Commonwealth Edison Company
Zion Generating Station
101 Shiloh Boulevard
Zion, IL 60099-2797
Tel 847-746-2084

ComEd

ZRA97016
September 5, 1997

U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Attention: Document Control Desk

Subject: Zion Nuclear Power Station, Units 1 and 2
Response to Request for Additional Information
Concerning Containment Coatings
NRC Docket Nos. 50-295 and 50-304

References:
1) Letter from C. Shiraki, NRC, to I. Johnson, Commonwealth Edison, dated May 23, 1997, Request for Additional Information Concerning Containment Coatings at Zion Station, Units 1 and 2

2) Letter from J. H. Mueller, Commonwealth Edison, to U.S. Nuclear Regulatory Commission, dated February 5, 1997, Submittal of Requested Documentation

3) Letter from A. B. Beach, NRC, to J. H. Mueller, Commonwealth Edison, dated June 6, 1997, Supplement to Confirmatory Action Letter RIII-97-002

This letter provides Commonwealth Edison's (ComEd's) response to the NRC Request for Additional Information (RAI) concerning containment coatings at Zion Station (Reference 1).

During the current Unit 2 outage, concerns were identified regarding the qualification and condition of coatings in the containment building. In response to an NRC request made in a January 7, 1997, teleconference, ComEd submitted, via Reference 2, documentation associated with the containment coating issues. Following additional teleconferences, on May 1 and May 15, 1997, the NRC requested, in Reference 1, additional information concerning these issues. In a letter dated June 6, 1997, (Reference 3) the NRC supplemented a previous Confirmatory Action Letter, and documented ComEd's intent to resolve containment coating concerns prior to re-start of the unit. ComEd's response to the RAI is provided in Attachment A to this letter.

Based on the complexity of the coating issue, we would be pleased to meet with you at your earliest convenience to discuss the details of this RAI response

A001

DRAWINGS. Located IN CENTRAL FILES

Attachment C to this letter lists the commitments made by ComEd in this submittal. Please direct any questions you may have concerning this submittal to this office.

Respectfully,

John C. Brons
Site Vice President
Zion Nuclear Station

Attachments
Enclosures

cc: NRC Regional Administrator - RIII
Zion Station Project Manager - NRR
Senior Resident Inspector - Zion Station
Office of Nuclear Facility Safety - IDNS
IDNS Resident Inspector
Zion NLA
Engineering Manager
Master Files
Reg. Assurance File
DCD Licensing

ATTACHMENT A

RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION CONCERNING CONTAINMENT COATINGS AT ZION STATION

ATTACHMENT A

RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION CONCERNING CONTAINMENT COATINGS AT ZION STATION

Requested Information

1. **In discussions with ComEd, the staff was informed that a zone of influence with a radius of 20 feet was selected. However, the analysis in the February 5, 1997, submittal gives a variety of calculated radii for the zones of influence depending on the type of coating, some of which are greater than 20 feet.**

    - **What is the basis for the 20 foot zone of influence?**

ComEd Response

The initial 20 foot Zone of Influence (ZOI) was based on preliminary information provided by the preparers of the ZOI Calculation (Attachment A of Reference 2). At that time the majority of the ZOIs calculated were 20 feet or less. The 20 foot ZOI was used for focusing the initial removal of unqualified coatings effort. Subsequently, the one 20 foot ZOI was superseded by individual ZOIs, based on component coating type. The ZOI for a particular coating is a function of specific gravity and dry film thickness (DFT).

The final ZOI Calculation addresses a range of coating systems, including coating systems not found in the Zion containment. The results of the ZOI Calculation are summarized in Tables 1 through 3 of the ZOI Calculation.

- Table 1 summarizes the results of the calculation for undocumented coatings inside Zion containment with known specific gravities.
- Table 2 summarizes the results of the calculation for undocumented coatings for three different specific gravities with various DFTs. The Table 2 information is used to estimate ZOIs for undocumented coatings inside the Zion containment with unknown specific gravities.
- Table 3 summarizes the results of the calculation for documented coatings inside Zion containment. The information in this table does not play a role in evaluating the quantity of undocumented coating which may reach the containment sump.

Note: the terms "qualified" and "documented" in the context of this attachment are synonymous as are "unqualified" and "undocumented."

Requested Information

2. **The February 5, 1997, submittal describes a zone of influence calculation and a net positive suction head (NPSH) calculation. The zone of influence calculation determined a zone of influence for each paint type and the NPSH calculation predicted the largest amount of blockage that could be tolerated without loss of NPSH. However, there does not appear to be a connection between the two calculations.**

   - **Describe how the calculations are used.**

ComEd Response

The ZOI Calculation establishes the ZOI for a variety of coating systems. The net positive suction head (NPSH) calculation (Attachment B of Reference 2) establishes that 11.56 ft^2 of sump screen open area blockage can be tolerated without affecting RHR pump operation. Using the System Materials Analysis Department (SMAD) Report M-00282-97 (Attachment C of Reference 2) and the information detailed below, the maximum quantity of unqualified coating postulated to reach the sump screen was estimated to be approximately 1 ft^2. The 1 ft^2 was established based on an undocumented coating (SMAD Report, Table 1, item 195) that was not removed and has a credible pathway to the sump. This is much less than the 11.56 ft^2 of screen blockage postulated to affect pump operation.

SMAD Report, Table 1 represents a listing of items inside the Unit 2 containment for which the status of the coating qualification was unknown. Subsequent to the initial preparation of the list, several items in SMAD Report, Table 1 were determined to have qualified coatings (3371 ft^2). This is reflected by a "Y" in the SMAD Report, Table 1 column labeled "Accept w/o Rem," (i.e., Acceptable Without Removal). Two items on the list (items 5 and 103, totaling 3 ft^2) were determined to have no coating.

Items with undocumented coating which were removed are annotated with a "Y" in the SMAD Report, Table 1 column labeled "REM ITM" (i.e., Removed Item). Items whose coating was removed are annotated with a "Y" in the SMAD Report, Table 1 column labeled "REM PNT" (i.e., Removed Paint). This represents 2186 ft^2 of undocumented coating.

For the remaining items on the list, with the exception of item 152, dry film thickness (DFT) measurements were made and representative samples of specific gravities were determined such that the item's ZOI could be estimated. The coating associated with item 152 (Main Steam Line Supports) was determined to have a tortuous (not credible) path to the sump and no measurements were recorded. The ZOIs for the undocumented coatings were estimated utilizing the measured DFTs, an assumed specific gravity and the parametric evaluation of ZOIs provided in ZOI Calculation, Table 2. The specific gravity was assumed to be 1.6. This value is rounded down from the lowest specific gravity value found in the undocumented coatings inside the Zion containment with known specific gravities (1.61 from ZOI Calculation, Table 1).

The undocumented coatings with a ZOI of less than 20 feet were either removed or were confirmed to be located outside their ZOI. While the ZOI calculations are based on the centerline of the sump, removal of coatings or components was based on radial measurement from the nearest edge of the sump. For example, if a component was calculated to have a ZOI of 18.5 feet and it was physically located 18.5 feet radially from the centerline of the sump, but was located only 16 feet radially from the nearest edge of the sump screen, the coating or component would have been removed.

For the items with unqualified coatings, with a ZOI greater than 20 feet, the coating location was verified to be outside its respective ZOI with 3 exceptions; items 34, 161, and 195. For all items except item 195, based on the experience of the personnel, the knowledge from walk downs, and a review of general arrangement and structural drawings, it was determined that the path from the component(s) to the sump was tortuous to the extent that the coating could not be transported to the sump (not a credible pathway), or that the trash curb at elevation 568' would prohibit the coating debris from reaching the sump. Item 195 is located inside its respective ZOI. The quantity of coating associated with this item is approximately 1 ft^2. Conservatively, it is assumed that the 1 ft^2 is transported to the sump and blocks the open area of the sump screen.

Requested Information

3. **ComEd took numerous actions to ensure the integrity of the Unit 2 containment coatings.**

   a. **Describe, in detail, the steps taken to remove failed, undocumented and unqualified coatings from the Zion, Unit 2, containment prior to its next startup.**

ComEd Response

Identified failed coatings were removed by scraping or grinding, as appropriate. Undocumented coatings were removed by either removing the components containing the undocumented coating or removing the coating by scraping or grinding. This is reflected by a "Y" in the SMAD Report, Table 1 columns labeled "REM PNT" (i.e., Removed Paint) and "REM ITM" (i.e., Removed Item).

Identification of the coating to be removed came from several sources. Zion personnel along with coating specialists performed walk downs of the Unit 2 containment specifically to identify locations of failed or undocumented coatings. In addition, system readiness walk down teams were alerted to look for degraded coating during subsequent system walk downs in the containment. When identified, failed coatings were removed. The disposition of undocumented coatings is described in the response to Question 2.

Requested Information

b. Estimate the amount of unqualified paint remaining.

ComEd Response

It is estimated that 3100 ft^2 of undocumented coating remains in Unit 2 containment. Table 1 of the SMAD Report identified 8021 ft^2 of equipment and component coatings for which the status of the coating qualification was initially unknown. As described in the response to Question 2, 3371 ft^2 of coatings were subsequently determined to be qualified; 2186 ft^2 of coatings were removed; and items representing 3 ft^2 were determined to not have a coating.

The remaining items on SMAD Report, Table 1 represent 2461 ft^2 of undocumented coatings in containment. While the walkdowns which generated SMAD Report, Table 1 were extensive, some areas could not effectively be examined, either from a radiological standpoint or from an inability to erect scaffolding to allow direct examination. Based on these uncertainties, ComEd estimates that the 2461 ft^2 represents approximately 90% of the undocumented coatings inside containment. For additional conservatism, ComEd decreased the confidence level to 80% (or 3100 ft^2 of undocumented coatings remain inside containment).

Requested Information

c. Describe any in situ testing done on the remaining coatings.

