50-440

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

October 29, 1998

LICENSEE: Cleveland Electric Illuminating Company

FACILITY: Perry Nuclear Power Plant, Unit No. 1

SUBJECT: SUMMARY OF SEPTEMBER 15, 1998 MEETING ON REVISED ACCIDENT SOURCE TERM FOR PERRY PILOT PLANT REVIEW

On September 15, 1998, NRC staff met with representatives of Cleveland Electric Illuminating Company (CEI) and their contractors, Polestar Applied Technology, Inc., in Rockville, Maryland. The Perry facility is the lead pilot plant for the use of revised accident source term (RAST). The purpose of the meeting was to discuss the licensee's submittal of July 22, 1998, with both the licensee and their contractor. A list of the meeting participants is included as Enclosure 1. The non-proprietary handouts are included in Enclosure 2. As described in the staff's letter to the licensee dated October 6, 1998, the Polestar information identified as proprietary in the submittal of July 22, 1998, will be withheld from public disclosure pursuant to 10 CFR 2.790(b)(5) and Section 103(b) of the Atomic Energy Act of 1954, as amended. Accordingly, the meeting handouts containing similar, proprietary information will also be withheld from public disclosure.

While the staff has completed its rebaselining review under the overall RAST effort, the pilot plant reviews are just getting underway. The licensee stressed the importance of this submittal to support their seventh refueling outage (currently scheduled for April 1999). The submittal under review represents a limited, selective application of RAST. Pending staff approval, the licensee intends to eliminate the main steam isolation valve (MSIV) leakage control system and relax the maximum allowable leakage rates for the MSIVs. It is the staff's understanding that the licensee may revisit RAST in the future to request further relaxation to the technical specifications.

Polestar representatives provided an in-depth discussion of the AP600 work and its applicability to the Perry submittal. Detailed discussions focused on computer modeling, thermal-hydraulics assumptions, pH evaluation, and aerosol removal in the drywell, steam lines, and containment.

In previous discussions with the licensee, the staff has indicated its intention to support the licensee's outage schedule. However, the staff has also informed the licensee that some of the non-conservatisms in their modeling may need to be modified in order to reach this goal.

The meeting identified a number of areas that will require further staff review and other areas that must be addressed by the licensee. The following issues were identified:

- Regarding thermal-hydraulics assumptions, complete mixing between the drywell/containment atmospheres can be assumed 2 hours after the accident. However, resolution was not reached for the steaming rate between the drywell and containment during the initial 2 hours. The staff identified a conservative value of 500 standard cubic feet per minute (scfm) whereas the licensee's submittal assumed 6200 scfm.

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- The licensee needs to address the potential impact of automatic depressurization system actuation on the steaming rate.

- Current dose guidelines in the regulations address thyroid and whole body dose limits. However, in order to accept total effective dose equivalent doses, exemptions must be submitted against 10 CFR 50 (control room dose) and 10 CFR 100 (low population zone and exclusion area boundary doses).

- The licensee will need to address the impact of RAST on long-term equipment qualification.

- The calculation of record, to be included in any updated safety analysis report update reflecting RAST, must reflect any adjustments in the analysis made to obtain NRC staff approval.

- The staff has forwarded the pH analysis to contractors at Oak Ridge. No apparent issues have been identified.

- Arguments supporting aerosol removal rates appear persuasive. The staff has not identified any apparent issues.

In closing remarks, both the licensee and staff agreed that close communications must be maintained. The staff intends to complete their review by the end of the calendar year and this will require expedited efforts by both the staff and the licensee.

Douglas V Pickett

Douglas V. Pickett, Senior Project Manager
Project Directorate III-2
Division of Reactor Projects III/IV
Office of Nuclear Reactor Regulation

Docket No. 50-440

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DATE	10/27/98		10/27/98		10/27/98		10/26/98		10/ /98

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DATE	10/27/98		10/27/98		10/27/98		10/26/98		10/ /98	

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MEETING ATTENDEES

NRC AND CLEVELAND ELECTRIC ILLUMINATING COMPANY

REVISED ACCIDENT SOURCE TERM

SEPTEMBER 15, 1998

CLEVELAND ELECTRIC ILLUMINATING CO.

Jim Powers
Al Widmer
Gary Rhoads
Bradley S. Ferrell

SCIENTECH - NUS

Dave Studley

NEI

Kurt Cozens

POLESTAR

David Leaver
Jim Metcalf

NRC

Richard Emch
Jay Lee
Paul Boehnert
Carolyn Lauron
Charles Tinkler
Chester Gingrich
Michael Snodderly
Stephen Lavie
Mark Blumberg
Jason Schaperow
Kris Parczewski
Paul Shemanski
Doug Pickett

Enclosure 1

Perry Nuclear Power Plant

PROPRIETARY SLIDES ARE MARKED WITHIN

Revised DBA Source Term Application for Perry Plant

Presented to NRC

Presented by First Energy, Perry Nuclear Power Plant
and
Polestar Applied Technology, Inc.

