Alternative Source Term Analysis Status
WNP-2 (Columbia Generating Station)

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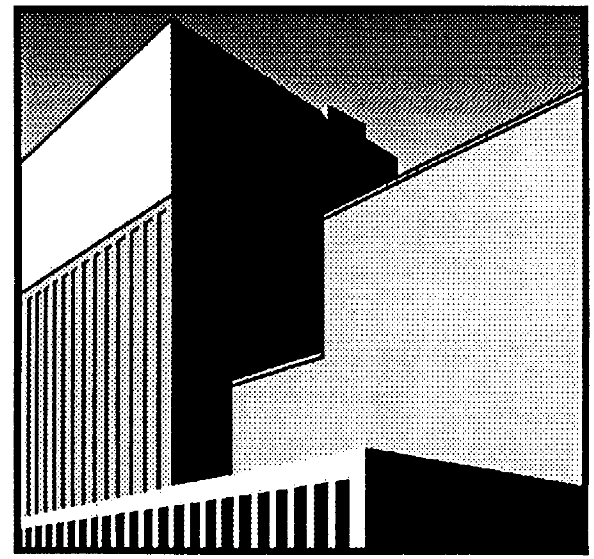


October 31, 2000
Rockville, Maryland

Energy Northwest

Overview

■ Introduction	P. Inserra
■ Analysis Objectives	M. Humphreys
■ Project / Schedule Update	M. Humphreys
■ Technical Issues	B. Boyum
	J. Metcalf
	M. Humphreys
■ Summary	M. Humphreys

Introduction

- Last Meeting - June 2000
  - Energy Northwest outlined approach and schedule using AST Methodology to resolve outstanding issues and Deactivation of MSLC
  - NRC Staff and Energy Northwest agreed upon periodic meetings to communicate developments to the staff and obtain staff feedback of potential problems or concerns
- This meeting is the first in the periodic updates

Analysis Objectives

- Primary Objectives
  1) Resolve the Secondary Containment Drawdown USQ and JCO
  2) Resolve Control Room Inleakage USQ
  3) Deactivation of Main Steam Leakage Control System (MSLC)
- Secondary Objectives
  4) Increase Allowable Secondary Containment Bypass Leakage
  5) Increase Allowable MSIV Leakage
  6) Removal of SGT Charcoal Design Basis Requirements (under consideration)

Project / Schedule Update

ID	Task Name	Schedule to NRC 6/00 Finish Date	Current Schedule (Draft) Finish Date
1	Evaluate CR Envelope	10/16/00	11/10/00
2	Develop Procedures	8/31/00	Complete
3	Conduct Testing	9/8/00	Complete
4	Finalize Results	10/16/00	11/10/00
5	Finalize CR X/Q	9/15/00	12/5/00
6	Complete Input Data	9/15/00	Complete
7	Review MSLC Feasibility Study	7/10/00	Complete
8	Select AST Vendor	7/31/00	Complete
9	Complete AST Analysis	1/31/01	1/31/01
10	Review / Approve Dose Calcs	4/16/01	4/16/01
11	Revise Related Calculations	4/16/01	4/16/01
12	Complete Licensing Submittal	6/15/01	6/15/01
13	Submit to NRC	6/29/01	6/29/01

Alternative Source Term (AST) / Main Steam Leakage Control (MSLC) System Deactivation / Secondary Containment (SC) Organization Chart

- **Abbas Mostala**
  Project Manager
  AST / MSLC / SC
  (509) 377-4197
- **Bruce Boyum**
  Management Oversight
  AST / MSLC / SC
  (509) 377-4730
- **Jim Metcalf**
  Project Manager
  Polestar
  (603)433-2711
  - Dr. Dave Leaver, Polestar President, (415)917-3755
  - Fred Hennion, (617)574-9285
  - Dr. Edward Fuller, (415)917-3755
  - Dr. Richard Hobbins, (415)917-3755
  - Dr. Rudy Sher, (603)433-2711

