 1.2 of Attachment 2 of Reference 1. Some inputs and assumptions are identified therein as being specific to events evaluated in Reference 1 and are not applicable to the analyses presented in this submittal.

1.3. Control Room Air Conditioning System and Control Room Ventilation Model

The control room air conditioning system and control room ventilation model are described in Section 1.3 of Attachment 2 of Reference 1. The description includes event-specific control room unfiltered in-leakage assumptions for the events evaluated in Reference 1 which are not applicable to events evaluated in this submittal. The in-leakage assumptions for events evaluated in this submittal are:

Sequence Type	Control Room Unfiltered In-leakage Modeled
LBLOCA	100 CFM

1.4. Exceptions to Regulatory Guide (RG) 1.183

Exceptions applicable to this submittal are identified in Section 1.4 of Attachment 2 of Reference 1. This supplement also assumes a 2%, vice 10%, flashing fraction for Engineered Safety Feature (ESF) leakage contributions to containment filter shine doses for beyond 24 hours into the analysis: this is discussed and justified in Section 5.

2.0 CONCLUSIONS

A summary of the calculated dose consequences of the LBLOCA event is presented in Table 2-1. The event meets the acceptance criteria for the Exclusion Area Boundary (EAB), Low Population Zone (LPZ), and Main Control Room (MCR).

TABLE 2-1
SUMMARY OF RESULTS

Event Scenario	Dose Consequences			Acceptance Criterion
	EAB	LPZ	MCR	EAB&LPZ/MCR
LBLOCA	5.080	2.303	1.417	25/5

Notes: All Results are presented in units of rem Total Effective Dose Equivalent (TEDE).

Detailed discussions for the LBLOCA event are presented in Section 4. The detailed analyses for the event demonstrate that radiological consequences meet the TEDE dose acceptance limits for off-site dose. The radiological consequences for MCR dose for the event are ≤ 5 Rem TEDE.

The total dose to control room personnel from the LBLOCA inhalation dose and doses from various post-LBLOCA shine sources is also ≤ 5 Rem TEDE. This is presented in more detail in Section 5.

3.0 REFERENCES

1. W3F1-2004-0053, "License Amendment Request NPF-38-256, Alternate Source Term, Waterford Steam Electric Station, Unit 3, Docket No. 50-382, License No. NPF-38," July 15, 2004.

2. W3F1-2004-0071, "License Amendment Request NPF-38-256, Alternate Source Term, Waterford Steam Electric Station, Unit 3, Docket No. 50-382, License No. NPF-38," August 19, 2004

3. W3F1-2003-0074, "License Amendment Request NPF-38-249, Extended Power Uprate, Waterford Steam Electric Station, Unit 3, Docket No. 50-382, License No. NPF-38," November 13, 2003.

4.0 LARGE BREAK LOSS OF COOLANT ACCIDENT (LBLOCA)

The LBLOCA dose analysis has been revised to specify a 100 CFM unfiltered in-leakage value and to correct a conservative error impacting control room does. A RADTRAD version 3.0.2 code error resulted in a doubling of the control room dose. The analysis has been reperformed using RADTRAD 3.0.3. The previous analysis had also conservatively included a noble gas source term in the modeling of the ESF leakage; this excess conservatism has been removed.

The design basis LBLOCA is postulated as a break in the reactor coolant pressure boundary piping. An abrupt failure of the main reactor coolant piping is assumed to occur and it is assumed that the emergency core cooling system fails to prevent the core from experiencing significant degradation. This is considered a Limiting Fault event. Activity from the core is released to containment and subsequently to the environment by means of containment leakage or leakage from the emergency core cooling system. Release of core radioactive inventory to the containment is postulated in accordance with RG 1.183 guidance on activity release and timing for the gap fraction release and early-in vessel release phases.

Other than adoption of the RG 1.183 methodology, the LBLOCA dose analysis is relatively unchanged compared to the analysis presented in Extended Power Uprate (EPU) Licensing Amendment Request, Reference 3.

