52-003

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

November 20, 1996

APPLICANT: Westinghouse Electric Corporation

PROJECT: AP600

SUBJECT: SUMMARY OF MEETING TO DISCUSS AP600 CONTAINMENT WATER pH CONTROL FUNCTIONAL ANALYSIS AND DESIGN DETAILS

The subject meeting was held at Westinghouse Electric Corporation (Westinghouse) offices in Monroeville, Pennsylvania, on October 17, 1996, between representatives of Westinghouse, Nuclear Regulatory Commission (NRC) staff, and NRC consultants. The purpose of the meeting was to discuss the details and effectiveness of the revised design of the pH control system which uses chemical baskets of trisodium phosphate (TSP) located in lower containment volumes. The staff wanted to understand (1) how the water introduced during various accident sequences comes into contact with the TSP baskets, (2) how the TSP mixes and gets uniformly distributed throughout various containment compartments during floodup, and the system capability in maintaining a pH above 7 over the entire period of an accident (30 days).

Westinghouse addressed the design of the containment pH control system baskets, which are to be located in the corridor between the loop compartments. The design details of the baskets and how the TSP is held in the baskets are not yet complete. It is assumed, for calculating the rate at which the TSP dissolves, that the baskets contain a monolithic block of TSP which comes into contact with the water at only the front face. The baskets are located in an area where there are no high energy pipes and pipe joints and fittings are minimal to prevent inadvertent wetting of the TSP; the baskets are also located one foot off the floor. Mixing will be driven by natural circulation along the outside of the reactor vessel into the loop compartments, past the TSP baskets, and through a vertical access tunnel back into the reactor vessel compartment. Westinghouse noted that because MAAP4 does not track the movement of TSP, the actual mixing analyses will be performed using a bounding hand calculation. The details will be provided in Westinghouse's response to request for additional information (RAI) 470.31.

Short term and long term pH response concerns were examined. Westinghouse stated that pH control does not significantly factor into the early accident (2 hour) exclusion area boundary (EAB) dose calculations and that it is primarily needed for the 30 day low population zone (LPZ) dose assessment. The pH control system is generally not dependent on the accident scenario so long as the containment sump floods up to a nominal level with a pH of 7 or greater. The EAB dose calculation sensitivity to pH during the early part of an accident scenario is expected to be a minor factor. Typical containment floodup sequences, water flow paths, and water levels and locations were discussed.

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Because of the staff's concern about pH control of the in-containment refueling water storage tank (IRWST) and the effectiveness of the pH control system in conjunction with the natural deposition process of aerosols, two bounding accident scenarios were proposed for analysis. One case would evaluate offsite doses assuming the radioiodine bypasses passive pH control as much as possible. This could be accomplished by assuming the entire source term is deposited directly into the IRWST where pH control is believed to be ineffective. The IRWST water, after draining to the same level as the sump water, would be treated as isolated from mixing with the sump water. This case is expected to produce the largest 30 day LPZ and control room doses.

The other case would assume mixing of the IRWST water with the rest of the containment sump water to maximize the challenge of achieving a pH of at least 7 (due to the high boron concentration in the IRWST). The entire source term is deposited directly into the containment atmosphere. This is expected to result in the largest two hour offsite dose at the EAB.

Westinghouse and the staff [supported by the staff's consultants from Oak Ridge National Laboratory (ORNL)] committed to evaluate the details of these bounding accident scenarios and determine what data and assumptions would be necessary to perform such calculations. In telephone conversations between Westinghouse, the NRC and ORNL, on October 25 and October 30, 1996, the details of the bounding accident scenarios were agreed to and the data needed by the staff to perform an independent analysis was provided Westinghouse. This information is included as an attachment to this meeting summary (Enclosure 1 of Attachment 3).

The validity of previous RAI responses was also discussed. Westinghouse stated that RAIs 470.18, 19, 22, 28, and 29 were unaffected by the design change. The RAI 470.17 concerning the MAAP noding scheme is being revised and a draft was provided at the meeting and attached with this summary (Enclosure 2 of Attachment 3). The changes that would be necessary to RAI 470.20 will be addressed by the response to 470.31. A draft of the response to RAI 470.30 was also provided to assist the staff in commencing its independent assessment (Enclosure 3 of Attachment 3).