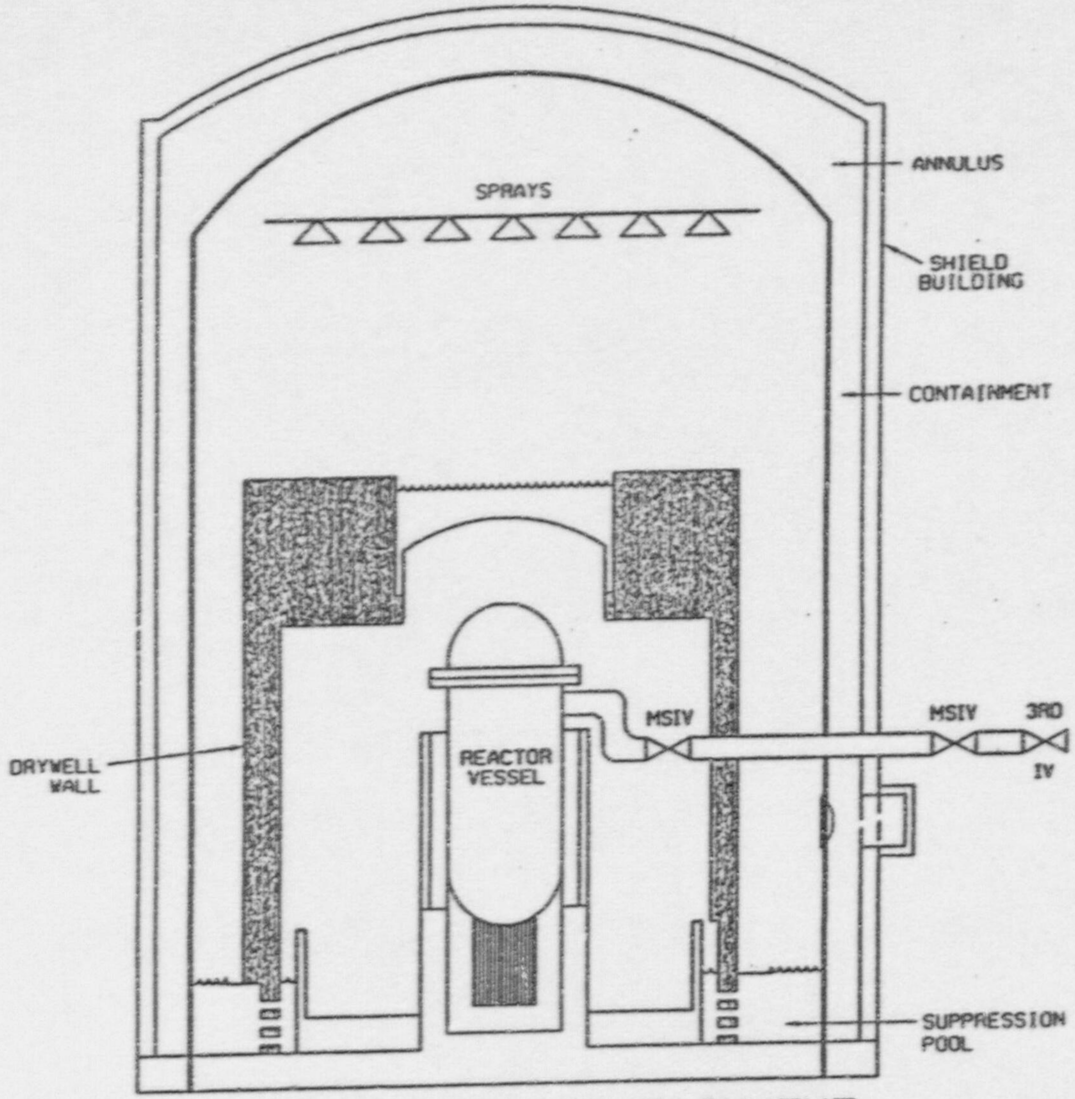
September 15, 1998

Enclosure 2

Polestar Applied Technology, Inc.

Contents of Presentation

- Discussion of AP600 work vs. Perry application
- Thermal-hydraulics assumptions and SECY 98-154
- pH evaluation
- Aerosol removal in drywell, steam lines, and containment



PERRY MARK III CONTAINMENT

AP600 Discussion in Perry Context

- Containment T/H would tend to play an important role for AP600 since AP600 credited heat transfer-driven aerosol removal in addition to sedimentation (note that the only natural removal credited in the Perry analysis is sedimentation)
- Because of this, we looked at sensitivity of the removal to sequence type in AP600; we found that as long as total heat transfer did not change too much, removal also did not change much
- The ACRS April 9, 1998 letter states that sedimentation processes can be accounted for explicitly without specifying T/H conditions; for Perry, T/H effects on natural aerosol sedimentation removal are very small
- The ACRS letter also states that the NRC should make it clear that credit for thermophoresis and diffusiophoresis is not intended to be generic for other plant designs; it was never our intent to try to obtain generic approval of any particular AP600 phenomenon for application to operating plants, and this is part of the reason why we have provided detailed analyses for Perry

AP600 Discussion in Perry Context (continued)

- The Perry analysis specified containment T/H conditions to assure reasonably conservative treatment of three effects:
  - The mass of gas and aerosol contained in a standard cubic foot of MSIV leakage (MSIV leakage is specified in units of standard cubic feet per hour [scfh]) - lower drywell pressures were selected to increase the fission product mass per scfh leaked through the MSIVs
  - The volumetric steam flow rate during core-melt and from the recovered core-melt at 2 hours into the accident; minimal steam was considered in estimating the volumetric flow; a similar effect occurred in AP600 for sequence 3BE and other sequences at the time of reflood, resulting in steam generation into containment
  - Suppression pool bypass - all of the above volumetric flow was assumed to bypass the pool and flow directly into the containment

Thermal-Hydraulic Analysis

- Importance
  - Transport of Activity from DW to Containment
  - Pool Bypass / Scrubbing
  - Spray Initiation (Note that Sprays are Currently Credited in Perry DBA Dose Analysis)
  - Conditions in DW and Containment (Temperature, Density, Etc.)

Thermal-Hydraulic Analysis

- Historical Use of Containment Thermal-Hydraulics in DBA Dose Analysis
  - Purge Valve Closure / Coolant Release Mass
  - Spray Initiation Time
  - Spray Lambda for Elemental Iodine
  - Recirculation Time / Spray pH and Max I_2 DF
  - ESF Leakage Treatment
  - Suppression Pool Bypass Fraction

Thermal-Hydraulic Analysis

- Core Damage Accident Progression
  - Loss of Coolant
    - » Loss of RCPB Integrity (Fast)
    - » Loss of Heat Removal (Slow)
  - Core Heat-Up (Augmented by Clad Oxidation)
  - Fission Product Release
  - Debris Relocation / Partial Quench
  - ECCS Recovery and Complete Quench (for DBA - see SECY-94-300)

