Westinghouse Electric Corporation **Energy Systems**

Box 355
Pittsburgh Pennsylvania 15230-0355

AW-95-818

May 1, 1995

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

ATTENTION: MR. T. R. QUAY

APPLICATION FOR WITHHOLDING PROPRIETARY
INFORMATION FROM PUBLIC DISCLOSURE

SUBJECT: PRESENTATION MATERIALS FROM THE APRIL 27, 1995 MEETING ON AP600 IN-VESSEL RETENTION SEVERE ACCIDENT TOPICS

Dear Mr. Quay:

The application for withholding is submitted by Westinghouse Electric Corporation ("Westinghouse") pursuant to the provisions of paragraph (b)(1) of Section 2.790 of the Commission's regulations. It contains commercial strategic information proprietary to Westinghouse and customarily held in confidence.

The proprietary material for which withholding is being requested is identified in the proprietary version of the subject report. In conformance with 10CFR Section 2.790, Affidavit AW-95-818 accompanies this application for withholding setting forth the basis on which the identified proprietary information may be withheld from public disclosure.

Accordingly, it is respectfully requested that the subject information which is proprietary to Westinghouse be withheld from public disclosure in accordance with 10CFR Section 2.790 of the Commission's regulations.

Correspondence with respect to this application for withholding or the accompanying affidavit should reference AW-95-818 and should be addressed to the undersigned.

Very truly yours,

N. J. Liparulo, Manager
Nuclear Safety Regulatory And Licensing Activities

/nja

cc: Kevin Bohrer NRC 12H5

AW-95-818

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared Brian A. McIntyre, who, being by me duly sworn according to law, deposes and says that he is authorized to execute this Affidavit on behalf of Westinghouse Electric Corporation ("Westinghouse") and that the averments of fact set forth in this Affidavit are true and correct to the best of his knowledge, information, and belief:

Brian A. McIntyre, Manager
Advanced Plant Safety and Licensing

Sworn to and subscribed
before me this 3 day
of May, 1995

Notary Public

Notarial Seal
Rose Marie Payne, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires Nov. 4, 1996
Member, Pennsylvania Association of Notaries

2391A

(1) I am Manager, Advanced Plant Safety and Licensing, in the Advanced Technology Business Area, of the Westinghouse Electric Corporation and as such, I have been specifically delegated the function of reviewing the proprietary information sought to be withheld from public disclosure in connection with nuclear power plant licensing and rulemaking proceedings, and am authorized to apply for its withholding on behalf of the Westinghouse Energy Systems Business Unit.

(2) I am making this Affidavit in conformance with the provisions of 10CFR Section 2.790 of the Commission's regulations and in conjunction with the Westinghouse application for withholding accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by the Westinghouse Energy Systems Business Unit in designating information as a trade secret, privileged or as confidential commercial or financial information.

(4) Pursuant to the provisions of paragraph (b)(4) of Section 2.790 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld.

(i) The information sought to be withheld from public disclosure is owned and has been held in confidence by Westinghouse.

(ii) The information is of a type customarily held in confidence by Westinghouse and not customarily disclosed to the public. Westinghouse has a rational basis for determining the types of information customarily held in confidence by it and, in that connection, utilizes a system to determine when and whether to hold certain types of information in confidence. The application of that system and the substance of that system constitutes Westinghouse policy and provides the rational basis required.

Under that system, information is held in confidence if it falls in one or more of several types, the release of which might result in the loss of an existing or potential competitive advantage, as follows:

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), the application of which data secures a competitive economic advantage, e.g., by optimization or improved marketability.

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.

(e) It reveals aspects of past, present, or future Westinghouse or customer funded development plans and programs of potential commercial value to Westinghouse.

(f) It contains patentable ideas, for which patent protection may be desirable.

There are sound policy reasons behind the Westinghouse system which include the following:

(a) The use of such information by Westinghouse gives Westinghouse a competitive advantage over its competitors. It is, therefore, withheld from disclosure to protect the Westinghouse competitive position.

(b) It is information which is marketable in many ways. The extent to which such information is available to competitors diminishes the Westinghouse ability to sell products and services involving the use of the information.

(c) Use by our competitor would put Westinghouse at a competitive disadvantage by reducing his expenditure of resources at our expense.

(d) Each component of proprietary information pertinent to a particular competitive advantage is potentially as valuable as the total competitive advantage. If competitors acquire components of proprietary information, any one component may be the key to the entire puzzle, thereby depriving Westinghouse of a competitive advantage.

(e) Unrestricted disclosure would jeopardize the position of prominence of Westinghouse in the world market, and thereby give a market advantage to the competition of those countries.

(f) The Westinghouse capacity to invest corporate assets in research and development depends upon the success in obtaining and maintaining a competitive advantage.

(iii) The information is being transmitted to the Commission in confidence and, under the provisions of 10CFR Section 2.790, it is to be received in confidence by the Commission.

(iv) The information sought to be protected is not available in public sources or available information has not been previously employed in the same original manner or method to the best of our knowledge and belief.

(v) Enclosed is Letter NTD-NRC-95-4449, May 1, 1995 being transmitted by Westinghouse Electric Corporation (W) letter and Application for Withholding Proprietary Information from Public Disclosure, N. J. Liparulo (W), to Mr. T. R. Quay, Office of NRR. The proprietary information as submitted for use by Westinghouse Electric Corporation is in response to questions concerning the AP600 plant and the associated design certification application and is expected to be applicable in other licensee submittals in response to certain NRC requirements for justification of licensing advanced nuclear power plant designs.

This information is part of that which will enable Westinghouse to:

(a) Demonstrate the design and safety of the AP600 Passive Safety Systems.

(b) Establish applicable verification testing methods.

(c) Design Advanced Nuclear Power Plants that meet NRC requirements.

(d) Establish technical and licensing approaches for the AP600 that will ultimately result in a certified design.

(e) Assist customers in obtaining NRC approval for future plants.

Further this information has substantial commercial value as follows:

(a) Westinghouse plans to sell the use of similar information to its customers for purposes of meeting NRC requirements for advanced plant licenses.

(b) Westinghouse can sell support and defense of the technology to its customers in the licensing process.

Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Westinghouse because it would enhance the ability of competitors to provide similar advanced nuclear power designs and licensing defense services for commercial power reactors without commensurate expenses. Also, public disclosure of the information would enable others to use the information to meet NRC requirements for licensing documentation without purchasing the right to use the information.

The development of the technology described in part by the information is the result of applying the results of many years of experience in an intensive Westinghouse effort and the expenditure of a considerable sum of money.

In order for competitors of Westinghouse to duplicate this information, similar technical programs would have to be performed and a significant manpower effort, having the requisite talent and experience, would have to be expended for developing analytical methods and receiving NRC approval for those methods.

Further the deponent sayeth not.