Westinghouse stated that, although there is some margin in the amount of TSP to account for uncertainties in the acidic effects of boron or breakdown of cabling hyperlon, there has been no attempt to determine how severe accident ex-vessel or late in-vessel fission product releases will influence the sump pH.

Based on comments from the staff, Westinghouse took an action to investigate the need for periodic chemical surveillance testing of TSP samples. For example, TSP is known to undergo gradual degradation from exposure to carbon dioxide gas. Westinghouse will need to specify the acceptable testing criteria and the replacement criteria. The staff felt that such a requirement should be included in the technical specifications.

Attachment 1 is the list of meeting attendees. Attachment 2 is the agenda. Attachment 3 contains handouts provided by Westinghouse during the meeting and during the subsequent telecons on October 25 and October 30, 1996.

original signed by:

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Docket No. 52-003

Attachments: As stated

cc w/attachments:
See next page

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AP600
CONTAINMENT pH CONTROL
MEETING ATTENDEES
OCTOBER 17, 1996

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JOHN BUTLER	WESTINGHOUSE
TERRY SCHULZ	WESTINGHOUSE
JIM SCOBEL	WESTINGHOUSE
BOB HAMMERSLEY	FAI/WESTINGHOUSE
JAY LEE	NRC
BILL HUFFMAN	NRC
ED BEAHM	ORNL
CHUCK WEBER	ORNL

Attachment 1

WESTINGHOUSE/NRC MEETING ON AP600
pH CONTROL
OCTOBER 17, 1996

Agenda

1. Describe the methodology to be used for the final mixing analyses including how pH influencing materials and pH effects from source term and other radiation will be accounted for. Also, discuss the DBA/LOCA scenario to be used by Westinghouse for the AP600 containment water pH control system?

2. Provide a physical overview of the anticipated mixing process of trisodium phosphate (TSP) within the lower containment volumes, reactor vessel and piping and IRWST. Also describe the floodup progression, steam and water condensate pathways. Discuss how the iodine postulated to exist in the containment will come in contact and interact with alkaline water. Other consideration to discuss:

   a. Removal and transport of iodine from containment atmosphere.

   b. Possible concentration of iodine in the IRWST and IRWST pH control.

   c. Possible concentration of TSP in the reactor vessel due to long term recirculation boiloff and condensate return processes.

3. How much margin exists within the pH control system design to account for severe accident which include ex-vessel and late in-vessel fission product releases.

4. Quick Review of past Westinghouse responses to the following RAIs for its validity due to the recent design changes:

RAI Nos.	470.17	NTD-NRC-95-4413 (March 7, 1995)
	470.18	NTD-NRC-95-4413 (March 7, 1995)
	470.19	NTD-NRC-95-4413 (March 7, 1995)
	470.20	
	470.21	NTD-NRC-95-4431 (April 7, 1995)
	470.22	
	470.28	NTD-NRC-96-4810 (August 30, 1996)
	470.29	NTD-NRC-96-4810 (August 30, 1996)

5. Discussion on Westinghouse progress in responding to RAIs 470.30 and 470.31

6. Volumes and temperatures (liquid and gas) in each control volume as a function of time.

Attachment 2

7. Flow rates (liquid and gas) between control volumes as a function of time. Inter-compartmental flows should not include counter-current (i.e., buoyancy-driven) flows.

8. Distribution of nuclide groups in each control volumes as a function of time.

9. Source rate of cesium iodine into the containment (mol/sec, kg/hr, etc.)

10. To the extent currently known, discuss the location, amount, chemical form of all pH-influencing materials.

11. Discussion on design and placement of the pH control chemical baskets.

12. Discussion on assumptions on water inventory and boron concentrations.

13. Provide information on the physical stability (such a slumping, caking, and solubility) of granulated TSP as a function of age.

