Log # TXX-4267
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TEXAS UTILITIES GENERATING COMPANY

SKYWAY TOWER • 400 NORTH OLIVE STREET, L.B. 81 • DALLAS, TEXAS 75201

August 17, 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-4239 dated 7/26/84 Schmidt to Youngblood

Dear Mr. Youngblood:

Reference a. above transmitted our consolidated report regarding Containment Sump Performance. Reference b. supplemented that report with additional information from Westinghouse. This letter transmits additional information developed as a result of matters discussed in public meetings with your staff to clarify selected sections of the report. Specifically, the following information is provided:

1. Gibbs & Hill letter GTN-69312 dated August 3, 1984 with responses to NRC questions, addenda, and errata in the June 29 report.

2. G&H letter GTN-69345 dated August 15, 1984, with revisions to Section 6 and Section 8 of the report.

3. G&H letter GTN-69355 dated August 16, 1984, with revised pages 3-2, 6-6, 6-7, and 6-8.

We will incorporate the above information, along with that contained in reference b. into a complete revision of the report after you have completed your review. If you need more information, please advise.

HCSchmidt

H. C. Schmidt
Manager, Nuclear Services

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A Dravo Company

GTN- 69355

August 16, 1984

Texas Utilities Generating Company
Skyway Tower
400 North Olive Street
LB 81
Dallas, Texas 75201

Attention: Mr. H. C. Schmidt
Manager of Nuclear Services

Gentlemen:

TEXAS UTILITIES GENERATING COMPANY
COMANCHE PEAK STEAM ELECTRIC STATION
G&H PROJECT NO. 2323
GIBBS & HILL PAINT REPORT

Per your request, we are attaching the following revised pages regarding the Report on "Evaluation of Paint and Insulation Debris Effects on Containment Emergency Sump Performance" June 1984:

Pages: 3-2, 6-6 thru 6-8

You are requested to submit the above information to the NRC after review.

Very truly yours,

GIBBS & ~~HILL,~~ Inc.

R. E. Ballard

Robert E. Ballard, Jr.
Director of Projects

REBa-MC:lc
1 Letter + 1 Attachment
~~cc: ARMS (B&R Site) OL~~
J.T.Merritt (TUSI Site) 1L
R.Tolson (TUSI Site) 1L 1A
R.Iotti (Ebasco, NY) 1L 1A
H.C.Schmidt (c/o Westinghouse Bethesda) 12L + 12A
T.R.Puryear/L.Berkowitz (Westinghouse PA) 1L 1A

Paint impurities for the steel coatings are presented in 38
Table 3.1-2.

Decomposition temperatures for all the containment coatings are 40
≥ 350 F. They are thermally stable for continuous exposure at 41
200 F. Carbozinc is thermally stable for continuous exposure at 42
750 F. The characteristics of all coating systems used at CPSES 43
are summarized in Table 3.1-2.

Paint Failure Modes 45

Paint can fail by two general modes: chalking and 48
flaking/peeling. Chalking is loss of the paint film by powdering 49
to small (micrometer-size) particles. Flaking/peeling is loss of 51
the paint film by flakes of small (usually <one inch) particles.
Field and laboratory observations of the containment coatings 52
used at Comanche Peak confirm that the failure modes are by 53
flaking of small (1/8 - 1 inch) particles, except for the 54
Carbozinc 11. The Carbozinc 11 failure mode is by chalking 55
(powdering). Phanoline 305, NUTEC 11, NUTEC 11S and Reactic 1201,
when cured, form a strong adherent bond with the substrate. The
paint forms rigid and hard crust of protective layer. The failure
mode for these coating systems will be by flaking of small particles
in the size range of 1/8-1 inch. Delamination of large sections of
coatings is not likely when the paint is cured.

Other terminologies to explain coating failure used in the 57
industry, such as blistering, intercoat delamination, cracking,
undercutting (lifting of the paint film by substrate corrosion), 58
checking, mud-cracking, alligatoring, erosion, wrinkling, 59
pinpoint rusting and pitting, lead to either chalking or 60
flaking/peeling.

Blistering, checking or mud-cracking can lead to failure by 62
flaking/peeling of small size (< 1/2 inch) particles ("Good 63
Painting Practice, Vol. 1, Steel Structures Painting Manual,"
SSPC 1982, Chapter 23; ASTM D772-47, "Standard Method of 65
Evaluating Degree of Flaking (Scaling) of Exterior Paints," ASTM
Vol. 06.01, 1984; ASTM E714-56, "Standard Method of Evaluating 66
Degree of Blistering of Paints," ASTM Vol. 06.01, 1984; ASTM 67
D660-44, "Standard Method of Evaluating Degree of Checking of
Exterior Paints," ASTM Vol 06.01, 1984).

Revised
August 15, 1984

assumed to be transported towards the sumps. Table 6.2-23 summarizes the results presented in Tables 6.2-1 through 6.2-18. The data presented in Table 6.2-23 is for very conservatively assumed containment water temperature of 200 F (higher temperatures give higher critical velocities for transport). The lowest critical velocity for transport of 0.27 ft/sec is for 1/8-in.-size particles of the Phenoline 305 and Reactic 1201 coatings. The critical velocity for 1/8-in. size, Carbozinc 11 particles exceeds 0.57 ft/sec. Also, the critical velocity for transport increases with increase in particle size. The transport velocity for one-in. size particles varies from 0.75 to 1.62 ft/sec.

The particle size distribution from failed paint is not known with any degree of certainty, since experience with failures of the coatings used in the containment is almost non-existent. As stated in Section 3, there is information that the range of particle sizes is between 1/8 in. and 1 in., but the distribution within that range is unknown. In the interest of conservatism, it was assumed in paint transport calculations that all paint particles are 1/8 in. in diameter. This is the smallest size that can block the screen. Any larger size will be less easily transported, as can be seen by inspection of any column from Tables 6.2-1 through 6.2-20. It was also assumed in paint transportation calculations that the specific gravity of paint was 1.5 (90 pounds per cubic foot). From the same tables, inspection of any row shows that lower paint density yields the most easily transported paint. Also, as shown in Table 3.1-2, the minimum specific gravity of any paint used in the containment is 1.5.

Using these assumptions, it can be seen from Tables 6.2-1 through 6.2-20 and 6.2-23 that the minimum velocity required to transport paint is at least 0.27 ft/sec.

Using this critical velocity and the existing velocities in Table 5.3-2, it can be seen that all paint initially on floor elevations 905, 860 and 832, and paint which falls on these levels (e.g., paint from the containment dome), if it fails, will be transported to openings in the floor and thence to the 808 floor level.

The distribution of the paint debris was evaluated based on the flow paths available for transport from the upper floors. The flow paths correspond to the open areas in the upper floors where the curbing is not present. The quantity of paint transported through each opening will be proportional to the water flow through the opening. Tables 6.2-24 and 6.2-25 give the flow openings, their locations and the quantity of paint debris transported from each of the upper floors. Paint from the containment liner below the dome will be washed by spray water

directly to the 808 level. It will be distributed uniformly around the periphery at the bottom of the containment.

The amount of paint thus transported to the 808 level is shown in Table 6.2-25.

The transport of paint debris on the 808'-0" elevation where the sumps are located is discussed in the following section.

6.2.4 Paint Transport at 808'-0" Elevation

Based on the critical velocities for paint transport discussed in Sections 6.2.1 and 6.2.3 and the available water velocities at the 808'-0" elevation, the transport potential for paint particles was evaluated. As discussed in Section 6.2.3, a very conservative critical velocity of 0.27 ft/sec was used for this evaluation.

Paint particles in any given zone of the containment were considered to have a potential for transport with the water flow towards the containment sumps if the available water velocity exceeded the critical velocity for transport. Figures 6.2-3 and 6.2-4 show the critical areas on the 808'-0" elevation of the containment, where the paint particles have a potential for transport. The critical areas are marked cross-hatched. Figure 6.2-3 is based on the low water level and Figure 6.2-4 is for the high water level.

For the purpose of this evaluation the following assumptions were used to determine paint transport at the 808'-0" elevation:

a. All the paint at the 808'-0" elevation and the paint deposited from the upper levels (discussed in Section 6.2.3) is available for transport to the near sump zone Azimuth 30-0-315°.

b. Paint particles transported from critical areas continue to move from the critical areas until either the particle reaches the sump or enters a zone where the available flow velocity is less than the critical velocity for transport.

c. The water velocities used are based on the low water level in the containment.

d. No credit was taken for possible paint debris hideout at obstructions, corners and curbs.

Applying the above assumptions and using Figure 6.2-3, the quantity of paint that can be transported to the sumps is summarized as follows:

a. All the paint in the Azimuths 60-0-315° between Elevations 808'-0" and 832'-10".

b. All the paint on the containment liner in the Azimuths 60-0-315° from Elevation 808'-0" to the spring line.

c. All the paint transported from the upper floors to Elevation 808'-0" between Azimuths 60-0-315° (see Table 6.2-25).

Table 6.2-26 gives the quantity of paint debris that can be transported to the sumps. The remainder of the paint shown in Table 6.2-25 remains on the 808 level at locations away from the sumps. Paint that reaches the 808 level between Azimuths 100° and 80° will accumulate near Azimuth 80° (see Figure 6.2-3). The remainder of paint which reaches the 808 level at locations distant from the sump (Azimuths 60° to 315°) will accumulate approximately where it falls.

Revised
August 15, 1984

Gibbs & Hill, Inc.

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A Dravo Company

August 15, 1984

GTN- 69345

Texas Utilities Generating Company
Skyway Tower
400 North Olive Street
LB 81
Dallas, Texas 75201

Attention: Mr. H. C. Schmidt
Manager of Nuclear Services

Gentlemen:

TEXAS UTILITIES GENERATING COMPANY
COMANCHE PEAK STEAM ELECTRIC STATION
G&H PROJECT NO. 2323
GIBBS & HILL PAINT REPORT

Per your request, we are attaching the following information regarding the Report on "Evaluation of Paint and Insulation Debris Effects on Containment Emergency Sump Performance" June 1984:

1. Page 6-7 - Revised to include additional information requested by NRC.

2. Table 6.2-25 - This Table is revised. This Table is now divided into two (2) separate Tables with additional data. The second Table is designated as Table 6.2-26.

3. Table 6.2-26 - see Item 2 above.

4. Section 8.0 - This Section is revised to incorporate the new analysis performed for near field effects. This analysis was presented to the NRC at the July 27, 1984 meeting on this subject.

5. Section 9.0 - This Section is revised to incorporate the methodology and the results of calculations for combining the far field effects and the near field effects discussed at the July 27, 1984 meeting with the NRC.

You are requested to submit the above information to the NRC after review.

Very truly yours,

GIBBS & HILL, Inc.

R. E. Ballard

Robert E. Ballard, Jr.
Director of Projects

REBa-MC:lc Mc.
1 Letter + 1 Attachment
CC: ARMS (B&R Site) OL
J. T. Merritt (TUSI Site) 1L
R. Tolson (TUSI Site) 1L + 1A
R. Iotti (Ebasco NY) 1L + 1A
H. C. Schmidt (c/o Westinghouse Bethesda) 12L + 12A
T. R. Puryear/L. Berkowitz (Westinghouse PA) 1L 1A

Figure 6.2-3 is based on the low water level and Figure 6.2-4 is for the high water level.

For the purpose of this evaluation the following assumptions were used to determine paint transport at the 808'-0" elevation:

a. All the paint at the 808'-0" elevation and the paint deposited from the upper levels (discussed in Section 6.2.3) is available for transport to the near sump zone Azimuth 30-0-315°.

b. Paint particles transported from critical areas continue to move from the critical areas until either the particle reaches the sump or enters a zone where the available flow velocity is less than the critical velocity for transport.

c. The water velocities used are based on the low water level in the containment.

d. No credit was taken for possible paint debris hideout at obstructions, corners and curbs.

Applying the above assumptions and using Figure 6.2-3, the quantity of paint that can be transported to the sumps is summarized as follows:

a. All the paint in the Azimuths 60-0-315° between Elevations 808'-0" and 832'-0".

b. All the paint on the containment liner in the Azimuths 60-0-315° from Elevation 808'-0" to the spring line.

c. All the paint transported from the upper floors to Elevation 808'-0" between Azimuths 60-0-315° (see Table 6.2-25).

Table 6.2-26 gives the quantity of paint debris that can be transported to the sumps.

TABLE 6.2-25

COATINGS CONTRIBUTION
FROM UPPER ELEVATIONS

AZIMUTH RANGE	905 ELEV	860 ELEV	832 ELEV	TOTAL AT 808 ELEV. (NOTE 1)
COATINGS AVAILABLE	87800	128200	128200	76480
0-45	0	0	26805	46743
45-60	0	0	0	6579
60-90	0	0	0	13358
90-135	0	0	16316	36254
135-180	4248	10395	6993	41573
180-225	50981	34649	32633	138200
225-270	32571	45043	23309	120861
270-315	0	38114	0	58051
315-360	0	0	22144	42081

NOTE 1. CONTRIBUTION FROM LINER PLATE UP TO THE SPRING LINE AND PAINT AT THE 808 ELEV. ARE INCLUDED.

REVISED

AUGUST 14, 1984

TABLE 6.2-26

PAINT DEBRIS TRANSPORTABLE
TO THE SUMP SCREENS (NOTE 1)

SOURCE OF THE PAINT DEBRIS (NOTE 2)	QUANTITY OF DEBRIS SQ.FT. (NOTE 3)	CU.FT. (NOTE 4)
PAINT AT AZIMUTH 0-45	46743	139
PAINT AT AZIMUTH 45-60	6579	16
PAINT AT AZIMUTH 315-360	42081	123
TOTAL PAINT DEBRIS	95403	278

NOTES

1. QUANTITY OF PAINT INCLUDES:
   a. PAINT TRANSPORTED FROM UPPER LEVELS
   b. PAINT ON LINER PLATE FROM 808 TO SPRING LINE
   c. PAINT BETWEEN 808 AND 832 FT. ELEVATIONS.

2. ALL PAINT LOCATED IN AZIMUTHS 60-0-315 IS ASSUMED TO BE AVAILABLE FOR TRANSPORT.

3. PAINT DEBRIS IS BASED ON QUANTITIES PRESENTED IN TABLE 6.2-25.

4. DEBRIS VOLUME IS DETERMINED USING AN AVERAGE PAINT THICKNESS OF 10 MILS FOR STEEL AND 30 MILS FOR CONCRETE. A BULK DENSITY FACTOR OF 0.5 WAS USED.

ADDED

AUGUST 14, 1984

SECTION 8.0

REVISED

AUGUST 14, 1984

8.0 NEAR SUMP EFFECTS

This section of the report summarizes the results of analyses conducted to study the behavior of paint fragment which become dislodged in the event of paint failure and fall to the surface of the pool of water existing at the containment lower floor during the post-LOCA recirculation mode.

As will be evident from the results of these analyses, only paint which is located near the ECCS sumps or can be washed to the pool surface in the vicinity of the sumps (including the paint on the containment liner segment defined between the azimuthal angles of 30 and 330° which can be washed down by the action of the containment spray water) has the potential for adversely affecting the performance of the sump.

This section of the report is subdivided into two subsections. The first subsection addresses the theories employed to describe the motion of the paint particles through the pool of water. The second subsection considers the propensity for particles reaching the screen to stick to it and result in partial or full clogging of the ECCS sump fine screens.