Thermal-Hydraulic Analysis

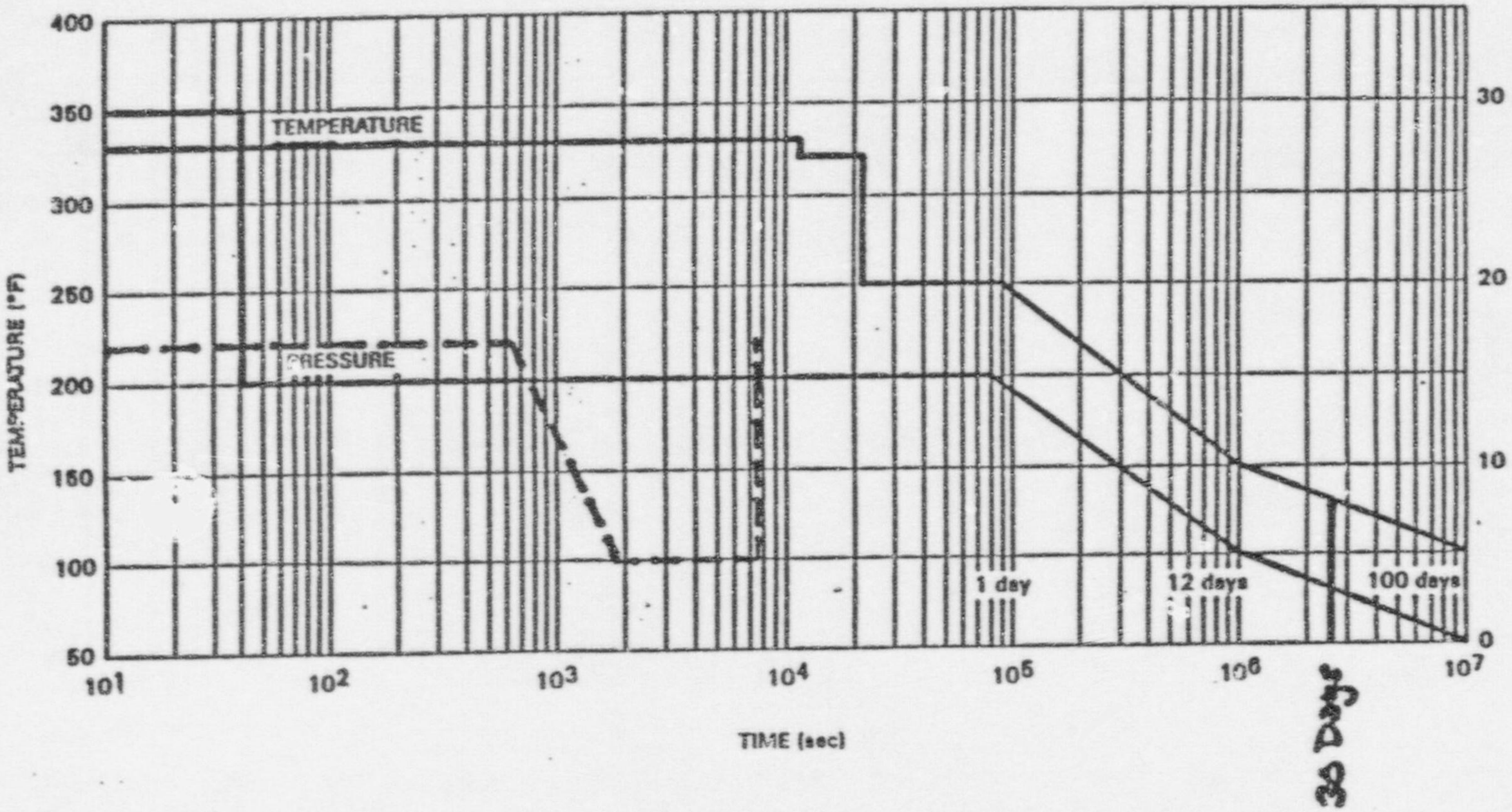
- Current Containment DBA for Perry is a Main Steamline Break - Basis for T-H Conditions for DBA Dose Analysis
- Differences between MSLB for Dose Analysis Vs. Containment DBA
  - Design Basis Levels of Pool Bypass
  - Spray Actuation at 10 Minutes after Vessel Low Level
  - Substantial Clad Oxidation Yielding H_2

Thermal-Hydraulic Analysis

- Findings for Perry
  - DW Substantially Purged of Activity when Core Debris Quenched ("Sweep-Out")
  - Pool Scrubbing Neglected for Design Levels of Pool Bypass and Conservative Sweep-Out
  - Sprays Available at 10 Minutes with Pool Bypass (Supports Current Assumption)
  - Sprays without Core Cooling Tend to Keep Containment Pressure Low Even with Bypass