14. Provide information on the replacement/replenishment of the TSP is necessary (Including discussions of under what circumstances Westinghouse anticipates that TSP replenishment may be necessary).

15. Discuss surveillance and proof of functionality (e.g., sampling, testing, other monitoring).

16. General discussions.

MATERIALS PRESENTED

AT THE OCTOBER 17, 1996,

AP600 CONTAINMENT pH CONTROL MEETING

AND

SUPPLEMENTAL MATERIAL PROVIDED DURING

TELECONS ON OCTOBER 25 AND 30, 1996.

Attachment 3

Enclosure 1.

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Attachment - Description of pH Adjustment Analysis Cases

The following identifies two cases bound the post accident containment water pH adjustment of the AP600. It is expected that case 1 will result in a larger 2 hr offsite dose. Case 2 is expected to result in a larger 30 day offsite dose.

These cases assume the same release of radioactivity from the RCS during the same time period. The containment leak rate is 0.12%/day for first day; after the first day the leak rate drops to 50%.

Case 1 - Challenge to pH Adjustment in Containment

Accident - 2" CL LOCA

System Operation -

- ADS stages 1/2/3 fail, all stage 4 work
- Two CMT inject
- Two Accumulator inject
- IRWST doesn't inject (causes core damage)
- IRWST dump to containment works (both lines)
- IRWST gutter doesn't work
- CVS BAT is injected

Comments - All of the activity released from the RCS initially enters the containment atmosphere. Mechanistic retention and transport of activity in the containment must be assumed.

It should be assumed that some water circulates from the containment into / throug the IRWST. This assumption results in the largest challenge to the pH in the containment by mixing in the borated water in the bottom of the IRWST.

Case 2 - Challenge to pH Adjustment in IRWST

Accident - Spurious ADS (stage 1)

System Operation -

- ADS stages 1/2/3 all work, all stage 4 fail
- Two CMT inject
- Two Accumulator inject
- IRWST doesn't inject (causes core damage)
- IRWST drain to containment works (both lines)
- IRWST gutter works
- CVS BAT is injected

Comments - All of the activity released from the RCS initially enters the IRWST through the ADS spargers under water. The retention of activity in the IRWST water and subsequent release to the IRWST gas space must be treated mechanistically. In addition, the treatment of activity retention in the containment and transport back to the IRWST must also be treated mechanistically.

The IRWST drain to the containment should be assumed to be initiated just as activity release from RCS is completed. The activity initially retained in the IRWST water is assumed to be uniformly distributed in the IRWST. The drain should be assumed to occur over 2 hours. This case will result in water in the bottom of the IRWST that

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has not mixed with TSP from the containment (no recirculation should be assumed as was in case 1). As a result the IRWST pH will remain low.

IRWST Gas Space Exchange with Containment; During the ADS stage 1/2/3 blowdown from the RCS, significant quantities of steam are released to the IRWST. In about a 1/2 hour the IRWST becomes saturated and steam is then vented to the containment through IRWST vents. These vents have gravity operated louvers which close when there is no flow through them. After the blowdown of the RCS and the subsequent release of non-condensable gases as the core is damaged, the vents will close. Because of the transfer of fission products into the IRWST, some decay heat will be produced in the IRWST. This heat input will result in some steam generation which will also vent to the containment. It is recommended that the long term flow from the IRWST to the containment be based on this steam generation. This steam generation is estimated to be about 250 cfm at 2 hours, decreasing to 100 cfm at 24 hours and to 40 cfm in 6 days.

Gutter Operation; Because there is no LOCA in this case and the ADS stage 4 valves do not open, the containment pressure will not increase until the ADS stage 1/2/3 lines heatup the IRWST to saturation. This will happen in about 1/2 hour. After that the containment pressure will increase to 29 psia in about 2 hours. Much of the steam generated in this two hours will not return to the IRWST because it ends up in the containment atmosphere or it condenses on surfaces other than the containment shell. The containment pressure will decrease gradually to about 22 psia in 30 days. Because of the slower / delayed changes in containment pressure, the rate of steam condensation return to the IRWST will stay within its capability.