8.1 Motion of Paint Fragments Through the Pool of Water

a. Introduction

Motion of paint fragments through the pool water is affected by many parameters including fragment size, shape, density, and water velocity. In general, however, the principal characteristics of the fragment motion are related to the local Reynolds number and the fragment mass moment of inertia.

For very low local Reynolds numbers ($N_R < 1.0$), paint fragments (herein idealized as thin disks) will move through the water maintaining their original orientation, i.e., the pitch angle with which they begin their descent through water. This particular type of behavior can be described by a theory which maintains the initial angle of the fragment constant throughout its descent through the water. Since the local Reynolds number is defined as:

$$N_R = \frac{Wd}{\gamma}$$

where W is the particle relative velocity (relative to the water), d is the fragment (disk) diameter, and γ is the kinematic viscosity of water, values of N_R less equal to one exist only in regions of low fragment velocity and/or virtually stagnant pool conditions. These conditions would not simultaneously exist for fragments which exceed 1/8 inch diameter (particles having diameters less than 1/8 inch will not clog the ECCS sump screens).

For higher Reynolds numbers ($1 < N_R < 100$), the motion of the fragment is characterized by damped pitching oscillations about a diameter. For low Reynolds numbers the damping is very large and the disk would immediately assume horizontal face-down attitude without oscillations. As the Reynolds numbers approaches 100 the damping is very small. Reference 14 notes that the type of motion that would be expected is also influenced by the mass moment of inertia of the fragment. The latter is given by

$$I = md^2/16$$

where m is the fragment mass which equals $\rho_p \pi d^2 t/4$ (ρ_p = fragment density, d = fragment (disk) diameter and t = fragment thickness).

A dimensionless mass moment of inertia of the fragment defined as

$$I^* = I/\rho_w d^5$$

where $\rho_w d^5$ is proportional to the mass moment of inertia of a rigid sphere of water about its diameter d, is used as s second independent parameter governing the fragment motion.

For $N_R > 100$ the amplitude of the pitching oscillations increases and depending on the dimensionless mass moment of inertia, the Reynolds number and the height of the water, can eventually overturn and start tumbling. For the 1/8 - inch fragment the dimensionless moment of inertia is approximately 3×10^3 and $N_R \approx 250$, from reference 14 this corresponds to a region where the fragment can either tumble or oscillate with increased amplitudes.

Because of the uncertainty inherent in the behavior of the fragment as it travels through the water, all of the motions described above have been studied, so that the most conservative type of motion, ie that resulting in the longest horizontal distance travelled, could be selected. The theory and results for each type of motion are described below.

b. Analysis of Motion With Constant Angle

This analysis assumes that the paint fragment is idealized as a disk which hits the pool surface at any incident angle. Conservatively, and because of surface tension effects (particles smaller than 1/8" will break through the surface with difficulty), small paint fragmentr (i.e., 1/8-inch diameter, 5 mils thick) are assumed to be momentarily arrested at the water surface, then to start their travel through the water at the angle of impact with zero initial velocity. Any angle of impact is assumed to be equally probable since for travel in air (or together with spray droplets) the local Reynolds number is high and the dimensionless mass moment of inertia (with respect to air) is also large and hence tumbling motion would be expected.

Referring to Figure B.1-1, the equations describing the motion of the paint fragment through water when the pitch angle is assumed constant are the following:

$$\rho_p V_p \frac{du}{dt} = \rho_p V_p g - \rho_w V_p g - \frac{C_D(\phi)}{2} \rho_w A_{proj} \sin \beta \; W^2 - \frac{C_L(\phi)}{2} \rho_w A_{proj} \cos \beta \; W^2$$

$$\rho_p V_p \frac{du}{dt} = \frac{-C_D(\phi)}{2} \rho_w A_{proj} \cos \beta \, W^2 + \frac{C_L(\phi)}{2} \rho_w A_{proj} \sin \beta \, W^2$$

$$W^2 = u^2 + (V_o - v)^2$$

$$A_{proj} = \frac{\pi d^2}{4} \sin(\phi)$$

Herein u = vertical component of the fragment velocity defined as positive downward

v = horizontal component of the fragment velocity

ρ_f = paint density (assumed to be the minimum - 90 lb/ft³)

ρ_w = water density (60 lb/ft³ at 200°F)

W = fragment relative velocity

V_0 = velocity of pool water toward the screen

C_D = Drag coefficient which varies with ϕ

C_L = Lift coefficient which varies with ϕ

β = angle from pool surface to the velocity vector

V_p = fragment volume

The equations describing the motion of the paint particle have been written for a two dimensional problem only. Strictly speaking, the problem is tridimensional, and under the assumption of constant angle with presence of lift, a particle can travel sideways with respect to the direction of the pool drift velocity. However, if one assumes that lift is negligible, the side motion can be considered negligible, and the problem redu[ces] to a two dimensional problem.

The value of C_D for the circular disk is described as a sine function of the incident angle of the disk relative to flow for $N_R < 250$. It has a maximum value of 1.9 when the disk is oriented normal to the relative velocity vector and a minimum value of $C_D = .074/N_R^{0.2}$ when the disk is parallel to the flow (Reference 15). The lift coefficient, C_L, is, conservatively assumed to be negligible for consistency with the observations of References 14 and 16, which found it to be so for low Reynolds numbers. However, comments by W.W. Willmarth to Reference 16 point out that if the motion is accompanied by large oscillation, appreciable lift is developed. Hence, neglect of lift may not be entirely justifiable.

As will be shown later inclusion of lift results in lesser horizontal distance travelled by the fragment.

The results of the constant angle analysis, indicated on Figure 8.1-2, show that if the initial incident angle assumed for the disk approaches 90°, the relatively large downward vertical velocity dominates over the pool "drift" (recirculated pool velocity) velocity so that the fragment does not travel horizontally a significant distrance.

While mathematically this result is correct, physically it may be unrealistic because the actual behavior at the local Reynolds

numbers ($N_R \simeq 250$) is expected to result in an adjustment of the pitch angle.

As Reference 14 indicates, at the local Reynolds numbers of interest, the fragment will tend to orient itself in the most stable equilibrium state (unless large oscillations are present). This state is defined as that which would have the largest dimension being normal to the relative velocity, i.e., the disk will move in a perpendicular position to the velocity that propels it (or drags it).

The results of this analysis show that only paint contained within a distance of 6.6 feet of the edge of the screens has the potential for reaching the screen (i.e., bottom of screen from 9.5 ft. pool surface). Moreover, since the angle remains constant, not all paint within this area will reach the screen, but only a certain fraction.

That fraction is related to the angle with which the paint fragment hits the surface. Since, as will be discussed later, this is not the most conservative mode of paint transport, discussion of the quantity of paint transported in this fashion is deferred to a later subsection of this section.

c. Oscillatory Motion of Fragment

The second analytical method employs the same equations as the method described in Item b above, but adds one additional equation which describes the rotation of the particle fragment. This equation is

$$I \frac{d^2\Theta}{dt^2} = -L\left(\frac{C_D}{2}\rho_w A_{proj} W^2 \sin\Phi + \frac{C_L}{2}\rho_w A_{proj} W^2 \cos\Phi\right) - \frac{C_R}{2}\rho_w A R^3 |\dot{\Theta}|\,\dot{\Theta}$$

Here R is the disk radius, $\dot{\Theta} = \frac{d\Theta}{dt}$ is the angular velocity, C_R is the rotational drag coefficient, and L is the distance from the fragment center of mass to the center of applied pressure. This distance is given by (Reference 16).

$$L = \frac{0.44d}{\pi^2}\left(90^\circ - |\Phi|\right)$$

Using the two equations given in Item b, plus the third equation given above, the maximum horizontal distance travelled by the fragment does not vary with the initial angle of descent as shown in Figure 8.1-2. However, proportionately more paint located within this distance away from the edge of the screen can reach the screen, since paint which begins its travel at angles near 90° can now reach the screen from distances further away than calculated in the prior method.

In the results shown in Figure 8.1-2 lift has been neglected. As Reference 17 indicates, lift may be present when large oscillation occur. Analyses performed with consideration of lift indicate that in general lift will reduce the maximum horizontal distance that a particle can travel. Because of the large uncertainty associated with the choice of a value for lift coefficients, no credit can obviously be taken for the effect. However, one can intuitively understand this effect by visualizing that since the particle will travel substantially with its face aligned normal to its motion (on the average since the particle oscillates about this position), it presents an angle of attack to lift which causes lift to reduce its forward motion.

[illegible]

Figure 8.1-3 illustrates the trajectory of a 1/8-inch paint fragment descending through a pool of water with a drift velocity of 0.8 fps. Two trajectories are shown. One trajectory assumes no lift, and the other assumes a large lift coefficient. As previously stated, little confidence can be placed on the accuracy of the latter. However, its behavior tends to confirm that lift will reduce the horizontal distance travelled.

The frequency of oscillation of the particle illustrated in Figure 8.1-3 is 4.17 sec-1. Reference 16 provides an equation from which the expected frequency of oscillation of disks falling through a medium can be predicted from the equation.

$$n(\text{frequency of oscillation}) = 0.169\ W(\rho_w C_D/\pi\rho_p t d)^{1/2}\,\text{sec}^{-1}$$

herein all symbols have been previously defined, one computes that for a particle 1/8 inch in diameter falling with a velocity approximately equal to 0.8 fps, its frequency of oscillation should be about 4.53 sec^{-1}.

The last term in the equation describing the rotation of the paint particle about its diameter is the damping term. Similar to the drag force it represents the inertia term which opposes the rotation of the fragment.

Since no literature was found for the rotational drag coefficient of a disk rotating about its diameter, a sensitivity study conducted by reproducing Reference 14 experimental results showed that $C_R >> 0.1C_D$ corresponds to damped oscillations and $C_R << 0.1C_D$ corresponds to tumbling. Figure 8.1-4 illustrates the effect of C_R on the damping of the oscillations.

d. Tumbling Fragments

The third analysis performed assumes that the fragment tumbles as it descends through the water. For tumbling, the fragment is idealized as a sphere having an equivalent mass as the disk (a sphere having a diameter equal to the disk would travel a much shorter distance horizontally).

Under this assumption the equations of motion are considerably simplified since there is no preferred orientation. This sphere corresponding to the 1/8-inch paint fragment is computed to travel horizontally a maximum distance of 2-1/2 feet.

Drag for the sphere in the range of Reynolds numbers of interest is approximated by

$$C_D = \frac{24}{N_R} \left(1 + \frac{3}{16} N_R\right)^{\frac{1}{2}}$$

8.2 Analysis of Potential for Sump Clogging

If one conservatively assumes that any paint fragment larger than the minimum screen opening which reaches the screen surface sticks to the surface, and further conservatively assumes that no fragment overlays another fragment, then results of the analysis employing method a) (Item (b) above indicate that a large area of the fine screens can be blocked.

The precise amount of screen blockage depends on many factors, including the amount of paint debris which may have been transported to the screen by mechanisms described in other sections of this report. This section however, demonstrates that regardless of mechanism of transport, i.e., global transport from other containment areas as addressed in the other sections of this report, which clogs the lower portion of the screens, or local transport through the pool in the immediate vicinity of the sumps, as addressed in this section, which clogs a significant area of the upper portion of the screens, there will remain on the top portion of the screen a band estimated to be a minimum of 2 inches wide, which will be free of paint. This is not the only area of the screen free of paint, debris, . The minimum amount of sump free area resulting from failure of all paint in containment will be 24 sq. ft. . Results of the full scale test conducted by Western Canada Ltd. have shown that this level of blockage is acceptable from the standpoint of sump performance and NPSH requirements of the ECCS pumps.

The 24 sq. ft. is a conservativefigure, since as will be shown later there are other areas of the screen which will only be partly blocked. To understand how the 24 sq. ft. composite figure is derived, it is necessary to understand the precise

geometry of the top portion of the sump. This geometry is shown in Figure 8.2-1.

The top of the sump rack is a solid steel plate which extends more than 1 foot outward from the fine screen, and approximately 8 inches outward from the course screens.

A distance of 5-3/8 inches separates the fine and coarse screens (5.5 inches from outer edge); and a solid plate connects the fine screen frame to the coarse screen frame.

The top of the fine screens is a solid plate extending downward approximately twelve inches. Likewise, the coarse screens are separated from the top plate by a gap, which is approximately ten inches. The top of the coarse screen consists of a solid plate 2-11/16 inches wide.

The results of the analyses in this section indicate that at the beginning, when the screens are relatively free and the inlet velocity at the fine screen is 0.08 fps, the descent of the smallest paint particles through the pool (1/8 inch, 5 mils thick) takes place at approximately 45° trajectory in pool regions far away from the screens where the pool drift velocity is also about 0.08 fps, but at steeper angles in nearer regions where the pool drift velocity falls to about 0.04 fps. As particles accumulate against the screen (including debris from the other transport mechanism described in other sections), the inlet velocity at the fine screen itself will increase, although further away from the fine screen (i.e., just outside the coarse screens) the velocity will not change nearly as much. Ultimately, as the fine screens become blocked to the maximum extent, the inlet velocity reaches a value of about 1.18 fps at the fine screens.

Two dimensional models were constructed to simulate the flow of water into blocked and unblocked trash racks. A section of the region around the trash rack was modeled using the BEACON/MOD3 code which was run to steady state conditions. The section measures sixty inches wide by 114 inches high (the pool height). The region is subdivided into a 9 by 14 matrix of cells. The fine screen is assumed to be a rigid boundary for the

case, where parts of the screen are assumed blocked to progressively higher degrees. The upper structure of the rack is simulated by layers of obstacle cells, and the pressure drop across the coarse screen is modeled with a loss coefficient.

BEACON is a best-estimate, advanced containment analysis code which provides two-dimensional flow modeling capability for the solution of two-component two-phase fluid problems. The basic solution procedure used in BEACON is based on the K-FIX code developed by Los Alamos Scientific Laboratory. Each phase is described in terms of its own density, velocity and temperature. The six field equations for the two phases are coupled through mass, momentum and energy exchange. The equations are solved using an Eulerian finite difference technique that implicitly couples the rates of phase transitions, momentum, and energy exchange to the determination of the pressure, density and velocity fields. The implicit solution is accomplished iteratively.

The details of the model analyzed are shown in Figures 8.2-2 to 8.2-4 show the flow field for each specific case. Outflow (sinks, i.e. flow into the sump) and inflow (sources) into the model (i.e. the boundary conditions) were adjusted to satisfy the equation of continuity for the sump screen as a whole.

The results of the BEACON models are shown in Figures 8.2-2, 8.2-3 and 8.2-4 for a free fine screen, a fine screen blocked so that only a 5.63 inch band remains free at the top, and for a 2" band being free at the top of the screen respectively. The 5.63 inch free band is shown since it reveals that the maximum distance away from the sump top plate edge from which paint flakes can reach the screen is only about 4 feet for steel paint and 11.5 inches for concrete paint. The distances would also be obtained for the case of a free screen and hence represent the maximum extent of the region within which paint falling to the surface of the

pool can ultimately result in screen blockage.

