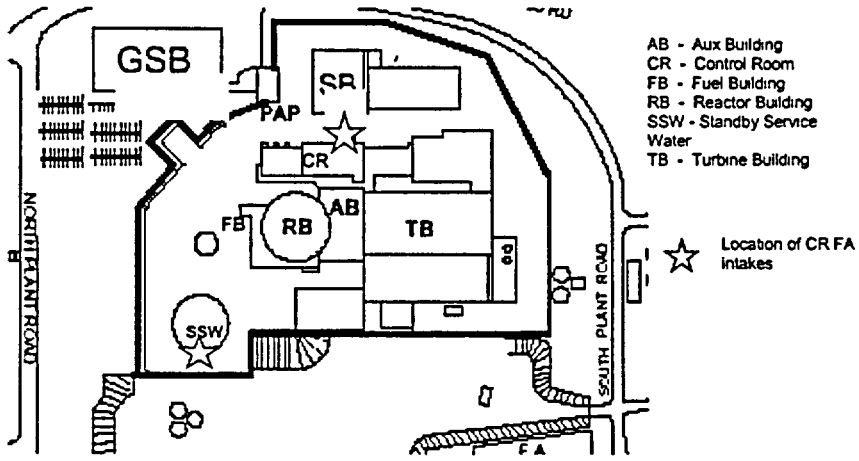
River Bend Station
Full Scope Application of Alternate Source Terms

Presented to USNRC
By Entergy
October 8, 2002

Agenda

- Introduction
  - Participants
  - Purpose
- River Bend General Plant Layout
- Licensing Background
- Proposed TS Changes
- Discussion of Analyses

Plant Layout



Licensing Background

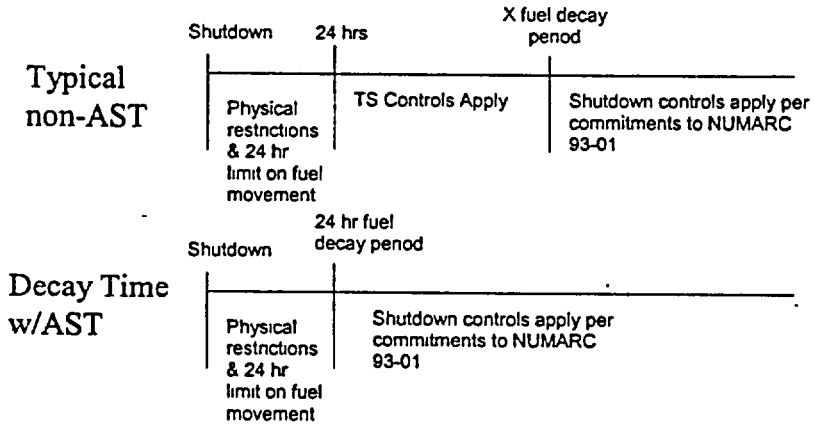
- Use of alternate source terms
  - Entergy applied AST at GGNS
  - Limited scope application at RBS (IFTS)
- Use of fuel decay times in FHA
  - **Initial License:** TS required 24-hour decay time before allowing fuel movement. TS requirement was removed by ISTS.
  - **Amend. 35** (1989): Allowed LLRT of vent and drain lines 80 hours after fuel decay.

Licensing Background

- Use of fuel decay times (cont.)
  - **Amend. 85** (1996): Allowed PC airlocks to be open 11 days after fuel decay.
  - **Amend. 113** (2000): Fuel Building & FBV not required 11 days after fuel decay.
  - **Amend. 119** (2001): TSTF-51 applied to containment. Committed to shutdown controls per NUMARC 93-01, including having ventilation and radiation monitoring systems available.

Licensing Background

- Use of fuel decay times with AST



Proposed TS Changes

- Automatic actuation not required for:
  - secondary containment isolation
  - SGTS
  - CRFA
- FB isolation & FBV not required
  - FBV will continue to be available per committed shutdown controls.