It is recommended that the steam condensation return to the IRWST be based on the following assumptions:

- Steam release to containment should be based on decay heat (ANS 79 plus 2 sigma).
- Steam condensed on containment shell should be assumed to be same as that generated by decay heat.
- Gutter return efficiency should be assumed to be 100% of the steam condensed on the containment shell.

These assumptions maximize the gutter return flow which is conservative for this case.

Enclosure 2

AP600

Question 470.17

The MAAP noding scheme provided with the AP600 fission product transport analysis dated September 23, 1994, includes 2 nodes (9-PCCS Dome and 10-PCCS Annulus). These nodes do not appear to be connected to the rest of the system (through a junction or flow). Is this correct? If so, why are they presented?

Response:

INSERT "A"

The MAAP4 generalized containment model noding scheme provided with the AP600 fission product transport analysis is from the MAAP4 analyses which support the AP600 PRA, Revision 8. Nodes ~~9~~ 10 and ~~10~~ 11 model the annular baffle region of the Passive Containment Cooling System (PCS) which is outside the containment pressure boundary, and are not directly connected to the nodes inside the containment pressure boundary with flow junctions, but are connected by the two-sided heat sinks which model the PCS shell. These nodes are needed to calculate the passive heat removal from the AP600 containment. The evaporation of the PCS water from the outside of the containment dome and shell is modeled in nodes ~~9~~ 10 and ~~10~~ 11, and the density differences between these nodes and the environment node (node 12) determine the natural circulation flow through the PCS baffle region (junctions 17, 18 and 19). The heat sinks of the containment shell passively cool nodes 7 and 8 through convection and condensation and transfer the heat to the gas space of nodes 10 and ~~9~~ 11 through convection and evaporation.

SSAR Revision: NONE

PRA Revision: NONE

"A" THE MAAP4 CONTAINMENT MODEL FOR REV. 8 IS MODIFIED OVER PREVIOUS REVISIONS. NODE 9 IS NOW THE VALVE VAULT (INSIDE THE CONTAINMENT), 10 IS THE PCS DOME, AND 11 IS THE PCS ANNULUS.

Enclosure 3

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AP600

Question 470.30

Re: pH Control System

Provide the configuration of water volumes and water flow paths in the containment for dissolving and mixing the trisodium phosphate following an DBA.

Response:

The sources of water and boron that can be involved in post accident flooding of the containment include the following:

	Water Volume (max / min ft3)	Boron Concentration (max / min ppm)
RCS (without Pzr)	ft3	2000 ppm
	ft3	0 ppm
Pressurizer	1008 ft3	2000 ppm
	660 ft3	0
Core Makeup Tank	2040 ft3	3700 ppm
	2000	3400
Accumulator	1732 ft3	2900 ppm
	1667 ft3	2600
IRWST	80000 ft3	2900 ppm
	74500	2600
CVS Boric Acid Tank	8700 ft3	4375 ppm
	0	na

Note that the CVS boric acid tank is a nonsafety-related component and as a result its minimum injected volume is zero. Two bounding combinations of these water sources are shown below. The minimum post accident pH occurs with the maximum amount of water and boron, as shown in the "Min pH" case. The maximum post accident pH occurs with the minimum amount of water and boron, as shown in the "Max pH" case.