Enclosure 2

AP600 In-Vessel Retention of Molten Core Debris

Description of AP600 Cavity Flooding System

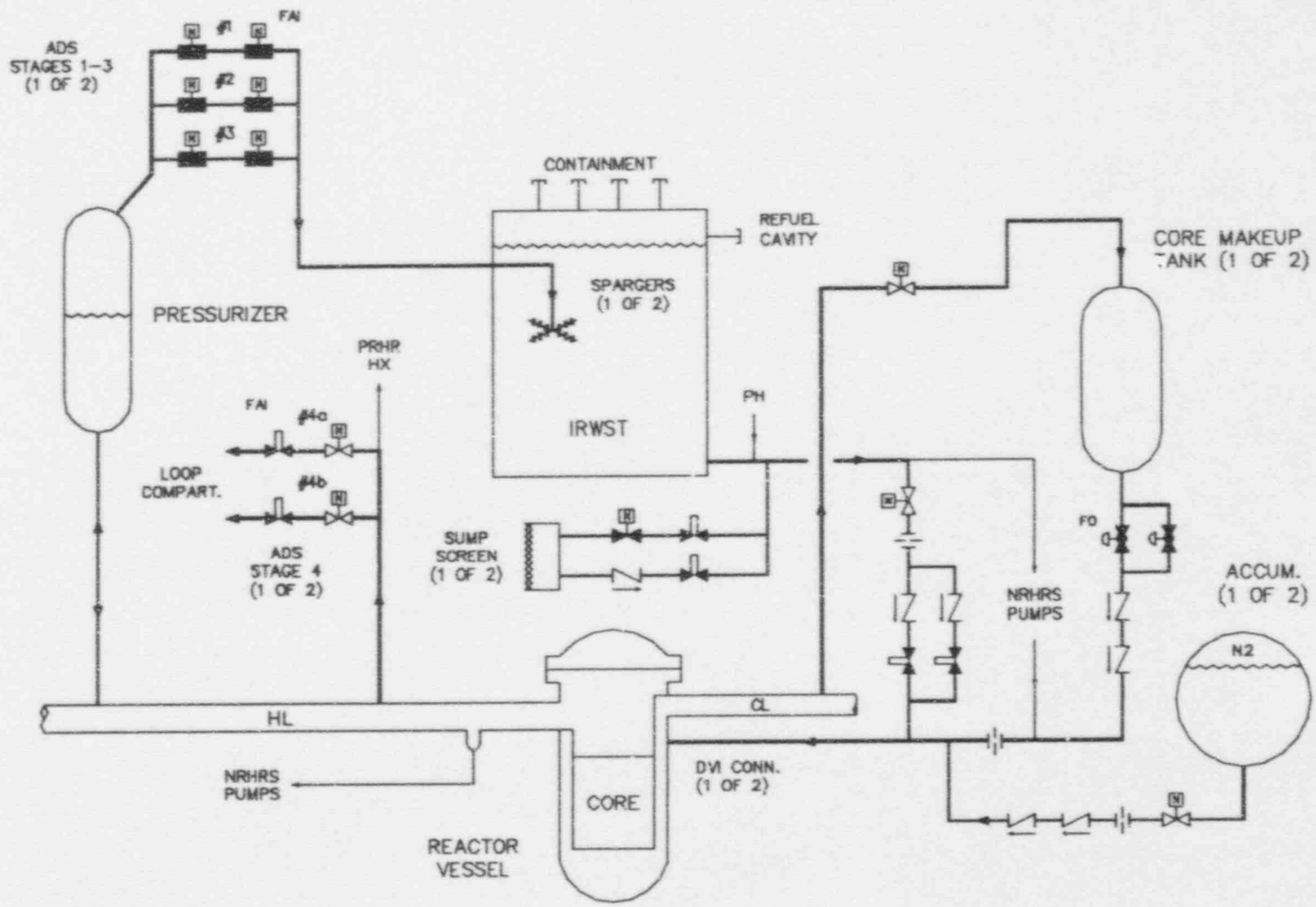
- Cavity flooding valves are part of SI recirculation system.
  - passive recirculation (4" diameter lines)
  - NRHR recirculation (6" diameter lines)
  - cavity flooding (6" diameter lines)

- Valves are required for design basis
  - PMS System
  - redundant trains of valves
  - class 1E dc power diverse between lines
  - located in PXS-A and PXS-B vaults under 107'2" elevation

- Each line has a squib valve and a MOV in series in parallel with passive recirculation lines

