TEXAS UTILITIES GENERATING COMPANY
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July 26, 1984

Director, Nuclear Reactor Regulation
Attention:
Mr. B.J. Youngblood
Licensing Branch No. 1
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

SUBJECT: COMANCHE PEAK STEAM ELECTRIC STATION
DOCKET NOS. 50-445 and 50-446
CONTAINMENT SUMP PERFORMANCE

REFERENCES:
a. Meeting of June 7, 1984 - NRC & TUGCO (Containment Sump Performance)
b. TUGCO Letter #TXX-4189 dated June 4, 1984 (Schmidt to Youngblood)
c. TUGCO Letter #TXX-4210 dated June 29, 1984 (Schmidt to Youngblood)

Dear Mr. Youngblood:

Attached for your review is additional information from Westinghouse in response to verbal requests from your staff regarding certain aspects of our consolidated report (ref. c). If you have further questions, please advise.

Sincerely,

HCSchmidt

H.C. Schmidt
Manager, Nuclear Services

HCS:sk

3001
1/1

WPT-7435

Westinghouse Electric Corporation

Water Reactor Divisions

Nuclear Operations Division

Box 355
Pittsburgh Pennsylvania 15230

July 24, 1984

Mr. J. T. Merritt, Jr.
Assistant Project General Manager
Texas Utilities Services, Inc.
P.O. Box 1002
Glen Rose, Texas 76043

RECEIVED

JUL 25 1984

H. C. SCHMIDT

TEXAS UTILITIES GENERATING COMPANY
COMANCHE PEAK STEAM ELECTRIC STATION
Containment Paint Evaluation -
Reply to NRC Questions

Dear Mr. Merritt:

Westinghouse was requested to evaluate the CPSES Emergency Core Cooling System to determine if the system function/components would be degraded by the Ingestion of Containment Paint Fines following a Large Break Loss of Coolant Accident (LOCA). Westinghouse completed this evaluation and provided a report to Gibbs & Hill which was subsequently used as an appendix to Gibbs & Hill Report "Debris Effects On Containment Emergency Sump Performance". This report was submitted to the NRC on June 29, 1984. The attachment to this letter provides a reply to several NRC Questions dealing with the Westinghouse Evaluation Results. The results of Westinghouse's evaluation indicate a negligible effect on the ECCS and its ability to maintain long term core cooling even in the conservative scenarios studied.

Very truly yours,

WESTINGHOUSE ELECTRIC CORPORATION

T. R. Puryear, Manager
WRD Comanche Peak Projects

T.Bengel/jjs/9377D:1
Attachment

cc:	J. T. Merritt (TUS)	1L, 1A
	H. C. Schmidt (TUS)	2L, 2A
	R. E. Ballard	1L, 1A
	ARMS (TUS)	1L, 1A
	J. B. George (TUS)	1L, 1A
	R. Tolson (TUGCO)	1L, 1A
	J. Marshall (TUGCO)	1L, 1A
	M. H. Phillips	1L, 1A
	M. Vivirito (Gibbs & Hill)	1L, 1A

CONTAINMENT PAINT EVALUATION - REPLY TO NRC QUESTIONS

Appendix 1 to Gibbs & Hills Report, "Evaluation of Paint and insulation Debris Effects on Containment Emergency Sump Performance" provided Westinghouse's assessment of the potential degradation of the CPSES Emergency Core Cooling System (ECCS) based on the ingestion of paint and insulation debris into the ECCS following a postulated large break LOCA. The potential degradation effects of the Emergency Core Cooling System components due to the ingestion of paint and insulation debris were evaluated based on the following assumptions:

1) NUREG/CR-2792 is applicable. Based on this paint debris 1% by volume (0.1% abrasive by volume) in the ECCS fluid is acceptable for RHR and containment spray pumps and no detailed evaluation is required.

2) The concentration of insulation and paint debris ingested into the ECCS is $\leq$1% by volume ($\leq$0.1% abrasive).

3) Homogeneous mixing of paint fines in the ECCS coolant.

The questions and reply to the NRC questions are as follows:

1) What is the basis for concluding that paint fines will settle out in the Reactor Vessel?

Reply:

The basis for concluding that paint fines will settle out of solution in the Reactor Vessel lower plenum is based on a balance of hydrodynamic, hydrostatic, and gravitational forces. The significant parameters of the force balance are fluid velocity, cross-sectional area of the fine, and the difference in specific weight between the paint fines and the liquid. Known

as Stokes law, this force balance is commonly used in sediment analysis to estimate the size of solid particles, References 1 and 2. The results of these analyses are discussed below.