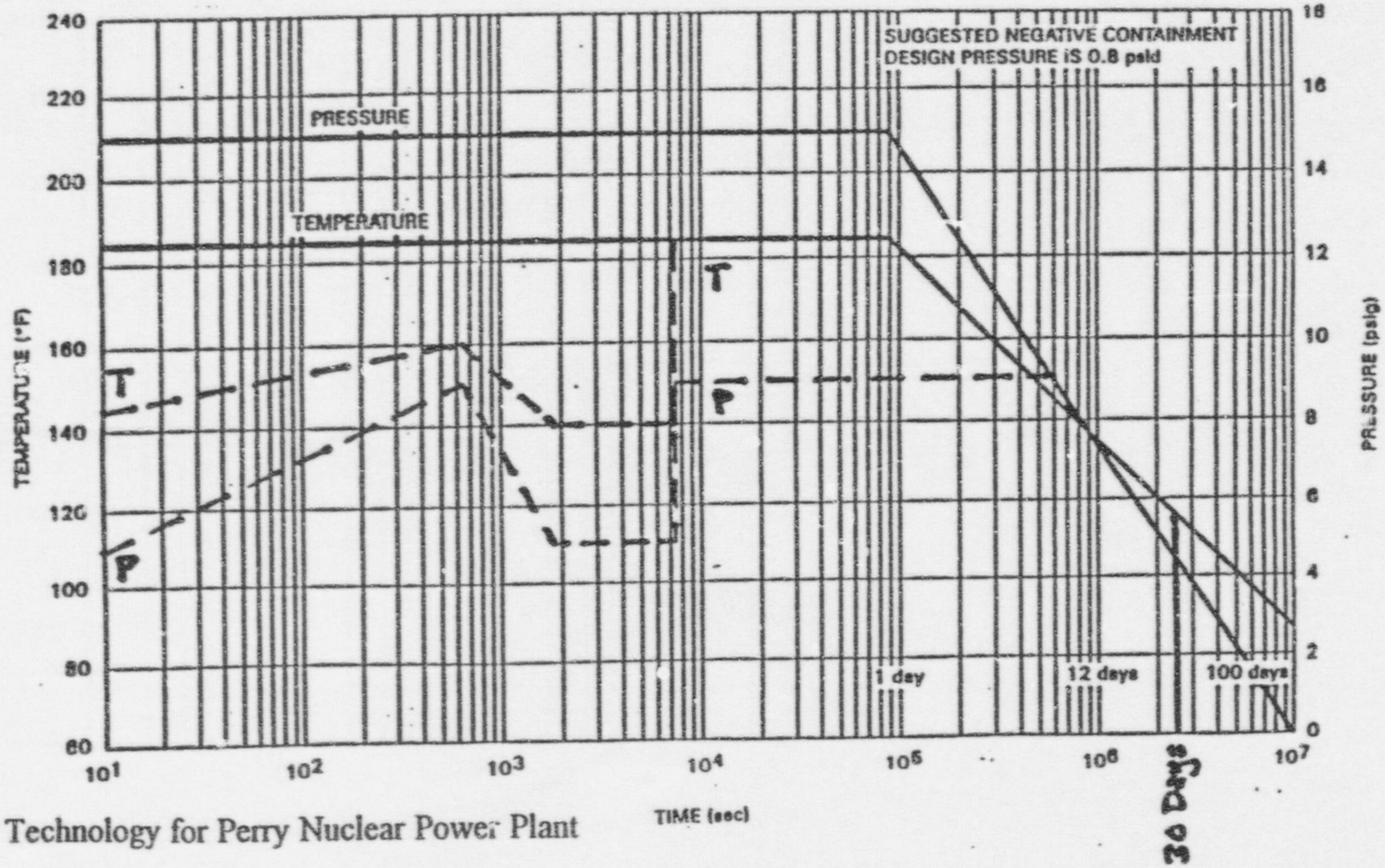
Thermal-Hydraulic Analysis

- DW Pressure and Temperature Used



Thermal-Hydraulic Analysis

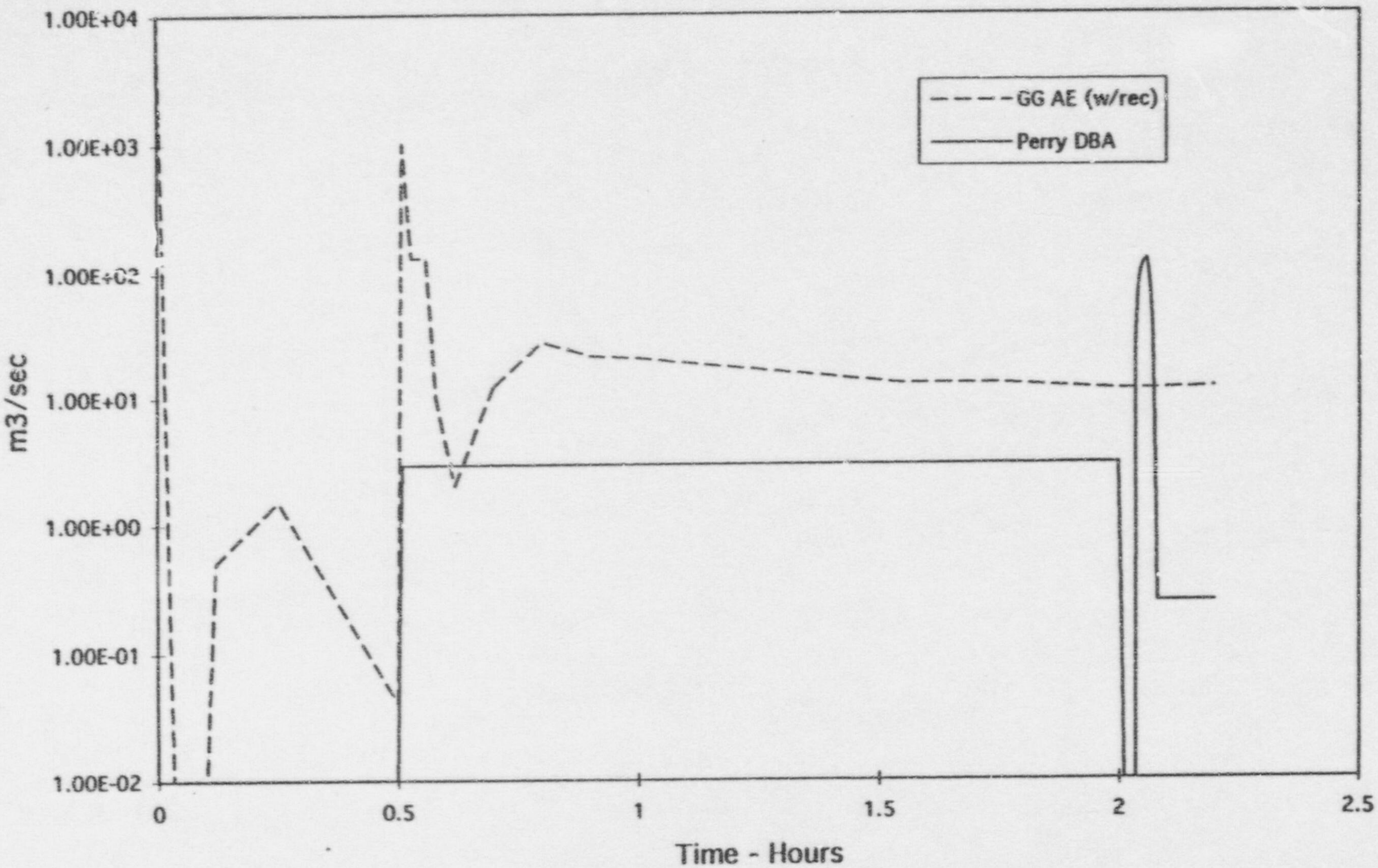
◆ Containment Pressure and Temp Used



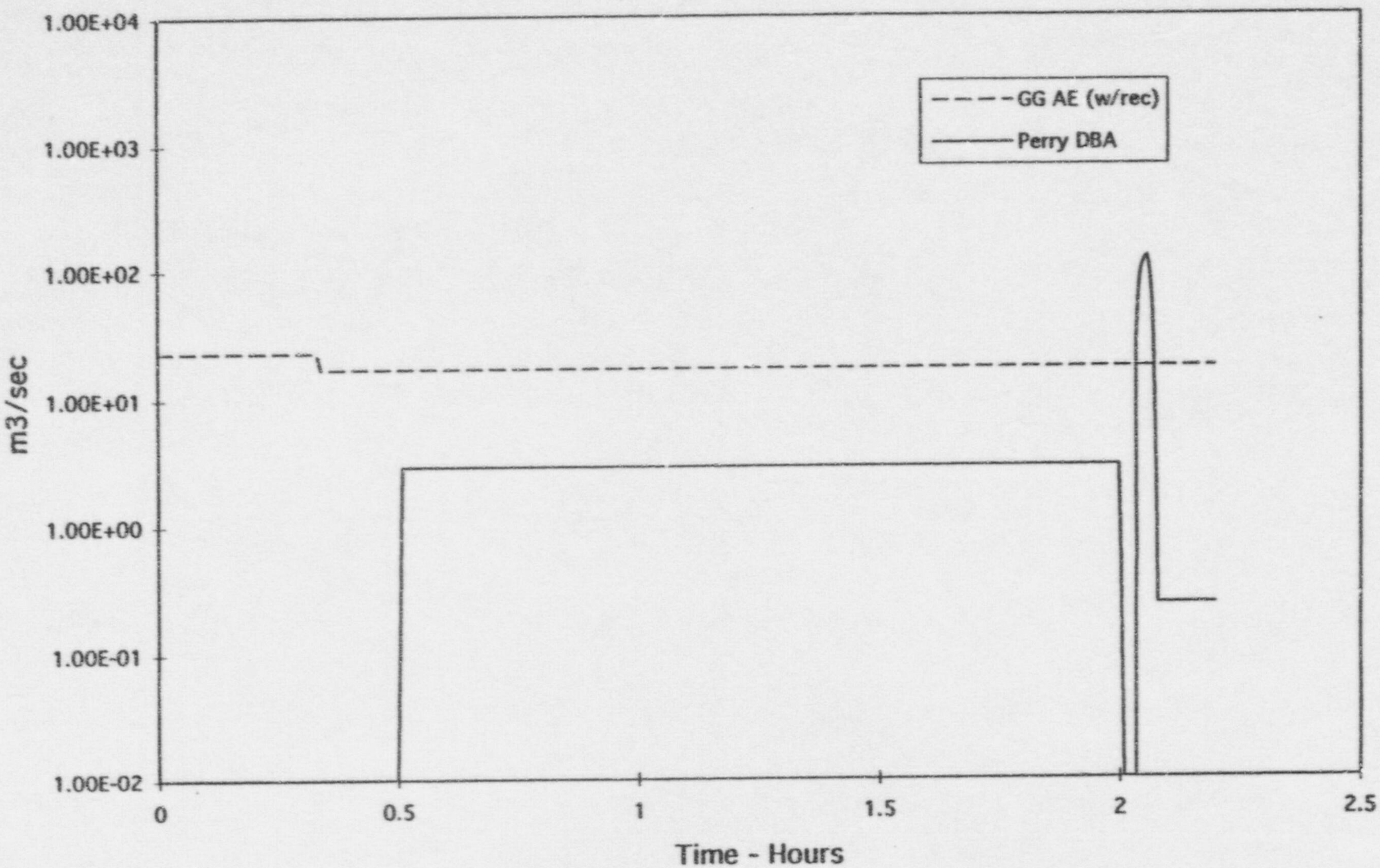
Thermal-Hydraulic Analysis

- Comparison of Grand Gulf Recovered Core Melt from SECY-98-154 to Perry DBA
  - Grand Gulf Done with MELCOR