4.1. Input Parameters and Assumptions

The input parameters and assumptions are listed in Table 4-1. Certain assumptions are discussed in additional detail below.

4.1.1. Source Term

Table 1-1 of Reference 1 documents the core inventory assumed for the LBLOCA radiological dose calculations. Two separate ORIGEN calculations were conducted for the Waterford 3 EPU project to provide core inventories. One calculation was performed to determine the gap fission product activities in peak power rods. A second calculation was performed to determine the core-wide fission product inventory. There was generally good agreement between these two calculations, with their slightly separate biases. A LOCA source term (Table 1-1 of Reference 1) was constructed using the more conservative (larger) value of core inventory from the two sources. Several isotopes are modeled in RADTRAD for which inventories were not calculated in the ORIGEN calculations. For those isotopes, the default Pressurized Water Reactor (PWR) core inventories (on a Ci/MWt basis) from NUREG/CR-6604 were assumed.

The release fractions applied to the various species of fission products are consistent with Table 2 of RG 1.183 for PWR core inventory fraction releases for the gap release phase and early in-vessel phase of release. Timing of the release phases is from Table 4 of RG 1.183 for LOCA release phase timing. This information is documented in Table 4-2.

The reactor coolant initial activity is insignificant in comparison with the releases due to the postulated core damage for this event.

4.1.2. Iodine Chemical Form

As listed in Table 4-2, iodine released to containment is assumed to be 95% aerosol/particulate, 4.85% elemental, and 0.15% organic. This is consistent with Section 3.5 of RG 1.183.

The radioiodine postulated to be available for release to the environment through ESF leakage is assumed to be 97% elemental and 3% organic. This is consistent with Section 5.6 of RG 1.183 Appendix A.

4.1.3. Release Pathways

Activity from the reactor coolant system and the failed core is released into the containment. Releases are postulated from the containment to the environment by three containment air leakage pathways (Reactor Auxiliary Building (RAB)/Controlled Ventilation Areas System (CVAS), Shield Building, and Direct Bypass) and by leakage from ESF systems (safety injection and containment spray) which take suction, upon recirculation, from the safety injection sump. The fraction of the release associated with each of the three containment air leakage pathways is specified in Table 1-2 of Reference 1.

The containment is modeled as a sprayed and an unsprayed region, where the sprayed region is subject to fission product removal due to the action of the containment sprays (80% of the containment volume is assumed subject to containment spray). Consistent with RG 1.183, Appendix A, a mixing rate due to natural convection between the sprayed and unsprayed regions of containment can be assumed to equal two turnovers of the unsprayed region per hour; this assumption has been adopted for the LBLOCA dose calculation. This is considered a conservative assumption since at least one containment fan cooler is assumed available, providing forced circulation mixing within the containment.

The containment is assumed to leak at the design rate of 0.50 w/o per day for the first 24 hours, and at half that rate (0.25 w/o per day) thereafter. This is consistent with RG 1.183, Appendix A.

Direct bypass releases are assumed to be released unfiltered directly to the environment. Releases to the area of the RAB serviced by the CVAS are assumed to be filtered and directly released to the environment; no credit is taken for holdup in the RAB. Shield Building holdup and dilution is modeled. A Shield Building Ventilation System (SBVS) maximum flow rate of 11,000 CFM per train is modeled. It is assumed that when one train is operating, flow is induced in the second train, which is assumed to be unfiltered. The Shield Building pressure transient following a LBLOCA is documented in UFSAR Figures 6.2-47a and 6.2-47b. Conservatively, when the SBVS is in exhaust mode releasing to the environment, a total flow of 24,244 CFM is assumed with a 89.8% filter efficiency; this very conservatively assumes that even though each train is operating, it is also inducing the unfiltered flow. When the SBVS is in recirculation, only a nominal flow rate of 10,000 CFM is assumed and it is assumed that only one train is operating. Thus, the modeling of the SBVS is very conservative. A small effective exhaust flow of approximately 35 CFM is assumed for long-term operation of the SBVS (i.e., beyond about 43 hours); the remaining flow, based on the nominal 10,000 CFM flow rate, is assumed to be in recirculation. After 168 hours, the SBVS is assumed to be exhausting to account for the postulated failure of the containment Maintenance Hatch seal.