- Each line is sized to feed NRHR recirc with both pumps running unthrottled

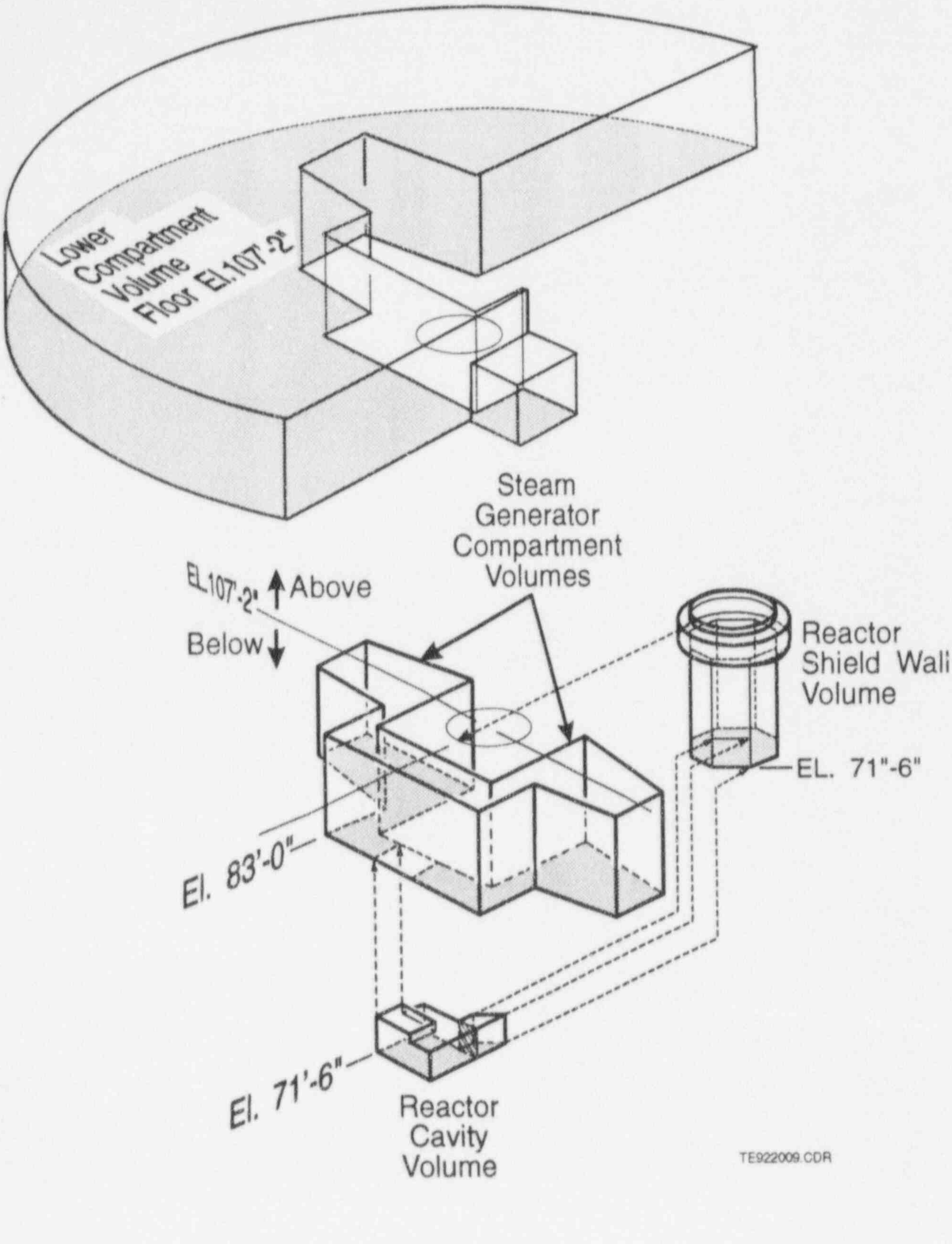
AP600 PASSIVE SI SYSTEM



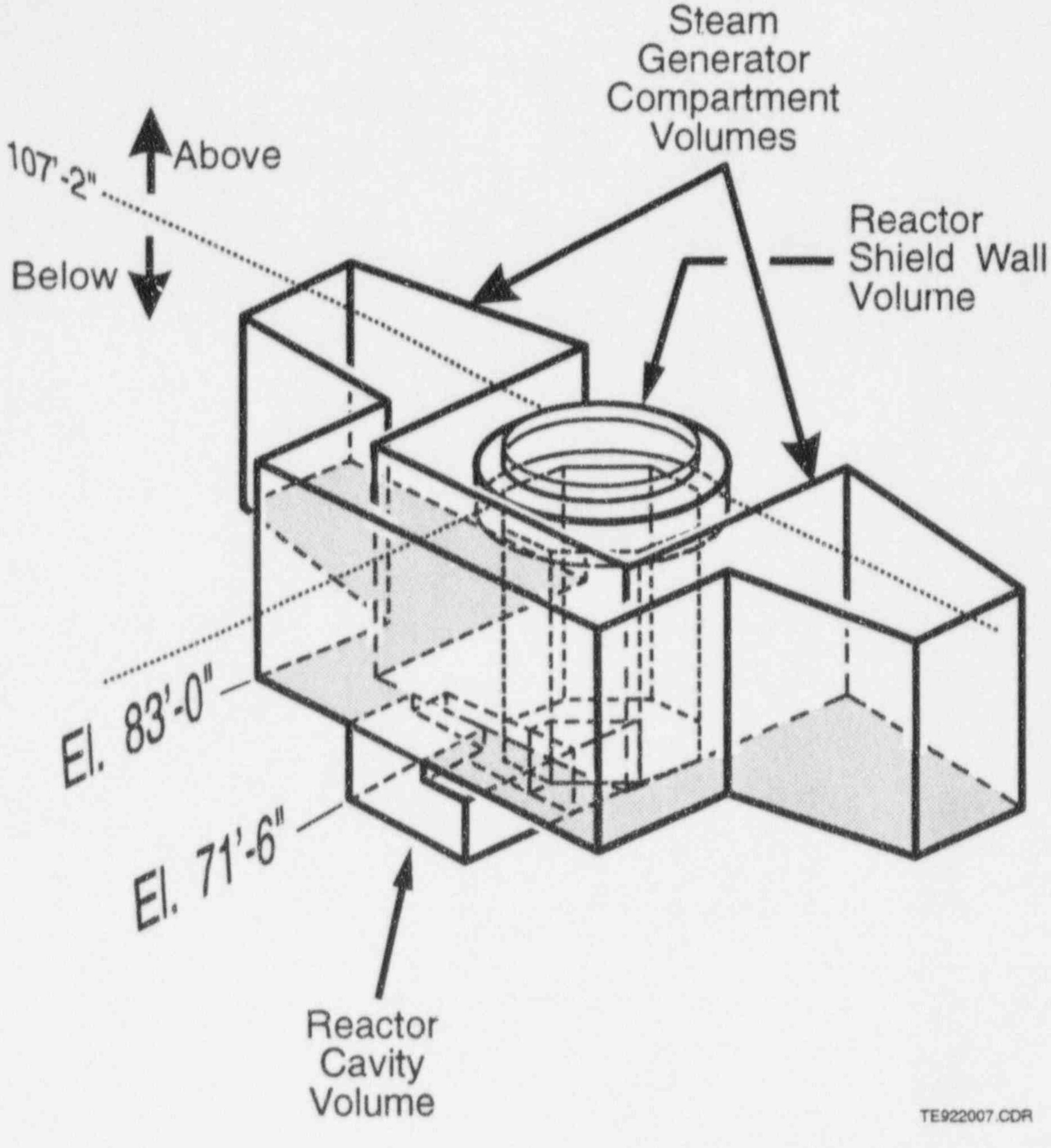
TLS 4/21/95 2

Containment Flooding

- Water drains into the containment at the 83' elev
- Spills into the reactor cavity volume from the access tunnel
- Fills the loop compartments up to approximately 107'2" elev
- Circulation Pathway during IVR
  - Out of the cavity through the loop holes to the RCS Loop Compts
  - Loop Compts to the Reactor Cavity through the Access Tunnel
  - Steam condensing on the PCS Dome recircs to water pools through the IRWST