ComEd Response

Adhesion tests were performed on qualified coatings inside containment, and dry film thickness and specific gravity determinations were made on unqualified coatings.

The adhesion tests were performed by a Level 3 Coatings Inspector to verify that the coating systems meet ANSI N5.12, "Protective Coatings for the Nuclear Industry," Paragraph 6.4 requirements. The minimum adhesion strength specified by ANSI N5.12 is 200 psi. No adhesion test of qualified coating in proper application failed the acceptance criterion. One test which failed the criterion was for a qualified coating in an improper application. This coating was subsequently removed.

Thirty-three adhesion tests were performed at various elevations, on various surfaces; including concrete surfaces, carbon steel liner plate, structural steel carbon steel surfaces and component carbon steel surfaces. Test areas were chosen based on visual observations and included areas of previously distressed or visibly degraded coatings, as well as areas where coatings appeared to be in good condition. In the areas near prior coating failure (and subsequent removal), tests were performed within 3 inches, 16 inches, and 36 to 48 inches of the failed edge to determine if adhesion had been degraded in the vicinity of the failure. A minimum clearance of 3 inches from the failed edge was necessary to properly mount the Elcometer adhesion tester.

Requested Information

4. **The analysis calculates the farthest distance from which a paint particle would be transported to the sump (the radius of the zone of influence). But the analysis uses a radial model and does not address the height above the water level in the zone of influence.**

   - **To what height above the elevation 568 foot floor level were the coatings removed?**

ComEd Response

Coatings were visually examined from elevation 568' up to and including the dome. Unqualified coatings were found and removed on elevation 617', as reflected by a "Y" in the SMAD Report, Table 1, columns labeled "REM PNT" (i.e., Removed Paint) and "REM ITM" (i.e., Removed Item). In addition, unqualified coatings were found and subsequently removed on the 2A and 2C Steam Generator catwalks (elevation 624'). The ZOI Calculation considers the ZOI to be a cylinder with a vertical axis at the center of the containment sump with a height extending to the surface of the water. However, the removal of coatings was based on extending the cylinder to the containment dome. As described in the response to Question 2, the removal of coatings or components was based on radial measurement from the nearest edge of the sump rather than the centerline of the sump.

Requested Information

5. **ComEd has reapplied the coating to sections of the Unit 2 containment.**

   a. **Describe the extent of the recoating being done in the Zion, Unit 2, containment.**

ComEd Response

The Unit 2 containment recoating is near completion in the following areas:

1. An area outside the missile barrier bounded by the containment wall and the missile barrier wall at Elevation 568' between Azimuth Z22 and Z23, floor to ceiling. This area is approximately 25 feet long. The coating effort will include the coating of concrete walls and floors, containment liner, and structural steel.

2. An area inside the missile barrier at Elevation 568' centered at Azimuth Z22. This area is approximately 32 feet by 12 feet and will include the concrete floor and adjacent walls to a height of approximately 10 feet.

3. Components which had undocumented coatings removed within 20 feet measured radially distance from any edge of the sump.

As discussed in the May 15, 1997, teleconference, this initial scope of containment recoating is scheduled to be complete prior to Unit 2 startup. In addition, an overall plan for the long term inspection and maintenance of containment coatings is under development. This plan will be completed by second quarter, 1998.

Requested Information

b. What standards were used for this recoating?

ComEd Response

The following standards are being used for the recoating effort during the Z2R14 outage:

- 10 CFR 50 Part B, Quality Assurance
- ANSI N101.4, Quality Assurance for Protective Coatings Applied to Nuclear Facilities
- ANSI N101.2, Protective Coatings for Light Water Nuclear Reactor Containment Facilities
- ANSI N5.12, Protective Coatings for the Nuclear Industry
- ANSI N45.2, Quality Assurance Program Requirements (Design & Construction)

Requested Information

c. Will any in-situ testing of the newly applied coatings be performed?

ComEd Response

Testing of the newly applied coating system consists of dry film thickness measurements and visual examination of the completed application. This testing is performed by certified coating inspection personnel. These activities are performed per work specifications and procedures to assure that the field application meets installation requirements such that the qualification of the coating remains valid.

Requested Information

6. The transport calculations assume a steady slow flow toward the containment sump. The coating particles are assumed to drop onto the surface of the water and flow toward the sump while they are settling at the terminal velocity.

a. How would the turbulence due to the break discharge, spillage, and operation of the containment sprays, occurring during and following blowdown, affect the amount of coating material reaching the sump?

ComEd Response

The effects of turbulence are not considered in the ZOI Calculation. Based on test results, discussed in Question 8, significant margin exists between the quantity of unqualified coating remaining inside containment and the quantity of coating required to create appreciable effects on available NPSH. Given this margin and the qualitative points discussed below, specific analyses to determine the potential effects of turbulence is considered unnecessary.

The issue of turbulence during blowdown (break discharge) can be considered in terms of general turbulence outside the jet impingement zone, and jet impingement from the break. General turbulence outside the jet impingement region during the relatively short blowdown period is not expected to generate additional quantities of coating material that would reach the sump screens because 1) in the absence of jet impingement, failure of unqualified coating material is a time dependent process and 2) documented coatings are qualified for the LOCA environment such that the coating system would remain on the substrate that it coats.

Jet impingement from the break has the potential to create debris from coating, insulation and other material. However, the velocity of the flow in the vicinity of the break is expected to be less than the velocity at the sump screen (0.72 ft/sec) because of the increased surface area over which the break flow will travel. The decreased velocity would increase the potential for material to stay in the vicinity of the break versus being carried to the sump. Insulation debris is discussed in the response to Question 7. The response to Question 11, describes activities which would minimize the existence of other material that could be carried to the sump.

Turbulence following blowdown is considered in terms of turbulence prior to and upon recirculation flow initiation. Recirculation is not expected to occur until approximately 30 minutes after the LOCA while blowdown is expected to last approximately 30 seconds. Therefore, a uniform velocity field on the containment floor is not expected until slightly after recirculation flow initiation. However, as described in the response to Question 9, the ZOI Calculation conservatively models velocities and flow, maximizing the ZOI and minimizing sliding velocities, which would compensate for the effects of recirculation flow initiation turbulence.

Spillage flow out of the break is not expected to create significant turbulence in the area of the sump. By the time the spillage reaches the sump area, the flow would not significantly impact the uniform velocity field in the sump assumption (associated with the 9000 gpm recirculation flow rate) considered in the ZOI Calculation. The velocity of the spillage in the vicinity of the break is expected to be less than the velocity at the sump screen (0.72 ft/sec) because of increased surface area over which the spillage will flow. This would minimize the transport of debris.

Finally, containment spray rapidly disperses as fine particles covering the majority of containment surfaces. Spray impingement on containment surfaces is much less severe than jet impingement effects from the initial break and therefore the effects of containment spray on the quantity of material transported to the sumps screens is considered negligible.

NEI and the NRC are in conversation with respect to a planned review of PWR ECCS sump designs based on insights gathered from ECCS strainer blockage at BWRs. How to properly account for turbulence and jet impingement is best handled in a generic matter by the industry with participation of all PWRs. These generic efforts may result in modifications to the estimates of material reaching the sump. However, ComEd believes that any additional amount of coating that might reach the sump as the result of turbulence will not change the conclusion that adequate NPSH would be available.

Requested Information

b. In particular, would coatings located outside the zone of influence be swept into the zone of influence by these effects?

ComEd Response

The only coatings outside their associated ZOI that might be postulated to be swept into the ZOI are the remaining unqualified coatings. Based on the test results discussed in the response to Question 8, which demonstrate significant margin exists between the quantity of unqualified coating remaining and the quantity of coating required to appreciably affect the available NPSH, no specific analyses have been performed nor are deemed necessary to determine if coatings located outside their ZOI would be swept into their ZOI by turbulence.

In addition, based on the containment layout and the conservative calculation of the ZOI, it is not expected that sufficient quantifies of undocumented coatings outside the ZOI would be swept into the ZOI so as to jeopardize the available RHR pump NPSH.

Requested Information

c. Justify why it is not necessary to account for these effects in the analysis.

ComEd Response

To summarize the response provided in parts a and b of this question, ComEd believes it is not necessary to account for the effects of turbulence in the analysis for the following reasons:

- Test results (refer to the response to Question 8) indicate significant margin is available between the quantity of unqualified coating remaining inside containment and the quantity of coating required to develop any appreciable loss in the available NPSH.

- Conservatisms in the NPSH and ZOI calculations would offset some of the effects of turbulence.

- For coatings located outside the general sump area (e.g., unqualified coatings outside their ZOI), the containment layout would typically provide a pathway which was tortuous to the extent that the coating would not reach the sump.

Furthermore, because NEI and the NRC are in conversation with respect to properly accounting for turbulence and jet impingement effects in analyses, modifying the analyses to account for these effects may be contrary to the final resolution of the issue between the NRC and the industry.

Requested Information

d. What action was taken for those coatings that are undocumented, unqualified or failed that may have a calculated zone of influence greater than that selected (20 feet), or have an "unbounded" zone of influence (Table 3 of Calculation 22S-B-040M-002, Revision 1, Page 26) but that may enter the zone of influence through the mechanisms described above?

ComEd Response

As described in the response to Question 2, there is only one case where the unqualified coating with a ZOI greater than 20 feet remains inside its respective ZOI and is postulated to have a credible pathway to the sump. The quantity of coating is approximately 1 ft^2. The other coatings were determined to be located outside their respective ZOI. The unbounded ZOIs in Table 3 of Calculation 22S-B-040M-002 (ZOI Calculation) are for qualified coating systems which do not play a role in the determination of how much undocumented coating may reach the containment sump. As described in the response to Question 3, part a, any identified failed coatings were removed. Thus the only coatings of concern would be unqualified coatings outside their respective ZOIs. Because these coatings are not postulated to reach the sump screen, no action has been taken for these coatings. However as discussed in the response to Parts a and b of this Question, any additional undocumented coatings entering the ZOI would not be expected to change the conclusion that the RHR pumps will have adequate NPSH.