2) Will paint fines settle out anywhere else in the ECCS?

Reply:

In general, two types of regions within the ECCS recirculation flow path may make it possible for paint fines to settle out of solution; regions in which the fluid flows vertically at low velocity (such as in the Reactor Vessel Lower plenum), and long horizontal runs of piping in which fluid velocities are low. For vertical flows, Stokes law may be applied to estimate the maximum size of paint fines that can be carried by the vertical flow.

In the case of low flow in long horizontal runs, the fluid velocity in the vertical direction may be taken conservatively to be zero. Under these conditions, the hydrodynamic force component of Stokes law results only from the motion of the paint fines settling out of solution, and all particles will tend to settle towards the bottom of the horizontal run of pipe. Thus, the tendency of all paint fines will be to migrate toward the bottom of the horizontal piping run. The viscous action of the flowing liquid, however, will be to drag the paint fines along with the flow. Thus, it is anticipated that, in smaller diameter horizontal piping runs where the velocity of the recirculating fluid is large, paint fines will most likely be swept along with the flow. It should be noted that if paint fines do settle out, the flow area of the piping is decreased, which in turn increases the viscous drag of the fluid on the paint fines to be dragged with the flow. In any case, the small reduction in flow area for the relatively large RHR piping would have a negligible effect on flow. A Study of the ECCS identified portions of the ECCS in which paint fines could accumulate. A potential area for the accumulation of fines would be in the small valves and small bore orifices in

the high head SI piping. However, the high head system is not required for post-accident recirculation. The core flooding and long term decay heat removal functions are expected to be largely unaffected.

3) What is the impact of paint fines on the core?

Reply:

Westinghouse evaluated the CPSES RCS and ECCS system configuration to assess the system's ability to filter or settle out paint debris during ECCS recirculation. The results of this evaluation address both hot leg and cold leg recirculation modes.

COLD LEG RECIRCULATION

An assessment of the separation of paint debris out of solution in the reactor vessel (RV) lower plenum during cold leg recirculation following either a cold leg or a hot leg break was made based on the following assumptions:

- o Debris density is 96 lb/ft^3. (Paint with a specific gravity of 1.6)
- o Thermodynamic properties of water are evaluated at 200°F and 60 psia.
- o Debris geometry is approximately spherical (reasonably approximates debris shape and is conservative for this analysis.)

Using the preceding assumptions and performing a force balance that accounts for drag, gravity, and hydrostatic forces, a relationship identifying the maximum debris particle size that can be carried by a vertically flowing fluid with a given velocity was developed. A plot of that relationship is given in Figure 1.

The vertical velocity of the recirculating fluid in the lower plenum prior to its passing through the core support plate will determine the maximum debris size that can be carried into the core. A typical fluid velocity in the core during cold leg recirculation following a cold leg break is 0.1 ft/sec. Using the core velocity to evaluate a conservatively large debris particle size, the data of Figure 1 indicates that the maximum size of debris passing through the core will be about 0.011 inches in diameter.

The fluid velocity in the core during cold leg recirculation following a cold leg break is independent of the number of RHR trains operating. The core receives adequate flow to remain cool from the operation of just one RHR pump; any excess flow spills out the break. The fluid velocity in the core during cold leg recirculation following a hot leg break, however, is dependent upon the number of RHR pumps operating; all flow supplied by the RHR pump(s) must flow through the core before spilling out the break and returning to the reactor sump. Based on data from the cold leg break, the fluid velocities in the core during cold leg recirculation for one and two RHR pumps operating following a hot leg break are summarized in Table 1. Using these fluid velocities and the data of Figure 1, debris particle sizes that could be carried into the core during the operation of one and two RHR pumps was also evaluated. These evaluation results are also listed in Table 1.

From the data of Table 1, the largest debris size that could enter the core during cold leg recirculation is predicted to be 0.036 inches. Typically, particle sizes as large as 0.040 inches will be able to pass through the core without causing flow blockage. Also, the debris sizes given in Table 1 are conservatively large, having been evaluated using the fluid velocity in the core rather than the vertical fluid velocity in the lower plenum. Thus, for cold leg recirculation following either a hot leg or cold leg break, it is concluded that the formation of flow blockage in the core by paint debris is not a concern.