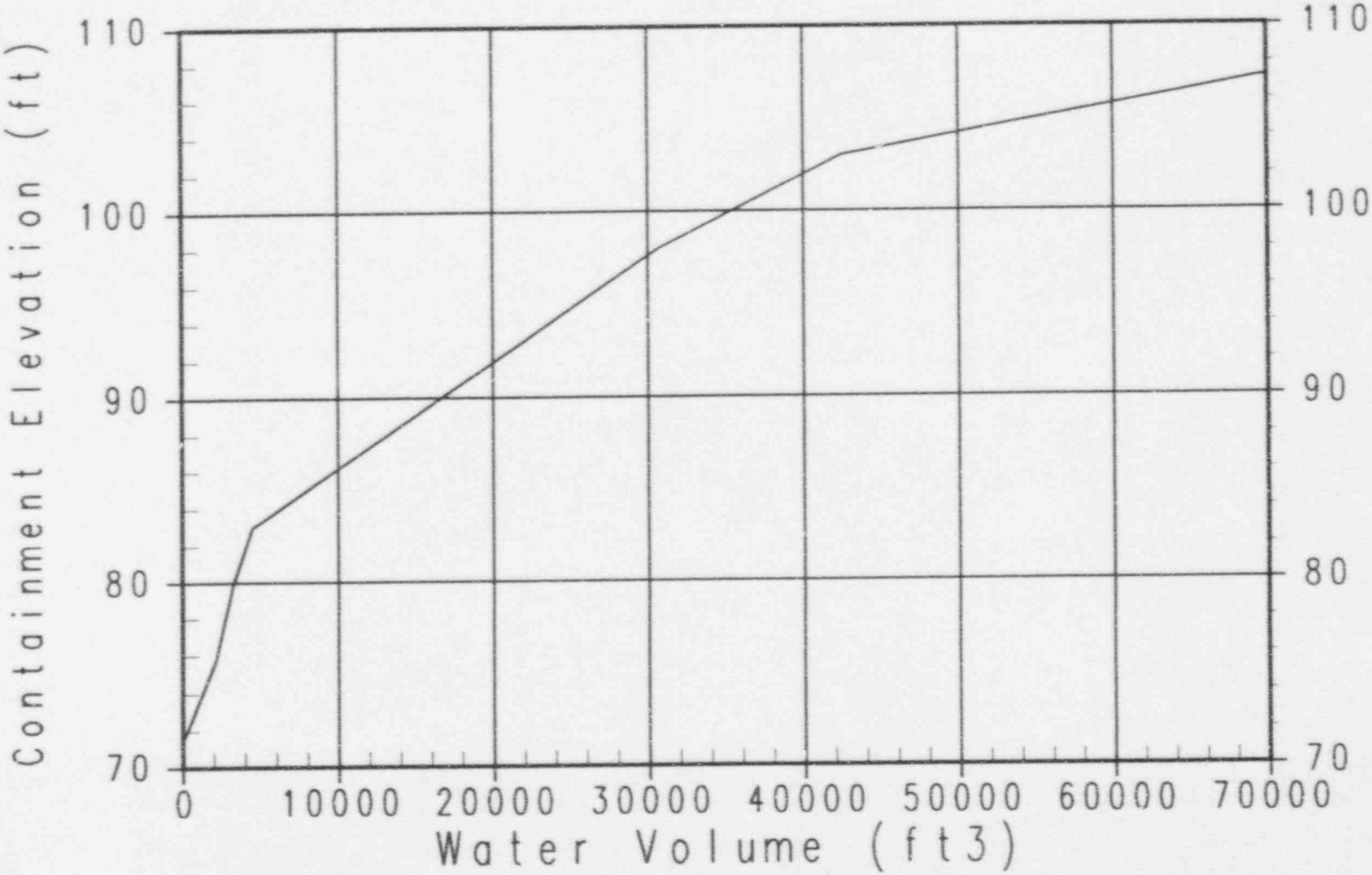


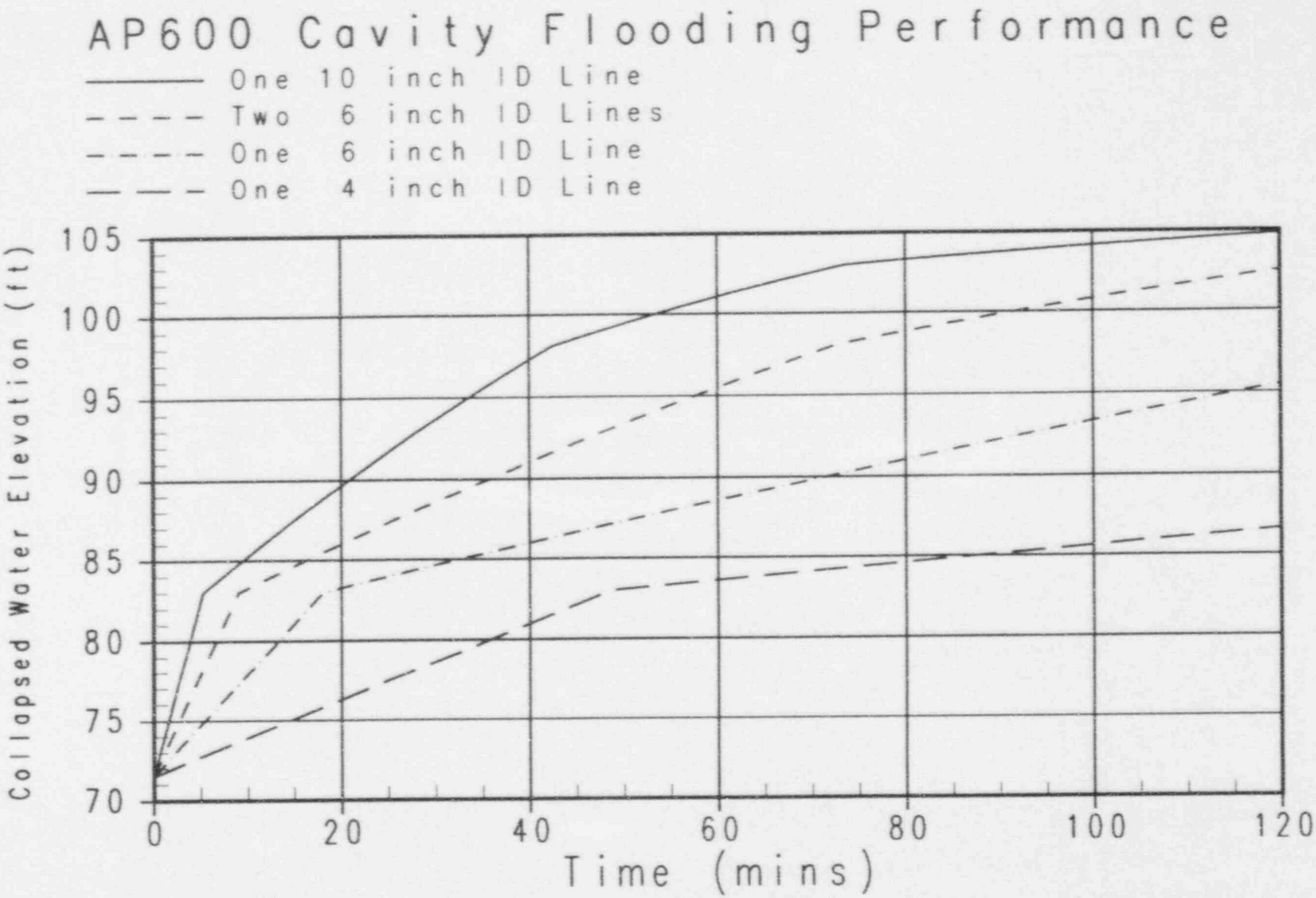
Lower Compartment Volume Floor El.107'-2"
Steam Generator Compartment Volumes
EL.107'-2"
Above
Below
Reactor Shield Wall Volume
EL. 71"-6"
El. 83'-0"
El. 71'-6"
Reactor Cavity Volume
TE922009.CDR



TE922007.CDR

AP600 Containment Flood Height
(IRWST Water Volume = 71000 ft3)




AP600 Cavity Flooding Performance
One 10 inch ID Line
Two 6 inch ID Lines
One 6 inch ID Line
One 4 inch ID Line
Collapsed Water Elevation (ft)
105
100
95
90
85
80
75
70
0
20
40
60
80
100
120
Time (mins)

Timing of Vessel Flooding

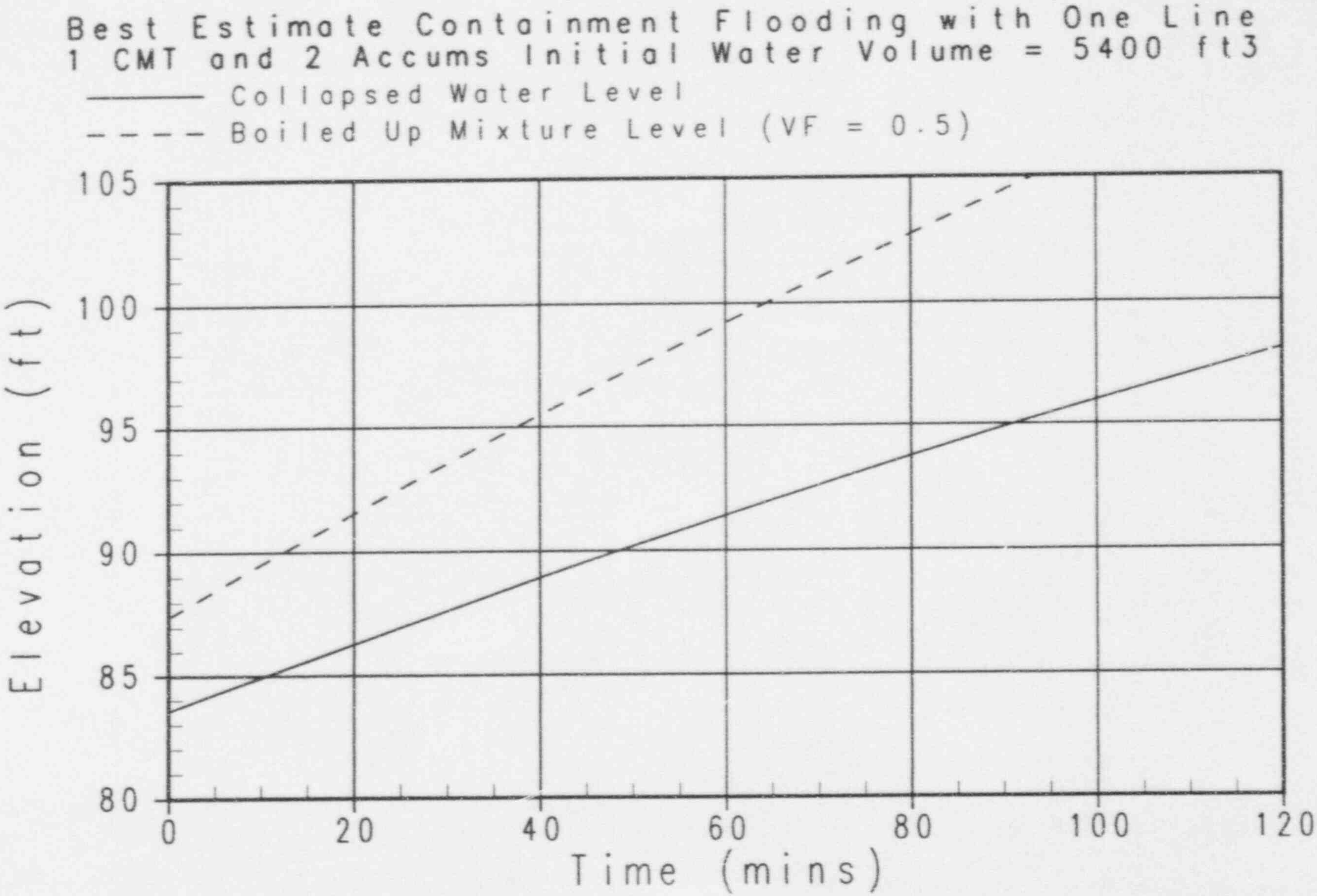
- Best-Estimate Considerations
  - Initial water level in cavity above max debris elevation (1 failed CMT = 5400 ft^3)
  - Void Fraction approximately 0.5
  - Water in lower head prior to relocation
  - <100% of core relocated within 1 hour