Requested Information

7. **This analysis does not account for any insulation debris which may be transported to the sump screens as a result of a loss-of-coolant accident (LOCA). If any coatings are assumed to reach the sump (i.e., all coatings which could reach the sump are not removed prior to the next plant startup) then the combined effect of the paint and the insulation must be taken into consideration since the pressure drop from this combination of debris can be significantly higher than that due only to failed coatings (see NUREG/CR-6224, "Parametric Study of the Potential for BWR ECCS Strainer Blockage Due to LOCA Generated Debris" dated October 1995; see especially Appendix B) and the method of calculating NPSH margin in Section 2.3 of Calculation 22S-B008M-092 would not be correct.**

   a. **Verify and provide calculations that show that the zone of influence is determined so that either no coatings will reach the sump or that the effect on the pressure drop across the sump screens of any that do reach the sump is correctly calculated.**

ComEd Response

The phenomenon described in the introduction to Question 7 is not applicable because the NPSH calculation assumes complete screen blockage of a percentage of the screen area. The method of calculating NPSH margin (Section 2.3 of Calculation 22S-B-008M-092) is not affected by the type of material postulated to cause blockage. The amount of undocumented coatings postulated to reach and block the sump screen (1 ft^2) is small relative to the 69% of the open screen surface that can be blocked per the NPSH calculation (11.56 ft^2), as described in the response to Question 2. In addition, the tests described in the response to Question 8 indicate that failure of large quantities of coatings would not result in appreciable pressure loss across the sump screens.

Requested Information

   b. **What type of insulation is used in the Zion, Unit 1, containment?**

ComEd Response

Insulation inside the containment missile barrier is stainless steel reflective metal (mirror) type insulation (RMI). Three hundred and thirty seven cubic feet of stainless steel jacketed fiberglass insulation is installed on service water piping outside the missile barrier. No other insulation type is installed inside the containment.

Requested Information

   c. **Is it a type which could readily clog screens?**

ComEd Response

RMI has a density greater than paint, and it would therefore have a relatively small ZOI. Based on the approach velocity determined in the ZOI Calculation and the information provided in NUREG/CR-3616, "Transport and Screen Blockage Characteristics of Reflective Metallic Insulation Materials," RMI outside the 7 L/D is not expected to reach the sump screens. Furthermore, NUREG 0737, Supplement 9 for Commanche Peak, concluded that the RMI dislodged from jet impingement would not travel to the sump screen. While specific analyses have not been performed, based on the conclusions for Commanche Peak, ComEd does not believe that any RMI dislodged from jet impingement would reach the sump screens so as to clog the screen or act as a filter media.

The stainless steel jacketed fiberglass insulation is not postulated to reach the sump screens since it is outside the missile barrier (i.e., will not be subjected to jet impingement from a postulated reactor coolant system pipe break), jacketed with stainless steel, and banded to preclude failure during a LOCA or postulated high energy line break. The stainless steel jacketed insulation is not affected by the spray effects of containment spray flow.

Requested Information

8. **Describe any experimental verification of the zone of influence or NPSH analyses or other relevant experimental work and provide any available documentation.**

ComEd Response

Flow model tests performed by Continuum Dynamics Incorporated (CDI) for Zion Station demonstrate a large volume of paint (several thousand square feet) can fail within the ZOI without an appreciable pressure loss across the sump screens. (5000 ft^2 of coating would result in a pressure drop of 0.25 inches of water.) Final tests were completed in July. These tests use parameters that are representative of the conditions at Zion (e.g., screen opening size and flow rates). The final test report is included as Enclosure 1 to this letter. Attachment B provides a brief discussion of some of the CDI test parameters and their correlation to the parameters utilized in the ZOI Calculation.

Requested Information

9. **List and discuss any conservatisms in the Zion zone of influence calculation and NPSH calculation.**

ComEd Response

ZOI Calculation conservatisms:

a) The maximum dimension of the failed paint chips is assumed to be equal to the outer sump screen mesh opening, 0.5 inches. A larger particle size would result in a smaller calculated ZOI, based on the greater velocity required to initiate sliding of the particle.

b) The dynamic coefficient of friction between failed paint chips and concrete is assumed to be 0.35. This is conservative with respect to the Gibbs & Hill report documented in NUREG-0797, Supplement 9, which uses a value of 0.42 for the dynamic coefficient of friction. Using this conservative coefficient of friction results in lower velocities required to slide debris along the containment floor. Thus, the calculated ZOI is larger. Similarly, the static coefficient of friction is conservatively assumed to be 0.40 versus the 0.60 used in the Gibbs and Hill report documented in NUREG-0797, Supplement 9. Using this conservative coefficient of friction results in lower velocities required for coatings to begin to slide along the containment floor.

c) When calculating the terminal velocity of a sinking coating particle, the debris was modeled as a circular disk parallel to the floor. The terminal velocity is minimized for horizontal alignment, since the greatest possible area is projected normal to the direction of motion, maximizing the drag force. Minimum terminal velocities result in longer transit times for a sinking particle. Thus, the calculated ZOI is larger.

d) Worst case flow conditions were assumed to occur when calculating the ZOIs. Specifically, maximum RHR pump flow rate of 9000 gpm during recirculation which maximizes the approach velocities is assumed. A conservatively low water temperature of 100 °F, which maximizes the water density and correspondingly minimizes the calculated velocity to initiate particle slide and terminal particle velocities is assumed.

e) ZOIs were calculated at both the minimum and maximum expected flood heights and the largest of the calculated ZOI was used. (See the response Question 10). The largest ZOI calculated under these bounding conditions is presented in summary Tables 1 through 3 of the ZOI Calculation.

NPSH Calculation conservatisms

a) No credit is taken for elevated containment pressures which may exist following a LOCA, nor is credit taken for nominal atmospheric pressure at which the containment is maintained. These pressures would increase the available NPSH.

b) Maximum pipe lengths and number of fittings for the RHR system are used. This maximizes the pressure drop which increases the required NPSH.

c) The available NPSH is compared to the required NPSH at pump run out conditions (4500 gpm per pump; 9000 gpm total). This is conservative since the required RHR pump flow at the time of cold leg recirculation is much less than run out conditions. Using maximum flow also maximizes system pressure drop, which increases the required NPSH.

d) The sump flood level is taken to be 1 foot above the containment floor prior to initiating recirculation. Actual flood level during a large break LOCA is expected to be greater than 1 foot. (The maximum level is 5.06 feet.) The increased sump flood level would increase available NPSH.

e) For purposes of determining the kinematic viscosity, the minimum sump water temperature at the time of recirculation is assumed to be 150 °F. This maximizes system pressure drop. Actual sump temperature during a large break LOCA, at the time of recirculation, is expected to be greater (on the order of 225 °F).

Requested Information

10. Explain why the zone of influence is less at a depth of 3 feet than at 1 foot or 5.06 feet of water above the containment floor. (Calculation 22S-B-040M-002, Section 7, SUMMARY AND CONCLUSION.)

ComEd Response

The ZOI calculated at a flood height of 3 feet is not always less than the calculated ZOI for a flood height of 1 foot or the ZOI calculated for a flood height of 5.06 feet. However, the ZOI at a flood height of 3 feet is always less than the ZOI reported, because the reported ZOI represents the bounding value of the 1 foot flood height <u>or</u> the 5.06 feet flood height value. As stated in the Conclusion Section of the ZOI Calculation, the bounding ZOI was always used.

The ZOI for a particular coating system is chosen based on two values. The first value represents the maximum radius from the centerline of the sump for possible coating particle movement along the containment floor. The second value represents an assessment of the coating particle trajectory as it sinks to the containment floor.

The radius of potential particle movement is maximized by high horizontal water velocities. The minimum flood height of 1 foot maximizes this horizontal water velocity. The particle trajectory is maximized when the particle has the largest possible residence time in the water before making contact with the containment floor. This translates to the flood height of 5.06 feet value. (Refer to Figure 1 of the ZOI Calculation.)

Requested Information

11. **Describe the Zion Foreign Materials Exclusion Program and how it prevents foreign material (tools, clothing, plastic sheeting, etc.) from clogging or damaging the sump screens. This seems especially important to Zion, given the relatively small area of the sump screen.**

ComEd Response

The Foreign Material Exclusion (FME) Program applies to all personnel who perform functions that have the potential to introduce foreign material into any plant system. The program includes specific work practices and requirements for training of personnel. In addition to the FME program requirements, Zion Checklist E "Containment Close-out for H/U or S/U" of GOP-0, "Plant Startup Documentation Requirements" requires that Operating personnel perform a containment walk down prior to Unit operation. This check list specifically requires inspection of containment areas for material which could potentially clog the containment sump. Adherence to the requirements of the FME program and GOP-0 provides assurance that the items referred to in this question are not left in the containment during operation. Checklist E of GOP-0 is provided for reference as Enclosure 2 to this letter.

Requested Information

12. **Provide the following documents that are referenced in the February 5, 1997, submittal.**

    a. **[Reference, sic] 5.14 of Calculation 22S-B-008M-092.**

    b. **[Reference, sic] 5.5 of Calculation 22S-B-008M-092.**

    c. **Table on page 2-10 of Reference 5.2.**

    d. **Page 17 of Reference 5.17.**

    e. **Drawing of the containment sump.**

ComEd Response

The requested information is provided as Enclosures 3 through 7. It should be noted that items 12a and 12b (Enclosures 3 and 4) were referenced in Calculation 22S-B-008M-092 for historical purposes and are considered superseded by that calculation.

Also note that the statement at the bottom of item 12d (Enclosure 6), indicating that the document is not to be sent outside of Sargent & Lundy, may be disregarded. Sargent & Lundy has authorized ComEd to release this page to the NRC as public information.