An assessment was also made of the rate at which the mass concentration of paint debris in solution would change due to settling out in the RV lower plenum. Significant assumptions of the evaluation are:

- o Debris size is uniformly distributed over the range 0.001 inch to 0.125 inches
- o No credit is taken for settling out of debris in the containment building. (This is an extremely conservative assumption.)
- o Once in solution, the size of debris particles remains constant.

The rate at which debris mass concentration is decreased, or the debris removal efficiency, was found to be dependent on the mass flow through the core. A cold leg break, having the smallest core flow during cold leg recirculation of the three cases studied, requires the longest time to clean the recirculating flow by means of debris settling out in the RV lower plenum. A hot leg break with 2 RHR pumps running, having the largest core flow during cold leg recirculation, requires the shortest time to clean the recirculating flow by means of debris settle out. Time histories of the debris mass concentration for each of the three cases considered are given in Figure 2.

In studying the debris removal efficiency of the RV lower plenum, it was noted that some amount of debris always remains in solution. Two parameters determine the amount of debris remaining in solution; the vertical fluid velocity (which determines the maximum particle size that can be carried by the fluid) and the distribution of particle sizes. The mass of paint debris remaining in solution, expressed as a percentage of the total debris mass that is initially in the system, is given for each of the three cases considered in the debris removal efficiency study in Table 1. The data of Figure 2 show that for the three cases considered, no more than 1.0 percent of the initial debris mass remains in solution.

HOT LEG RECIRCULATION

At about 18 hours after the hypothetical LOCA occurs, emergency procedures require that the ECCS be realigned so as to prevent boron precipitation in the reactor vessel; delivery of RHR flow is changed from the cold legs to the hot legs. Now, debris in the RHR flow is delivered to the core without passing through a separation volume such as the RV lower plenum, and the delivery of a large debris particles to the hot leg could result in the formation of flow blockages in the core. From Figure 2, however, it is noted that after 18 hours of cold leg recirculation there is less than 1% of the initial debris mass remaining in solution. This amount of debris is small, and is not considered to result in flow blockage of the core that is of any consequence.

For hot leg recirculation following a cold leg break, it is possible that debris deposited in the RV lower plenum during cold leg recirculation may be reentrained in solution since all RHR flow must pass through the core and lower plenum prior to spilling out the break. Fluid velocities in the RV/core barrel annulus under these conditions are estimated to be about 0.25 ft/sec for one RHR pump operating and about 0.50 ft/sec for two RHR pumps operating. From Figure 1, the maximum debris size that can be reentrained by the hot leg recirculation flow is found to be 0.028 inches and 0.075 inches for the operation of one and two RHR pumps, respectively.

Thus for two RHR pumps operating, the fluid velocity in the RV/core barrel annulus is sufficient to reentrain debris that may cause core blockage if it is reintroduced to the RV. From Figure 1, it is concluded that if the fluid velocity in the lower plenum is less than 0.33 ft/sec, only debris that is less than 0.040 inches in size may be entrained. Typically, the fluid velocity in the lower plenum is a maximum where the fluid turns to flow up the downcomer. Figure 3 shows the relationship between vessel flow rate, debris bed height, and fluid velocity as it turns into the downcomer from the lower plenum. From Figure 3, the velocity of the turning fluid is predicted to be below 0.30 ft/sec for debris beds less than 4.7 feet in height. From Figure 4, which is a plot of vessel volume versus vessel height, the debris bed

volume corresponding to a height of 4.7 feet is about 400 cubic feet. Thus, it is concluded that the formation of a debris bed in the RV lower plenum during cold leg recirculation whose volume is less than 400 cubic feet is not likely to promote reentrainment of large size debris that could result in the development of core blockage when the ECCS is realigned to hot leg recirculation.

SUMMARY

It has been shown that debris which could cause flow blockage in the core will settle out in the RV lower plenum during cold leg recirculation rather than flow into the core. Furthermore, it was shown that virtually all separable debris will be removed from solution within 18 hours after initiation of cold leg recirculation. It has also been shown that realignment of the ECCS to hot leg recirculation is not likely to result in debris forming flow blockage in the core.