In Figure 8.2.3 the trajectories of steel paint particles and concrete paint particles are shown superimposed on the flow field. Also shown are the trajectories which divide the particles into two categories: those which will be sucked into the screen open area and clog it further, and those which will settle into already blocked areas. These trajectories (for either kind of paint particles) are defined as the separatrix. Also shown in the separatrix in the case of the free screen. Figure 8.2-5 shows in more detail the trajectories of concrete and steel particles which can reach the screen in the vicinity of 2 inch free area band. The concrete paint flakes, which possess a specific gravity of 1.65 and a thickness of 20 mils, fall at a terminal velocity of approximately 0.2 ft/sec. Assuming that these flakes do not tumble and considering the geometrical considerations on the top of the trash rack, this velocity if sufficient to insure that the concrete paint flakes would fall at a trajectory which would be unaffected by the suction from the two inch free area. Thus the concrete paint flakes would be unable to cause additional blocking since they couldn't reach the screen near the open area.

A steel paint chip would have a minimum specific gravity of about 1.5 and a thickness of 5 mils. If a paint chip of the minimum size capable of blocking the fine screens, about 1.8 inch, is assumed to originate at the top of the trach rack at the worst possible location dictated by geometry, the untumbling particle can be calculated to reach approximately the lower quarter of the 2 inch free area if a maximum drag coefficient of 1.9 is assumed. The terminal falling velocity for this case is about 0.08 fps. However, the effect of the drag coefficient, particle size, and tumbling mode assumed is important in determining trajectory. If a drag coefficient of 1.2 is used (corresponding to the higher Reynolds number) the resulting terminal velocity would be increased to about .1 fps. An untumbling steel paint flake at this terminal velocity would be calculated to reach an even lower portion of the 2 inch free area.

Moreover, in the free flow orifice of two inches, the velocity at the fine screen is about 1.18 fps and the velocity at the coarse screens inlet is about 0.4 fps. At these higher velocities the particles will tumble and behave more as an equivalent sphere than flakes. For the lighter particle, the 1/8 inch steel paint chip with a specific gravity of 1.5 and thickness of 5 mils, the terminal velocity of an equivalent sphere would be about 0.28 fps. Tumbling particles at this velocity would be unaffected by the 2 inch free area.

In reality the particle will behave somewhere between the case of the untumbling flake and the tumbling flake, and hence it is expected that an approximate 2-inch band of screen at the top will remain free. It must also be stated that the assumption of all particles of paint having a specific gravity of 1.5 is conservative, as is the assumption that all will have an equivalent diameter of 1/8 of an inch. The uncertainty in this type of analysis is discussed later in this section .

In addition to the free band of fine screens that would remain on all sides of the sump, there is some additional area of the screen which will not be blocked.

The screen facing the steam generator wall is computed to be not completely blocked. Most of the paint on concrete walls is computed not to reach the screen because of its relatively large thickness (≈25-30 mils). Of the remainder of the paint a fraction consisting of approximately 35 ft of paint from the ceiling plus about 30 ft of paint on pipes, supports, etc., is computed to reach the screen over about half its width. The remainder of the width is completely clogged by the ceiling paint and support paint. If there were no other debris against that side of the sump, the screen open area would be about 25 ft². With debris covering the bottom half of the screen, only about 12.5 ft² would remain open. This figure is equally applicable to either sump. Together with the free area at the very top of the screen, the total free area would be approximately 24 ft². This blockage would not impair the capacity of the ECCS sump to function, since as stated in Section 4, 19 ft² is sufficient.

The precise amount of fine screen area that can become clogged as a result of paint fragments raining to the surface of the water in the vicinity of the sumps (near-field effect) depends on several factors, some of which can be determined with good precision, while others have more uncertainty associated with them.

For the kind of analysis reported above the two factors influencing the results in the most direct manner are the drift velocity of the water in the pool and the settling (vertical) velocity of the paint fragment. is primarily a function of the water depth, the geometry of the pool (whether there are any obstacles) in the immediate vicinity of the sumps, and the flow through the ECCS pumps. Continuity (conservation of mass) enables the precise determination of the drift velocity of the water in the region of the pool close enough to the fine screens so that no obstacles are impeding flow to the screen, yet far enough away from it so that the screen effect is not felt; regardless of how much blockage may exist. Thus the pool velocity at the boundary of the "near field" is accurately known.

As seen in the preceding, it is about 0.04 fps at a distance of more than four feet away from the fine screen. The water velocity fields in the pool in the near-region up to the screens can be computed for different amounts of screen blockage by means of finite difference ,two dimensional computer models (which solve all of the conservation equations), as is shown in the preceding analyses. For the relatively simple geometries of sump and pool, the results obtained by these computer models are expected to be accurate.

The second factor, the settling (vertical) velocity of the paint fragment, depends on the local Reynolds number and the drag coefficient (and lift coefficient) assumed for the particle. The local Reynolds number depends on the relative velocity between fluid and particle, and this in turn depends on the settling velocity which depends on the drag and lift coefficients (in turn these are functions of the local Reynolds numbers). The largest amount of uncertainty

in the preceding calculations is associated with the value of drag coefficient assumed to represent the behavior of the paint particle. This affects the settling velocity and therefore the particle trajectory in water.

Uncertainty in the drag factor does not influence the extent of the region away from the screen from which any paint that can clog the screen must originate (i.e. 11.5 inches for concrete paint and about 4 feet for steel paint) since the local Reynolds number near the pool surface is known with good precision. It can however, affect the trajectory computed for the paint particle near the screens. There, if the paint fragments are computed to tumble and behave as equivalent spheres, then one is led to the 2" minimum free gap at the screen top. If larger drag coefficients are employed then one could conclude that less of a gap could remain, since trajectories would be affected.

In recognition of the uncertainty in the precise trajectory of the paint fragments, the amount of fine screen area that can become clogged by "near field" paint has also been evaluated in a different manner as described hereinafter.

A third very important factor not discussed so far, but one which can be precisely determined, is the total amount of paint which is in the region above the surface of the pool of water, close enough to the sumps, so that when falling to the pool, it can be transported to the screen. From the preceding that region is defined as an area surrounding each sump which extends 11.5 inches away from the edge of the sump top overhang for concrete paint and 4 feet for steel paint.

Teams of TUGCO personnel have inspected these areas and determined the quantity (in ft^2) of paint of either kind contained in an imaginary volume defined from the surface of the pool to the floor above (or further up if grating is present).

The quantities of paint determined to be present in the region of interest are shown in the following plan view. There the cross hatched region is the region

of interest for concrete paint while the dashed plus cross hatched region is the region of interest for steel paint. The figures shown are for combined steel and concrete paint surface area available.

Clearly the traditional amount of sump area blocked, in the absence of any other effect, will be the ratio of the available paint surface area to the screen surface area on a section by section basis. Since 4 feet defines the region of influence for steel paint, each screen has been divided into 4 foot segments and the fractional blockage of each segment has been computed as the ratio of the paint available per segment of screen segment area. Where the ratio is larger than 1, the particular screen segment is assumed to be totally blocked. Excess paint can also move laterally to help block adjacent segments. However, lateral movement cannot be more than about 4 feet for steel paint or 11.5 inches for concrete paint (for the same trajectory considerations given previously). Figure 8.2-6 shows the results of these calculations.

From Figure 8.2-6 it is clear that there are two regions in each sump where the sump screen area exceeds the amount of paint that can be deposited on it (from near field effects).

One of the important results of the finite difference analyses if the definition of the near sump flow field. As can be seen from the results, velocities near the sump are insufficient to transport debris or paint from other areas of the containment. Velocities computed in different locations of the containment lower elevation are on occasion sufficiently high to transport paint and debris along the floor. However, as the flow reaches the vicinity of the sump proper (i.e. within four to five feet) the flow velocities reduce to approximately 0.04 fps.

Any material or debris capable of clogging the sump screens which is carried by the fluid would thus be settling to the floor without further transport. Hence it is unlikely that any degree of accumulation of debris or paint transported along the floor from far regions of containment would occur right againt the sump (e.g. accumulation at an angle of repose against the screens). Therefore the far-field paint accumulation and near-field paint cloggings are not additive in realty even though they have been considered so, in the initial analysis which led to the 2" open area at the top of the fine screens.

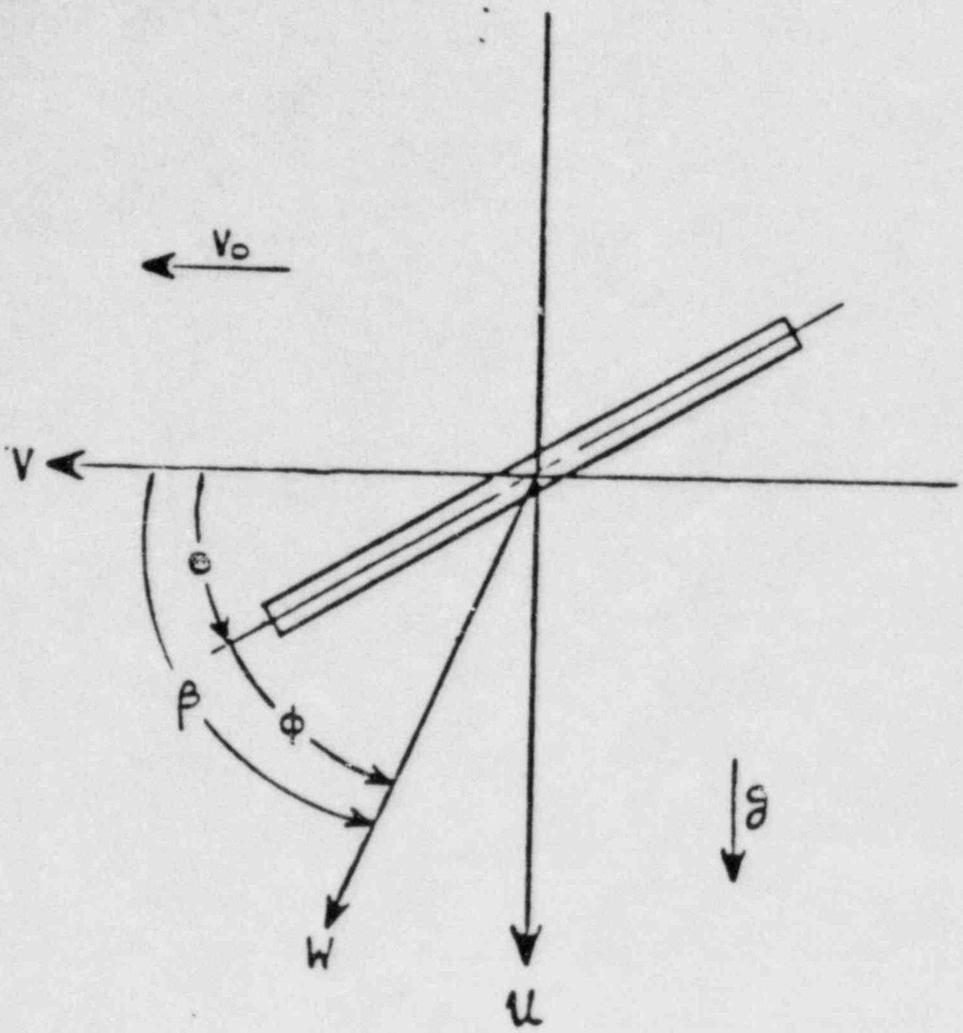


FIGURE 8.1-1

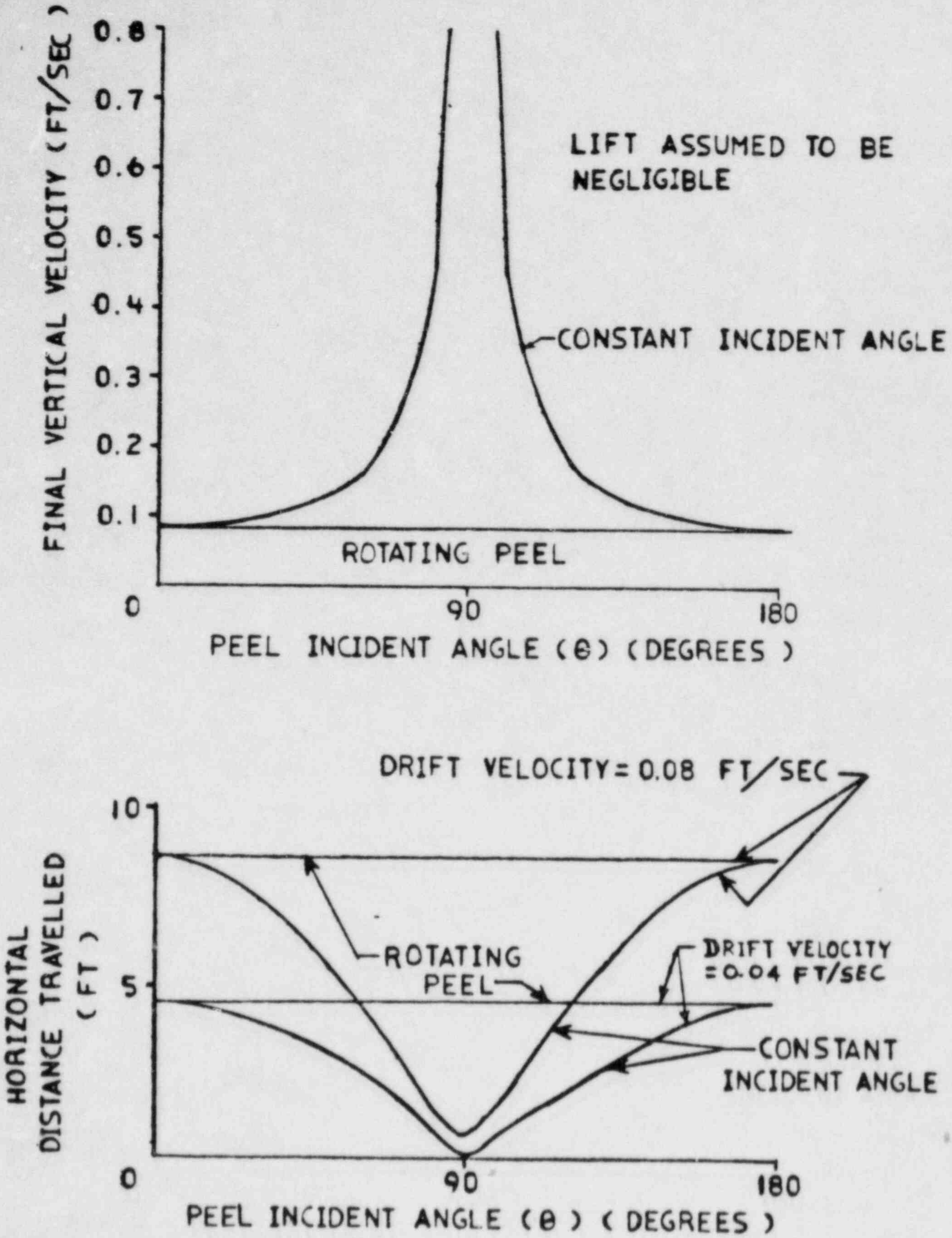

FINAL VERTICAL VELOCITY (FT/SEC)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
90
180
LIFT ASSUMED TO BE NEGLIGIBLE
CONSTANT INCIDENT ANGLE
ROTATING PEEL
PEEL INCIDENT ANGLE (θ) (DEGREES)
DRIFT VELOCITY = 0.08 FT/SEC
HORIZONTAL DISTANCE TRAVELLED (FT)
10
5
0
ROTATING PEEL
DRIFT VELOCITY = 0.04 FT/SEC
CONSTANT INCIDENT ANGLE
90
180
PEEL INCIDENT ANGLE (θ) (DEGREES)