CDI TEST PARAMETERS CORRELATION TO ZONE OF INFLUENCE CALCULATION PARAMETERS

Coating Specific Gravity

The coating used in the test is described in Section 3.1 of the CDI report (page 7), Ameron/Amercoat 90HS, was in stock ready for use at CDI. This coating has a specific gravity of 1.4 to 1.5. As described in the Zone of Influence (ZOI) calculation (Reference 2, Attachment A), the postulated lowest specific gravity of coating at Zion Station is 1.6. Using material with a slightly lower specific gravity in the flow model tests is conservative. Lower specific gravity results in larger ZOIs due to lower velocities required to initiate sliding and increased transport time. (Refer to Reference 1, ComEd response to Question 10.)

Screen Size and Orientation

The vertically oriented screen segment used in the test is the same height and vertical orientation as the Zion recirculation sump screens. The screen segment was provided by ComEd to CDI and has the same size grid openings as the Zion sump screens.

Coating Thickness and Chip Size

The coating chip thicknesses used in the CDI tests (2-3 mils) are representative of the paint thicknesses found in Zion Station (Refer to ZOI Calculation, Table 1). Additional quantities of coatings with different thicknesses were also used to obtain as much information as possible on the impact of large volumes of paint on the pressure drop across the sump screen (Refer to Section 3.3 of the report). The chip sizes were of a random size distribution ranging between 1/8" x 1/8" to 2" x 2". The ZOI Calculation conservatively assumed the maximum dimension of the chips to be equal to the outer sump screen mesh opening, or 0.5 inches. The utilization of varying paint chip sizes is appropriate. A varying chip size would be expected in reality. The ZOI Calculation states that the assumption is conservative since a larger particle size would have a smaller ZOI. However, the utilization of larger chips in the relatively (compared to Containment) small test apparatus, would tend to cause more restriction of the sump screens.

Water Height

The height of water in the test tank was chosen to be one foot to correspond to the height at which recirculation is initiated. As described in the response to Question 10, a height of one foot maximizes the horizontal water velocity, which in turn maximizes the radius of potential particle movement.

Flow Velocity

The test flow velocity of 0.72 ft/sec was based on the expected Zion maximum velocity (Refer to ZOI Calculation, Table 1).

List of Commitments Identified in ZRA97016

The following table identifies those actions committed to by ComEd in this document. Any other actions discussed is this submittal represent intended or planned actions by ComEd. They are described to the NRC for the NRC's information and are not regulatory commitments. Please notify Mr. Robert Godley, Zion Station Regulatory Assurance Manager, of any questions regarding this document or any associated regulatory commitments.

Commitment	Committed Date or Outage
ComEd will develop an overall plan for the long term inspection and maintenance of containment coatings	Second Quarter 1998
Testing of newly applied coating systems will include dry film thickness measurements and visual examination of the completed application.	Ongoing

ENCLOSURE 1

CONTINUUM DYNAMICS, INC. TEST REPORT

C.D.I. TECHNICAL MEMORANDUM NO. 97-14

EVALUATION OF PAINT CHIP HEAD LOSS ON VERTICALLY ORIENTED ZION STATION STRAINER SCREEN JULY 1997 TEST PHASE

Revision 0

Prepared by

Richard G. Louderback, Jr.
Robert W. Dierl
Andrew E. Kaufman

CONTINUUM DYNAMICS, INC.
P.O. BOX 3073
PRINCETON, NEW JERSEY 08543

Prepared for

COMMONWEALTH EDISON COMPANY
1400 OPUS PLACE - SUITE 400
DOWNERS GROVE, ILL 60515

Approved by

Alan J. Bilanin

Alan J. Bilanin

July 1997

TABLE OF CONTENTS

1.0 INTRODUCTION

This document describes testing conducted for Commonwealth Edison Company, Zion Station to evaluate the effects of paint chips on sump strainer screen head loss. Testing was conducted at the laboratory facilities of Continuum Dynamics, Inc. in Princeton, New Jersey following the test plan described in Reference 1. The primary objective of the program was to determine the head loss across the strainer sump screen as a result of the buildup of paint chips. Paint chips of different sizes and thicknesses were tested. All tests were conducted with chips made from Ameron/Amercoat 90HS high performance epoxy paint. The test apparatus consisted of a simulated portion of the full scale Zion Station strainer sump screen mounted in a 675 gallon, 82 inch diameter tank. Prototypical, full scale strainer screen approach velocities were maintained for all of the tests.

The tests documented in this report were observed by Commonwealth Edison personnel on July 9, 1997 at the Continuum Dynamics, Inc. laboratory facilities. A series of tests were conducted in March 1997 under similar conditions with essentially the same results but the tests were not witnessed by Commonwealtn Edison perosnnel (Reference 2). The March 1997 tests were documented in C.D.I. Technical Memorandum No. 97-05, April 1997.

2.0 TEST FACILITY APPARATUS

2.1 Strainer Model

The test apparatus is shown schematically in Figure 2-1. One corner of the full scale Zion Station sump strainer was modeled using nominal 1/2 inch mesh, 14 gage, 304 SS wire cloth supplied by Commonwealth Edison. The cloth was painted with Keeler & Long E-1-7475 Epoxy Enamel paint. The strainer was constructed with two approximately 6.25 inch deep by 12 inch high sides with a 3 inch by 3 inch angle added at the intersection of the two sides to model a support angle. The total surface area of the strainer was 1.05 square feet. To better visualize the testing, the remainder of the structure (remaining sections of sides and the top) were fabricated from 1/2 inch thick clear polycarbonate sheet. A photograph of the model is shown in Figure 2.2. The model was mounted to the floor of a 675 gallon tank with a diameter of approximately 82 inches and a height of 30 inches. To simulate prototypical flow conditions through the strainer, bulkhead fittings were inserted in the floor of the 82 inch tank to produce flow from the bottom of the strainer. The bulkheads in the floor are visible in Figure 2.2.

2.2 Flow System

Four Hayward 1.5 horsepower pumps were used to provide system flow. Each pump could produce on the order of 95 to 100 GPM. Flow rate for the pumps was determined by establishing the time required to fill a container of known volume. Knowing the total strainer area and that an approach velocity of 0.72 ft/sec was required for the test, the corresponding system flow rate could then be calculated. To minimize the turbulence from the discharge of the pumps back into the 82 inch diameter tank, return flow was directed into a 36 inch diameter diffuser tank installed above the water surface. The center of the diffuser tank was approximately 30 inches away from the tip of the strainer model at the nominal centerline of the tank. Holes were drilled into the bottom of the tank to create a rain effect for water re-entry. A photograph of the test apparatus setup showing the diffuser tank (left side of photograph) and the strainer mounted in the tank is shown in Figure 2.3. If required, flow from an individual pump was regulated through the use of a butterfly valve. Since there was essentially no change in head loss across the pumps, system flow rate was assumed to remain constant throughout each test. This was confirmed during shakedown testing when flow rate through the pumps was found to be the same at the beginning and end of a test.

2.3 Head Loss

Pressure drop across the strainer screen was measured through the use of a water filled manometer and recorded manually during testing. One end of the manometer was connected to a pressure tap inserted into the model and the other end to a bulkhead fitting in the side of the tank wall behind the strainer. The pressure tap in the strainer is visible exiting the top of the model in Figure 2.2.

2.4 Instrumentation

Minimal instrumentation was required to perform the tests for the program. Measurements of paint chip size and thickness were made using commercial grade dial calipers and tape rules. Head loss was measured using a water filled manometer. Readability on the manometer was +/- 1/16 inch of water. The mass of paint chips used in a test was measured using an AND model FX-300 electronic balance. The balance has a readability of 0.001 grams. The commercial grade accuracy of this instrument was adequate for its use in the test program. The balance was subject to confidence checks during testing.