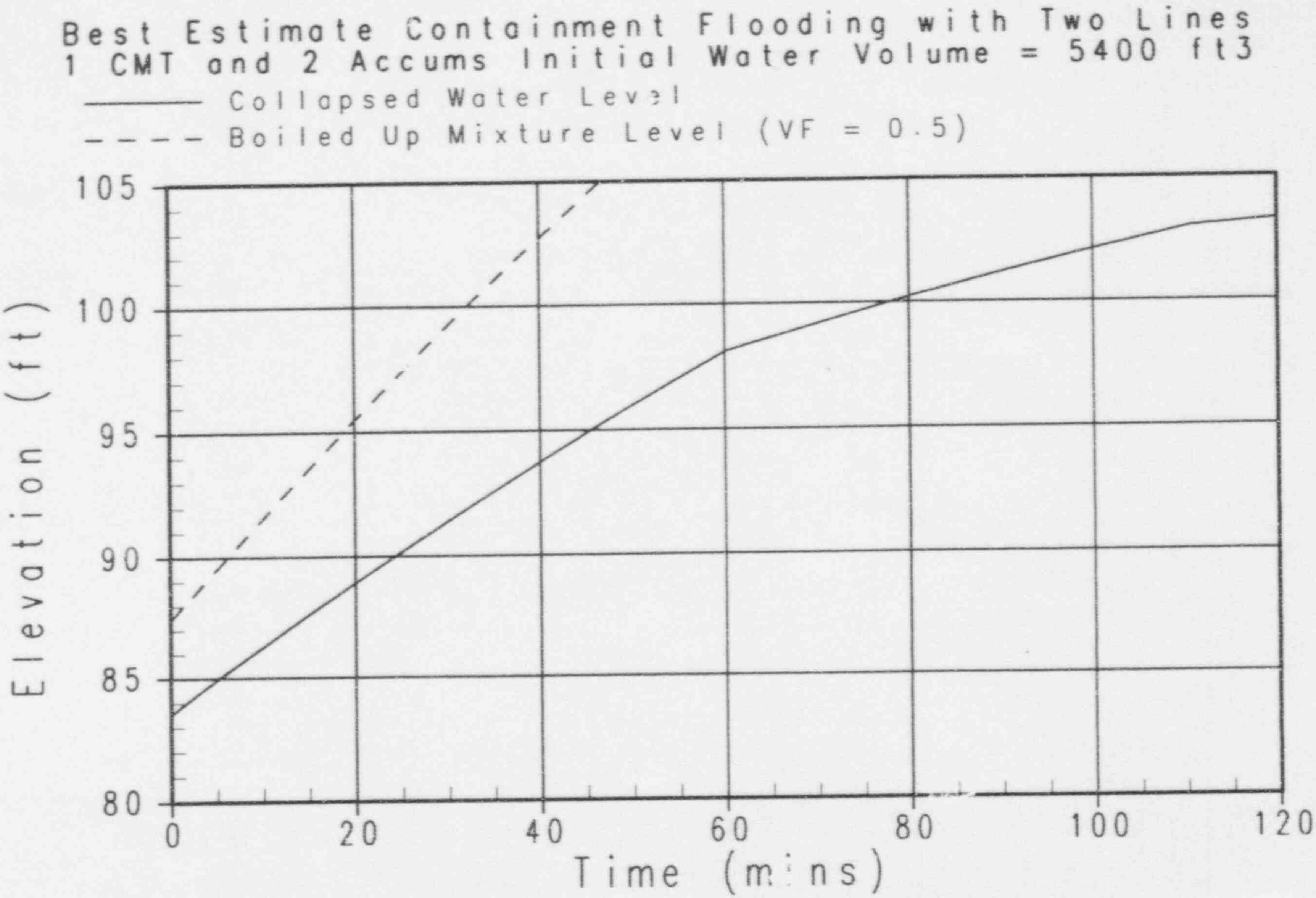
- Collapsed Water Level > 2m above top of hemisphere (elev 90') enough to accommodate steady-state heat flux with 100% of core relocated

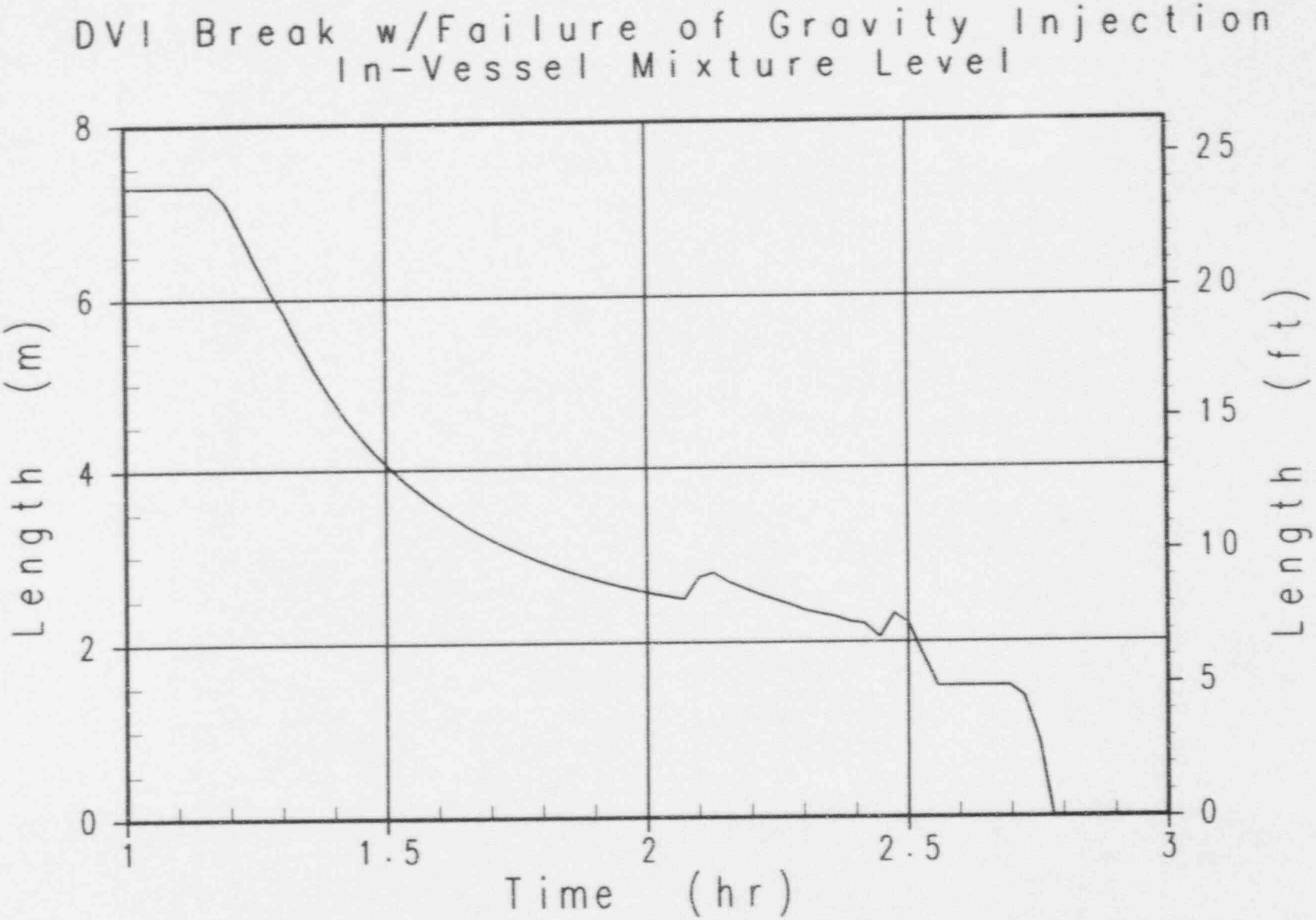
- One 6" Flooding Line
  - collapsed level >90' elev within 50 minutes
  - boiled-up level >99' elev within 60 minutes

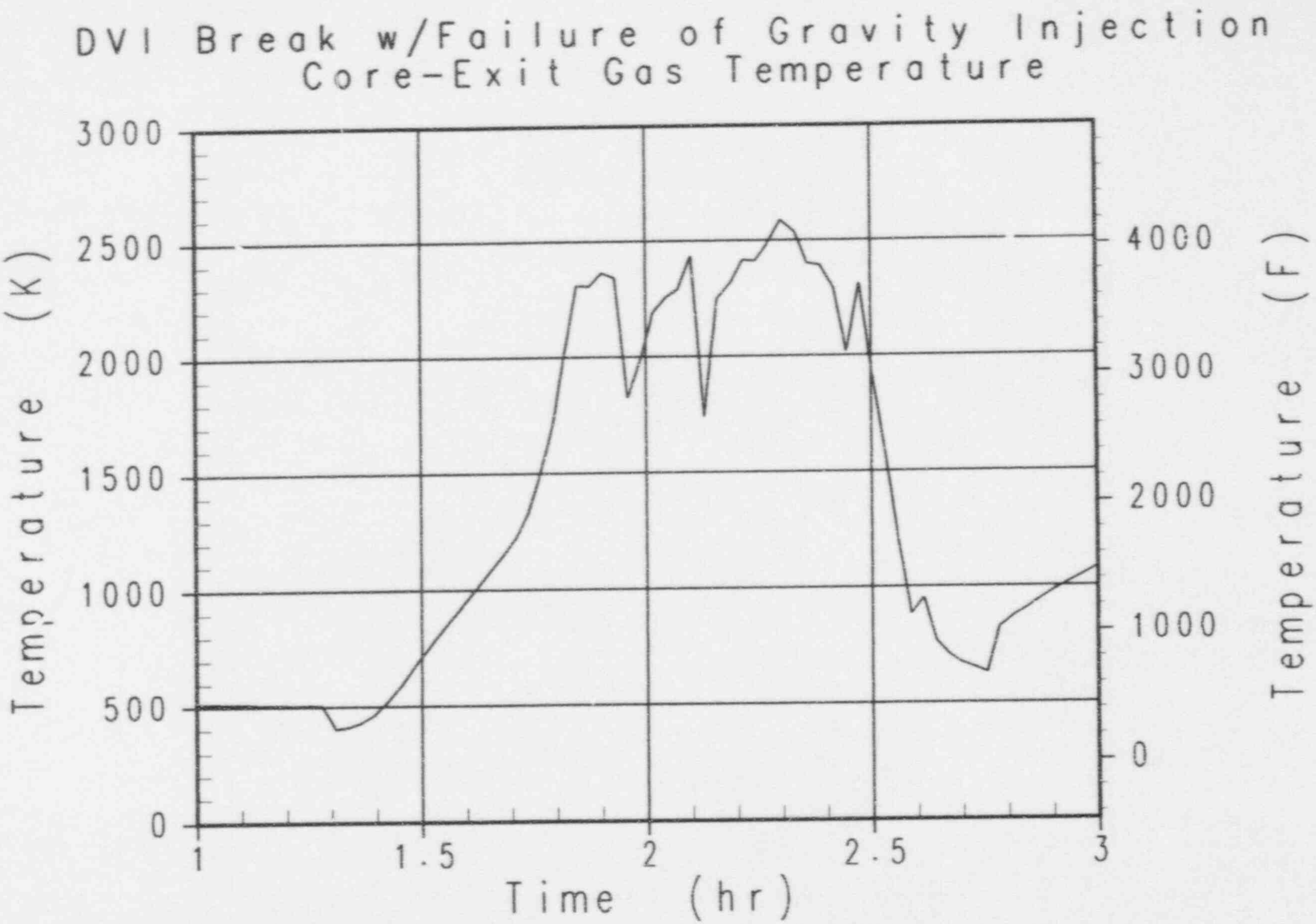
- Two 6" Flooding Lines
  - collapsed level >90' elev within 25 minutes
  - boiled-up level >99' elev within 30 minutes