FIGURE 8.1-2

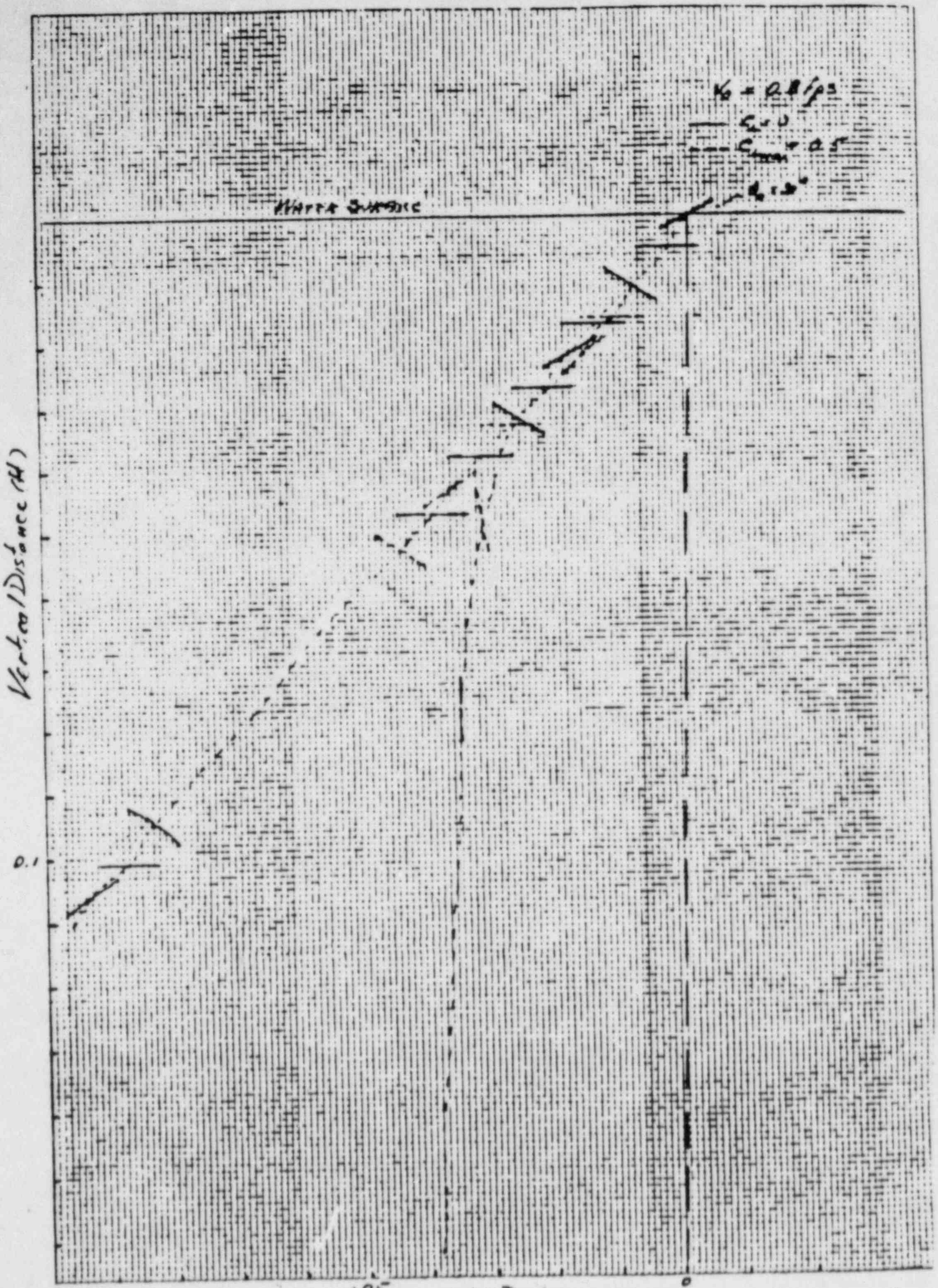
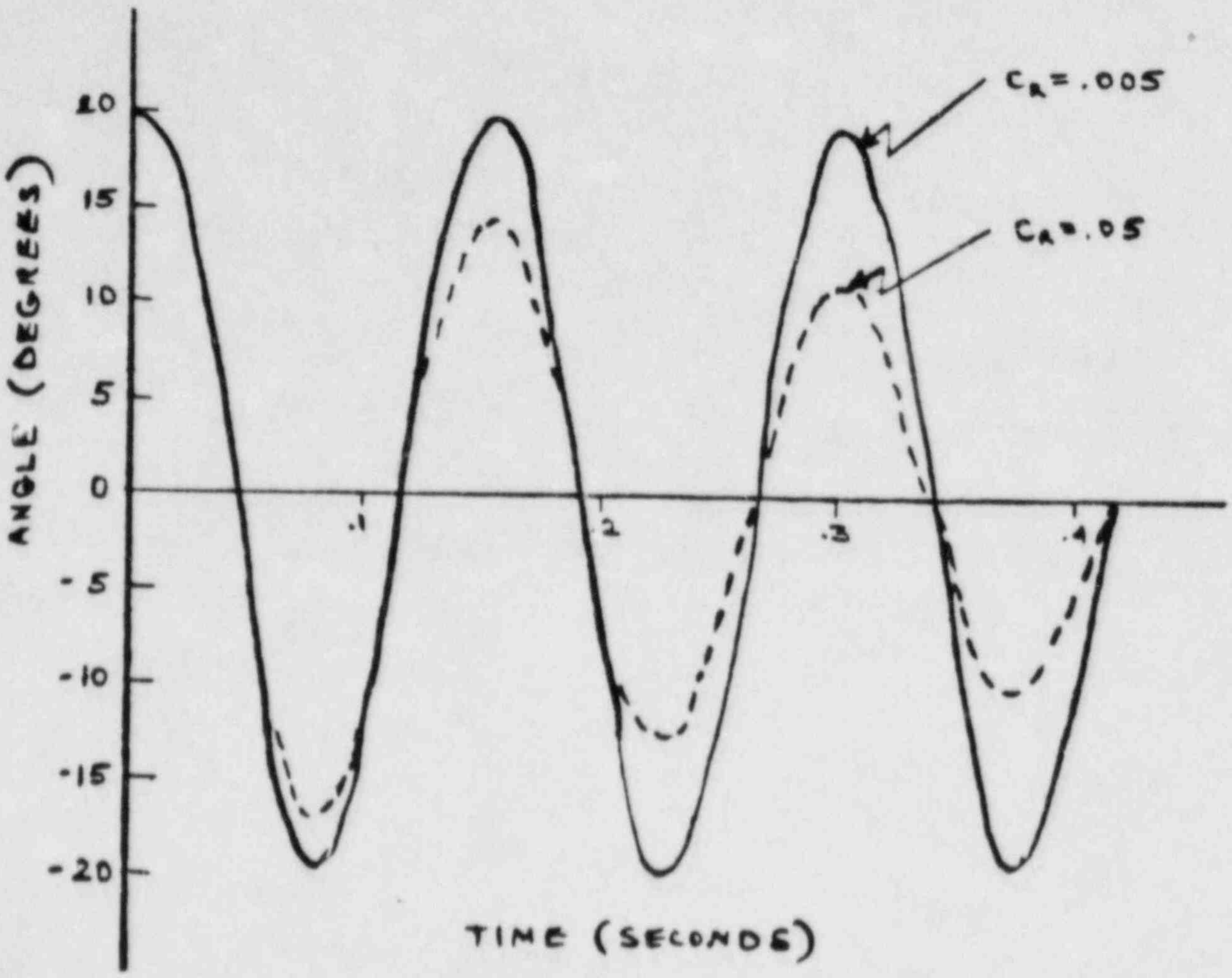

Water Surface
V_0 = 0.8 fps
C_L = 0
C_{Lmax} = 0.5
Vertical Distance (ft)
0.1
.05
0
Horizontal Distance (ft)

FIGURE 8.1-3



$C_R = .005$
$C_R = .05$
20
15
10
5
0
-5
-10
-15
-20
.1
.2
.3
.4
ANGLE (DEGREES)
TIME (SECONDS)

FIGURE 8.1-4

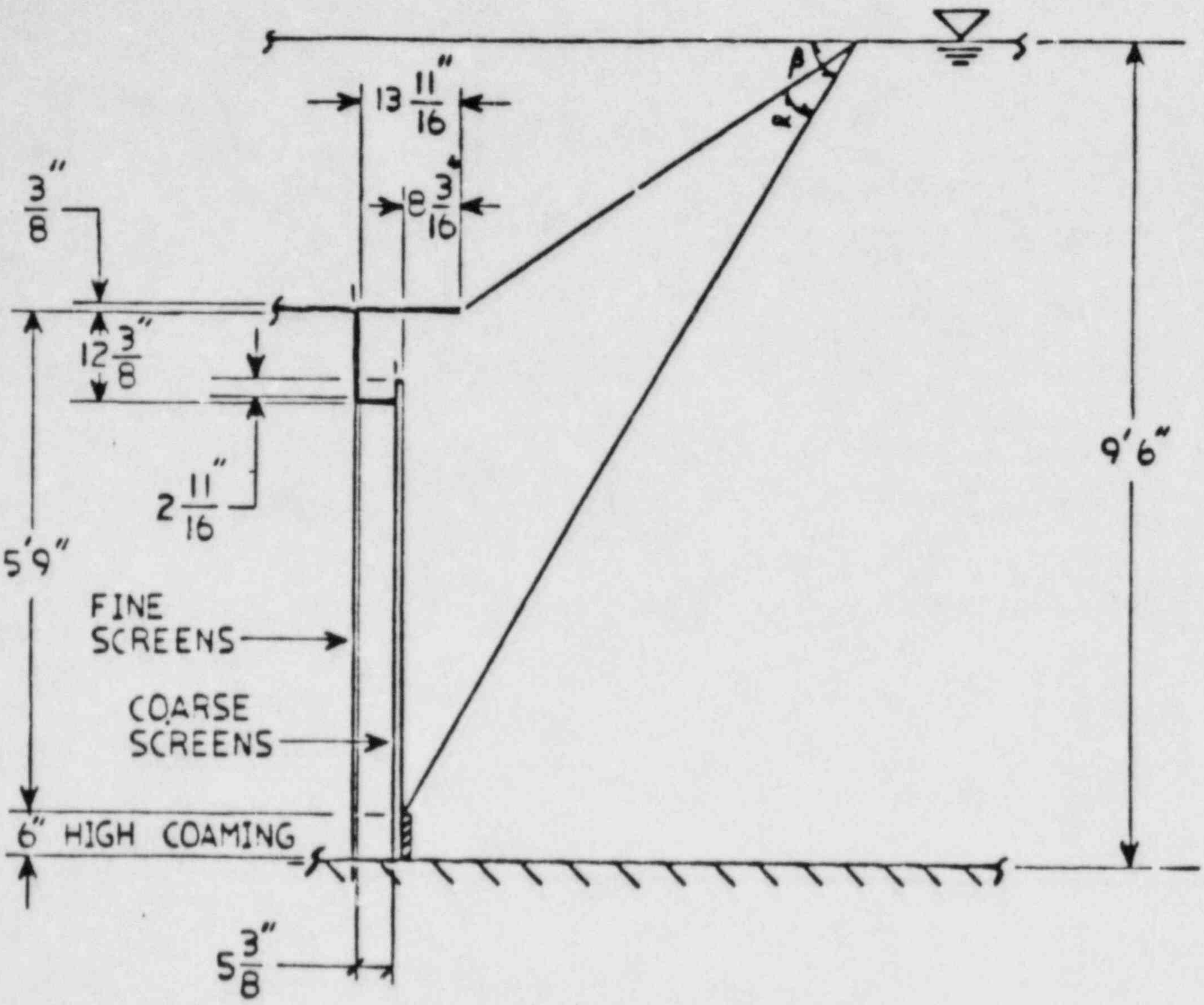
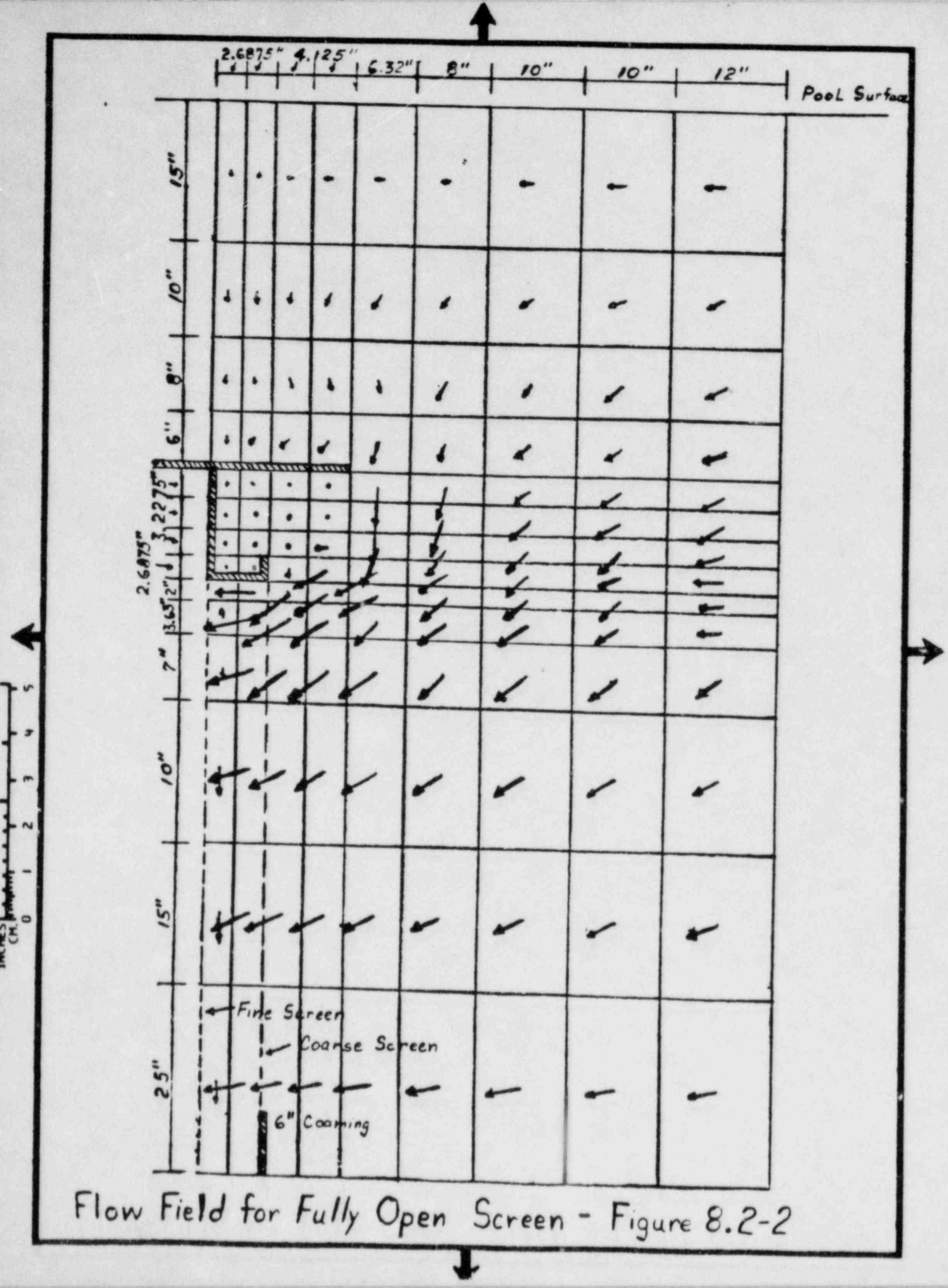
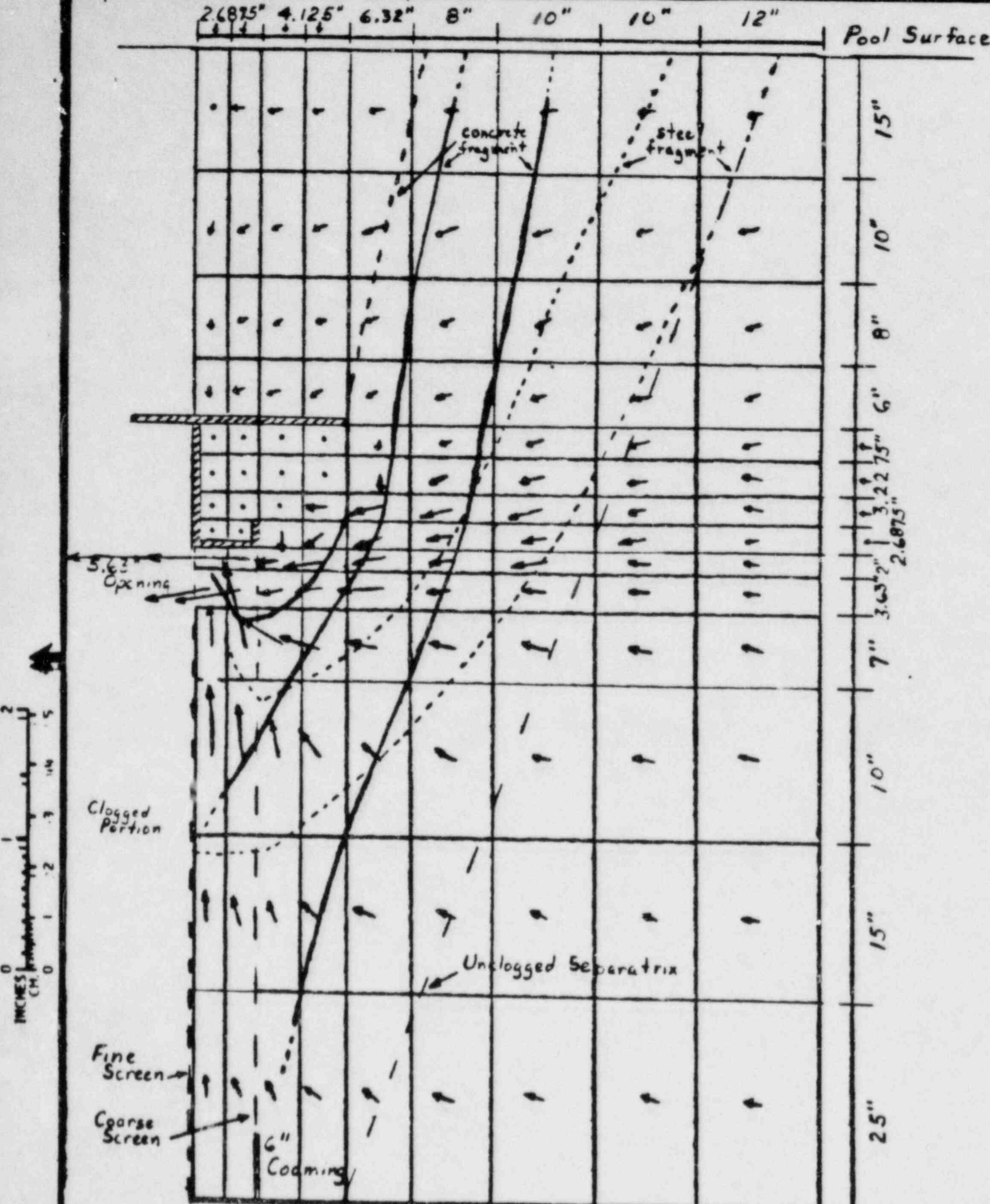