- **Dwayne Gregory**
  MSLC Deactivation
  (BDC 97-0045-0B)
  - Dwayne Gregory, x 4707, Cog Engr
    - Steve McDonald, x 4507, Elec Engr
    - Bao Ha, x 4396, Civil Engr
    - John Blake, x 8540, Stress Engr
    - Scott Payne, x 4485, Mech/I&C/Civil Dsgr
    - Jeff Lomax, x 4796, Elec Dsgr
- **Jim Zimmershied x4412**
  EQ
  - Mike Curren x4512, EQ Engineer
- **John Arbuckle x4601**
  Licensing
  - Contractor Licensing
- **System Engineering Support**
  - John Bartholomew, x2177, MSLC Sys. Engr.
  - Carl Zeamer, x4155, CR-HVAC Sys. Engr.
  - Joe Stacks, x4324, IST Engr
  - Dave Giroux, x4465, SGT Sys. Engr.
  - John Bartholomew, x2177, SLC Sys. Engr.
  - Mike Schmitz, x4296, RHR Spray Sys. Engr.
  - John M Williams, x4326, MSIV, MSRV Sys. Engr.
  - Steve Richter, x4703, PASS Sys. Engre.
- **Robert Vosburgh, x 4344**
  AST/SC Technical Lead
  Rx/Fuels Engineering
  BDC 97-0045-0A
  - Mohammed Abu-Shehadeh, x-4274, Fuels Engr. Cognizant Engr.
  - Albert Chiang x4220, PRA, Tech. Services
  - Linda Woosley, x 8446, Fuels Engr, Lead Analyst
  - John Fisher, x 4179, Fuels Engr, Support Analyst
  - Contractor Fuels Engr
- **Project Team Member Support**
  - Operations- Jeanne Kittler, Jim Prescott
  - Maintenance- Ron Barbee
  - Chemistry- Larry Mayne, Allen Alexander
  - Materials Engr- Tom Erwin
  - Fire Protection Engr- Wayne Harper
  - ASME- Kuldip Singh
  - Health Physics-Mike Wozencraft
  - Project Controls- Jim Parker
  - NPS - Steve Jacobs
  - Facilities- Steve Jacobs
  - Outage Org- Mike Ross
  - Ops Trng- Rita Abdella
  - HP/Chem Trng- Charlie McDonald
  - Maintenance Trng- Chad Bliss
  - Simulator Trng- Carl Golightly
  - QC- Dennis Kerlee
  - Contracts- Linda Parrella
  - EOP, SAG- OJ Brooks
  - Ops Procedures- Mark Pratt
  - Maint Procedures- Paul Ziemer
  - ESP Trng- John Perry
  - EP - Ron Jorgensen

10/25/2000

Technical Issues

1) Application of Containment Thermal-Hydraulic Analysis Results
2) Suppression Pool Scrubbing
3) Crediting of Drywell Sprays
4) Evaluation of Drywell as Source of MSIV Leakage
5) Impaction at Entrance to Inboard MSIV
6) Iodine Release from ESF Leakage
7) Liquid Bypass Leakage
8) Control Room X/Q Methodology (Murphy/Campe vs. ARCON96)
9) Crediting of Control Room Recirc Filter
10) MSLB X/Q Methodology (expansion and movement of puff release)

1) Application of Containment Thermal-Hydraulic Analysis Results

- DBA Containment T/H Data Used for:
  - Determination of When Drywell Sprays May Be Expected to Operate
  - Quantification of Drywell-to-Wetwell Flow and Suppression Pool Bypass
  - Specification of Drywell Conditions for Spray Removal Rate Calculation
  - Justification of 50% Reduction in Containment and MSIV Leak Rate at 24 Hours (RG 1.183)

1) Application of Containment Thermal-Hydraulic Analysis Results

- Containment DBA T/H Data Obtained from MAAP4 Analyses
- ECCS (HPCS) Assumed to Be Restored at End of In-Vessel Release Phase
  - No Vessel Failure
  - No Core Debris Relocation from Core Region
- Sensitivity Study: Variations in Drywell Initial Temperature and Relative Humidity, Service Water Temperature, and Hydrogen Production Considered

1) Application of Containment Thermal-Hydraulic Analysis Results

- Case for Large LOCA as T/H Basis
  - Maximum Activity Release to Containment
  - Minimum Time for Noble Gas Decay
- Events Investigated:
  - Large Recirculation Suction Break
  - Steam Line Breaks Both Upstream and Downstream of Flow Limiter (Large and Small)
- Large Steam Line Break Appears Most Limiting (Greatest Challenge to Spray Operation)

1) Application of Containment Thermal-Hydraulic Analysis Results

- Conservatisms
  - Effects of Steam Condensation Ignored
  - Prolonged (2 hr) Period of High Activity Concentration in Drywell before Sweep-Out
  - Suppression Pool Bypass Maximized to Minimize Suppression Pool Scrubbing, but Not Currently Being Credited in Assessment of Spray Operation

2) Suppression Pool Scrubbing

- Permitted by SRP 6.5.5
- DF=2 Used for ABWR Design Certification Based on MAAP Analysis
- Pool Flow and Pool Bypass Must Be Realistically Treated and Conservatively Quantified
  - Flow Through Pool During Activity Release to Containment May Be Minimal
  - Steam/Hydrogen Production When Core Debris Finally Quenched Will Be Considerable