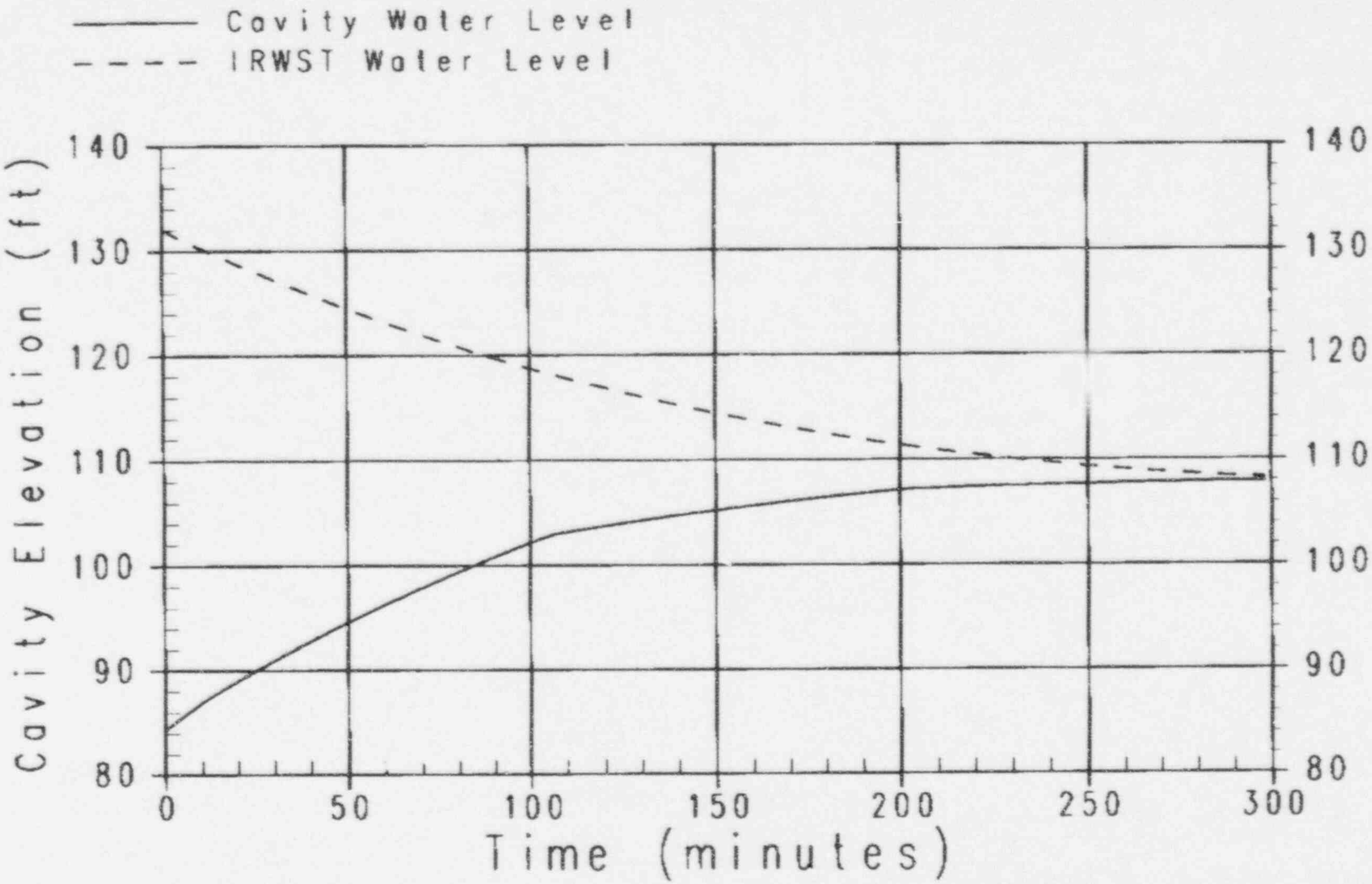
	Max pH	Min pH	
Total amount water	5.39×10^6	6.37×10^6	lb
Boron concentration	2474	3007	ppm

The distribution of this water in the containment is described in section 4 of WCAP-1470, WGOTHIC Application to AP600. Note that the final post accident containment water flood level is about the 108' 2" elevation. Since the IRWST bottom is at the 103' elevation, some of the IRWST will not drain. The IRWST has a internal surface area of 2760 ft2; this results in about 14260 ft3 of water remaining in the IRWST.

In the event of a severe accident, the primary mixing mechanism is natural circulation driven by the hot reactor vessel containing the damaged fuel. Water and steam will flow up along the outside of the hot reactor vessel and into the loop compartments. The water carried into the loop compartments will flow through the corridor between the loop compartments past where the TSP baskets are located and down a vertical access tunnel to the reactor vessel compartment. This flow path promotes mixing of the TSP with the water inside the containment.