The analysis considers a leak rate of 0.5 GPM from Emergency Core Cooling System (ECCS) systems that are recirculated and may leak to locations serviced by the CVAS system in the RAB. While no credit is taken for holdup and dilution in the RAB, CVAS filtration is credited. A flashing fraction of 10% is assumed, consistent with RG 1.183. The release is assumed to begin at the postulated earliest time before ECCS recirculation of 23.4 minutes.

4.1.4. Removal Coefficients

Containment spray removal coefficients consistent with NUREG-0800, Section 6.5.2 are assumed. One train of Containment Spray is assumed to operate following a LOCA, with a minimum flow rate of 1750 GPM. These values are documented in Table 4-1. Removal of elemental iodine from the containment atmosphere is assumed to be terminated when the airborne inventory drops to 0.5% of the total elemental iodine released to the containment (a Partition Factor (PF)of 200). With RG 1.183 source term methodology, this is interpreted as being 0.5% of the total inventory of elemental iodine that is released to the containment atmosphere over the duration of the gap and in-vessel release phases. This occurs after 1.8 hours. The removal coefficient for particulate/aerosol iodine is assumed, consistent with NUREG-0800, to decrease by a factor of ten when the airborne inventory has dropped to 2% of the total particulate iodine released to the containment (a PF of 50). This also occurs after 1.8 hours.

Per RG 1.183 Appendix A Section 3.2, reduction of airborne activity by natural deposition within the containment may be credited for LOCA. The Powers 10% Aerosol Deposition is specified for natural deposition of aerosols/particulates. This model is described in NUREG/CR-6604. The lower bound of this deposition model (10th percentile) is specified. Use of this model is consistent with RG 1.183, Appendix A, Section 3. The guidance of NUREG-0800, Section 6.5.2 is applied for natural deposition of elemental iodine. Natural deposition removal coefficients are documented in Table 4-1.

4.1.5. Main Control Room Model

The MCR ventilation model is described in Section 1.3 of Reference 1. The LBLOCA dose model assumes an unfiltered in-leakage of 100 CFM for the event duration. It is assumed that the preferred control room intake is selected at two hours into the event, at which time the operators also initiate the pressurized mode of control room operation. However, no credit is taken in this event scenario for the lower in-leakage during the pressurized mode of operation.

4.2. Results

The radiological consequence results in Rem TEDE are listed below and compared with the acceptance criteria for LOCA provided by RG 1.183 and 10CFR50.67:

	LBLOCA	Acceptance Criteria
EAB (worst two hour dose)	5.080	25 Rem TEDE
LPZ (worst 30 day duration)	2.303	25 Rem TEDE
MCR	1.417	5 Rem TEDE

Thus, the radiological consequences for LBLOCA are < 25 Rem TEDE for the EAB and LPZ doses and < 5 Rem TEDE for the MCR, based on a maximum control room unfiltered in-leakage of 100 CFM.

TABLE 4-1
ASSUMPTIONS USED FOR LBLOCA RADIOLOGICAL ANALYSIS

Core Power Level:	3735 MWt
Containment Leak Rate:	0.50 % volume/day (0-24 hours) 0.25 % volume/day (24 hours - 30 days)
Natural Deposition:	
Elemental	0.40/hr
Organic	0
Particulate	Powers 10% Aerosol Decontamination Factor
Spray Fission Product Removal (LBLOCA):	
Elemental	20/hr (maximum PF = 200)
Organic	0
Particulate	3.596/hr (until PF = 50) 0.3596/hr (once PF > 50)
Containment Mixing Rate Between Sprayed and Unsprayed Regions:	17,122 CFM
Maximum Spray Delay Time:	60 seconds
Containment Leakage Pathway:	
Controlled Ventilation Area System (CVAS) Filtration (Reactor Auxiliary Building)	54%
Shield Building	40%
Unfiltered Direct Bypass	6%
Control Room Parameters	See Table 1-2 of Reference 1