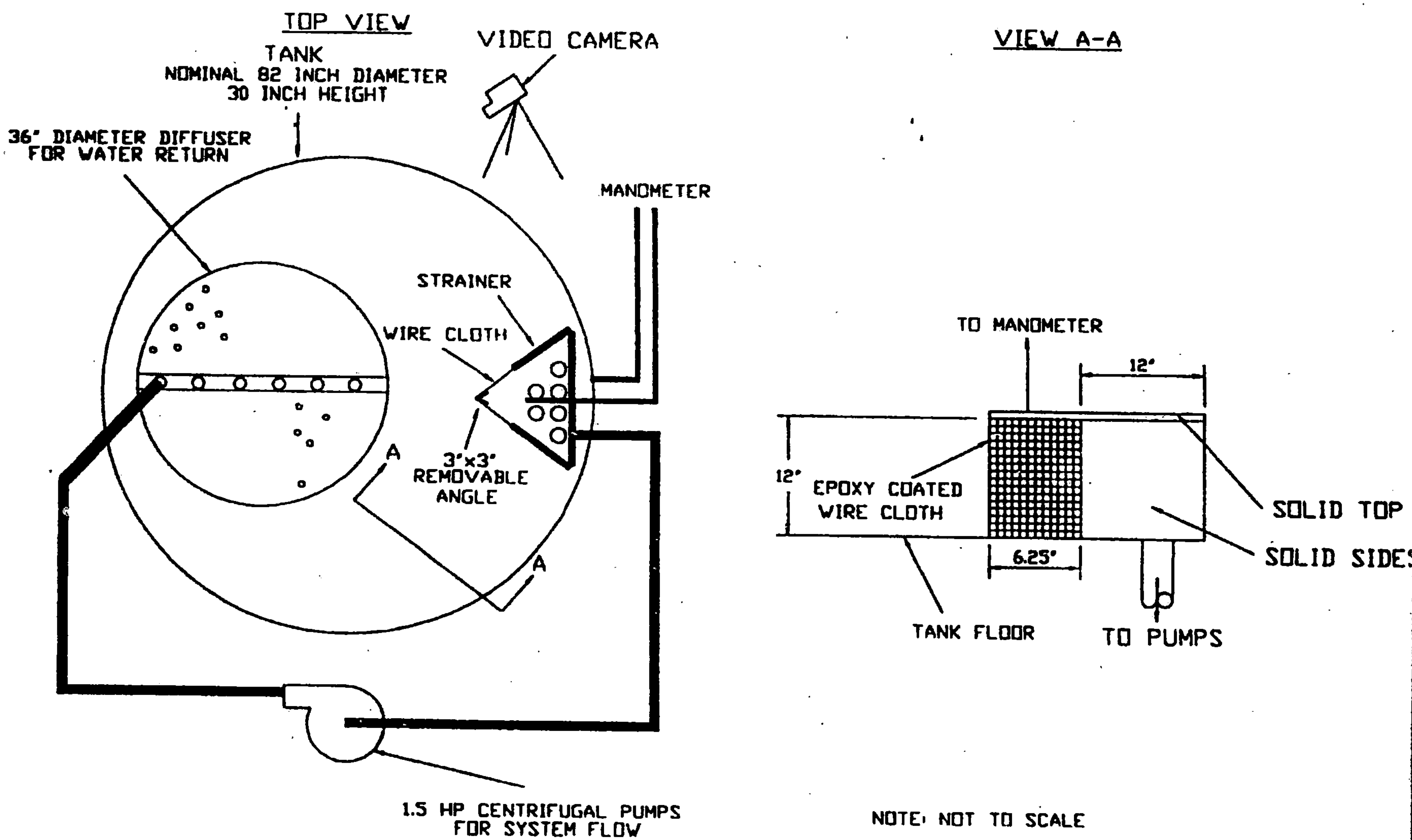


Figure 2.1: Test apparatus schematic.

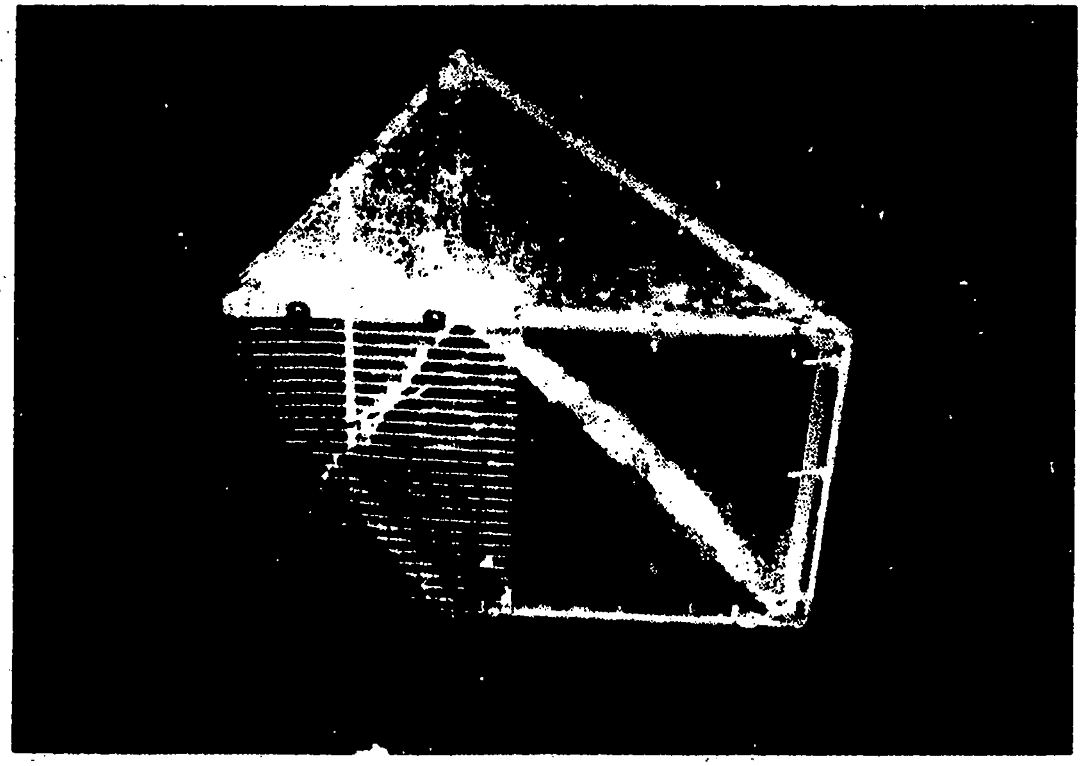


Figure 2.2: Photograph of strainer model.

Figure 2.3: Photograph of test apparatus setup.

3.0 PAINT CHIP DEBRIS

3.1 Paint Type

Ameron/Amercoat 90HS two part high performance white epoxy paint was used to create the chips for the tests. The paint has a specific gravity of 1.4 - 1.5.

3.2 Paint Chip Generation

The two part paint was first mixed together according to the manufacturers specifications. A known area (typically 10 foot by 10 foot) of one mil thick plastic sheeting was painted and the paint was allowed to cure for at least 48 hours. The amount of paint that was applied to the sheets was based upon the required thickness of the chips to be produced. The cured paint was peeled from the plastic sheets and its thickness was measured at random locations using a dial caliper. The paint chips were then produced either by breaking the cured paint up by hand or by using a standard household blender.

3.3 Paint Chip Quantity

The amount of paint chips used in the test was documented on a mass basis as well as an area basis. By measuring the area painted and the total mass of the dried paint collected from the area, the weight per square foot of the chips was determined. For the tests documented in this report, three different thickness paint chips were generated: 2-3 mils thick, 10 mils thick and 20 mils thick. A random size distribution was used for the chips with the majority of the chips falling into the range between 1/8" x 1/8" to 2" x 2" pieces.

4.0 TEST PROCEDURE SUMMARY

The general test procedure for conducting a head loss test is described below. Test descriptions and initial conditions were recorded. The required amount of paint chips were then prepared and presoaked to insure they would not float on the water surface when introduced into the tank. The tank was then filled with water to the required height and the pumps primed for operation. The screen area was verified and the required flow rate calculated to give an approach velocity of 0.72 ft/sec. System flow was started and the paint chips were added to the tank under the nominal center of the diffuser with the returning water. Tests continued to run until steady state conditions were observed. Steady state conditions were reached when there was no significant movement of the paint chips in the tank and the head loss across the strainer had been steady for approximately five minutes. Typically, this was about 10 to 15 minutes after introduction of the chips. The strainer head loss was recorded and the strainer photographed. An estimation of the amount of the strainer screen blocked by the paint chips was then performed. Each test was also documented by a video camera. After steady state conditions were reached, the test would be stopped or more paint chips would be added with the flow system continuing to run.

5.0 TEST RESULTS

5.1 Test Matrix

Table 5.1 contains a matrix of the paint chip tests conducted and the corresponding steady state head loss measured for each test.

TABLE 5.1 - Test Matrix

All tests conducted at an approach velocity of U = 0.72 ft/sec

All tests conducted with approximately 12 inches of water in the tank (i.e. water level in tank was even with top of strainer)

Test #	Nominal Size of Paint Chips (inches)	Nominal Thickness of Paint Chips (mils)	Quantity of Paint Chips (square feet)	Steady State Pressure Drop Across Strainer Screen (inches of H_2O)	Approximate Steady State % of Strainer Screen Blocked by Paint Chips	Comments
11	1/8 to 2	2-3 10 20	43 (~ 14 square feet each thickness)	0	20	Chips added into tank under diffuser with flow on
12 (Cont. of Test #11)	1/8 to 2	2-3 10 20	85 (~ 28 square feet each thickness)	0	30	Chips added into tank under diffuser with flow on
13 (Cont. of Test #12)	1/8 to 2	2-3 10 20	128 (~ 42 square feet each thickness)	0	45	Chips added into tank under diffuser with flow on
14 (Cont. of Test #13)	1/8 to 2	2-3 10 20	170 (~56 square feet each thickness)	3/16	65	Chips added into tank under diffuser with flow on

5.2 Test Observations

The majority of the paint chips introduced into the tank sank and remained immobile on the tank floor and did not reach the strainer for all of the tests. Turbulence in the tank due to return flow patterns caused some chip movement. When flow was terminated upon completion of test 14, the paint chips which had accumulated on the strainer screen immediately fell off of the strainer screen, regardless of paint chip thickness or size.

Photographs of the strainer taken during testing are shown in Figures 5.1 through 5.5. Each photograph was taken looking down at the strainer from outside the tank and shows one side of the strainer screen. Figure 5.1 was taken after reaching steady state conditions during Test #11 with the pumps running and approximately 43 square feet of paint chips in the tank (~ 14 square feet each of 2 to 3, 10 and 20 mil thicknesses, paint chips sizes ranging from ~ 1/8 to 2 inches). Note the cleanliness of the strainer screen. Figure 5.2 was photographed after reaching steady state conditions after Test #12 with approximately 85 square feet of paint chips in the tank (~ 28 square feet each of 2 to 3, 10 and 20 mil thicknesses, paint chips sizes ranging from ~ 1/8 to 2 inches). Note the small build up of chips along the base of the strainer screen. Figure 5.3 shows steady state conditions for Test #13 with approximately 128 square feet (~42 square feet of 2-3 mil, 10 mil and 20 mil) paint chips in the tank. Figure 5.4 was taken after reaching steady state conditions during Test #14 with the final increment for a total of 170 square feet of paint chips in the tank (~56 square feet each of 2 to 3, 10 mil and 20 mil thicknesses, paint chip sizes ranging from ~ 1/8 to 2 inches). Note that some of the strainer screen remains free of paint chips. Figure 5.5 shows the strainer upon completion of Test #14 with flow stopped. Compare Figure 5.5 to Figure 5.4 (the test just completed) and note that all of the paint chips on the strainer screen have fallen off after flow was stopped. The top of the strainer has been marked for clarity.