3) Crediting of Drywell Sprays

- Spray Operation Assumptions
  - EOPs and SAGs Direct Spray Operation
  - Spray Operation When Radiation Dose Rate Approaches 14,000 R/Hr in Drywell
    - » Must Be within Safe Region of DSIL Chart to Start
    - » Sprays Will Be Terminated when Pressure Reduces to 1.68 PSIG
  - Currently Planning to Assume One Loop of Spray Beginning at 15 Minutes After Start of Accident (Approx 13 Minutes After Start of Release)

3) Crediting of Drywell Sprays

- Spray Design
  - Spray Flux Much Higher in Drywell Than in PWR Containment
    - » WNP-2 Spray Flux = ~ 0.025^{+} $cm^3/s\text{-}cm^2$
    - » Typical PWR Range = 0.005 - 0.01 $cm^3/s\text{-}cm^2$
  - Excellent Mixing Expected
  - Spray Credit Must Recognize Droplet Loss Due to Impingement at Spray Exit and Reduced Fall Height Caused by Obstructions

4) Evaluation of Drywell as Source of MSIV Leakage

- Evaluation Completed to Determine if Drywell with Sprays Operating Can Adequately Represent the Source of Activity for Release through MSIVs
- Upper Reactor Vessel Has Smaller Volume and No Sprays (Intact Vessel Case)
- Performed a Study Comparing Aerosol Mass Leaked for Vessel-Source Case with that for Large Steam Line Break with Drywell Sprays

4) Evaluation of Drywell as Source of MSIV Leakage

- Findings
  - High Sedimentation Rates, Vessel/SL Stratification, and Greater Impaction Removal Compensate for Drywell Volume and Sprays
  - Contained In-Vessel Source Produces no Greater Aerosol Leakage through MSIVs than Large Steam Line Break (Even with DW Sprays)
  - Use of Sprayed Drywell as Source of MSIV Leakage is Valid DBA Assumption

5) Impaction at Entrance to Inboard MSIV

- Aerosols Have Difficulty Following Carrier Gas Streamlines Around/Through Obstructions
- Stokes Number Characterizes Degree of Departure from Streamlines Where:

  $Stk = Constant{*}uL_p^2\rho_p/\mu_g L'$

  u = Speed Approaching Obstruction,

  L_p, ρ_p = Particle Characteristic Length, Density

  μ_g = Gas Viscosity

  L' = Obstruction Characteristic Length

5) Impaction at Entrance to Inboard MSIV

- Leak Path Plugging Predicted When "Suspended Mass Carried to or Past Plug" = KD^3 Where K = 30 $\pm$ 20 g/cm^3 (Model Developed by Vaughan and Reported by Morewitz)
- For MSIV Leak "Orifice"
  - D = ~ 0.05 cm at 11.5 SCFH/MSIV
  - D = ~ 0.15 cm at 100 SCFH/MSIV
- Plugging Predicted When
  - 0.0063 g Leaked (max) for 11.5 SCFH/MSIV
  - 0.17 g Leaked (max) for 100 SCFH/MSIV

5) Impaction at Entrance to Inboard MSIV

- Plugging Concept Can Be Used to Justify DF
- DF=2 is a Conservative Minimum for Columbia
  - at 11.5 SCFH/MSIV Analysis Shows 0.5 g Leaked
  - at 100 SCFH/MSIV Analysis Shows 4.3 g Leaked
- Higher DFs Expected for Unsprayed Cases (Including Cases with Vessel as Source) Because of Higher Stokes Number (Larger Particles, Same Gas Temperature and Composition)

6) Iodine Release from ESF Leakage

- ESF Leakage Occurs within RB Areas Served by SGTS
- Elemental/Organic Iodine Released by ESF Leakage Determines Need for Charcoal Filtration in SGTS
- ESF Leakage Assumed to Start with DW Sprays
- Polestar Investigating Potential for <10% Iodine Release Using Same Approach as Used for TMI-1 and IP-2

7) Liquid Bypass Leakage

- Status of Issue

Liquid Leakage Criteria Inappropriately Added to FSAR	**1995**
NRC SSFI Inspection Identified Valve Testing Issue	1998
PER 298-0928 written to document the issue with Corrective Actions	Completed
Liquid Leakage Study Calculation NE-02-99-12-00 Approved	**10/00**
SAR Change Approved to Remove Liquid Leakage Criteria from FSAR	**10/00**