Main Control Room X/Q Assumed:

Time	Unfiltered In-leakage	Pressurization Flow
0-2 hr	2.77E-03	2.77E-03
2-8 hr	1.78E-03	3.90E-04*
8-24 hr	7.22E-04	1.79E-04*
1-4 days	5.27E-04	1.37E-04*
4-30 days	4.05E-04	1.08E-04*

* factor of 4 reduction credited per SRP 6.4.

TABLE 4-2
SOURCE TERM ASSUMPTIONS: LBLOCA RADIOLOGICAL ANALYSIS

Core Inventory Fraction Released into Containment:

Group	Gap Release Phase	Early In-Vessel Phase
Noble Gas	0.05	0.95
Halogens	0.05	0.35
Alkali Metals	0.05	0.25
Tellurium Metals	0.00	0.05
Ba, Sr	0.00	0.02
Noble Metal	0.00	0.0025
Cerium group	0.00	0.0005
Lanthanides	0.00	0.0002

LOCA Release Phases:

Phase	Onset	Duration
Gap Release	30 sec	0.5 hr
Early In-Vessel	0.5 hr	1.3 hr

Iodine Chemical Form (release to containment):

Aerosol/Particulate	95%
Elemental	4.85%
Organic	0.15%

Iodine Chemical Form (ESF system leakage):

Elemental	97%
Organic	3%

5.0 LARGE BREAK LOCA (LBLOCA) SHINE CALCULATIONS

Per Section 4.2 of RG 1.183, control room dose consequences must be addressed for the following applicable sources:

- Radiation shine from the external radioactive plume released from the facility,
- Radiation shine from radioactive materials in the reactor containment, and
- Radiation shine from radioactive materials in systems and components inside or external to the control room envelope, e.g., radioactive material buildup in recirculation filters.

Since the LBLOCA results in the largest release of fission products in comparison to the other accident sequences analyzed in support of the Waterford 3 AST, the radiation shine contribution from the above mentioned sources the to LBLOCA TEDE dose was quantified. The radiation shine from radioactive materials deposited on systems/components external to the control room envelope considered radioactive material deposition on the recirculation filters of the following three systems:

1. Shield Building Ventilation System (SBVS),
2. Controlled Ventilation Areas System (CVAS), and
3. Control Room Emergency Air Recirculation System

The deposition of radioactive materials on the filters shown above for a LBLOCA can occur via two mechanisms: containment air leakage and ESF leakage. RADTRAD Version 3.03 was used to model these leak paths and quantify the amount of radioactive materials deposited on the filters. The radioactive material loadings on the filters were then input into MicroShield Version 5.01, along with the geometry of the filters and the dose points to calculate the integrated 30-day radiation shine TEDE dose to the control room due to filter shine. Control room occupancy factors consistent with Paragraph 4.2.6 of RG 1.183 were assumed.

The normal containment air leakage and the ESF leakage paths are the dominant means of releasing radioactive fission products for deposition on filters. This is particularly the case for the CVAS filters, since any ESF leakage is in the areas of the Auxiliary Building which are serviced by CVAS. Both analyses have inherent conservatisms built into the analyses, which results in conservative results in terms of main control room dose. These conservatisms are discussed below in more detail:

- The normal containment leakage model conservatively assumes that the 6% of normal containment leakage that is directed to the environment as Direct Bypass leakage was redirected to the CVAS, thus making the containment leakage split 60% to the CVAS and 40% to the Shield Building.

- The deposition on the control room filters conservatively assumed 200 cfm unfiltered in-leakage in calculating the radioactive material loading on the control room recirculation filters.