5.3 <u>Full Scale Data Application</u>

Testing was conducted on a section of a full scale strainer at full scale approach velocities. To determine the amount of paint chips that correspond to the entire strainer, simply multiply the test amount of paint chips by the area ratio $\text{Area}_{\text{full scale strainer}} / \text{Area}_{\text{test strainer}}$ where the full scale strainer has an area of approximately 28 square feet. The head loss values measured in the tests are the head loss values expected across the entire strainer in the plant. Since the containment floor velocities for the Zion Station are typical to those found in the test tank for this program, it is anticipated that the head loss results obtained in the test program are representative of that to be expected across Zion's sump screens. A plot of the predicted steady state pressure drop versus square feet of paint chips is shown in Figure 5.6.

Note that the tests conducted in March 1997 and detailed in C.D.I. Technical Memorandum 97-05 featured a slightly different strainer screen area, water level and approach velocity. Upon completion of the March tests, the strainer screen was removed from the test rig and coated with epoxy paint at the request of Commonwealth Edison.

When the screen was reinstalled, the measured surface area was 1.05 square feet instead of 1 square foot. The March 1997 tests were conducted with an approach velocity of 0.7 ft/sec whereas the July tests documented in this report were performed at an approach velocity of 0.72 ft/sec per the request of Commonwealth Edison personnel. The water level for the March tests was approximately 2 feet and was reduced to 1 foot for the July tests.

Figure 5.1: Photograph of strainer at steady state conditions during Test #11. Test run with approximately 43 square feet of paint chips, approximately 14 square feet each of 2 to 3 mil, 10 mil and 20 mil chips ranging in size from approximately 1/8 to 2 inches.

Figure 5.2: Photograph of strainer at steady state conditions during Test #12. Test run with approximately 85 square feet of paint chips, approximately 28 square feet each of 2 to 3 mil, 10 mil and 20 mil chips ranging in size from approximately 1/8 to 2 inches.

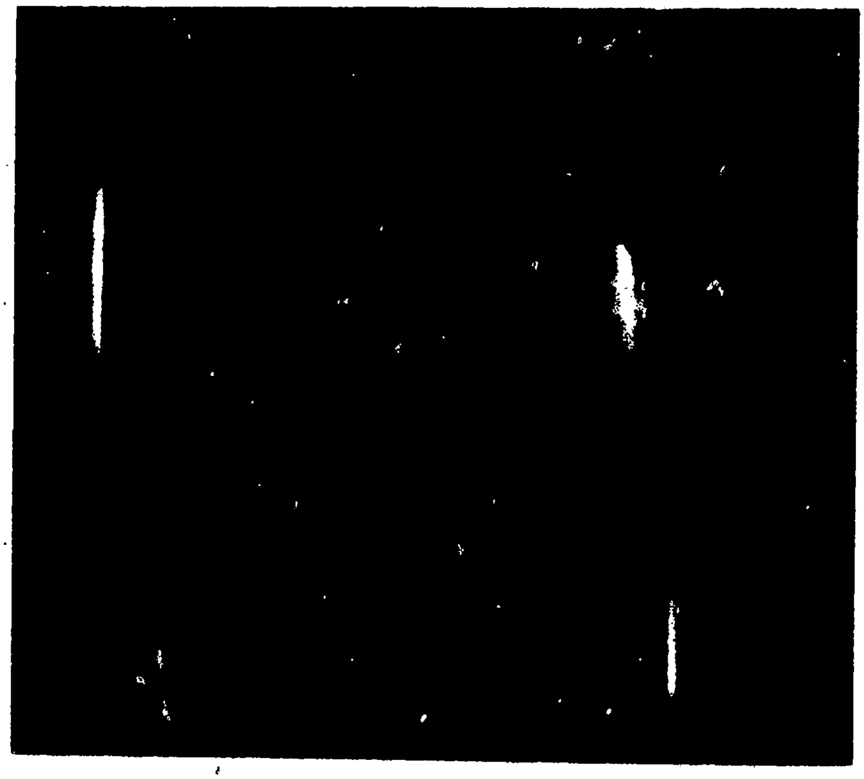


Figure 5.3: Photograph of strainer at steady state conditions during Test #13. Test run with approximately 128 square feet of paint chips, approximately 42 square feet each of 2 to 3 mil, 10 mil and 20 mil chips ranging in size from approximately 1/8 to 2 inches.

Figure 5.4: Photograph of strainer at steady state conditions during Test #14. Test run with approximately 170 square feet of paint chips, approximately 56 square feet each of 2 to 3 mil, 10 mil and 20 mil chips ranging in size from approximately 1/8 to 2 inches.

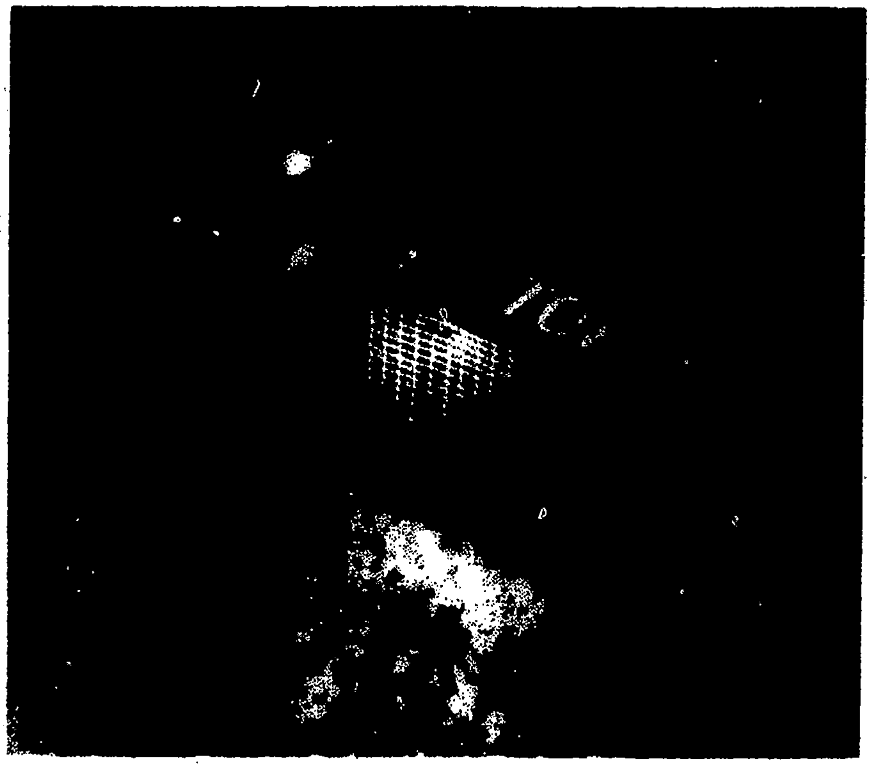


Figure 5.5: Photograph of strainer upon completion of Test #14.

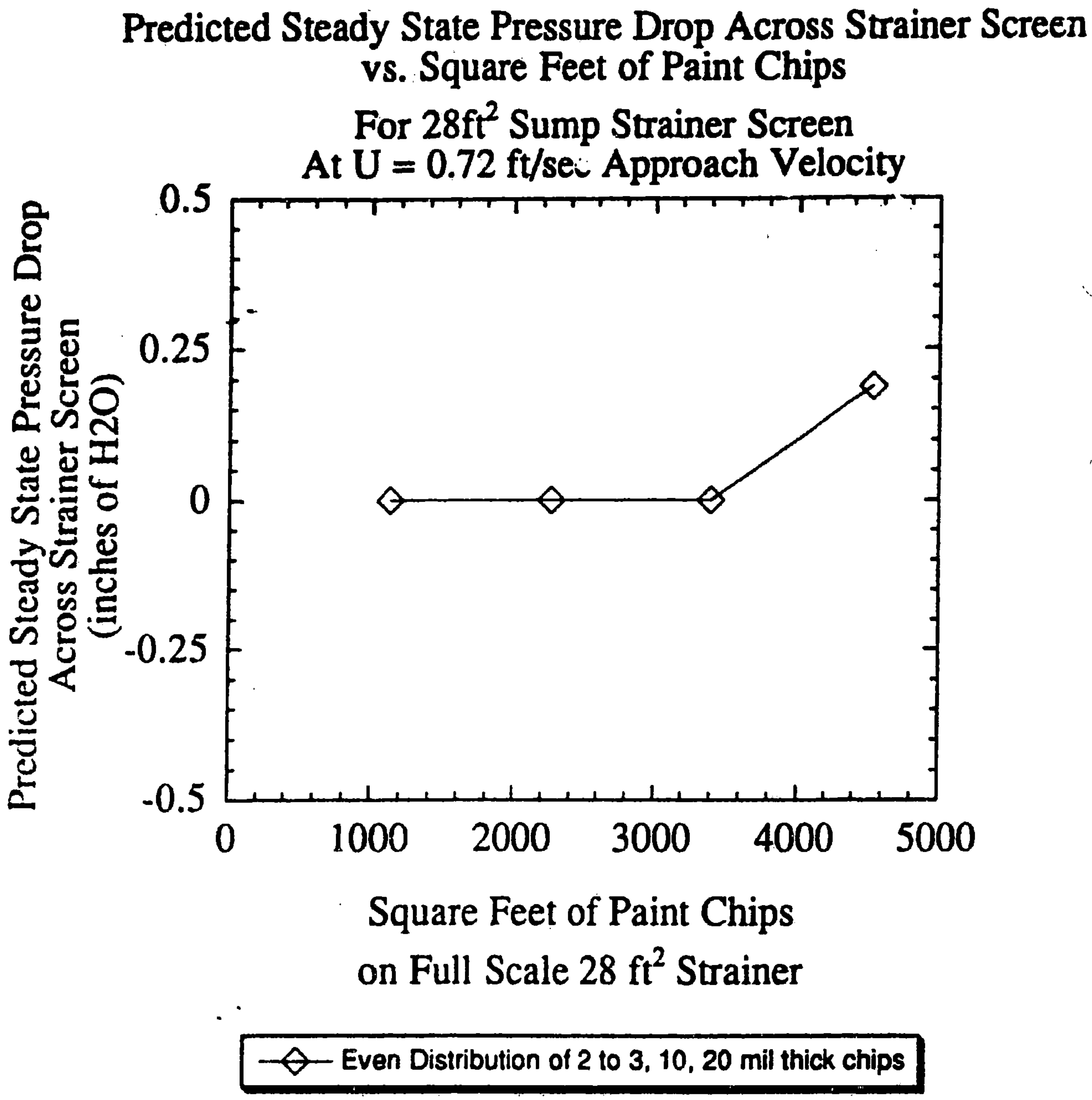


Figure 5.6: Predicted steady state pressure drop across strainer screen vs. square feet of paint chips.