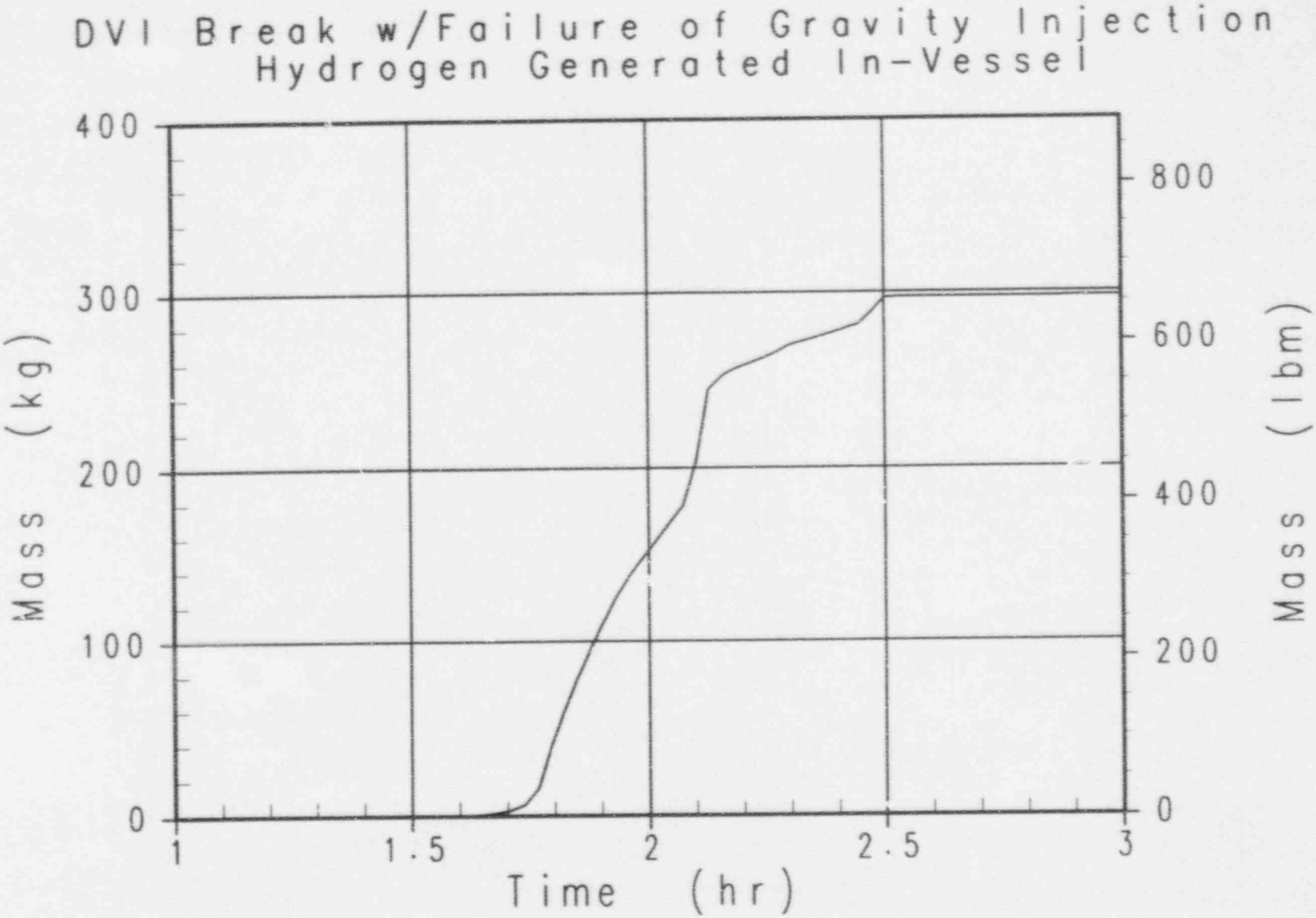
- MAAP4 Example - DVI Line Break
  - 2 CMTs and 2 Accums
  - 1 Six inch flooding line
  - No vessel reflood in peroid of interest
  - flooding initiated at 2000°F