Proposed TS Changes

- CRFA, containment, air locks, and power support systems not required for fuel movement.
- New single MSL limit established.
- Aux. Building drawdown time increased (18.5 seconds to 34.5 seconds).

Proposed TS Changes

- Leakage rate limits revised:
  - Containment Leakage (0.26 to 0.325%/day)
  - Secondary cont. bypass (170k to 580k cc/hr)
  - Annulus bypass leakage limits not required
  - PC airlock seals (1.28 to 1.50 psig/day)
  - Drywell airlock seals (0.67 to 20.0 psig/day)

Proposed TS Changes

- Ventilation filter testing program revised:
  - increased allowable penetration of SGTS filters (0.5% to 5.0%) & CRFA filters (0.5% to 1.0%)
  - eliminates FBV filter testing (testing will be per FSAR commitment to RG 1.140 for normal ventilation systems)

River Bend Station
Alternate Source Term

Full Scope Implementation
Analyses

Introduction

- Summary of Analyses
- Suppression Pool Post-LOCA Chemistry
- Atmospheric Dispersion Factors
- Dose Analyses
  - Common Assumptions
  - Control Room Modeling

Summary of Analyses

- Suppression Pool Chemistry Analysis
- Atmospheric Dispersion Factors (χ/Q)
- Loss of Coolant Accident (LOCA) Off-site and Main Control Room (MCR) Doses
- Fuel Handling Accident Off-site and MCR Doses
  - Light Load Drop Analysis (LLA)

Summary of Analyses

- Control Rod Drop Accident (CRDA) Off-Site and MCR Doses
  - Design Basis CRDA
  - Low Power CRDA
- Main Steam Line Break (MSLB) Off-Site and MCR Doses
  - Equilibrium Iodine Case
  - "Iodine Spike" Case

Suppression Pool pH Analysis

- Performed I.A.W. NUREG/CR-5950
- Severe Accident Procedures Already Direct Operators to Initiate System
- Release Fractions Consistent with Gap and EIV Release Fractions
- Initial Suppression Pool pH = 5.3
- Total Exposed Cable Mass = 38,000 lbm
- Bounding Dose Rates Used for Radiolysis

pH Analysis – SLCS

- SCLS Not Credited for 2 Hours
- Injection Rate is 41.2 gpm
- Minimum Sodium Pentaborate Weight % in Solution is 7.13%
- Minimum SLCS Volume of 1657 gallons injected
- Buffering by CsOH was Neglected

pH Analysis - Results

- Final Calculated pH was 8.13
- Parametric Study Demonstrated <30% of the Sodium Pentaborate is Needed to Maintain pH > 7.0.

Atmospheric Dispersion Factors (χ/Q) Analyses

- NRC Codes Used in Analyses
  - Off-site Analyses – PAVAN
  - MCR Analyses – ARCON96
- Main Control Room χ/Q Values Calculated Using NUREG/CR-6331
- Off-Site Values Consistent with Regulatory Guide 1.145 Requirements