7) Liquid Bypass Leakage

- NE-02-99-12 Key Assumptions

Parameter	Value
Source Term	50% equilibrium core iodine
Partitioning Coefficient	10%
CST Volume, gal	135,000
Liquid bypass leakage	RCIC, HPCS Suctions, Test Return Pathways
Iodine plate-out in piping, wetwell, CST atmosphere	None

7) Liquid Bypass Leakage

- RESULTS: The Activity at Site Boundary and Control Room Increases < 10% If Total Leakage <= 0.48 gpm for 30 days.
  - No Reduction taken for 2 valves in series
  - 0.48 gpm is equivalent to 2*(2 CST Suction Pathways +2 CST Test Return Pathways)
  - Values per valve are typical, measured in 15 years of leak rate testing for similar valves in service (>>ASME design value for new valve)

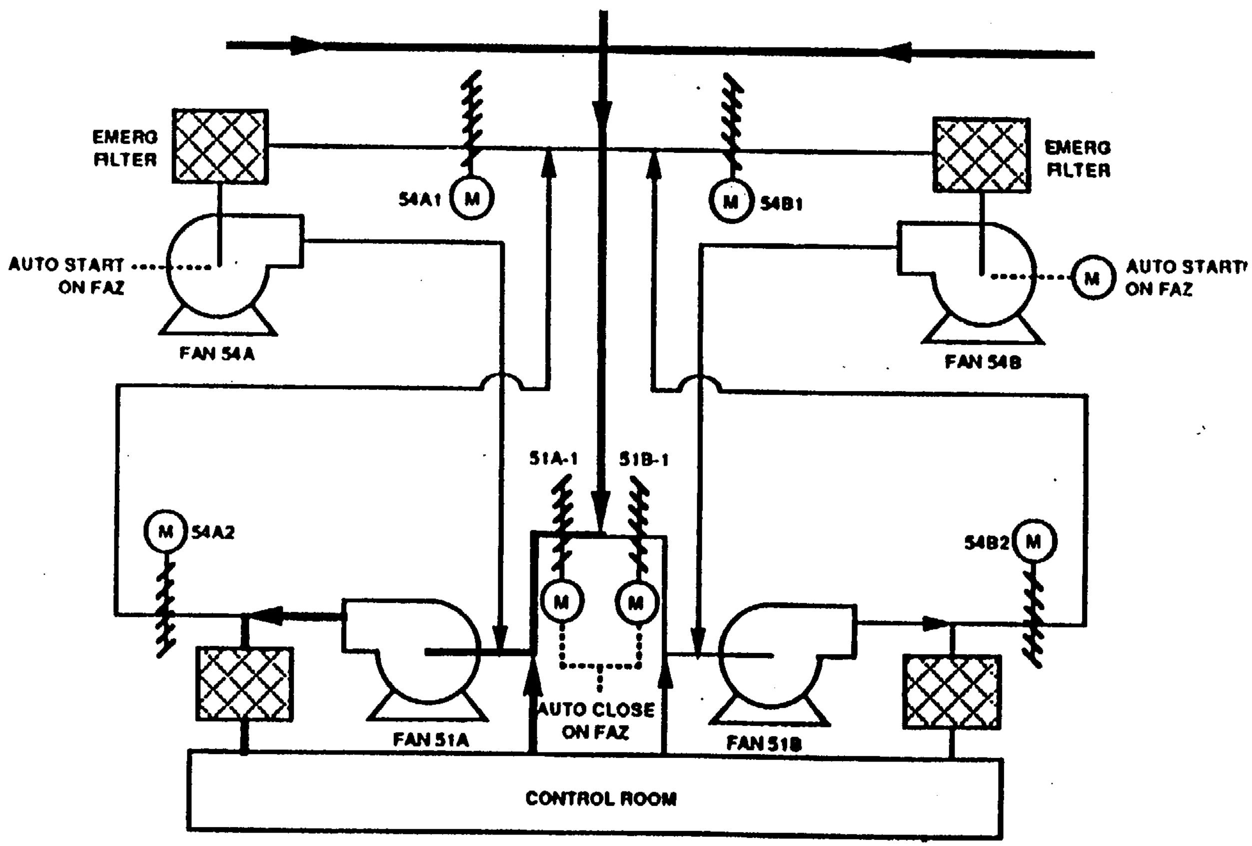
7) Liquid Bypass Leakage

- Current Analysis of Liquid Bypass Based on "TID-14844" Source Term
- Liquid Bypass Leakage is not of concern now, and is not expected to be a concern under AST methodology
- AST Evaluation
  - Plan to update NE-02-99-12 to confirm that the conclusion is consistent under AST methodology
  - Less total iodine (30% vs. 50% iodine release)
  - Application of PRA Techniques to further demonstrate low consequence of liquid leakage is under consideration