6.0 QUALITY ASSURANCE

Although Commonwealth Edison procured the testing services of Continuum Dynamics, Inc. as non safety related, all quality related activities were performed in accordance with the C.D.I. Quality Assurance Manual, Revision 12 (Reference 3). Quality related activities are those which were directly related to the planning, execution and objectives of the test. Supporting activities such as test apparatus design, fabrication and assembly are not controlled by the C.D.I. Quality Assurance Manual. C.D.I.'s Quality Assurance Program provides for compliance with the reporting requirements of 10 CFR Part 21. All test data will be contained in a Design Record File which will be kept on file at the C.D.I. offices.

7.0 REFERENCES

1. Continuum Dynamics, Inc., "Plan For Testing Evaluation of Paint Chip Head Loss on Vertically Oriented Zion Station Strainer Screen," First Draft, January 1997.

2. Continuum Dynamics, Inc. Technical Memorandum No. 97-05, "Evaluation of Paint Chip Head Loss On Vertically Oriented Zion Station Strainer Screen," First Draft, April 1997.

3. Continuum Dynamics, Inc., Quality Assurance Manual, Revision 12, October 1996.

ENCLOSURE 2

Checklist E of GOP-0, "Containment Close-out for H/U or S/U"

GOP-0 CHECKLIST E (Page 1 of 10)

CONTAINMENT CLOSE OUT FOR H/U OR S/U

1.0 PURPOSE

1. This checklist provides guidelines for inspecting Containment prior to plant heatup and startup after an outage.

2. This checklist should also be performed prior to plant startup if major work was performed in Containment.

2.0 INSTRUCTIONS

NOTE

1) The Shift Manager performs steps 1 and 2.

2) For short duration shutdowns when no scaffolding, step-off pads, or change areas have been set up in the Containment, the Shift Manager may eliminate totally or in part the requirement to perform the Containment inspection.

1. IF any portions of the Containment close out inspection checksheet are to be eliminated,
THEN mark such portions "N/A" and initial them.

2. Initiate Containment inspection checksheet for plant heatup or startup as applicable.

3. Inspect Containment for heatup or startup per GOP-0 Checklist E Checksheet guidance.

2.0 **INSTRUCTIONS** (Continued)

> **NOTE**
>
> The following step stems from an incident where material from the air filters of a temporary cooling unit plugged the RHR suction strainers in the suppression pool of a BWR (equivalent to Zion's containment recirculation sump strainers).
>
> NRC IEB 93-02. Debris Plugging of Emergency Core Cooling Suction Strainers. requires action to identify and remove all sources of fibrous material from containment prior to power operation.
>
> In addition to loose material. any item that could become dislodged during a LOCA and potentially restrict flow to the containment recirc sump should be evaluated (consider water/steam impingement and weakening of the item and its fasteners by exposure to water/steam).

4. Inspect all areas of containment for material which could potentially clog the containment recirc sump during the recirculation phase of a LOCA. (f/n 2)

   Examples:

   - Cleaning materials.
     - Rags. Kim Wipes. paper towels. etc.
   - Packing materials.
   - Wire.
     - Check for wire used in non-permanent installations. (Non-qualified installations could result in items becoming dislodged by steam/water impingement. and then being swept along to obstruct the sump intake screen).
   - Posted signs.
     - Radiation survey tags.
     - Inspection/maintenance tags.
       (e.g. on fire extinguishers and emergency lights)
   - OOS cards.
   - Plastic sheeting.
     - Visqueen.
     - Herculite.

2.0 **INSTRUCTIONS** (Continued)

- String, twine, rope, etc.
- Safety tape.
- Fire lagging material properly encased.
  - Must be enclosed in 1/8" wire mesh casing.
- Adhesive tape.
  - Check for installed tape also. (Adhesive tape will not withstand LOCA environment)
- Cardboard.
- Wood, plywood, pressboard, etc.
  - Check for installed wood products also. (Wood will not withstand LOCA environment)
- Sheet metal.
  - Check for installations that may not be of permanent design. (Non-qualified installations could result in the sheets becoming dislodged due to steam/water impingement, and then being swept along to obstruct the sump intake screen).

5. Document satisfactory items by initialing in the appropriate spaces.

6. IF an item is NOT satisfactory, THEN perform the following:

   a. Perform corrective action(s) as possible.

   b. IF an unsatisfactory condition can NOT be corrected, THEN perform the following:

      1) Mark the item "UNSAT".

      2) Describe the problem in the "remarks" section and mark it "H/U" or "S/U" as applicable.

CONTAINMENT CLOSE OUT FOR H/U OR S/U

2.0 INSTRUCTIONS (Continued)

7. WHEN the checksheet is completed, THEN perform the following:

   a. Sign and date the checksheet in the appropriate spaces.

   b. Forward the checksheet to the Unit Supervisor for review.

> **NOTE**
>
> The Unit Supervisor performs steps 8 through 10.

8. Review the completed checksheet.

9. IF any unsatisfactory conditions are noted, THEN initiate corrective actions.

10. WHEN the checksheet has been satisfactorily completed, THEN perform the following:

    a. Sign and date the checksheet in the appropriate spaces.

    b. Initial and date GOP-0 "Startup Package Document Checklist" in the appropriate spaces.

3.0 FOOTNOTES

1. Individual Plant Examination Insight Number ZI-330/IP.
2. 295-101-93-00205
3. 295-100-94-010-I.B.1.1
4. 295-180-94-00706

GOP-0 CHECKLIST E

CONTAINMENT CLOSEOUT FOR H/U OR S/U

CHECKSHEET (Sheet 1 of 6)

Date________
Startup #________
Unit #________

INSPECTION-REQUIRED CONDITION		PRIOR TO H/U (INITIALS)	PRIOR TO S/U (INITIALS)
590' ELEVATION INSIDE MISSILE BARRIER			
RCP Oil Levels - NORMAL (arrow mark to 1/2" above arrow mark)	Upper RCP A	______	______
	RCP B	______	______
	RCP C	______	______
	RCP D	______	______
	Lower RCP A	______	______
	RCP B	______	______
	RCP C	______	______
	RCP D	______	______

NOTE

All chain locked items require a UNIT KEY to unlock and position in proper location.

Ladders for RCPs - CHAINED & LOCKED TO STRUCTURAL STEEL OR FASTENED TO BRACKET	RCP A	______	______
	RCP B	______	______
	RCP C	______	______
	RCP D	______	______
Lead Storage Gang Boxes - CURBED or BOLTED DOWN or CHAINED & LOCKED TO STRUCTURAL STEEL	Box #1	______	______
	Box #2	______	______
	Box #3	______	______
Loose Tools or Equipment - NONE		______	______
Trash - REMOVED		______	______
Anti-C Clothing - REMOVED		______	______

GOP-0 CHECKLIST E (Page 6 of 10)

CONTAINMENT CLOSEOU)R H/U OR S/U

CHECKSHEET (Sheet 2 of 6)

INSPECTION-REQUIRED CONDITION		PRIOR TO H/U (INITIALS)	PRIOR TO S/U (INITIALS)
568' ELEVATION INSIDE MISSILE BARRIER			
Reactor Cavity Sump - STRAINER COVER CLEAR		______	______
Reactor Cavity Sump Blowout Panels - "SR" LOCKS REMOVED		______	N/A
- EXPLOSION PINS INSTALLED		______	N/A
Lead Storage Gang Boxes - INSIDE THEIR CURBS	Box #1	______	______
	Box #2	______	______
	Box #3	______	______
NIS Detectors (8) - FULLY INSERTED IN WELL AND 2 PINS INSTALLED. (located on Biological Shield Wall)		N/A	______
Reactor Containment Sump - STRAINER COVER CLEAR		______	______
1(2)DT-0001, "Refueling Cavity to Containment Sump Drain Valve" [Z-4(Z-31)] - LOCKED OPEN (f/n 1)		______	______
Recirc Sump - STRAINER COVER CLEAR		______	______
Tools and Maintenance Equipment - NONE (secure any loose equipment in authorized tool storage boxes on 617' elevation)		______	______
Trash - REMOVED		______	______
Anti-C clothing - REMOVED		______	______
568' ELEVATION OUTSIDE MISSILE BARRIER			
Missile Barrier Doors - LOCKED		N/A	______
Tools and Maintenance Equipment - NONE (secure any loose equipment in authorized tool storage boxes on 617' elevation)		______	______
FOP Ladder - CHAINED & LOCKED		______	______
Trash - REMOVED		______	______
Anti-C Clothing - REMOVED		______	______
Step-off Pad Papers - REMOVED		______	______
RCFC drains - CONDENSATION FLOW FROM RUNNING RCFCs		______	______

GOP-0 CHECKLIST E

CONTAINMENT CLOSEOUT FOR H/U OR S/U

CHECKSHEET (Sheet 3 of 6)