χ/Q Analyses - Data

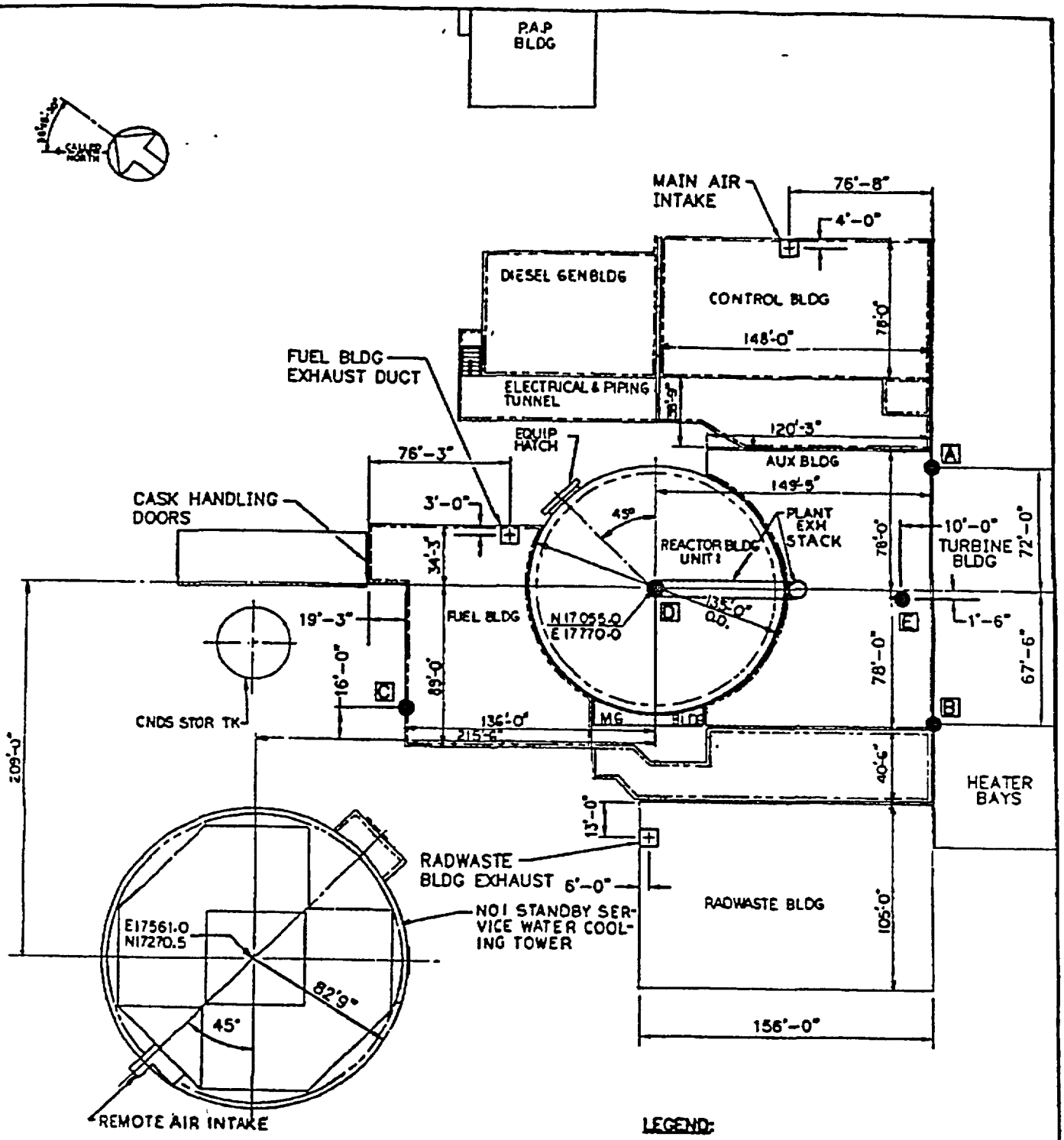
- Environmental Data Taken from Plant Meteorological Tower
  - Meets RG 1.23 Requirements (USAR Table 1.8-1 and Section 2.3)
- Five Years of Data Used
  - Off-Site used JFT: 1994-1999
  - MCR Used Hourly Data: 1995-1998, 2000

χ/Q – Release Points

- Main Plant Stack (SGTS Release Point)
- Radwaste Build
- Turbine Building
- Main Steam Tunnel Blowout Panel
- Edge of Containment (Equipment Hatch)
- Standby Cooling Tower
- Fuel Building (MCR Only)

χ/Q – Other Assumptions

- "Ground Level" Release Assumed
- "Point Source" Release Assumed
- MCR Values Calculated for Both Intakes:
  - Main (Local) Air Intake (Control Building Roof)
  - Remote Air Intake (Standby Cooling Tower)
- Shortest Distances Used in All Directions for Off-Site Calculations



LEGEND:

- [A] TURBINE BUILDING RELEASE POINT FOR MAIN AIR INTAKE
- [B] TURBINE BUILDING RELEASE POINT FOR REMOTE AIR INTAKE
- [C] FUEL BUILDING RELEASE LOCATION FOR REMOTE AIR INTAKE
- [D] MAIN PLANT STACK (SGTS) RELEASE LOCATION
- [E] MAIN STEAM TUNNEL PRESSURE RELEASE PANELS

NOTE:
THIS FIGURE IS INTENDED TO SHOW GENERAL BUILDING LAYOUT

Entergy Operations, Inc.