  - Earlier Debris Quench (Approx. 1/2 Hour Vs. 2 Hours for Perry)
  - Substantially Greater Flow From DW to Containment at Time of Quench
  - Substantial Pool Scrubbing (Vs. Limited Pool Scrubbing for Perry, Which was Neglected)

Comparison of GG AE/Rec (MELCOR-SECY-98-154) vs. Perry DBA
DW to Containment Flow



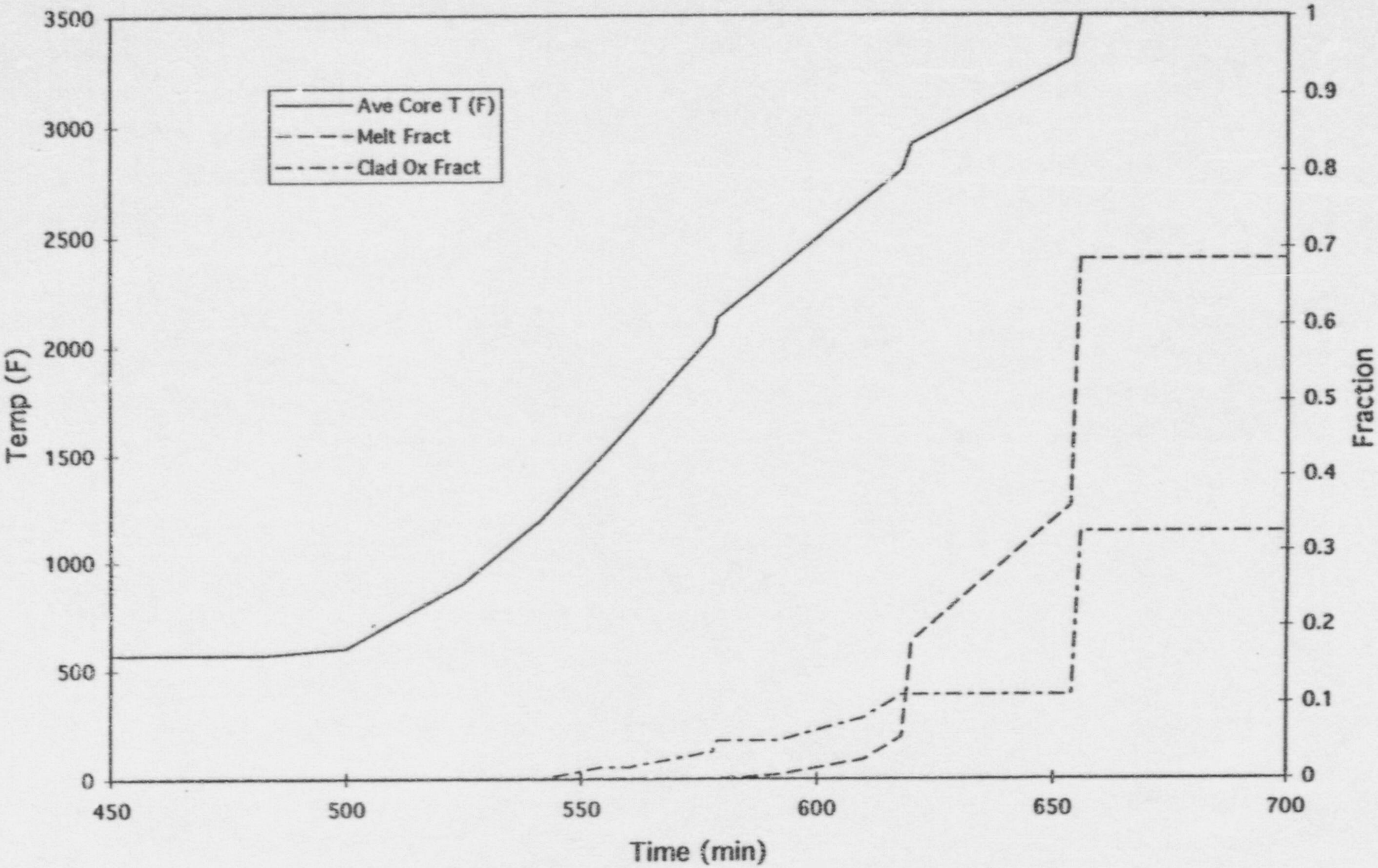
Comparison of GG AE/Rec (RADTRAD-SECY-98-154) vs. Perry DBA
DW to Containment Flow