8) Control Room X/Q Methodology

- ARCON96 analysis updated in accordance with draft NRC direction
- Draft calculation utilizing Murphy/Campe methodology completed using 1 m/s wind speed
- ARCON96 and Murphy/Campe results are similiar
- Planning Murphy/Campe calculation w/site specific meteorology

9) Crediting Control Room Recirc Filter



9) Crediting Control Room Recirc Filter

- Energy Northwest is considering crediting CR recirc filters for minimal efficiency of 30% to 50% (DF<=2)
- Current recirc design: 2-100% trains, safety related, class 1, seismic 1, airhandlers with medium efficiency filters, design flow of 21,000 cfm
- Option under consideration:
  - Replace existing medium efficiency filters with qualified HEPA(99% efficiency provides DF=100, 99.97% provides DF=3333) or equivalent tested per ASHRAE 52.2
  - Replace recirc fan motor to accommodate added pressure drop due to new filters

9) Crediting Control Room Recirc Filter

- Proposed Testing
  - Periodic Visual Inspection - rigorous testing per RG 1.52, N509, and N510 is not necessary. The N510 leak test limit is 0.05% (10.5 cfm limit) vs our application DF=2 (10,500 cfm limit).
    - » Use qualified filter and frame design
    - » Inspect every fuel cycle
    - » Housing pressurized so leakage is out, not in
    - » Recirculating system, not a once-through
  - Monitor pressure drop (local indication with high/low remote alarm)

10) MSLB X/Q Methodology (expansion and movement of puff release)

- Principal Issue is MSLB X/Q for Control Room
- Draft NEI 99-03 Addresses MSLB CR X/Q
  - Steam Expansion and Buoyant Plume Rise
- Columbia Plans to Follow NEI 99-03 Guidance
- Features of Energy Northwest Application
  - MSLB In Steam Tunnel or Turbine Building
  - Steam Tunnel Released to Atmosphere And/Or Turbine Building

10) MSLB X/Q Methodology (expansion and movement of puff release) (Cont'd)

- Features of Energy Northwest Application
  - Volume of Steam "Bubble" = Approx $6x10^4$ m^3
  - Comparable to Volume of Turbine Building
  - Atmospheric Release from Either Steam Tunnel Blowout Panel or Turbine Building Roof
  - Initial Dispersion by Expansion of Released Steam
  - Further Dispersion by Substantial Transient Buoyant Plume Rise

10) MSLB X/Q Methodology (expansion and movement of puff release) (Cont'd)

- Model Development
  - Consistent with NEI 99-03
  - Model Plume as Ground Level Puff (Transient) Release with Diameter Equal to That of a Sphere with Volume = 60,000 m^3
  - Energy Release Rate for BWR MSLB Very Large - Typically of the Order of 10E10 Joule
  - CALPUFF Code Being Used to Calculate the Relative Concentration of Plume at Receptor Location (i.e., the CR Local Intake)

10) MSLB X/Q Methodology (expansion and movement of puff release) (Cont'd)

- CALPUFF Code
  - Developed by the Emissions, Monitoring, and Analysis Division of the Environmental Protection Agency for Application to Forest Fires (Released in 1995)
  - Generalized, Transient Air Quality Modeling System
  - Capability of Treating Transient and Time-Varying Point Sources, Domains from Tens of Meters to Hundreds of Kilometers

10) MSLB X/Q Methodology (expansion and movement of puff release) (Cont'd)

- Polestar Use of CALPUFF Code
  - Results Being Checked
    - » Against Manual Calculations for Plume Rise and Dispersion Using a Gaussian Model and
    - » Against Manual Calculations for Plume Height Using an Empirical Model for Buoyancy Flux
  - Preliminary Results Indicate Significant Dilution Due to Large and Rapid Energy Release

10) MSLB X/Q Methodology (expansion and movement of puff release) (Cont'd)

- Polestar Use of CALPUFF Code (Cont'd)
  - Dilution Approx 5 Orders of Magnitude for High Stability, Low Wind Speeds (~1 m/s)
  - 1 - 2 Orders of Magnitude for Higher Wind Speeds (~20 m/s)
    - » Higher Wind Speeds Mean Less Time for Plume Rise and Dilution before Plume Passes CR Intake
  - Plans Exist to Further Refine this Work, Then Utilize Conservative Approximation for WNP-2 MSLB CR X/Q

Summary

- On Schedule for Submittal June 2001
- Capture Concerns, Questions, or Actions from this Discussion
- Propose Next Meeting ~ February 2001