TABLE 1

COMMANCHE PEAK

PAINT DEBRIS SETTLE-OUT STUDY SUMMARY

COLD LEG RECIRCULATION

Event/Conditions	Core Velocity (ft/sec)	Max. Dia. of Debris in Solution (inches)	Residual Debris Mass* (Per Cent of Total Initial Debris Mass)
Cold Leg Break 1 or 2 RHR Pumps Operating	0.10	0.011	0.007%
Hot Leg Break 1 RHR Pump Operating	0.15	0.023	0.03%
Hot Leg Break 2 RHR Pumps Operating	0.30	0.036	0.72%

* Mass not separable from solution; attained within first 18hrs of cold leg recirculation.

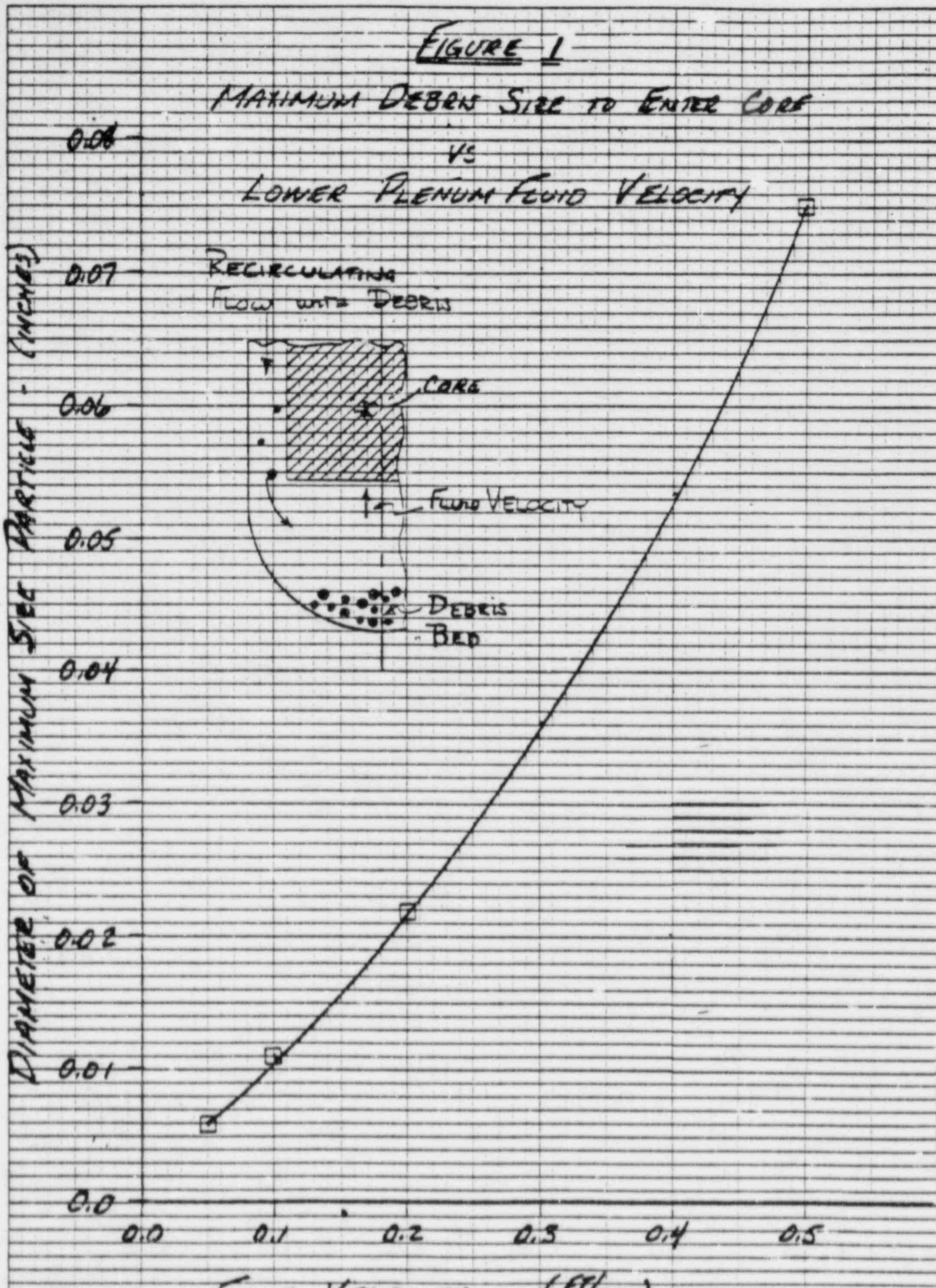


FIGURE 1