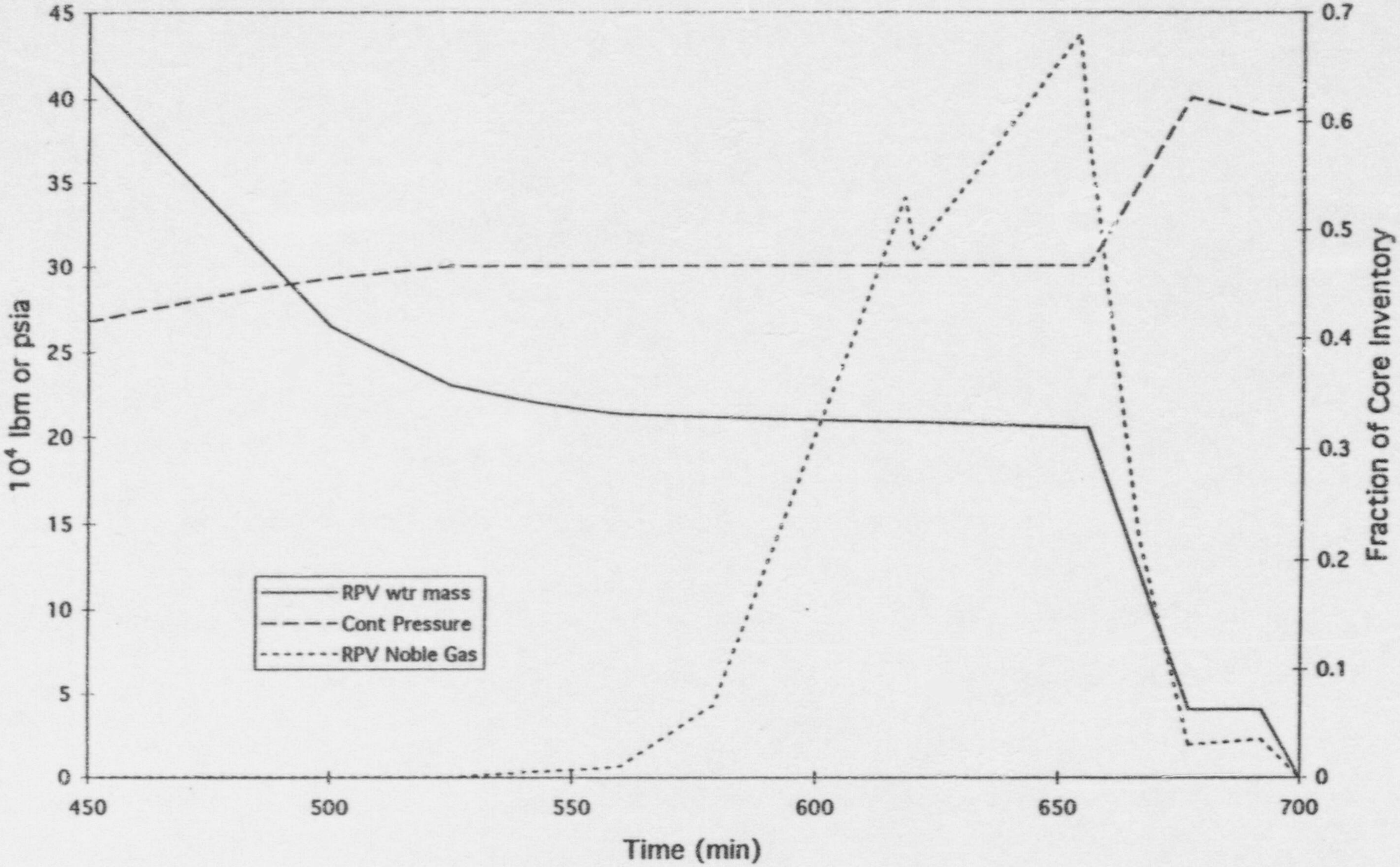
Thermal-Hydraulic Analysis

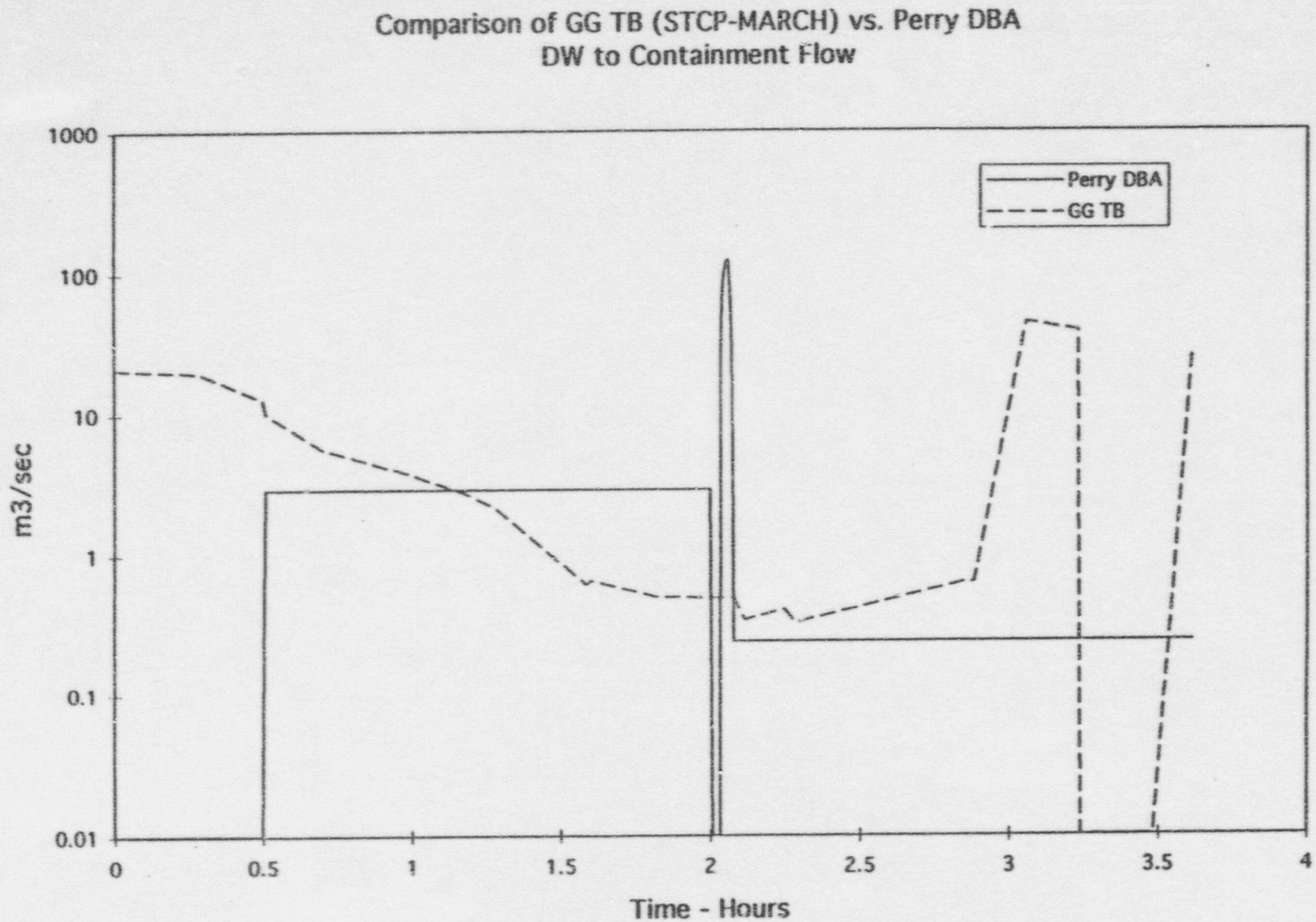
- Comparison of Grand Gulf Station Blackout from NUREG/CR-4624 to Perry DBA
  - Core Uncovery at t = 8 Hours Vs. t = 0
  - Quench of Core Debris in Lower Vessel Head (until Dry-Out) Vs. ECCS Recovery
  - Substantially Greater Flow from DW to Containment at Time of Quench (if Flow Viewed as Small Break Rather Than SRV Discharge)

Core Damage Progression - GG TB (STCP-MARCH-NUREG/CR-4624)



RPV Water Mass, RPV NG Inventory, and Containment Pressure - GG TB (STCP-MARCH)




Comparison of GG TB (STCP-MARCH) vs. Perry DBA
DW to Containment Flow
Perry DBA
GG TB
1000
100
10
1
0.1
0.01
m3/sec
0
0.5
1
1.5
2
2.5
3
3.5
4
Time - Hours

Thermal-Hydraulic Analysis

- Conclusions
  - Core Damage Accidents Involving Loss of Coolant (Whether by RCPB Break or Loss of Cooling) Have Characteristic Behavior Which Can be Abstracted and Simplified ("Stylized") for DBA Dose Analysis Purposes
  - "Stylized" DBA T-H Makes Sense (Consistent with Philosophy of NUREG-1465)
  - Perry DBA Analysis Conservative with Respect to Sweep-Out Rate and Pool Scrubbing Credit

Perry Nuclear Power Plant

pH Determination

- Perry containment post-accident water pool pH was determined using the benchmarked, QA code, STARpH.
- The pH models in STARpH are based primarily upon the ORNL methodology; there are three main models:
  - Radiolysis of Water: Calculates the generation of HNO_3 due to the radiolysis of air and water as a function of time
    - Time steps used in the code are 1 h, 2 h, 5 h, 12 h, 1 d, 3 d, 10 d, 20 d, and 30 d