SSAR Revision: NONE

AP600 IRWST Drain to Flood Reactor Cavity



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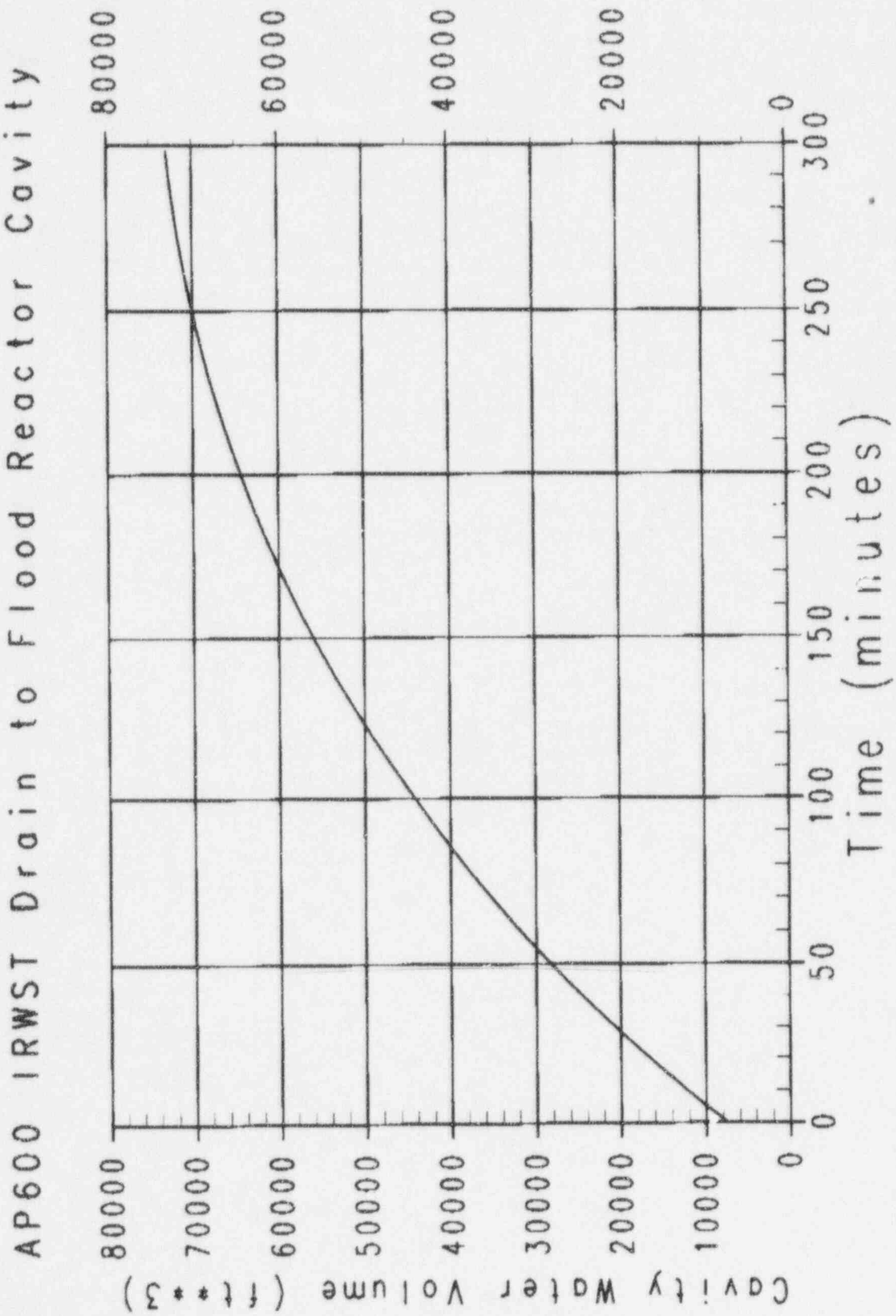
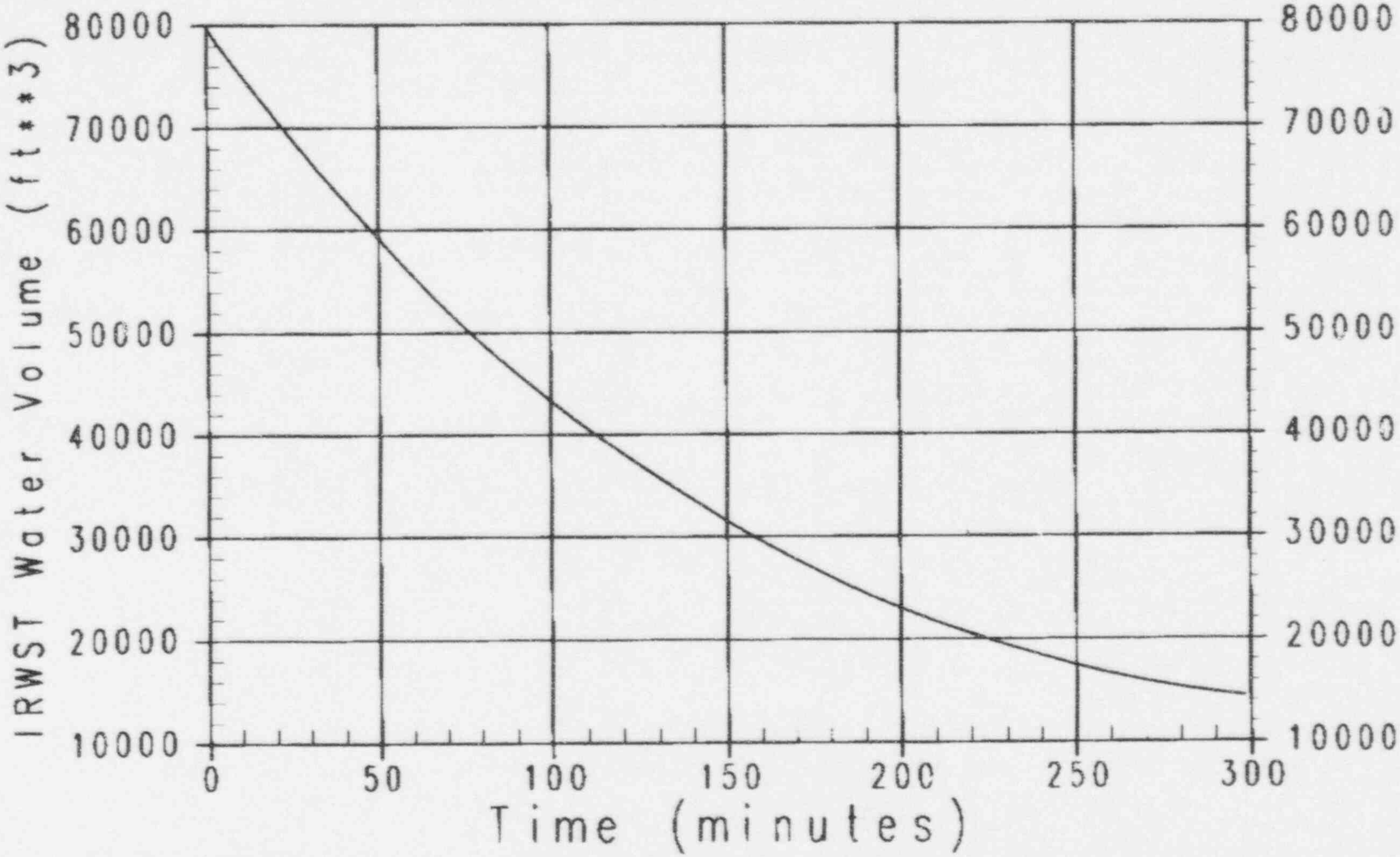