χ/Q – Results

- Results More Favorable Than Initial Licensing Analyses
- MCR Values
  - SGTS/Containment was 50% and 20% of Current Values for MAI/RAI
  - NUREG/CR-6331: Murphy & Campe Overpredicted Conc. in Low Wind Speed Conditions (1.3 mph/0.58 mps)

Dose Common Assumptions

- Power Level for Source Term is 3,100 MWt
  - 102% of Current Licensed Thermal Power
  - Also bounds Appendix K Power Uprate
- DCF Based on FGR 11&12
- Breathing Rates from RG 1.183 (RG 1.3)

CRFA Model – Normal Mode

- RBS has a Positive Pressure Control Room
  - Maintained >1/8"
- Normal Intake of 2,000 cfm from Control Building Roof
- No Filtered Recirculation
- Normal Discharge is 2,000 cfm

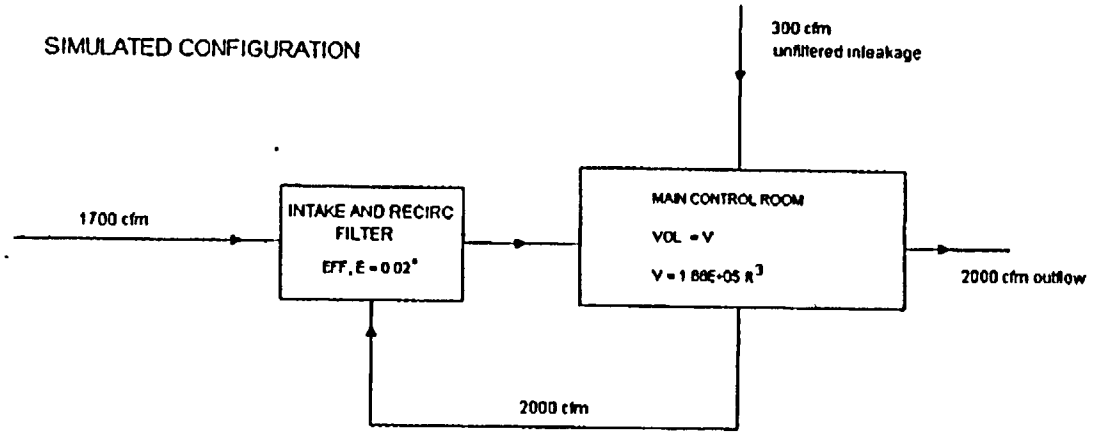
CRFA – Emergency Mode

- Only Credited in LOCA and CRDA
  - No credit for Automatic Initiation signals taken
  - Not credited in MSLB or FHA
- Maintains +1/8" per TS 3.7.2
- Filter Efficiencies:
  - Charcoal Efficiency of 98%
  - HEPA Efficiency of 99%

CRFA – Emergency Mode

- Actual ESF Filter Flowrate is 4,000 cfm
  - 50% Intake and 50% Recirculation
- Assumed Unfiltered Inleakage is 300 cfm
- Modeled Flows:
  - Unfiltered Inleakage = 300 cfm
  - Filtered Intake = 2000 – 300 = 1700 cfm
  - Recirculation = 2000 cfm
  - Discharge = 2000 cfm

Control Room Ventilation With Filtered Intake & Recirculation



CRFA – Emergency Mode

- RBS Has Dual Air Intakes which Can be Manually Selected
- Utilized "Flow Biased" Setpoints
  - Unfiltered Inleakage uses MAI (χ/Q_{MAI})
  - Filtered Intake uses the Most Favorable χ/Q (χ/Q_{MF}) and Applies a Reduction Factor of 4 for Dual Manual Air Intakes.
- "Effective" χ/Q Determined