MAXIMUM DEBRIS SIZE TO ENTER CORE VS LOWER PLENUM FLUID VELOCITY

K+E 10 X 10 TO THE CENTIMETER 18 X 25 CM KEUFFEL & ESSER CO. MADE IN U.S.A. 461510

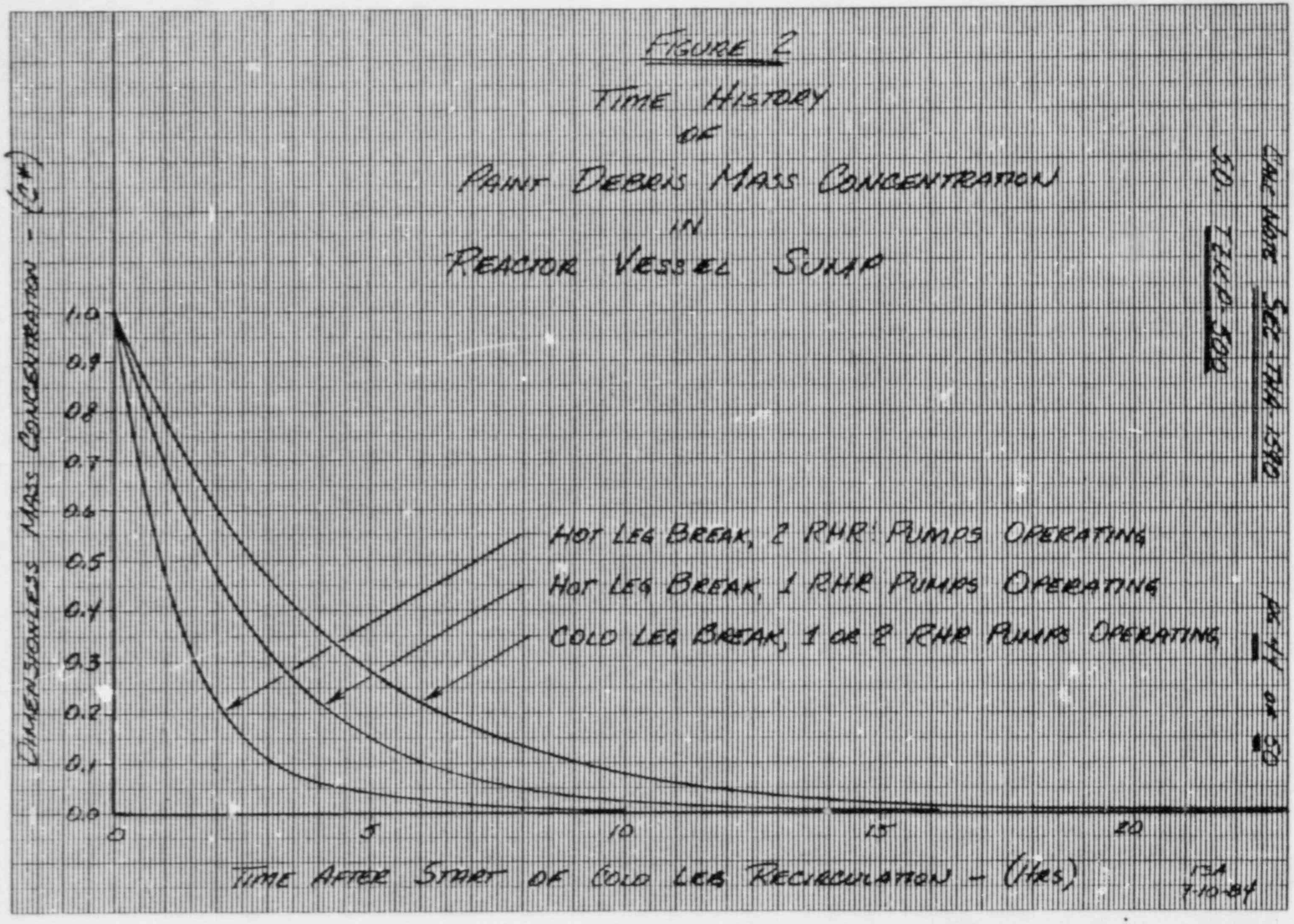
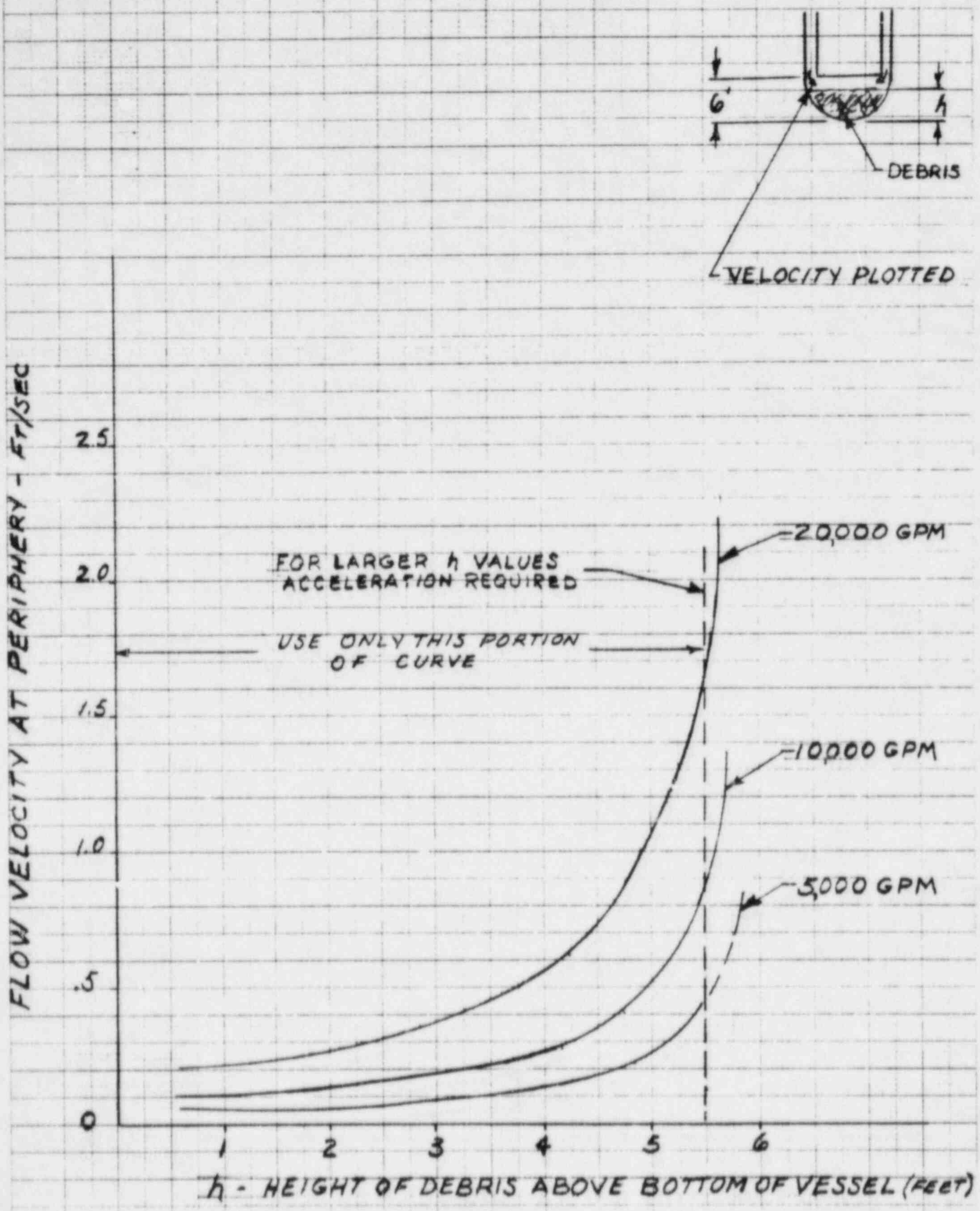
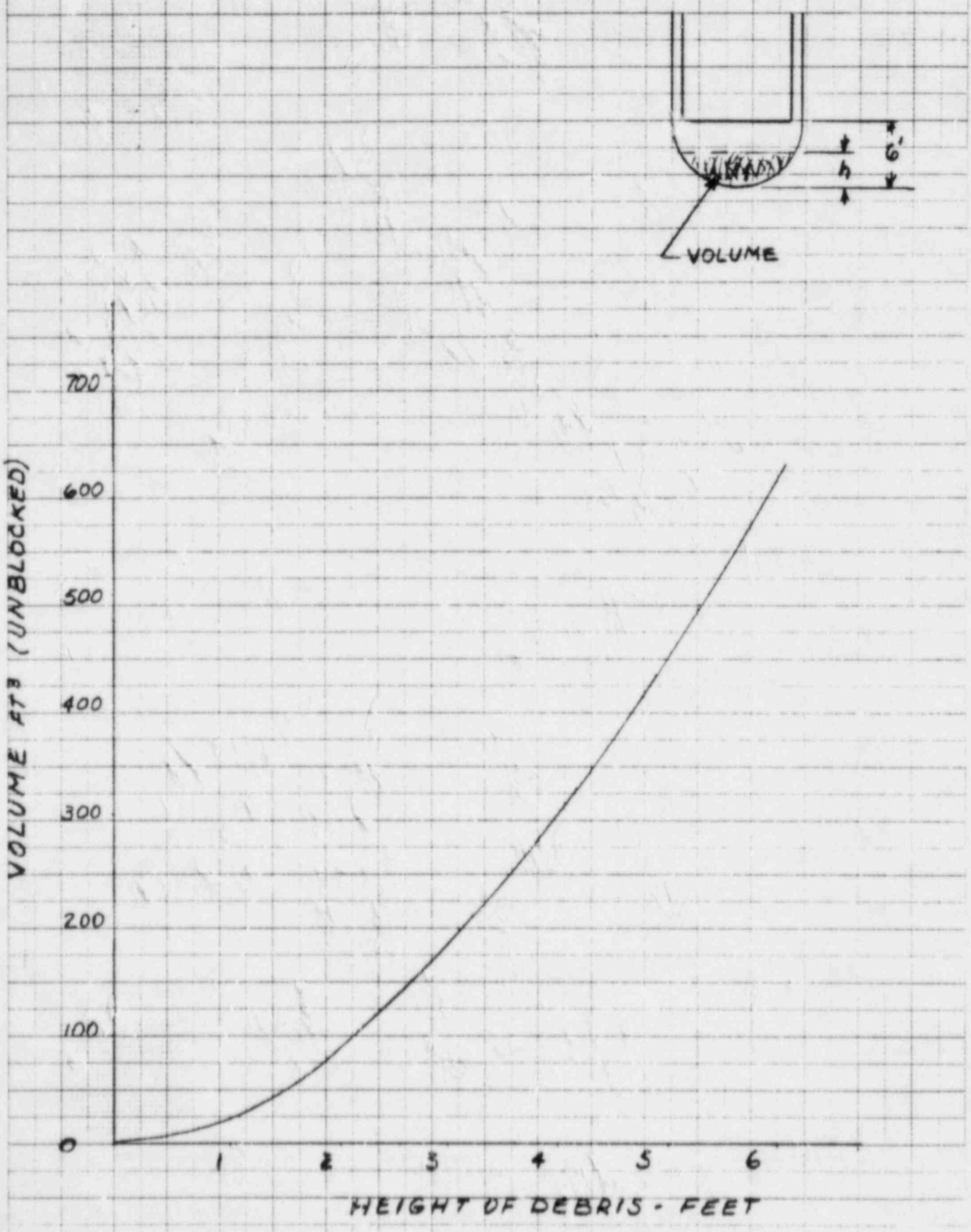