FIGURE 8.2-1

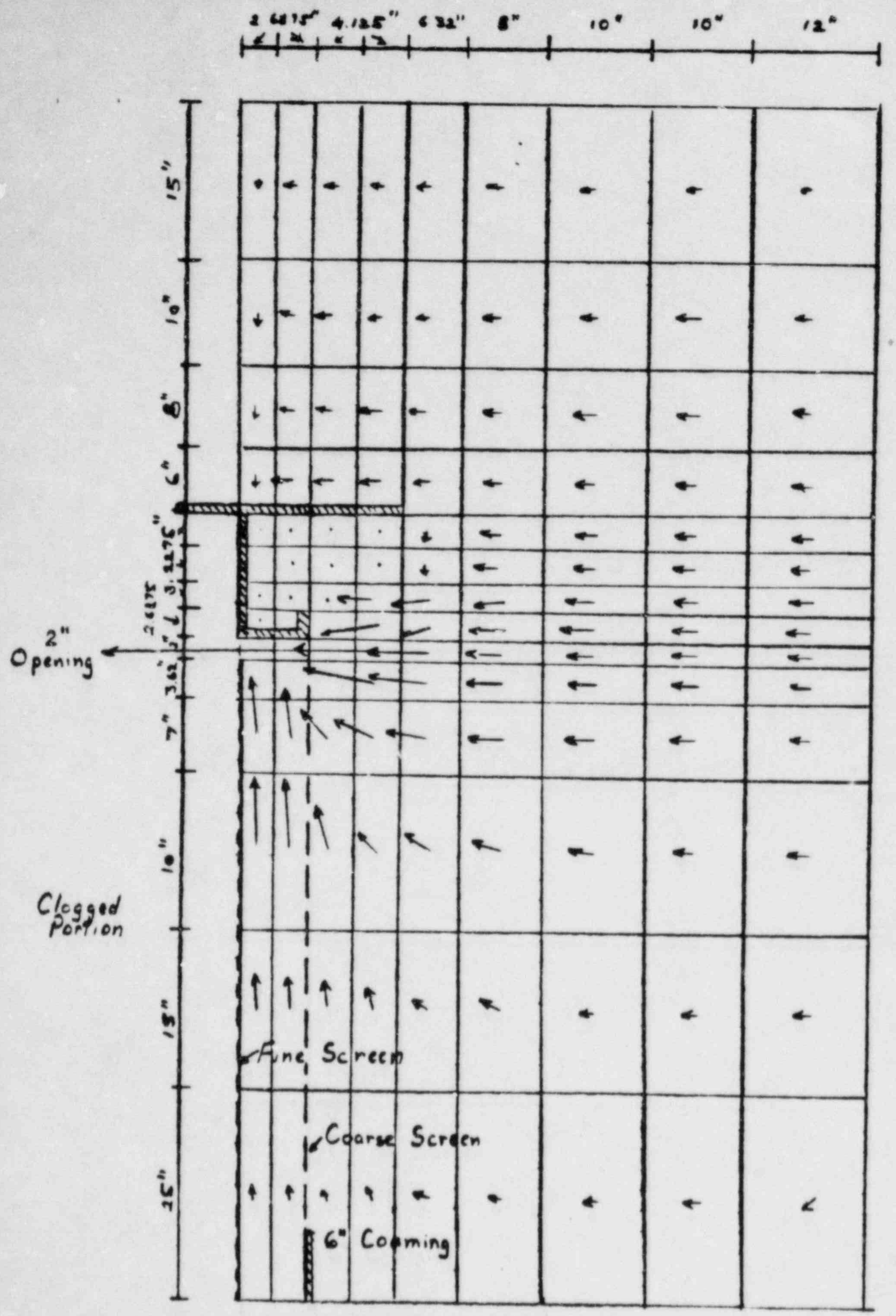
NOTE: NOT TO SCALE



Flow Field for Fully Open Screen - Figure 8.2-2



Flow Field for Screen with 5.63" Opening - Figure 8.2-3



Flow Field for Screen with 2" Opening - Figure 8.2-4

EQUIVALENT SPHERE - VERTICAL VELOCITY: 0.284 ft/sec — —

STEEL FRAGMENT - VERTICAL VELOCITY: 0.084 ft/sec ———

STEEL FRAGMENT - VERTICAL VELOCITY: 0.10 ft/sec - - - -

CONCRETE FRAGMENT - VERTICAL VELOCITY: 0.2 ft/sec — · —

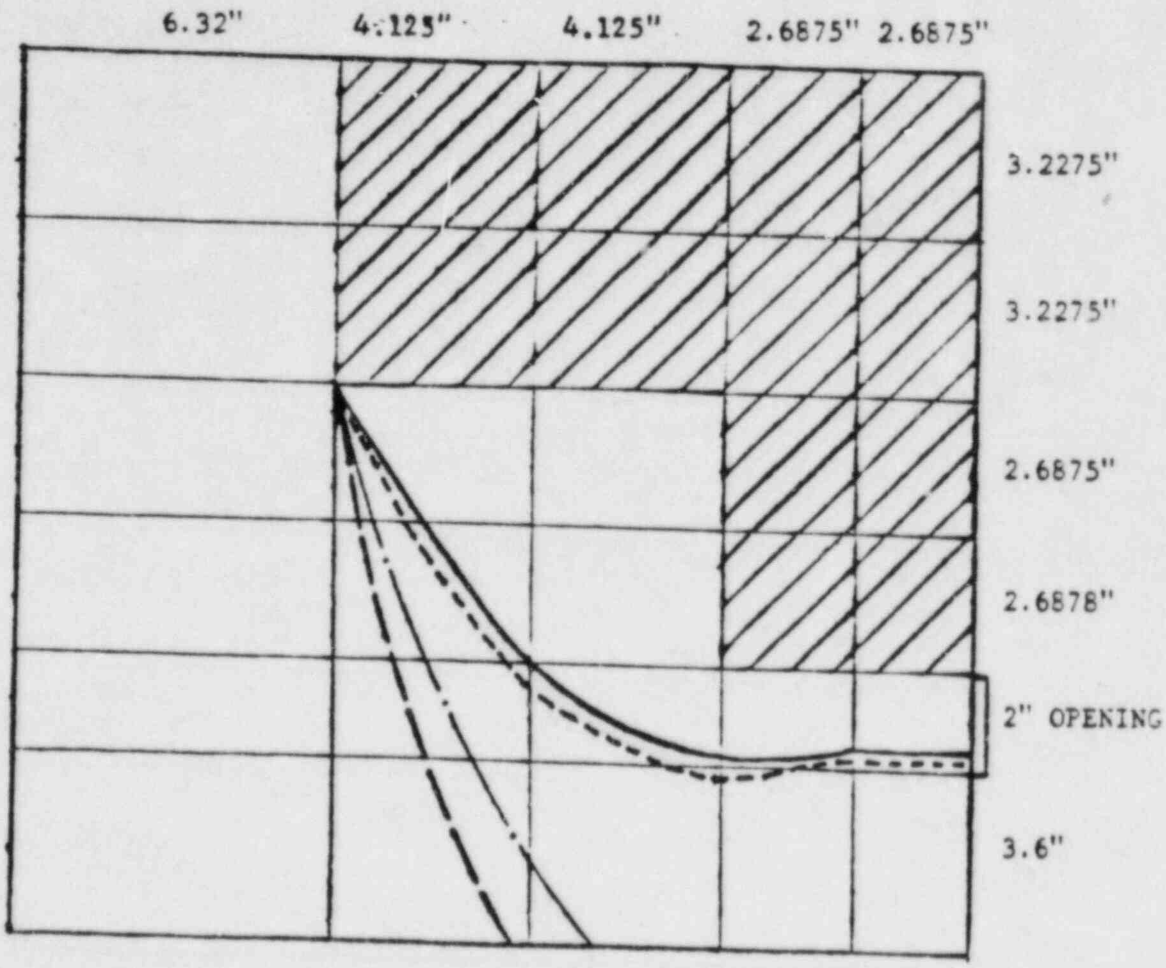


FIGURE 8.2-5

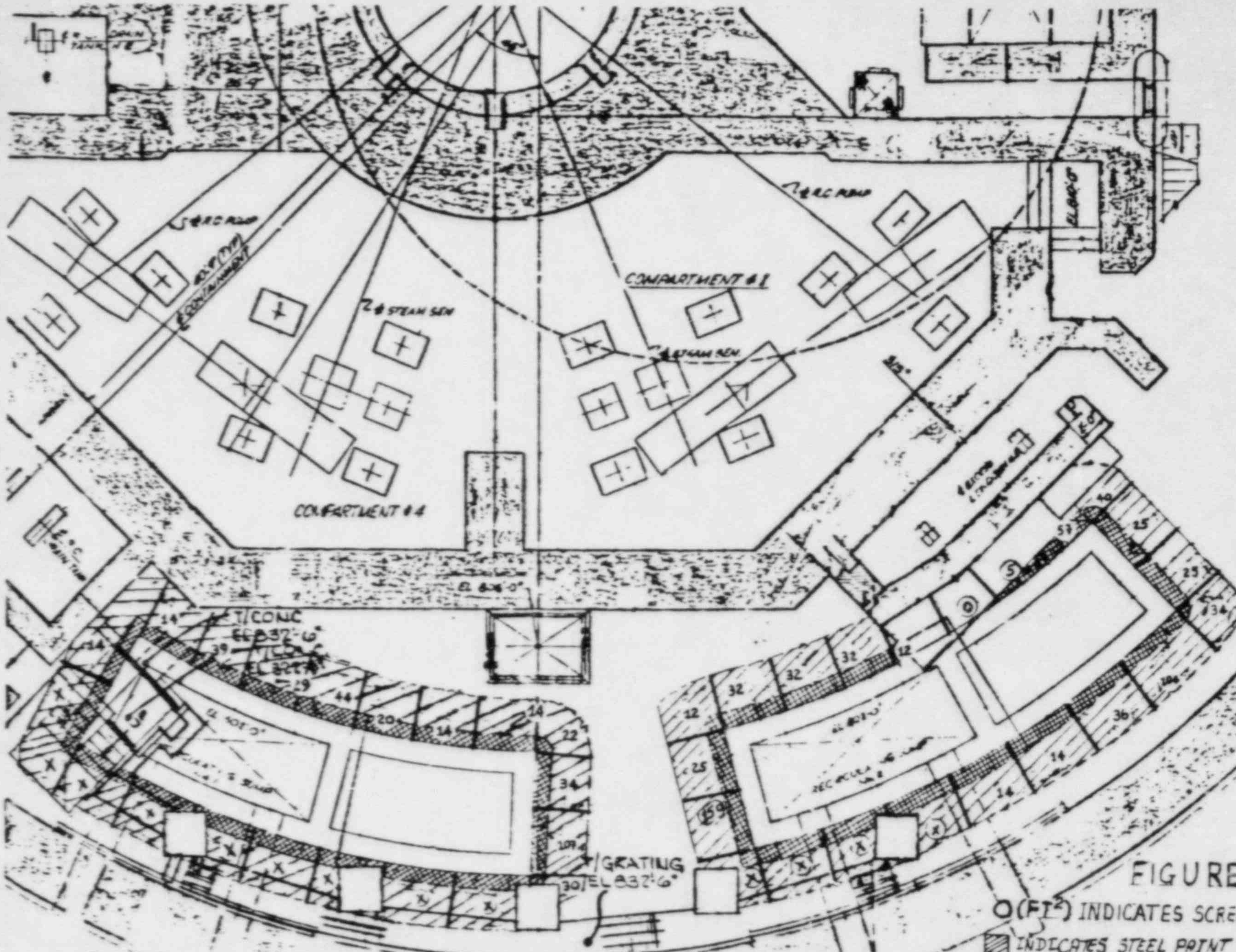


FIGURE 8.2-6

O(FT²) INDICATES SCREEN AREA BLOCKED BY PAINT

INDICATES STEEL PAINT WHICH CAN CLOG

INDICATES CONCRETE PAINT WHICH CAN CONTRIBUTE TO CLOGGING

③ CLOGGED. DUE TO GRATING ABOVE

REFERENCES

1) ANSI N101.2 - 1972 Protective Coatings (Paints) for Light Water Nuclear Reactor Containment Facilities