"Effective" χ/Q

$$\chi/Q_{effective} = \frac{1700cfm\left(\frac{\chi/Q_{MF}}{4}\right) + 300cfm\left(\chi/Q_{MAI}\right)}{2000cfm}$$

Loss of Coolant Accident (LOCA)

- Performed per RG 1.183, Appendix A
  - One exception to RG 1.183
- Assumed Failure of Emergency Diesel Generator
- Assumed Failure of Main Steam Isolation Valve
- Coincident with a Loss of Off-site Power
- Coincident with a Safe Shutdown Earthquake

LOCA – General Assumptions

- Automatic Initiation of Standby Gas Treatment System (SGTS) Not Credited
  - Secondary Containment Not Credited for the First 30 Minutes of the Event
- Automatic Initiation of MCR ESF Filters Not Credited
  - MCR ESF Filters Not Credited for First 20 Minutes of Event

LOCA – Source Term

- Gap and Early In-Vessel Release
- Fuel Releases - 2 Hour Duration
- Release Fractions per RG 1.183, Table 2
- Iodine Chemical Species
  - Aerosol 95%
  - Elemental 4.85%
  - Organic 0.15%

LOCA – Containment

- No Containment Sprays
- Natural Deposition of Halogens Credited in Drywell Only
  - Power's (10) Model
  - Elemental Removal Constant, $\lambda = 1.01\ hr^{-1}$
- No Suppression Pool Scrubbing Credited
- Release Rated Reduced by 45% at 24 Hours Based on Containment Pressure

LOCA - Containment

- Blowdown (DW → Cont.)
  - 4.74E+5 cfm for 10 minutes
- Hydrogen Mixing (DW ↔ Cont.)
  - 600 cfm starting at 25 minutes
- Steaming Data (DW → Cont.)
  - 3000 cfm starting at 25 minutes
- Infinite Mixing (DW ↔ Cont.)
  - 1E8 cfm assumed to homogenize DW/Cont. at 2 hours

LOCA - Releases

- Primary Containment Leakage (L_a)
  - 0.325% per day (0.179%/day after 24 hours)
  - Assumed from both DW and Cont.
  - Assumed Main Plant Stack Release Point
  - 0 – 30 Minutes Released to Environment
  - >30 Minutes Released to Annulus (SGTS)

LOCA - Releases

- Secondary Containment Bypass
  - Independent of L_a
  - Released Directly to Environment via Turbine Building
  - 580,000 cc/hr @ P_a (319,000 > 24 hours)
  - Released from Containment Node
- MSIV Failure
  - 50 scfh
  - MS-PLCS Operational @ 25 minutes
  - Released from Drywell

LOCA - Releases

- Engineered Safety Feature (ESF) Liquid Leakage
  - Assumed 1 gpm
    - 0 – 30 Minutes Released to Environment
    - >30 Minutes Released to Aux. Bldg. (SGTS)
  - 10% Flashing Fraction
  - Only deviation from RG 1.183 guidance

LOCA Results

Contributor	EAB	LPZ	MCR
Cont./Sec. Cont.	2.6	1.7	0.4
SCB/MSIV	12.3	5.4	2.9
ESF	<0.1	0.4	<0.1
Total	**15.0**	**7.5**	**3.4**
Reg. Limit	***25.0***	***25.0***	***5.0***

Fuel Handling Accident (FHA)

- Performed i.a.w. Reg. Guide 1.183, Appendix B
- Assumed 150 GE 9x9 Rods Damaged
  - Actual calculated is 122 9x9 Rods
- 24 hour Decay Time
- 2 hour Release
- Radial Peaking Factor (RPF) = 2.0

FHA - Assumptions

- Halogen Decontamination Factor of 200
- No MCR ESF Filters Credited
  - Credit Taken for Dual Intakes
- Containment Release Point Assumed
  - "Old" Dispersion Factors Used
  - Values Used Bound Those Calculated Using ARCON96

FHA – Light Load Accident (LLA)