FIGURE 3



6'
h
DEBRIS
VELOCITY PLOTTED
FLOW VELOCITY AT PERIPHERY - FT/SEC
2.5
2.0
1.5
1.0
.5
0
20,000 GPM
10,000 GPM
5,000 GPM
FOR LARGER h VALUES ACCELERATION REQUIRED
USE ONLY THIS PORTION OF CURVE
1
2
3
4
5
6
h - HEIGHT OF DEBRIS ABOVE BOTTOM OF VESSEL (FEET)

FIGURE 4



6'
h
VOLUME
700
600
500
400
300
200
100
0
VOLUME FT³ (UNBLOCKED)
1
2
3
4
5
6
HEIGHT OF DEBRIS - FEET

4) What are downcomer velocities?

Reply:

The flow area near the bottom of the downcomer is about 0.59 times the flow area at the bottom of the fuel. Thus, the velocity in the downcomer is about 1.68 times the velocity in the core.

5) What is the basis of using fluid velocities less than 0.1 ft/sec in the lower plenum for the paint debris settle-out calculations in the reactor vessel?

Reply:

Fluid velocities less than 0.1 ft/sec in the lower plenum are based on core velocities of 0.1 ft/sec that are predicted to occur during cold leg recirculation following a hypothetical cold leg large break LOCA.