2) SSPC, Volume 1, Steel Structures Painting Manual, Chapter 23 - 1982

3) ASTM D772-47, Standard Method of Evaluating Degree of Flaking (Scaling) of Exterior Paints, Volume 06.01 - 1984

4) ASTM E714-56, Standard Method of Evaluating Degree of Blistering of Paints, Volume 06.01 - 1984

5) ASTM D660-44, Standard Method of Evaluating Degree of Checking of Exterior Paints, Volume 06.01 - 1984

6) NUREG/CR -2791

7) Regulatory Guide 1.82

8) Western Canada Hydraulic Laboratory Report, Dated November 1981

9) Open Channel Hydraulics, Vente Chow, McGraw Hill, 1959

10) Handbook of Hydraulics, Brater King, McGraw Hill, 5th Edition, 1963

11) Design of Small Dams, U.S. Department of Interior, Bureau of Reclamation, U.S. Government Printing Office, 1974

12) NUREG - 0897, Rev. 1 (Draft), June 1984

13) NUREG/CR - 3616

14) W.W. Willmarth, N.E. Hawk, and R.L. Harvey, "Steady and Unsteady Motions and Wakes of Freely Falling Disks," The Physics of Fluids, 7, 2, 197-208 (1964).

15) B. McCormick "Aerodynamics, Aeronautics, and Flight Mechanics," John Wiley & Sons, New York, 1979.

16) E.K. Marchildon, A. Clamen, W.H. Gauvin, "Oscillatory Motion of Freely Falling Disks," Physics of Fluids, 9, 2018 (1964).

17) A.W.W. Willmarth "Reply to Comments by E.K. Marchildon, A. Clamen, and W.H. Gauvin," The Physics of Fluids, 9, 2019 (1964).

SECTION 9.0

REVISED

AUGUST 14, 1984

9.0 DEBRIS EFFECTS ON EMERGENCY SUMPS

Each of the two containment recirculation sump screens has a total through-flow area of 386 sq ft. The sump screen design is in accordance with the requirements of Regulatory Guide 1.82 with a through-screen velocity of 0.11 fps. Figure 3.2-2 shows the arrangement of the Emergency Sumps.

The NPSH for RHR/SI pumps and containment spray pumps during the recirculation phase is given in Table 4.1-2.

Blockage of the sumps by debris will tend to increase the pressure losses across the sump screens. The increase in pressure losses will depend on the extent of the blockage and the porosity of the debris. The increase in pressure losses will reduce the available pump NPSH. This can have an adverse effect on the operation of the recirculation pumps, if it exceeds the margin between available and required NPSH.

For totally-impermeable debris, the pressure loss across the sump screens was calculated based on the area available for flow, excluding the projected blockage area.

The evaluation of fibrous insulation debris generation shows that there are no zones inside the containment where such insulation can fail and cause debris coincident with a demand for the emergency sump operation.

The insulation debris transport analysis discussed in Section 7.3 determined that the high efficiency insulation and metallic insulation will not be transported to the sump screens.

The only debris that has any potential for sump screen blockage is the paint debris. The quantity of paint that can be transported to the near sump zone is discussed in Section 6.2 (Paint Transport). Table 6.2-26 gives the quantity of paint that can be transported to the near sump zone. The sump screen blockage due to this paint debris was determined and combined with the sump screen blockage due to near sump effects discussed in Section 8.0.

9.1 Sump Screen Blockage by Far-Field Effects

Any paint debris that is transported to the sump by sliding along the concrete surface will accumulate on the floor. This is because the water velocity at the screens is much lower than the velocity required to put the debris into suspension. However, for a conservative first approximation, to determine if pressure losses are excessive, it was assumed that the screens will be blocked by the paint particles, forming a heap next to the screens with an angle of repose of 45 degrees.

For the purpose of this evaluation, the sump screens were divided into several sections. Figures 9.1-1 and 9.1-2 show the two sump screens and the designations for each screen section.

Paint debris transported to the near sump zone was discussed in Section 6.2 and quantified in Table 6.2-26. This paint debris was postulated to accumulate at each section of the sump screens.

The distribution of paint accumulation at each screen section depends upon:

- The proximity of the source of debris to the screen section.
- The direction of water flow.

For all screen sections the quantity of paint between 808'-0" and 832'-0" Elevations is equally distributed to each screen section. In addition the paint debris distribution is performed for various screen sections as shown in Table 9.1-1.

Tables 9.1-2 and 9.1-3 show the calculated paint debris accumulation at each sump screen section and the area of the screen that can be blocked.

9.2 Sump Screen Blockage by Near-Field Effects

Section 8.0 of this report evaluates the sump screen blockage potential by various mechanisms involving direct impingement of paint particles on the screen without settling to the containment floor. This evaluation shows that:

a. A band of 2-in. screen openings will always be available for flow.

b. The sump screen Sections B1, B6, B7, F4, F5, F6, H3 and H4 will only be partially blocked. This is because the available paint for these sections is less than the required quantity for maximum blockage (all the screen below 2 in. from the top of the screen).

9.3 Overall Debris Effects on Emergency Sumps

The combined blockage of the emergency sump screens due to far-field and near-field effects were calculated in order to assess the performance of the emergency sumps. Tables 9.3-1 and 9.3-2 summarize the results of the calculations for the screen blockage from far-field and near-field effects.

The blockage from far-field transport of paint debris was determined as discussed in Section 9.1 and presented in Tables 9.1- 2 and 9.1-3.

The blockage from near-field effects was based on evaluations presented in Section 8.0 and Figure 8.2-6. The area blocked by near-field effects is limited by the available quantity of paint and its trajectory for impingement on the screen as discussed in Section 9.2. Also, the near-field blockage cannot occur in the top 2-in. sections of the screens. In Tables 9.3-1 and 9.3-2, the near-field blockage is presented based on the values given in Figure 8.2-6. The open area of the screen available flow was calculated and presented in Tables 9.3-1 and 9.3-2. This information shows that about 24 sq ft of open screen area will be available for sump at Azimuth 15° and an open screen area of about 58 sq ft will be available for sump at Azimuth 330°. The open areas for the two sumps is considerably larger than the minimum required screen free area of 19 sq ft discussed in Section 4.0 of this report.

9.4 Emergency Sump Pressure Drop

The performance criteria for the emergency sumps are discussed in Section 4.0 of this report. Based on the summary of Western Canada Hydraulic Laboratories' test data presented in Table 4.1-3, the maximum head loss through the screens is about 0.4 ft with a screen opening of 24 sq ft. Accounting for this loss and using the data on ECCS pump characteristics given in Table 4.1-2, the NPSH margins for these pumps is as presented in Table 9.4-1. This table shows that the spray pumps have an NPSH margin of 5.81 ft and the RHR pumps have an NPSH margin of 4.23 ft. Thus, there is no degradation in the performance of the sumps or the ECCS pumps.

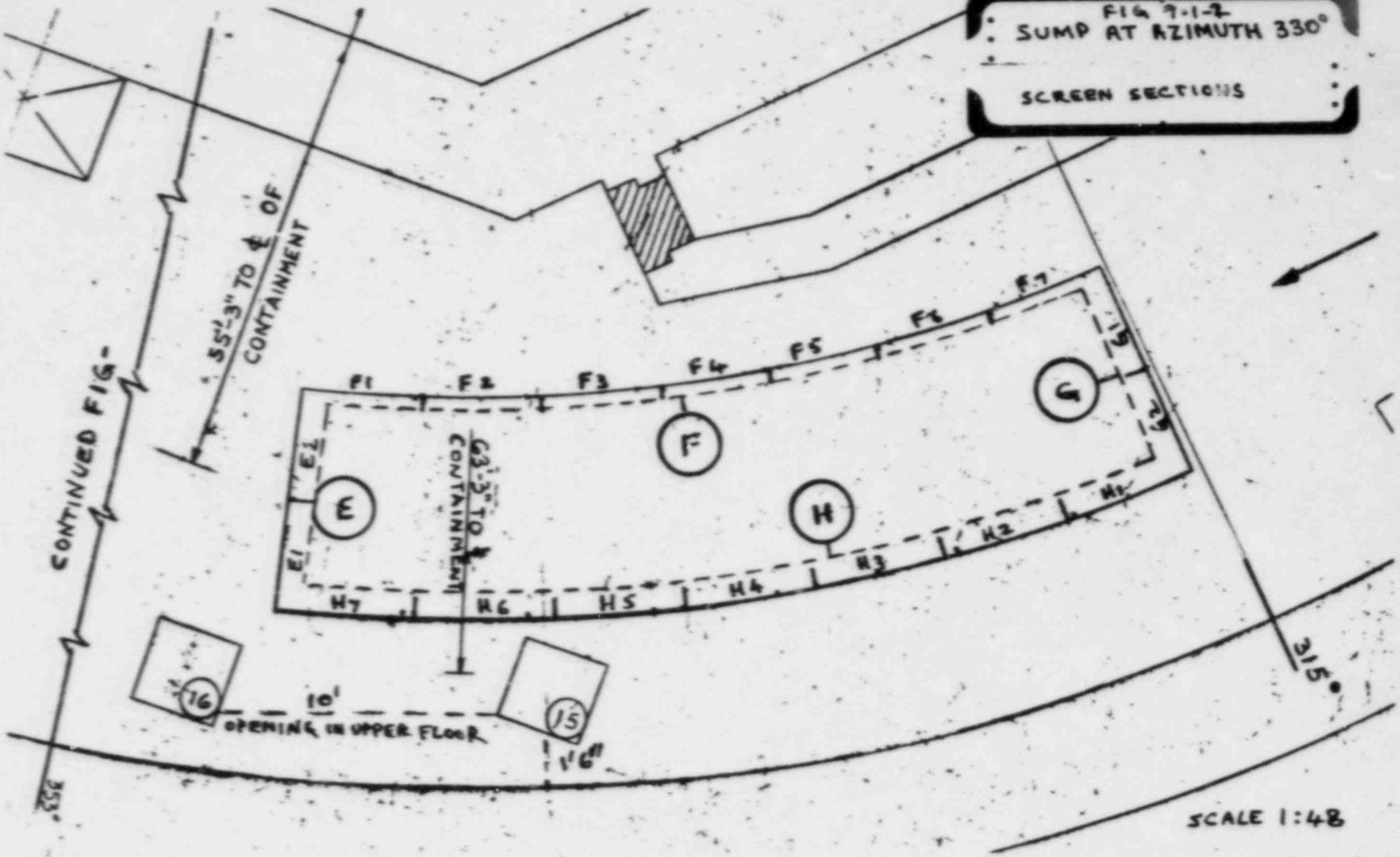
Based on the above evaluations for insulation and paint debris effects on the emergency sump performance, the following conclusions were arrived at:

a. Insulation has no potential for forming debris which can block the sump screens.

b. Paint debris accumulating in the near sump area resulting from all the coating systems failing in the containment cannot result in unacceptable sump screen blockage.

FIG 7.1-2
SUMP AT AZIMUTH 330°

SCREEN SECTIONS



SCALE 1:48

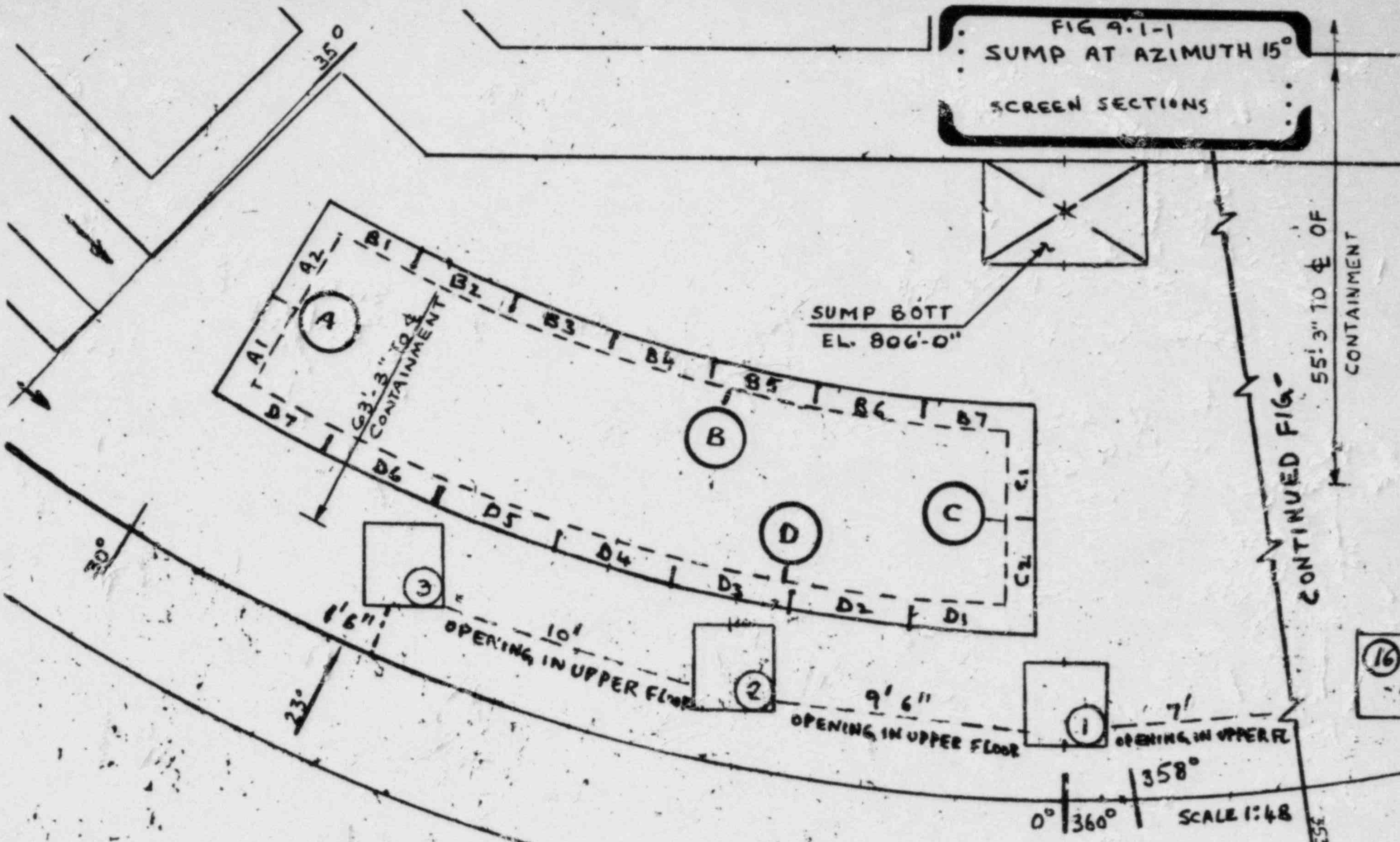


FIG 9.1-1
SUMP AT AZIMUTH 15°
SCREEN SECTIONS
SUMP BOTT
EL. 806'-0"
55' 3" TO ℄ OF
CONTAINMENT
63'-3" TO ℄
CONTAINMENT
CONTINUED FIG-
A
B
C
D
A1
A2
B1
B2
B3
B4
B5
B6
B7
C1
C2
D1
D2
D3
D4
D5
D6
D7
1
2
3
16
10'
OPENING IN UPPER FLOOR
9' 6"
OPENING IN UPPER FLOOR
7'
OPENING IN UPPER FL
1'6"
350
30°
23°
358°
0°
360°
353°
SCALE 1:48