    - Separate models are provided for BWRs and PWRs
    - Models initial pH of the pool and the effect of carbonic acid
    - Models the pH effect of fission products released to the pool
  - Radiolysis of Cable: Calculates the generation of HCl due to radiolysis of electrical cable insulation in the containment
    - Same time steps as above
    - Separate models for hypalon and PVC
    - Separate outputs for PWRs and BWRs
  - Add Acid and Add Base: Calculates the pH of water pools containing buffers (e.g., phosphate, borate) with strong acid (e.g., HNO_3, HCl) or strong base (e.g., NaOH) additions

Perry STARpH Inputs and Outputs

- Radiolysis of Water
  - Inputs
    - Fission product inventory (e.g., 43 kg of iodine group)
    - Containment water pool volume (incl RCS) - 4.81E6 L
    - Initial pH of pool - 6
    - Fraction of fission products released to containment in pool - 0.87
    - Presence of CO_2 in containment - yes
  - Outputs - see attached

Perry STARpH Inputs and Outputs (continued)

- Radiolysis of Cable
  - Inputs
    - Reactor thermal power - 3758
    - Containment free volume - 4.08E10 cm^3
    - Containment water pool volume - 4.81E6 L
    - Mass of hypalon bearing cable insulation jacket - 29,000 lbm
    - Fraction of fission products released to containment in pool - 0.87
    - Diameter of cable (2.26 cm), thickness of hypalon jacket (45 mils), and jacket density (1.55 g/cm^3) - used to evaluate constants in HCl production equation
  - Outputs - see attached

Perry STARpH Inputs and Outputs (continued)