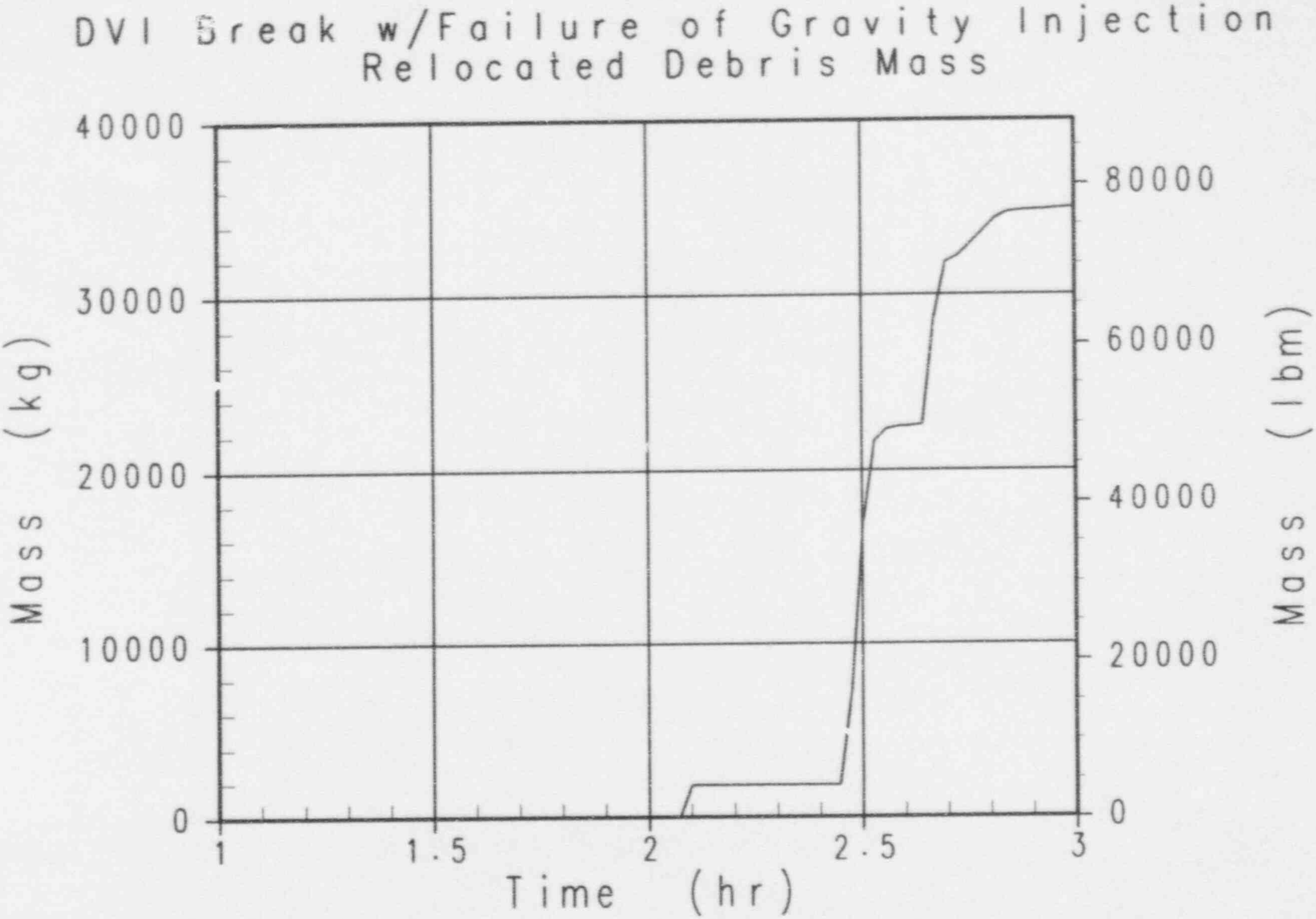

Best Estimate Containment Flooding with One Line
1 CMT and 2 Accums Initial Water Volume = 5400 ft3
Collapsed Water Level
Boiled Up Mixture Level (VF = 0.5)
Elevation (ft)
105
100
95
90
85
80
0
20
40
60
80
100
120
Time (mins)


Best Estimate Containment Flooding with Two Lines
1 CMT and 2 Accums Initial Water Volume = 5400 ft3
Collapsed Water Level
Boiled Up Mixture Level (VF = 0.5)
Elevation (ft)
105
100
95
90
85
80
0
20
40
60
80
100
120
Time (mins)

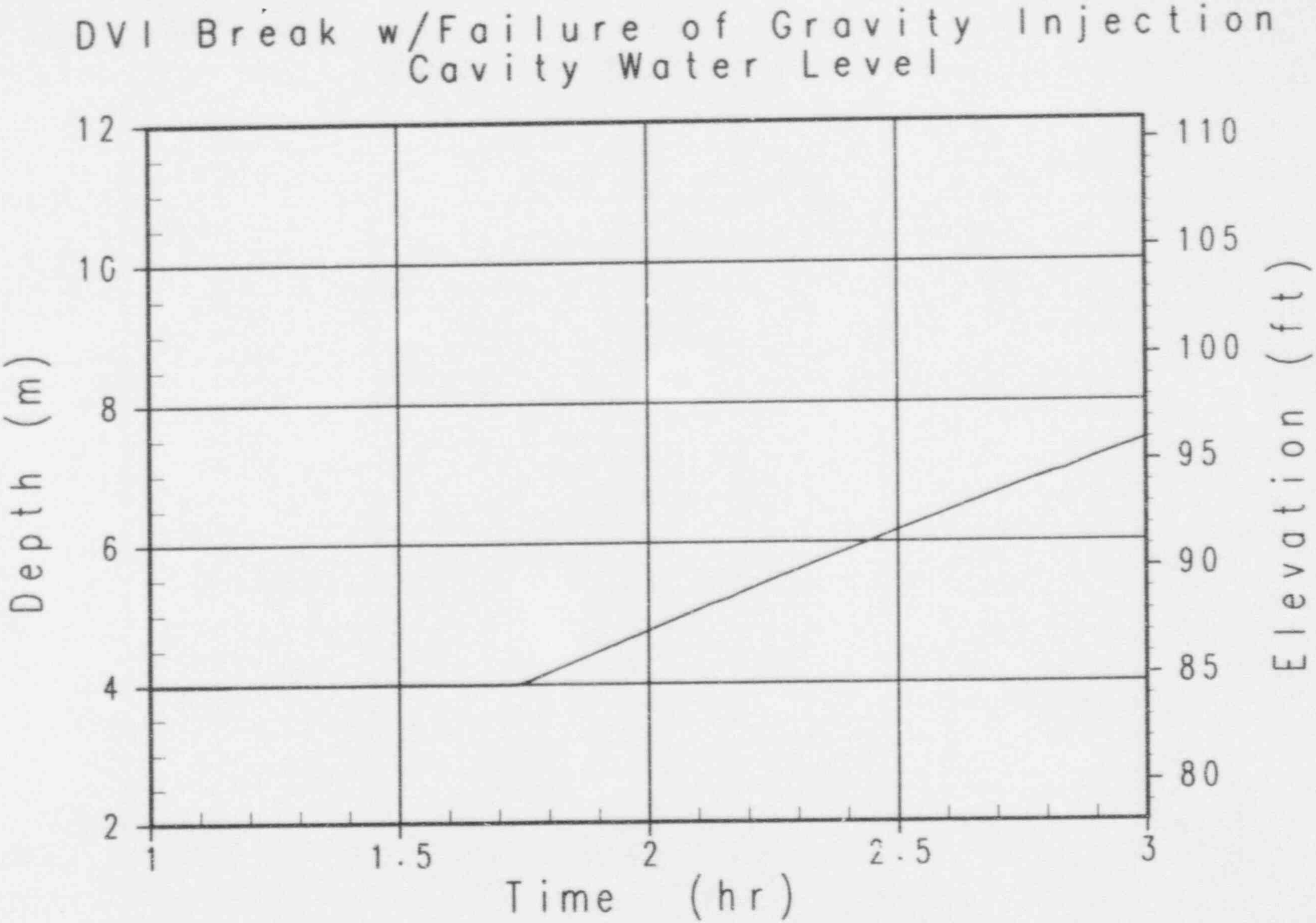

DVI Break w/Failure of Gravity Injection
In-Vessel Mixture Level
Length (m)
Length (ft)
Time (hr)
0
2
4
6
8
0
5
10
15
20
25
1
1.5
2
2.5
3


DVI Break w/Failure of Gravity Injection
Core-Exit Gas Temperature
Temperature (K)
Temperature (F)
Time (hr)
0
500
1000
1500
2000
2500
3000
0
1000
2000
3000
4000
1
1.5
2
2.5
3


DVI Break w/Failure of Gravity Injection
Hydrogen Generated In-Vessel
400
300
200
100
0
800
600
400
200
0
Mass (kg)
Mass (lbm)
1
1.5
2
2.5
3
Time (hr)



DVI Break w/Failure of Gravity Injection
Relocated Debris Mass
Mass (kg)
Mass (lbm)
Time (hr)
40000
30000
20000
10000
0
80000
60000
40000
20000
0
1
1.5
2
2.5
3



DVI Break w/Failure of Gravity Injection
Cavity Water Level
Depth (m)
Elevation (ft)
Time (hr)
12
10
8
6
4
2
110
105
100
95
90
85
80
1
1.5
2
2.5
3

Transient Phases of IVR

- Relocation of debris to lower head
  - in-vessel steam explosion
  - jet impingement on lower head

- Heat up of the debris in the lower head to molten conditions
  - benign compared to steady-state since energy is going into heating debris not lower head

- Jet impingement onto lower head represents bounding thermal loading for transient phase
  - none experienced in TMI-2
  - bounding ablation less than the thinning produced in steady-state conditions

AP600 In-Vessel Retention of Molten Core Debris

TMI-2 VIP "Hot Spot" Formation

- Higher heat flux than surrounding area
- Not due to jet impingement
- AP600 IVR configuration provides more favorable conditions for surviving hot spot than TMI-2
  - external cooling of vessel with water
  - low pressure in RCS
- Steady-state calculation is bounding estimate of heat-fluxes to vessel

AP600 In-Vessel Retention of Molten Core Debris

Reactor Vessel Insulation

- Purpose of insulation is to reduce heat losses and protect concrete from heat loads during normal operation
- Insulation serves no purpose during design basis accidents and is not considered to be safety grade or seismically qualified
- Design considerations are provided to accommodate IVR external cooling of the reactor vessel
  - outlined as functional specifications for performance during IVR
  - only during severe accident

IVR Functional Specifications for RPV Insulation

- Insulation shall provide a pathway to allow water in below the vessel, along the vessel and steam or two-phase flow out into the piping gallery
  - stand-off insulation
  - Annulus between vessel and insulation and outlet at the top of insulation will provide at least as much area as the loop clearances in the concrete (including piping insulation)
  - any pressure drop at the bottom inlet will be small compared to the losses through the loop clearances
- Individual panels shall be designed to be retained by the supporting structure to prevent contact with the vessel during IVR
  - individual panels may shift or leak to relieve pressure across insulation
- the supporting structure shall be designed to maintain structural integrity during IVR to prevent panels from contacting the vessel

480.80 Indication for the Operator Action to Flood

- Action falls under Severe Accident Management Guidelines (SAMG). Not yet implemented.
- No specific setpoints are determined.
- Flooding is to be initiated at the time that it is apparent that core damage is beginning.
- Core-exit T/C $\geq$ 1200°F enters Inadequate Core Cooling EOP
- Core-exit T/C > 2000°F has been used for cavity flooding which is the latest time envisioned for this action.