- The ESF leakage rate was assumed to be 0.5 GPM. This corresponds to twice the allowable leak rate per Section 5.2 of Appendix A of RG 1.183. Waterford 3 will commit to revise its procedures to specify a maximum ESF leakage of half the value specified in the LOCA radiological analysis, consistent with RG 1.183.

- The entire iodine inventory was assumed to be deposited in the sump fluid per Section 5.1 of Appendix A of RG 1.183.

- The assumed RAB volume of the CVAS model was conservatively biased low and an additional conservatism of a 50% mixing factor was assumed on top of that.

- No radioactive material deposition was credited in the CVAS or the Shield Building.

- Filter efficiencies of 100% were assumed on all filters to maximize the amount of radioactive material deposited on the filters.

The only exception to RG 1.183 taken in the filter shine analysis was pertaining to the flashing fraction assumed for the ESF leakage. Section 5.5 of Appendix A of RG 1.183 states that:

"If the temperature of the leakage is less than 212 °F or the calculated flashing fraction is less than 10%, the amount of iodine that becomes airborne should be assumed to be 10% of the total iodine activity in the leaked fluid, unless a smaller amount can be justified..."

A graph of the limiting sump water temperature case for the 3716 MWt power uprate conditions indicates a maximum sump temperature of around 212 °F at about 30,000 seconds. The actual calculated maximum temperature is 213.83 °F. Thus, the maximum flashing fraction corresponding this liquid temperature is:

$$\begin{aligned} FF &= h_f(213.83°F) - h_f(212°F) / h_{fg}(212°F) \\ &= (182.01 - 180.16) / (1150.48 - 180.16) \\ &= 0.19\% \end{aligned}$$

Based on the fact that the sump water temperature will be well below 212 °F after 24 hours, the filter shine calculations assumed a flashing fraction of 10% for the first 24 hours, then 2% thereafter for the remaining 29 days. The 2% flashing fraction was conservatively assumed based on 10 times the maximum calculated flashing fraction based on the maximum sump water temperature.

Table 5-1 illustrates the integrated 30-day radiation shine TEDE dose from the three filter sources discussed above as well as radiation directly from containment and an external radioactive plume. As shown in this table, the radiation shine dose from the external sources is dominated by the radiation sources from the filters, with an emphasis on the CVAS filters. The radioactive material loading on the CVAS filters is much larger than the other filters since these filters are loaded via both normal containment leakage and ESF leakage. Taking these conservative TEDE dose estimates due to radiation shine from external sources (containment, plume and recirculation filters) and adding this to the LBLOCA inhalation main control room TEDE dose discussed in Section 4.0 of this submittal yields a total main control room TEDE dose due to a LBLOCA which is below the 5 Rem acceptance criterion stated in Table 6 of RG 1.183.

TABLE 5-1
Dose Contributions for LBLOCA Due to Radiation Shine

Radiation Source	**TEDE Dose (mRem)**
Direct Containment Shine	4
External Plume Shine	13
Radiation Shine from CVAS Filters due to normal containment leakage	449
Radiation Shine from SBVS Filters due to normal containment leakage	1
Radiation Shine from Control Room Recirculation Filters due to normal containment leakage	24
Radiation Shine from CVAS Filters due to ESF Leakage	989
Control Room Inhalation Dose	**1.417 Rem**
TOTAL:	**2.897 Rem**

Attachment 2

W3F1-2004-0076

List of Regulatory Commitments

List of Regulatory Commitments

The following table identifies those actions committed to by Entergy in this document. Any other statements in this submittal are provided for information purposes and are not considered to be regulatory commitments.

COMMITMENT	TYPE (Check one)		SCHEDULED COMPLETION DATE (If Required)
	ONE-TIME ACTION	CONTINUING COMPLIANCE	
Waterford 3 plant procedures will be revised to specify a maximum ESF leakage of half the value specified in LOCA radiological analyses, consistent with RG 1.183.	X		EPU/AST Implementation