AP600 IRWST Drain to Flood Reactor Cavity
Cavity Water Volume (ft**3)
80000
70000
60000
50000
40000
30000
20000
10000
0
Time (minutes)
0
50
100
150
200
250
300

AP600 IRWST Drain to Flood Reactor Cavity



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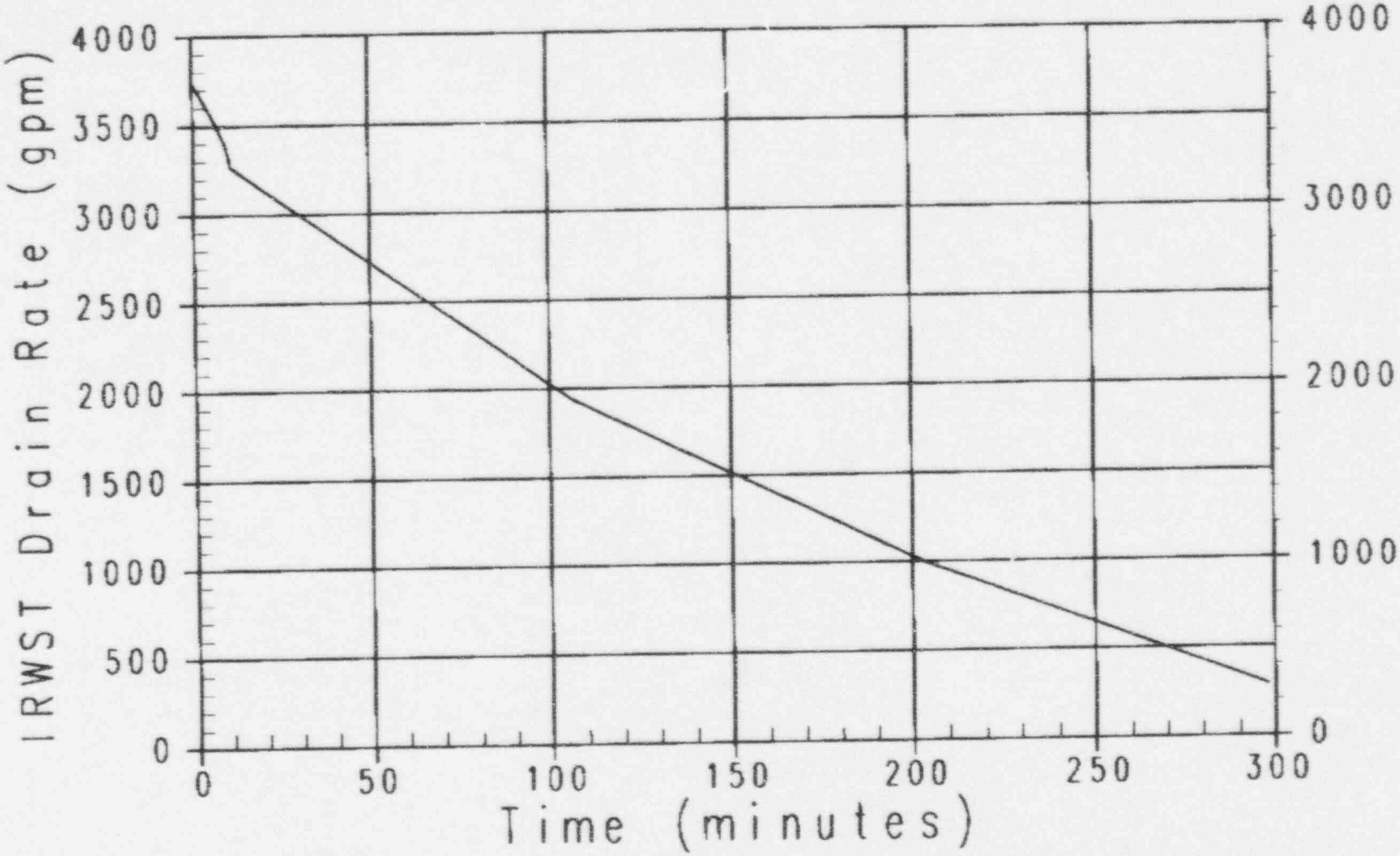
AP600 IRWST Drain to Flood Reactor Cavity



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AP600 IRWST Drain to Flood Reactor Cavity