TABLE 9.1-1

SOURCE OF PAINT DEBRIS ON
SUMP SCREEN SECTIONS

SCREEN SECTION	DEBRIS SOURCES (NOTE 1): LINER PLATE AZIMUTH RANGE	DEBRIS SOURCES (NOTE 1): UPPER FLOOR (NOTE 2) EQUIV. LENGTH, FT.	
A1 & A2	0	0	NOTE 3
B1 TO B7	0	0	
C1 & C2	353-358	7.0	
D1 & D2	358-12	9.5	
D3 TO D5	12-23	11.5	
D6 & D7	23-35	0	NOTE 3
E1 & E2	348-353	2.5	
F1 TO F7	0	0	
G1 & G2	0	0	
H1 TO H5	315-337	0	
H6 & H7	337-348	11.5	

NOTES:

1. PAINT DEBRIS IN AZIMUTHS 30-0-315 BETWEEN ELEVATIONS 808'0" AND 832'0" IS UNIFORMLY DISTRIBUTED FOR EACH SECTION OF THE SCREEN.

2. PAINT DEBRIS FROM THE UPPER ELEVATIONS IS DISTRIBUTED BASED ON THE OPENING LENGTH (GRATINGS) AT THE 832'0" ELEVATION IN THE 60-0-315 AZIMUTH RANGE.

3. ALL PAINT DEBRIS IN SUBCHANNEL 4B (INCLUDING LINER PLATE) IS DEPOSITED ON SCREENS A1,A2,D6 AND D7. THE DEBRIS FROM THE STEAM GENERATOR SIDE OF THE SUB-CHANNEL 4B IS DEPOSITED ON SECTIONS A1 AND A2. THE BALANCE (LINER SIDE) IS DEPOSITED ON SECTIONS D6 AND D7.

TABLE 9.1-2

PAINT DEBRIS TRANSPORTED TO THE SUMP AT AZIMUTH 15

SCREEN SECTION	LENGTH FT.	DEBRIS CU.FT.	DEBRIS HEIGHT,FT	AREA BLOCKED SQ.FT.
A1	3.34	5.07	1.74	5.82
A2	3.34	5.07	1.74	5.82
B1	3.86	1.63	0.92	3.55
B2	3.86	1.63	0.92	3.55
B3	3.86	1.63	0.92	3.55
B4	3.86	1.63	0.92	3.55
B5	3.86	1.63	0.92	3.55
B6	3.86	1.63	0.92	3.55
B7	3.86	1.63	0.92	3.55
C1	3.34	15.96	3.09	10.32
C2	3.34	15.96	3.09	10.33
D1	4.29	23.49	3.31	14.19
D2	4.29	23.49	3.31	14.19
D3	4.29	17.94	2.89	12.40
D4	4.29	17.94	2.89	12.40
D5	4.29	17.94	2.89	12.40
D6	4.29	14.01	2.56	10.96
D7	4.29	14.01	2.56	10.96

TABLE 9.1-3

PAINT DEBRIS TRANSPORTED TO
THE SUMP AT AZIMUTH 330

SCREEN SECTION	LENGTH FT.	DEBRIS CU.FT.	DEBRIS HEIGHT,FT	AREA BLOCKED SQ.FT.
E1	3.34	6.33	1.95	6.50
E2	3.34	6.33	1.95	6.50
F1				
F2	3.86	1.48	0.88	3.38
F3	3.86	1.48	0.88	3.38
F4	3.86	1.48	0.88	3.38
F5	3.86	1.48	0.88	3.38
F6	3.86	1.48	0.88	3.38
F7	3.86	1.48	0.88	3.38
	3.86	1.48	0.88	3.38
G1				
G2	3.34	2.56	1.24	4.13
	3.34	2.56	1.24	4.14
H1				
H2	4.29	26.95	3.55	15.20
H3	4.29	26.95	3.55	15.20
H4	4.29	3.30	1.24	5.32
H5	4.29	3.30	1.24	5.32
H6	4.29	3.30	1.24	5.32
H7	4.29	3.30	1.24	5.32
	4.29	3.30	1.24	5.32

TABLE 9.3-1

SUMMARY OF SCREEN BLOCKAGE FOR
SUMP AT AZIMUTH 15

SCREEN SECTION	SCREEN AREA,SQFT	AREA BLOCKED FAR FIELD	AREA BLOCKED NEAR FIELD	AREA FREE TOTAL SQ.FT.
A1	19.18	5.82	12.81	0.55
A2	19.18	5.82	12.81	0.55
B1	22.18	3.55	14.00	4.63
B2	22.18	3.55	17.99	0.64
B3	22.18	3.55	17.99	0.64
B4	22.18	3.55	17.99	0.64
B5	22.18	3.55	17.99	0.64
B6	22.18	3.55	14.00	4.63
B7	22.18	3.55	14.00	4.63
C1	19.18	10.32	8.30	0.56
C2	19.21	10.33	8.32	0.56
D1	24.64	14.19	9.74	0.71
D2	24.64	14.19	9.74	0.71
D3	24.64	12.40	11.53	0.71
D4	24.64	12.40	11.53	0.71
D5	24.64	12.40	11.53	0.71
D6	24.64	10.96	12.97	0.71
D7	24.64	10.96	12.97	0.71
TOTAL FREE AREA, SQ.FT. =				23.64

TABLE 9.3-2

SUMMARY OF SCREEN BLOCKAGE FOR
SUMP AT AZIMUTH 330

SCREEN SECTION	SCREEN AREA.SQFT	AREA BLOCKED FAR FIELD	AREA BLOCKED NEAR FIELD	AREA FREE TOTAL SQ.FT.
E1	19.18	6.50	12.12	0.56
E2	19.18	6.50	12.12	0.56
F1	22.18	3.38	18.16	0.64
F2	22.18	3.38	18.16	0.64
F3	22.18	3.38	18.16	0.64
F4	22.18	3.38	12.00	6.80
F5	22.18	3.38	0.00	18.80
F6	22.18	3.38	5.00	13.80
F7	22.18	3.38	18.16	0.64
G1	19.18	4.13	14.49	0.56
G2	19.21	4.14	14.51	0.56
H1	24.64	15.20	8.73	0.71
H2	24.64	15.20	8.73	0.71
H3	24.64	5.32	14.00	5.32
H4	24.64	5.32	14.00	5.32
H5	24.64	5.32	18.61	0.71
H6	24.64	5.32	18.61	0.71
H7	24.64	5.32	18.61	0.71
TOTAL FREE AREA, SQ.FT. =				58.39

TABLE 9.4-1

SPRAY AND RHR PUMP NPSH

Parameter	Pump CSS	Pump RHR
Loss through screen with 24 ft^2 area, ft	0.4	0.4
Water elevation to supply required NPSH, ft[1]	1.02	2.6
Water elevation available, ft[1]	6.83	6.83
NPSH margin, ft	5.81	4.23

[1] Ft above containment floor (El. 808 ft)

Gibbs & Hill, Inc.

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H. C. SCHMIDT

August 3, 1984

GTN- 69312

Texas Utilities Generating Company
Skyway Tower
400 North Olive Street LB 81
Dallas, Texas 75201

Attention: Homer C. Schmidt
Project Manager - Nuclear Power Plants

Gentlemen:

TEXAS UTILITIES GENERATING COMPANY
COMANCHE PEAK STEAM ELECTRIC STATION
G&H PROJECT NO. 2323
GIBBS & HILL PAINT REPORT

Per your request we are attaching the following information for your review and transmittal to the NRC:

1. Responses to NRC Questions
2. Addendum-1 to the report
3. Errata for the report

Very truly yours,

GIBBS & HILL, INC.

S M Marano

Robert E. Ballard, Jr.
Director of Projects

REBa-MC-DCP:sce
1 Letter + Attachments

cc: ARMS (B&R Site) OL
J.T. Merritt (TUSI Site) 1L
R. Tolson (TUSI Site) 1L + Attachments
R. Iotti (TUSI Site) 1L + Attachments

RESPONSE TO QUESTIONS

Question 1:

Provide a detailed analysis to verify the velocities presented in Table 5.4-11 using the area surrounding Sub-Channel 4A as a typical case where flow streams from Channels 5 and 8 mix. Evaluate the possibility of flow variations which may result in velocities greater than those presented in the report.

Response:

Attached Figure-1 shows the area in question in more detail than shown in the report. Flows at Sub-Channel 4A come from door 4 (Channel 5) and the containment annulus (Channel 8).

Table 5.4-11, "Total Velocity - Two Trains, Low Level", shows that the flow rate (Q) in Channel 5 is 5.26 cubic feet per second (cfs). At the top of a short flight of steps (section 5G), the water depth is 2.8 feet and the width (W) of the channel is 5 feet. Since this area is free of obstructions, the velocity (V) is 0.38 feet per second (fps). At the bottom of the steps the water depth is 6.8 feet and the velocity drops to 0.16 fps, well below the critical velocity of 0.27 fps required for transport. Thus all the debris would be retained upstream of Channel 5H prior to entering the mixing zone. At the exit from this region, section 5H, the velocity increases to 0.23 fps, still below the critical velocity.

The flow coming around the annulus (Channel 8) is 10.79 cfs, from Table 5.4-11. Section 8C is a choke point with a width of 5 feet. The resulting velocity is 0.30 fps. This flow decreases between section 8C and 8D, to a velocity of 0.20 fps. Thus, the velocity drops below critical approximately half way between these two sections and the debris would be retained upstream of Sub-Channel 8D. Entering Sub-Channel 4A, there are two streams of approximately equal velocity, both below the critical velocity. The velocities will decrease further as they enter the free space at Sub-Channel 4A, and will be below critical. As the water enters the narrow area approaching Sub-Channel 4B1, its velocity will increase, reaching an average of 0.32 fps.

In addition to the velocity distribution analysis of Sub-Channel 4A, Sub-Channel 3A and 3B were also analyzed for completeness. Figure-2 attached shows Sub-Channel 3A in more detail. The flows to Sub-Channel 3B come from Door 1 (Channel 6) and the containment annulus (Channel 2). From Table 5.4-11 of the

report, the flow rate in Channel 6 is 6.19 cfs and the flow rate in Channel 2 is 15.08 cfs.

As shown in Figure-2, the Channel 6 flow from steam generator compartment #1 passes through the door opening (Sub-Channel 6G) with a water depth of 2.8 feet and a clear length of 4.75 feet. This flow passes over few steps to 808 feet elevation (Sub-Channel 6H) and continues through Sub-Channel 6I. The flow length at Sub-Channel 6I is 5 feet and the water velocity is 0.19 fps. Similarly, the velocity at Sub-Channel 3A in the containment annulus is 0.10 fps.

Thus the two streams are at velocities less than the critical velocity required to transport debris. Entering Sub-Channel 3A1, these two streams mix to give an average velocity of 0.19 fps. Thus for Channel 3, the velocity throughout the path will be considerably less than the critical velocity required to transport debris.

FIGURE-1 OF ADDENDUM TO REPORT ON "EVALUATION OF PAINT AND INSULATION DEBRIS EFFECTS ON CONTAINMENT EMERGENCY SUMP PERFORMANCE"