480.81 Equipment Qualification Requirements for Cavity Flooding System

- Cavity Flooding System is Class 1E and qualified under the DBA EQ Program
- The time that the valves are required to perform is prior to or at the time that significant core damage is beginning.
- T/H Conditions are less severe than DBA since heat is not being transferred from the core.
- Hydrogen release is just beginning so no global burn to take out both valves (in separate vaults)
- Radiological releases are just beginning and well below EQ limits
- DBA EQ limits are sufficient to qualify the cavity flooding system.

440.82 Incorporation of Cavity Flooding into SAMG Program

- SAMG is not yet developed
- entrance into SAMG is through failure to re-establish core cooling in the Inadequate Core Cooling EOP.
- It is envisioned that Hydrogen Igniter Operation and Cavity Flooding would be first steps in SAMG
- No automatic actuation is considered since it is a SAMG action
- No time delay modeled in MAAP4 analyses

AP600 In-Vessel Retention of Molten Core Debris

480.83 Power Sources for Cavity Flooding Valves

- Batteries provide the power sources for the opening of the cavity flooding valves

- DET assumes successful cavity flooding. Node FL determines the rate of flooding in the cavity based on whether the 10" line is specifically failed.
  - 10"/4" Issue no longer exists

- Complete failure of flooding is treated on the CET and guarantees vessel failure.

- The !WF fault tree linked to the CET considers the availability of battery power sources to compute the failure probability of flooding.

- Station Blackout contributes < 0.2% to CDF

480.84 Surveillance and Maintenance Requirements

- Handled under the In-service Inspection program discussed under RAI 210.24

480.85 Cavity Flooding Valve Sizing Basis and Water Level Success Criteria

- Cavity Flooding System consists of two 6" diameter lines.

- Sizing based on NRHR pump suction requirements with both pumps running unthrottled

- Minimum water level is 2m above the top of the hemisphere (elev. 90') at the time that the bulk debris temperature exceeds the melting temperature of the wall (based on review of MAAP4 results)

480.86 Delayed Cavity Flooding

- Best-estimate is that cavity is flooded up to the top of the hemisphere prior to cavity flooding action
- Less than 20 minutes to flood up to the top of the hemisphere (max debris pool level) considering one 6" line and no pre-flooding
- less than 100% of debris relocation within 1 hour
- water in lower head cools debris heat transfer to vessel wall, then debris has to heat up again
- No delay is considered in current analysis

480.87 Assessment of Flooding After Relocation

- Timing is important parameter since boil-off of water in the lower head and outside vessel have significant effect
- Film boiling would be expected on vessel walls
- Vessel may fail prior to or during floodup

480.88-95 RPV Reflective Insulation
480.147-149

- Functional Specs for the Insulation with respect to IVR specify flowpaths, resistances and structural stability

- No ITAAC, or testing is intended for vessel insulation

- Final insulation design is not anticipated prior to design certification

480.96 Timing of IVR Sequences

- The requested information is provided in Chapter 34 of the PRA, revision 2/3

480.97 Long-Term Effects of Flooding and Saturation of Pool
480.143

- Steady-State calculations in DET analysis assume CHF temperatures (maximum possible) on vessel wall

- Maximum pool temperatures in the cavity are saturation temperature at local pressures (max pressure ~1 atm, T_{sat} = 393 K)

480.98 Debris Pool Configuration

- Metallic pool on top of oxide pool provides the most limiting debris configuration and well as the most realistic

  - highest heat fluxes on top
  - "focusing" of heat to sidewall by the metal layer

AP600 In-Vessel Retention of Molten Core Debris

480.99 Structural Assessment of Vessel
480.140
480.141
480.144

- RCS is depressurized
- Based on static loading of deadweight and buoyancy, vessel thickness required under IVR is > 0.15 mm
- At the CHF, the minimum thickness of the vessel is 2.5 cm
- Consideration of thermal stresses results in 1.1 cm of metal carrying the load
- Significant margin to failure
- Therefore, CHF has to be exceeded to fail the vessel
- DET analysis uses lower CHF values than IVR ROAAM report as success

AP600 In-Vessel Retention of Molten Core Debris

480.100 Transient Evaluation of IVR
480.138

- Jet impingement and steady-state calculations bound the transient phases of the phenomena
- ACOPO test to address slip conditions. Not expected to make a difference

AP600 In-Vessel Retention of Molten Core Debris

480.101 TMI "Hot Spot"
480.138

- AP600 IVR configuration provides more favorable conditions for surviving hot spot than TMI-2
  - external cooling of vessel with water
  - low pressure in RCS

- Steady-state calculation is bounding estimate of heat-fluxes to vessel

480.102 Applicability of Experiments to AP600

- IVR ROAAM Report (DOE/ID-10460) discusses the scaling of experiments and applicability in detail

- Data used in the DET for heat transfer is conservative with respect to the final ranges of data used in the ROAAM report which are based on the latest tests

480.103 Metal-Water Reactions

- No water in the cavity is the bounding condition for the heat transfer to the vessel, therefore, no metal-water reaction is present
- If water is in the cavity, the heat would go into making steam

480.104 75% Oxidation of the Cladding
480.146

- The DET only considers the situation in which no water is injected into the vessel

- 75% oxidation is considered to be a reasonable bound for core melt with no reflood in the vessel

- Case 3BE is reflooded which results in more oxidation and water cooling of debris in the vessel

AP600 In-Vessel Retention of Molten Core Debris

480.105 Decay Heat in Pool

- The decay heat (1.0 MW/m^3) was determined based on an examination of the timing of core relocation in the various MAAP4 analyses.
- Minimum time after scram that 100% of core debris could be in lower head is > 3 hours
- ROAAM report supports decay heat up to 1.4 MW/m^3 without vessel failures

480.106 Application of the IVR Failure Probability on the CET

- Not sensitive to initiating event or melt progression
- Applied only to low pressure cases with intact vessel, flooded cavity, regardless to internal reflooding of the vessel

480.107 Factor of 100 Increase in IVR Failure Probability

- A sensitivity analysis in which the IVR failure probability is increased a factor of 100 is presented in the CET Quantification (Chapter 43) of the PRA report revision 2/3.
- Little impact on overall results
- Margin increase with changes to CHF in ULPU

480.108 Success Criteria for Vessel Integrity
480.141

- The success criteria is maintaining the heat fluxes less than CHF
- Previous discussion on vessel structural capability indicates why
- DET analysis uses lower CHF values than IVR ROAAM report

480.109 Creep Rupture Analysis

- A creep analysis of the reactor vessel is performed in the IVR ROAAM report

480.110 Status of WCAP-13388

- DET analysis supersedes the analysis on WCAP-13388
- DET methodology draws on WCAP 13388 and references it
- Modeling of the metal pool at the top of the debris bed increases the heat fluxes at the top of the pool substantially

480.111 Crust Protection of the Vessel Wall

- In the analysis, it is true that the crust does not protect the wall. Assumes perfect conductivity between crust and wall.

- In reality, the crust formation will increase the gap resistance between the pool and the wall

480.112 Layer of Superheated Steel

- The layer of superheated metal is included in the steady-state model in the DET analysis. A crust is formed at the top of the oxide layer

480.113 In-Vessel Steam Explosion After Vessel Failure

- No assessment has been made
- Pre-mixing of debris and water does not occur (stratified configuration) which limits heat transfer
- No vessel failure is expected
- ARSAP program addressing steam explosions in vessel

480.114 Discussion of Experiments

- IVR ROAAM Report has detailed discussions of the experiments

480.115 CECO Experiments for Insulation

- IVR Functional Specs incorporated in AP600 insulation
- CECO tests apply to current plants and demonstrate feasibility of cooling through insulation

480.142 Conservation of Energy In Steady-State Analysis

- Calculation is performed from the bottom of the vessel to the top of the debris
- Plots are shown to 90° (max debris depth slightly greater)
- Energy conservation check is in calculation and verification of calculation is in calcnote