- Bounding Scenario is Light Load Drop from Polar Crane onto Reactor Core
- 300 GE 9x9 Rods
  - Actual calculated was 247 9x9 rods
- All Other Assumptions Identical to FHA

FHA/LLA – Results (REM TEDE)

Location	FHA	LLA	Regulatory Limit
EAB	2.5	5.0	6.3
LPZ	0.4	0.7	6.3
MCR	1.7	3.3	5.0

Control Rod Drop Accident (CRDA)

- Two Cases Analyzed
  - Design Basis Case (Full Power Event)
    - Regulatory Guide 1.183, Appendix C Assumptions
  - Lower Power Event
    - Limited CRDA with Condenser Mechanical Vacuum Pumps in Operation
- χ/Q Based on Turbine Building Release

CRDA Design Basis Event

- 850 GE 8x8 Rods (13.7 Assemblies)
- RPF = 2.0
- Assumed 100% Fuel Melt
- Fuel Melt Release Fractions – RG 1.183, Appendix C
  - 100% Noble Gases
  - 50% Iodines

CRDA Design Basis Event

- Plateout Consistent with RG 1.183, Appendix C Assumptions
  - Sections 3.3 and 3.4
- Condenser Release Rate = 1% per day
- Condenser Iodine Chemical Fractions
  - 97% Elemental/3% Organic
- No Credit for MCR ESF Filters

CRDA – Limited CRDA

- Control Rod Drop (or other reactivity event) which has Limited Fuel Damage
- Assumptions Consistent with GE NEDO-31,400A
- Plant Mechanical Vacuum Pumps are Assumed to be Operating

CRDA – Limited CRDA

- 10 Second "Burst" Release
- MSLRM Setpoint Based on 3.0x HWC Background Dose Rates
  - 30 R/hr including instrument uncertainty
- Assumed Cladding Damage Only
  - Gap Release Fractions per RG 1.183, Appendix C

CRDA – Limited CRDA

- Steam Dome Volume of 1.79E8 cc Used to Determine Steam Concentrations
- RPF = 2.0
- Determine 50 Rods Damaged for 30 R/hr
  - Neglects N-16 Background Radiation
- Plateout Consistent with RG 1.183, Appendix C Assumptions

CRDA – Limited CRDA

- Release Rates
  - 4,000 cfm through MVP for first 20 minutes
  - 1% per day for 24 hours
- Condenser Iodine Chemical Fractions
  - 97% Elemental/3% Organic
- MCR ESF Filters Manually Initiated at 20 Minutes
  - Flow Biased χ/Q (Consistent with LOCA)

CRDA Doses (REM TEDE)

Receptor	Regulatory Limit	100% Power Event	Low Power Event
EAB	6.3	0.9	4.7
LPZ	6.3	0.4	0.5
MCR	5.0	0.5	1.3

Main Steam Line Break (MSLB)

- Regulatory Guide 1.183, Appendix D
- No Fuel Damage due to MSIV Closure
- Main Steam Blowout Panel Release Point
- No Credit for CRFA ESF Filters
- 5.5 Second Release (MSIV Closure Time)

MSLB Assumptions

- Mass Release Based on Original Plant Licensing Conditions
  - 11,620 lbm of steam released
  - 68,942 lbm of coolant released
- 100% of Activity Released
- Two Cases Analyzed
  - Equilibrium Iodine – 0.2 uCi/gm
  - Iodine Spike – 4.0 uCi/gm

MSLB - Results

- Off-Site Doses
  - Equilibrium Iodine Case
    - EAB & LPZ – <0.1 REM TEDE (2.5 REM)
  - Iodine Spike Case
    - EAB – 1.4 REM TEDE (25 REM)
    - LPZ – 0.2 REM TEDE (25 REM)
- Main Control Room Doses
  - Iodine Spike Case Bounding – 2.2 REM

Conclusions

- AST methodology was applied per NRC regulations and guidance with significant conservatisms and margins.
- Dose consequences of postulated DBA analyses are within NRC guidance limits.
- The revised analyses demonstrate that certain TS limits and LCOs may be changed without compromising safety.

Discussion