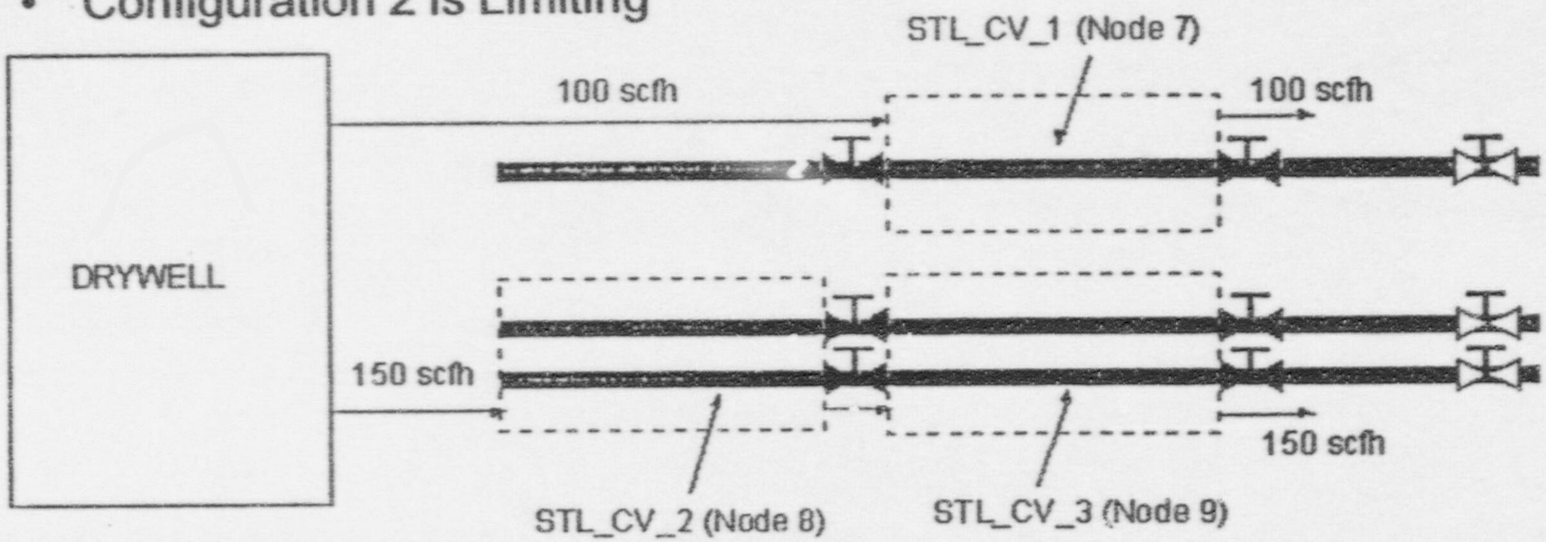
- Add Acid
  - Inputs
    - Chemical formula of buffer (sodium pentborate) - $Na_2O \cdot 5B_2O_3 \cdot 10H_2O$
    - Dissociation constant 5.8E-10
    - Starting pH 8.6
    - Mass of buffer - 5236 lbm (gives 8.4E-3 mol/L B)
  - Output - see attached

Aerosol Removal in Drywell

- Aerosol Sedimentation Calculated with Polestar STARNAUA Code
- No Diffusiophoresis or Thermophoresis Included
- Important Inputs
  - Aerosol Size Distribution
  - Active Aerosol Density / Shape Factor
  - Active Aerosol Mass
  - Inert Aerosol Density / Shape Factor
  - Inert Aerosol Mass
  - Compartment Volume
  - Compartment Sedimentation Area
  - Compartment Leakage

Aerosol Removal in Steamlines

- Two Steamline "Configurations" Considered
  - Configuration 1 - MSIV Failed Open in One Line
  - Configuration 2 - Third Isolation Valve in All Lines Fails to Close at t = 20 Minutes (Manual Action)
- Configuration 2 is Limiting



Aerosol Removal in Steamlines

- Main Steamline Break is DBA
  - Steamline Assumed to Break Just Inside Inboard MSIV in One Line with MSIVs Leaking at 100 scfh
  - One Other Line Leaks at 100 scfh, One at 50 scfh, and One at 0 scfh
  - Intact Steamlines Credited Upstream of Inboard MSIV and in Space between MSIVs
  - Broken Steamline Credited Only between MSIVs
  - Steamlines between Outboard MSIVs and Failed-Open Third Isolation Valves Not Credited
  - Steamline Sections between MSIVs are 49 feet in Length with a Support Clamp Located near the Midpoint - Heat Transfer (and Axial Temperature Gradients) Causes a Transition from a Uniform Flow State to a Well-Mixed State Over Time
  - Steamline Sections inside Inboard MSIVs Always Well-Mixed

Aerosol Removal in Steamlines

- For Configuration 2 Aerosol Retention Consists of
  - Retention in the Space between MSIVs for One Steamline Leaking at 100 scfh
    - Uniform Flow with Progressively Less Credit
    - Source = Drywell
  - Retention in the Space between the RPV and the Inboard MSIV for a Second Steamline Leaking at 100 scfh (and One at 50 scfh)
    - Well-Mixed Volume
    - Source = Drywell
  - Retention in the Space between MSIVs for the Second Steamline Leaking at 100 scfh (and One at 50 scfh)
    - Uniform Flow with Progressively Less Credit
    - Source = Well-Mixed Volume Upstream

Aerosol Removal by Containment Spray

- Perry containment spray aerosol removal was determined using the benchmarked, QA code, STARNAUA
- User specifies spray source including: one or more release periods, flow rates, spray temperature, spray droplet size distribution (mean droplet radius and geometric standard deviation)
- Model calculates the fraction of droplets in each droplet size bin, calculates the collection efficiency of the combination of each droplet size bin with each aerosol size bin, and sums these efficiencies to get the aerosol collection efficiency of the complete droplet distribution
- Mechanisms that contribute to collection efficiency include:
  - interception
  - impaction
  - Brownian diffusion of aerosol particles to the droplet
  - diffusiophoretic deposition of particles to the droplet if T/H conditions result in steam condensation on the droplets

Perry Spray Removal Inputs

- Calc PSAT 04202U.03 supplied inputs:
  - Sprayed region volume
  - Unsprayed region volume
  - Spray fall height
  - Mixing rate between sprayed and unsprayed regions
  - Geom. number mean radius and geom. std deviation of spray droplets
  - Spray flow rate
  - Time of spray initiation and spray duration
- Calc PSAT 04202H.05 supplied inputs:
  - Aerosol source rate into sprayed region
  - Spray temperature

Spray Removal Conservatisms

- Effect of pool scrubbing on aerosol source is neglected
- Utilized version of NUREG models which tended to reduce removal rate (Re correlation with min. terminal velocity, min. Brownian diffusion, neglected diffusiophoresis)
- Underestimated mixing rate between sprayed and unsprayed regions
- Neglected natural removal in unsprayed region
- Underestimated aerosol particle size entering sprayed and unsprayed regions
- Only one spray train credited