AUGUST 1984

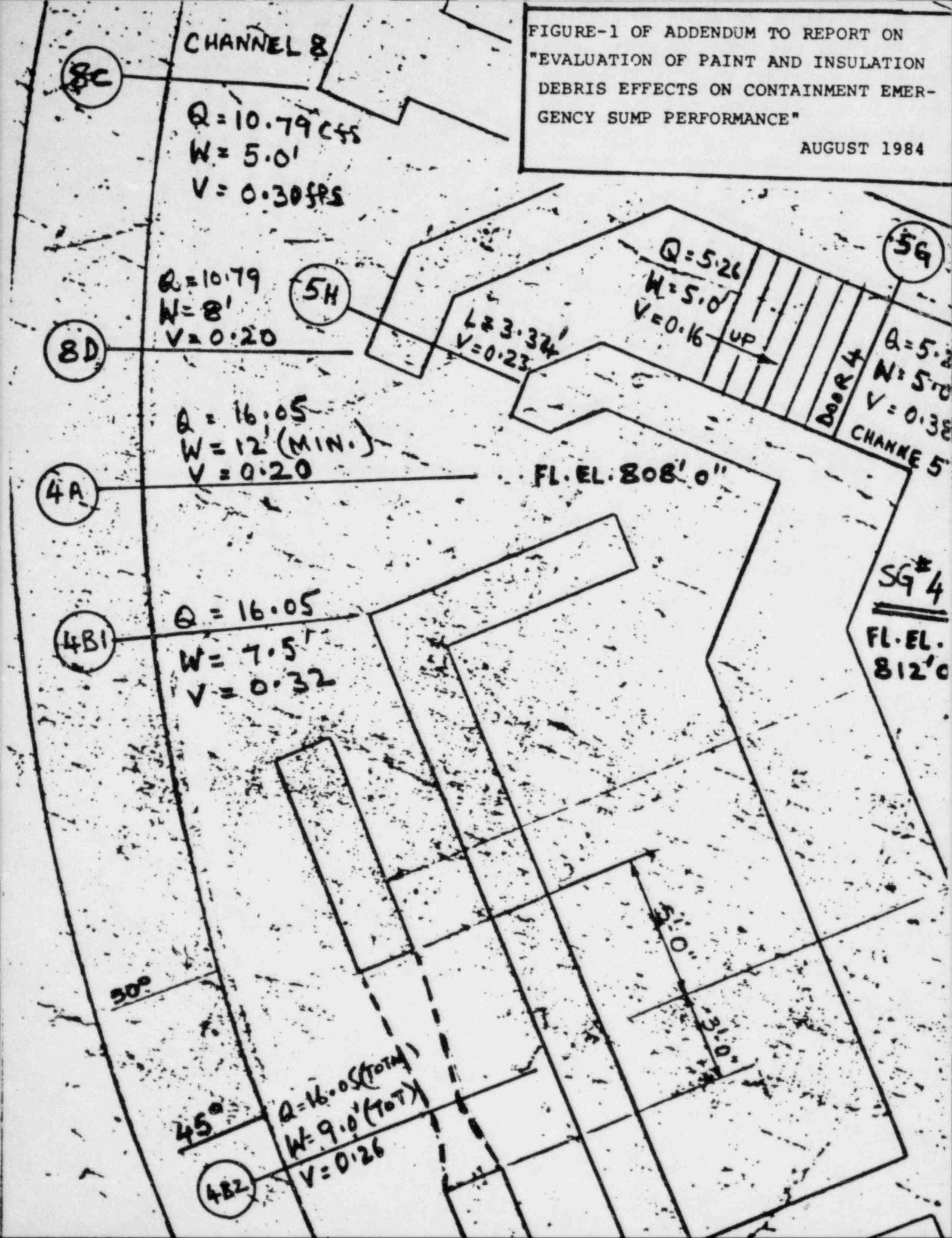
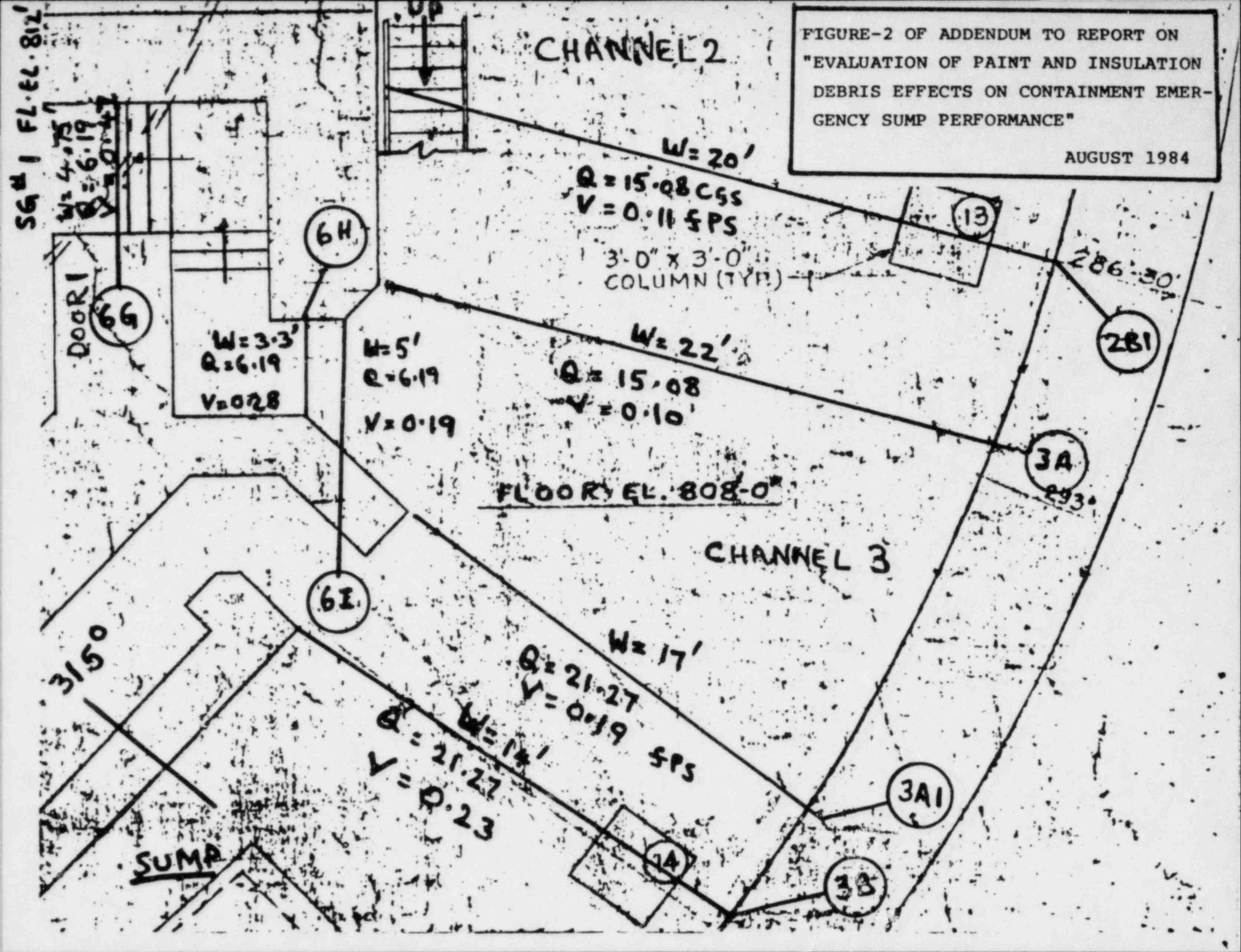


FIGURE-2 OF ADDENDUM TO REPORT ON "EVALUATION OF PAINT AND INSULATION DEBRIS EFFECTS ON CONTAINMENT EMERGENCY SUMP PERFORMANCE"

AUGUST 1984



Question 2:

In Table 5.1-1, the source of water from reactor coolant is specified as 12,740 cu.ft. for both maximum and minimum water inventories in the containment sump. Quantify the difference it may have between maximum and minimum and its effects to minimum water level, and water velocities in the flow channel.

Response:

The minimum quantity of reactor coolant inventory is calculated to be 12,000 cu. ft. The corresponding minimum water level will be 6.73 ft., instead of 6.8 ft. The variation in the level is less than 2 percent and is well within the accuracy of this evaluation. The results of the calculations for velocities are based on conservative field measurements of obstructions and flow openings which have a margin of 2 to 10 percent on the conservative side. In addition the water levels in the containment are calculated without taking credit for submerged piping, supports and equipment. For this evaluation, it is estimated that the actual water levels will be higher than the conservative values presented in the report.

Based on this, the flow velocities in the report will not change.

Question 3:

Justify the use of flow resistance term used in Table 5.4-2 to 5.4-10 as L/A instead of (L/A) Pw, where Pw is the wetted perimeter.

Response:

The use of L/A for flow resistance was based on the NUREG/CR-2791 Table C-8 calculations. This approach was used to maintain the paint transport analysis, similar to the NUREG methodology for insulation. The flow distribution determined from use of L/A and L/D are generally in agreement; see attached Table 5.4-11 (ALT) corresponding to Table 5.4-11, where L/D was used for flow distribution. The velocities calculated by either approach give very low values for Sub-Channels 3A and 4A (near sump areas) which are significantly below the critical velocity of 0.27 fps required for transport.

TABLE 5.4-11 (ALT)
TOTAL VELOCITY-TWO TRAINS, LOW LEVEL

WATER HT= 814.80 FLOWS,CFS:SPRAY= 25.87 ,RHR/SI= 11.45

CHANNEL NO.	BRANCH NO.	SPRAY FLOW CFS	SPRAY VELOCITY FPS	RHR/SI FLOW CFS	RHR/SI VELOCITY FPS	TOTAL VELOCITY FPS
5	DOOR 4	0.00	0.00	5.30	0.58	0.58
5	A4		0.00		0.35	0.35
5	B4		0.00		0.17	0.17
5	C4		0.00		0.14	0.14
5	D4		0.00		0.09	0.09
5	E4		0.00		0.09	0.09
5	F4		0.00		0.29	0.29
6	A1	0.00	0.00	6.15	0.40	0.40
6	B1		0.00		0.20	0.20
6	C1		0.00		0.16	0.16
6	D'		0.00		0.11	0.11
6	E1		0.00		0.11	0.11
6	F1		0.00		0.33	0.33
6	DOOR 1		0.00		0.67	0.67
7	DOOR 3	6.14	0.67	0.00	0.00	0.67
7	A3		0.40		0.00	0.40
7	B3		0.20		0.00	0.20
7	C3		0.16		0.00	0.16
7	D3		0.11		0.00	0.11
7	E3		0.11		0.00	0.11
7	F3		0.33		0.00	0.33
7	A2		0.40		0.00	0.40
7	B2		0.20		0.00	0.20
7	C2		0.16		0.00	0.16
7	D2		0.11		0.00	0.11
7	E2		0.11		0.00	0.11
7	F2		0.33		0.00	0.33
7	DOOR 2		0.67		0.00	0.67
8	A	12.95	0.36	0.00	0.00	0.36
8	B		0.16		0.00	0.16
1	A	6.81	0.08	0.00	0.00	0.08
1	B		0.25		0.00	0.25
1	C		0.06		0.00	0.06
2	A	12.92	0.11	0.00	0.00	0.11
2	B		0.17		0.00	0.17
2	C		0.13		0.00	0.13
3	A	12.92	0.09	6.15	0.04	0.13
3	B		0.15		0.07	0.22
4	A	12.95	0.10	5.30	0.04	0.14
4	B		0.34		0.14	0.47
4	C		0.13		0.05	0.18

Question 4:

Justify the conservatism of the assumption in Section 6.2-4 that the source of all the spray flow will be at azimuth 225 degrees.

Response:

The bulk of the containment spray flows from upper elevations to the 808 ft. elevation from the openings in the floors which do not have curbs. Referring to Table 6.2-24, it can be seen that most of these openings are in the zone between azimuth 180 degrees to 270 degrees resulting in an average location of 225 degrees. In assuming that all the spray flow originates at azimuth 225 degrees the calculated velocities at all points downstream of azimuth 225 degrees, will be maximized. Thus, the source of water farthest from the sumps and the maximized velocities provide the worst case for paint transport. Therefore this approach is conservative.

Question 5:

Provide the bases of the assumption that paint debris at 808 degrees elevation is available for transport within the near sump zone azimuth 45-0-315 degrees.

Response:

(Later. The response needs coordination with Section 8.0 results)

Question 6:

The application of leak before break has not been found acceptable for the purpose of calculating debris generation. The assumption of leak before break was used in Chapter 7. Revise the assumption in accordance with the current acceptable spectrum of breaks.

Response:

See attached Addendum-1 to the report.

ADDENDUM 1
July, 1984

selected for further investigation. The evaluation concentrates on the breaks which generate the maximum amount of debris and where debris transport to the sump is relatively direct. Two of the breaks release reflective metallic insulation and also cause activation of safety injection and containment sprays. The other breaks release fibrous insulation. The quantity of fibrous insulation used inside containment is limited to component cooling water and chilled water piping. This type of insulation is not located in any of the containment areas where high energy large breaks can release this insulation material to form debris. None of the breaks in the vicinity of the fibrous insulation are of the magnitude which would cause the activation of the safety injection or containment sprays. Therefore, the availability of the safeguards sumps is not required and sump blockage is not a concern. The quantities of debris generated are presented in Tables 7.2-1 through 7.2-5 for information purposes only.

High efficiency insulation was also evaluated. This insulation, which is a mineral wool type, 1/4-inch thick, is fully encapsulated in 1/8-inch thick sheeting of type 304 SS. The insulation is located at pipe whip restraints and in the gap between the restraints and the pipe.

7.2.2 Quantity of Insulation Debris

The quantities of fibrous insulation generated from various postulated breaks are shown on Tables 7.2-1 through 7.2-5. Short term transport of fibrous insulation was not analyzed because it was assumed to be transported to the sumps.

In the case of high efficiency insulation, it was conservatively assumed that insulation from five pipe whip restraints of safety injection pipes would be dislodged as a result of jet impingement from a pipe break. This resulted in the generation of about 40 square feet of high efficiency insulation.

The quantities of metallic insulation generated from the postulated breaks are shown on Tables 7.2-6 and 7.2-7. Table 7.2-6 is for primary coolant hot leg break. Although reactor coolant loop breaks are not postulated as credible in view of the generic work done by Westinghouse regarding alternate pipe break criteria, for the purposes of this evaluation for debris effects, metallic insulation quantities given in Table 7.2-6 were used. These quantities are based on worst case break in the reactor coolant loop. The metallic insulation debris generated by this break produced the maximum quantity of debris. NUREG-0897 Rev 1 (Draft) and NUREG/CR-3616 discuss the transport of metallic insulation materials. This information is based on experimental work done at Alden Research Laboratories during the second half of 1983. Based on these experiments, it

is postulated by Alden Research that metallic insulation inner foil can be transported at very low velocities.

In view of this new information, further evaluations were made for metallic insulation debris, its damage potential, and transport to the sump screens. In accordance with the recommendations of NUREG-0897 Revision 1 (Draft), it was postulated that all insulation within 7 pipe diameter lengths from the break will be completely destroyed to open up the metallic insulation. Figure 7.2-1 shows a typical metallic insulation section with all the sub-components. For the postulated reactor coolant hot leg break, it is conservatively assumed that all the affected metallic insulation will be damaged to release the inner foils. The maximum quantity of foil is calculated and presented in Table 7.2-6. For the postulated break outside the reactor coolant loop, Table 7.2-8 gives the quantities of insulation that will be damaged in this manner and the area of the inner foil that will be released.

The short term transport of metallic insulation for this break does not have a direct pathway to the door openings in the steam generator compartments. However, for a conservative evaluation, it was assumed that all the insulation released in this manner will be propelled by the jet through the doorway for steam generator compartment #1.

ERRATA

ERRATA FOR TABLES

TABLE	LINE	COLUMN	CHANGE FROM	CHANGE TO
3.1-2	8	4	NA	95-120
		5	NA	95-120
5.1-1	10	2	87,370	87,870
6.2-21	19	1	.005	.006
6.2-23	10	2	6200	>200
	12	2	100	>100
7.2-7	7	2	132.47	13.72
9-1	13	3	6.63	4.23

ERRATA FOR TEXT

PAGE	LINE	CHANGE FROM	CHANGE TO
vii	16	Breack	Break
ix	9	for 10-Inch Pipe	DELETE
2-1	Bottom margin		Add page # as 2-1
	2	coatings	paint and insulation
	36	ten feet of	DELETE
2-2	Bottom margin		Add page # as 2-2
3-4	17	shut	shuts
3-5	9	panels	paint
4-1	19	is	are
5-2	8	cooler	water
5-4	12	upper flows	upper floors
	17	wil	will
	36	within the contaiment	outside the shield wall.
6-2	27	F	F subscript N
6-4	11	point	paint
6-6	16	at	as
7-7	24	Table 5.2-1 and	Table 5.1-1. The
	25	5.3-1	5.4-2
	26	5.4-12 and 5.4-1	5.4-14
7-1	36	Table 7.2-8	Tables 7.2-6 and 7.2-8
	41	compartment B	compartment 4
8-2	10	1 NR	1 $<$ NR
	21	md^2	$md^2 / 16$
	24	fragment 4	fragment
	40	inches	inch
8-3	25	B	β
	27	$d^2/ 4$	$\pi d^2/ 4$
8-4	10	B	β
	21	1.9 when	1.9 for NR $<$ 250 when
8-5	29	given by	given by (Reference 14)
8-7	21	may	many
8-6	26	1.3	1.18
	36	angle	angle α
8-9	2	1.3	1.18
	20	35 ft	35 ft^2.
	21	30 ft	30 ft^2.