6) Can the ECCS heat transfer capability degrade as a result of paint chips being ingested into the system?

Reply:

Degradation of the ECCS heat transfer capability could result from chemical plate out of the paints constitutents and/or the erosive effects of the abrasives present in the paint fines.

The epoxy (two part mix) containment paint binders are thermosetting type plastics. The epoxy is hard and brittle in the

temperature ranges anticipated in the ECCS (≤300°F). Based on vendor supplied information (Reference 3) these epoxy binders do not become sticky. The paint chips that are postulated to be suspended in the ECCS coolant are therefore, not expected to cling or adhere to the surfaces of the heat transfer components and are not expected to affect the heat transfer properties of the ECCS components or core.

Westinghouse's evaluation of the potential erosive effects on the ECCS and its components assumes that paint and insulation debris in concentration levels up to 1% by volume are ingested into the ECCS during coolant recirculation. A Reactor Coolant Makeup study for large break LOCA was carried out to determine the minimum acceptable ECCS flow rate required to mitigate the effects of a large break LOCA and to also identify the ECCS critical components which are essential for long term decay heat removal.

This study disclosed that when the ECCS is switched-over to recirculation (approximately 30 minutes after the initiation of the coolant injection from the RWST) core decay heat will have decreased to a value for which only one RHR train is required to provide (core boil off) makeup from the sump to the RCS. This study also revealed that there are several critical ECCS components which are required for long term decay heat removal. These components include the RHR pump, RHR valves, and the RHR Heat Exchanger.

An assessment of these components with respect to erosion degradation revealed the following:

a) The RHR pump hydraulic performance degradation is negligible for the particulate concentrations assumed for this evaluation (Paint and insulation debris ≤1% by volume).

b) The RHR valves would be susceptible to erosion damage due to suspended particles in the ECCS fluid but this pitting and potential degradation in leak tightness is not expected to significantly affect the valve operation or functions.

c) The RHR Heat Exchanger tubes would be susceptible to some abrasive erosion. However, as previously discussed (question #3) calculations indicate that more than 99% of any ingested debris will fall out within 18 to 24 hours after the initiation of ECCS recirculation. Based on available erosion data (Reference 4), the degradation resulting from the original debris concentration level (≤1% by volume; ≤0.1% abrasive) for the first 24 hours will result in less than .001 inch reduction of the tube thickness. The residual debris concentration level after the first 24 hours will be less than 1% of the initial concentration and is expected based on available data to have minimal additional erosion impact on the heat exchanger tubes or on the heat exchangers long term decay heat removal capability (1 year design basis). The tube design thickness is .049 inch of which approximately .015 inch is required to retain pressure. Therefore, .034 inch is available for erosion before failure of the heat exchanger boundry would be expected.

7) Will small particles settle out in the inlet plenum of the RHR Heat Exchanger.

Reply:

The RHR heat exchangers are vertical two pass shell and U-tube heat exchangers. Reactor coolant is on the tube side and component cooling water is on the shell side. The heat exchanger tubes are 3/4 inch outside diameter and have an .049" wall thickness. The tube side flow velocity through the heat exchanger tubes is ~5 ft/sec based on an RHR pump feed rate of 3800 GPM. Initially some drop out of larger particles could be expected to occur in the low velocity regions of the heat exchangers below the inlet and outlet nozzles. However, the flow velocities through the RHR heat exchanger are high enough to ensure that the suspended particles which enter the heat exchanger plenum and remain in the flow path are carried up the U-tubes and out the outlet nozzle.

If a sufficient quantity of particles enter the heat exchanger and settle out in the inlet channel, the settling out of particles will cease when the low velocity regions are filled with particles and all additional particles entering the heat exchanger inlet after that point will be carried through the heat exchanger tubes and out of the outlet nozzle.

REFERENCES

1) pp. 236-239, Advanced Mechanics of Fluids, H. Rouse, editor, John Wiley & Sons, Inc., NY, NY, (1959).

2) pp. 203-210, Viscous Fluid Flow, Frank M. White, McGraw-Hill Book Company, NY, NY, (1974).

3) G&H/Westinghouse TELECON (WPT-7434 Dated 7/19/84)

4) Erosion-Corrosion of Selected Metals in Coal Washing Plant Environments, G. R. Hoey and T. S. Bendar, National Association of Corrosion Engineers, (1983).