INSPECTION-REQUIRED CONDITION	PRIOR TO H/U (INITIALS)	PRIOR TO S/U (INITIALS)
<u>590' ELEVATION OUTSIDE MISSILE BARRIER</u>		
VERIFY access doors for <u>ALL</u> RCFCs are LOCKED CLOSED.		
- RV0001 A Reactor Containment Fan Cooler.	______	______
- RV0002 B Reactor Containment Fan Cooler.	______	______
- RV0003 C Reactor Containment Fan Cooler.	______	______
- RV0004 D Reactor Containment Fan Cooler.	______	______
- RV0005 E Reactor Containment Fan Cooler.	______	______
Loose Tools or Equipment - NONE	______	______
Trash - REMOVED	______	______
Anti-C Clothing - REMOVED	______	______
Step-off Pad Papers - REMOVED	______	______
Escape Hatch - SECURED IN THE CLOSED POSITION	______	______
- CLEAR OF CLUTTER - Containment Side	______	______
- OPERABLE *	______	______
* Escape Hatch door seal air pressure greater than or equal to 2.5 PSIG as read on PI-PP34, 617' directly over Escape Hatch.		
<u>617' ELEVATION - RX CAVITY, PZR COFFIN, CRD FANS</u>		
Tool Storage Gang Boxes - BOLTED DOWN or CHAINED & LOCKED TO STRUCTURAL STEEL — Box #1	______	______
Box #2	______	______
Air Sampler and Dehumidifier - SECURED TO TABLE	______	______
RT Work Bench - BOLTED DOWN or CHAINED & LOCKED	______	______
Following Equipment - WIRED TO GRATING		
- Reactor Head Ladder	______	______
- Equipment Lifting Cables	______	______
- Lifting Rigs	______	______
Following Equipment - CHAINED & LOCKED TO STRUCTURAL STEEL		
- Reactor Head Bolt Storage Racks	______	______
Manipulator Crane Fans - OFF (switch on crane)	______	______
Loose Tools or Equipment - NONE	______	______
Trash - REMOVED	______	______
Anti-C Clothing - REMOVED	______	______
Step-off Pad Papers - REMOVED	______	______
Transfer Canal Blank Flange - INSTALLED	______	N/A
Purge Valves - Pins REMOVED	______	N/A
- Access Hatches INSTALLED	______	N/A

GOP-0 CHECKLIST E

CONTAINMENT CLOSEOUT FOR H/U OR S/U

CHECKSHEET (Sheet 4 of 6)

INSPECTION-REQUIRED CONDITION	PRIOR TO H/U (INITIALS)	PRIOR TO S/U (INITIALS)
CONTAINMENT DOORS		
Posted as High Radiation Area	N/A	_____
Personnel access hatch chained and locked after all personnel have exited containment.	N/A	_____
FUEL BUILDING		
Transfer Canal valve - CLOSED	_____	N/A
Containment lights - OFF unless required	N/A	_____
Manipulate Crane Power Supply - OFF U-1 = MCC 1331B - E5 U-2 = MCC 2331B - D4	_____	_____
R.C.C. Change Fixture Power Supply - OFF U-1 = MCC 1331A - C1 U-2 = MCC 2331C - J6	_____	_____
PERSONNEL HATCH		
Tools to open doors in place (located in hatch)	_____	_____

GOP-0 CHECKLIST E (Page 9 of 10)

CONTAINMENT CLOSEOUT FOR H/U OR S/U

CHECKSHEET (Sheet 5 of 6)

INSPECTION-REQUIRED CONDITION	PRIOR TO H/U (INITIALS)	PRIOR TO S/U (INITIALS)
<u>FME CAP CHECK</u> (f/n 3)		
617' Z-5 (Z-31) at bottom of hatch stairs by RP humidifier		
CONT AIR MONITORING INLET (P-44) Must be uncapped unless directed by LSS.	_____	_____
592' Z-5 (Z-30) in letdown orifice block valve room (penetration area)		
CONT PRESSURE SENSING LINE FOR PT-CS19 P-41 Must be uncapped in modes 1, 2, 3, and 4.	_____	_____
CONT PRESSURE SENSING LINE FOR PT-CS22 P-54 Must be uncapped in modes 1, 2, 3, and 4.	_____	_____
CONT PRESSURE SENSING LINE FOR PT-CS20 P-78 Must be uncapped in modes 1, 2, 3, and 4.	_____	_____
CONT PRESSURE SENSING LINE FOR PT-CS21 P-82 Must be uncapped in modes 1, 2, 3, and 4.	_____	_____
CONT PRESSURE AND VACUUM RELIEF P-60 Must be uncapped in modes 1, 2, 3, and 4.	_____	_____
ACCUMULATOR NITROGEN VENT P-76 Must be uncapped in modes 1, 2, 3, and 4.	_____	_____
CONT AIR MONITORING OUTLET P-44 Must be uncapped unless directed by LSS.	_____	_____
560' Z-5 (Z-30) pipe penetration area:		
HYDROGEN RECOMBINER OUTLET P-56 Must be uncapped in modes 1 through 4.	_____	_____
592' pump deck IMB:		
HYDROGEN MONITORING SYSTEM (P-15) ALL must be uncapped unless directed by LSS.		
- Z-6 (Z-28) by A RCP near missile barrier wall.	_____	_____
- Z-11(Z-24) by C RCP near missile barrier wall.	_____	_____
- Z-16(Z-20) by D RCP near missile barrier wall.	_____	_____
- Z-2 (Z-23) by B RCP near missile barrier wall.	_____	_____

GOP-0 CHECKLIST E (Page 10 of 10)

CONTAINMENT CLOSEOUT FOR H/U OR S/U

CHECKSHEET (Sheet 6 of 6)

REMARKS: ____

____

____

____

____

____

Prior to H/U ____________________ ____________________
Inspected By Date

| Unit Supervisor Review ____________________ ____________________
Approved By (f/n 4) Date

Prior to S/U ____________________ ____________________
Inspected By Date

| Unit Supervisor Review: ____________________ ____________________
Approved By (f/n 4) Date

FINAL

ENCLOSURE 3

Reference 5.14 of Calculation 22S-B-008M-092.

Commonwealth Edison Company
Engineering and Construction

Document Coding Form

Computer Entry:
Company SARG
Name SLD

CECo Station ID: ZI Zion

DBD Code Number: 004 (illegible handwriting)

Document Category: 08

DBD Reference Number: 08.00586

Document Identification:

Title/Subject: RECIRCULATION SUMP SCREEN

Revision: 0

Create Date: / /

Vendor Code: S040

Originating Organization: S&L
Department: MECHANICAL
Person:

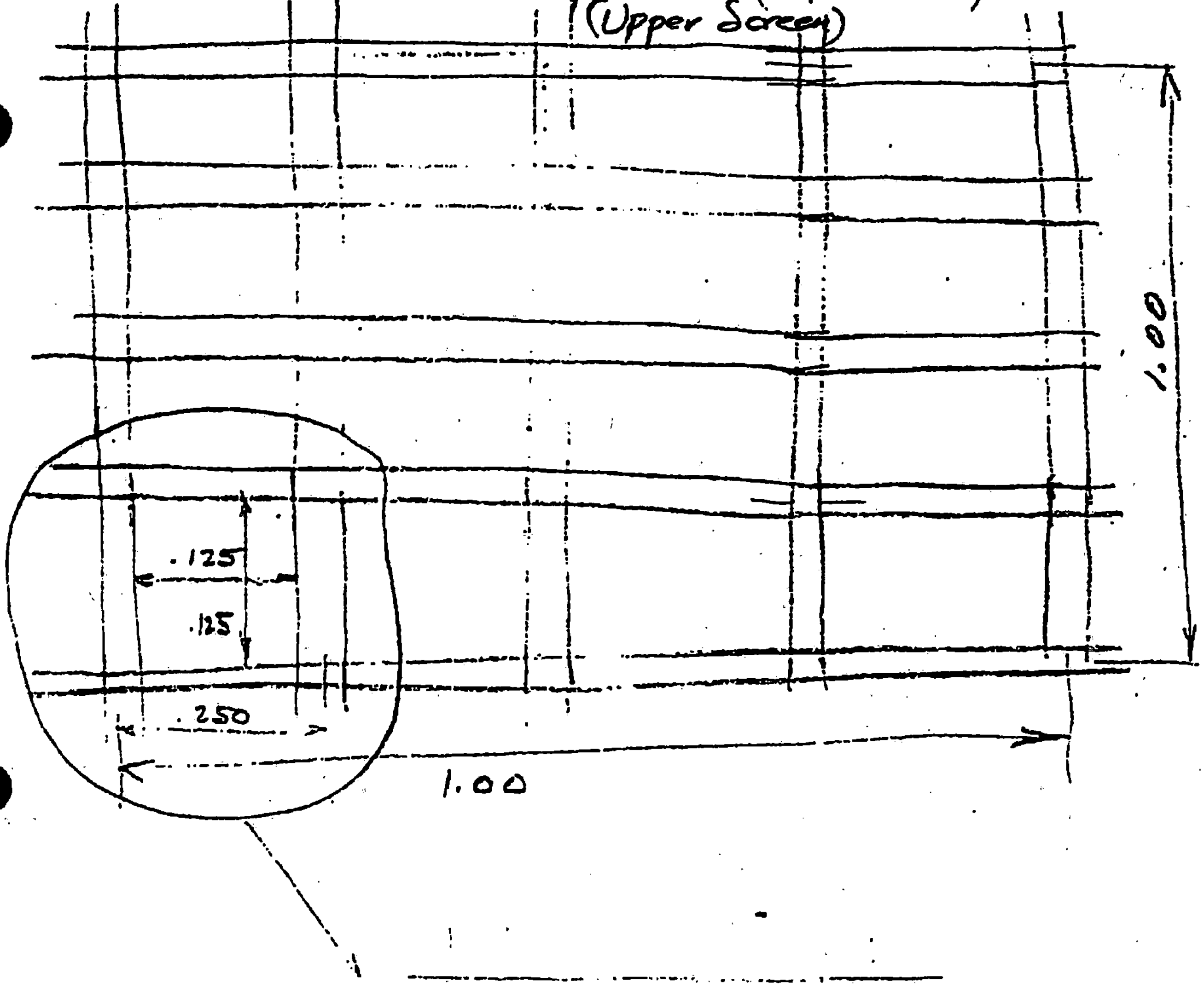
Related to DBD?:

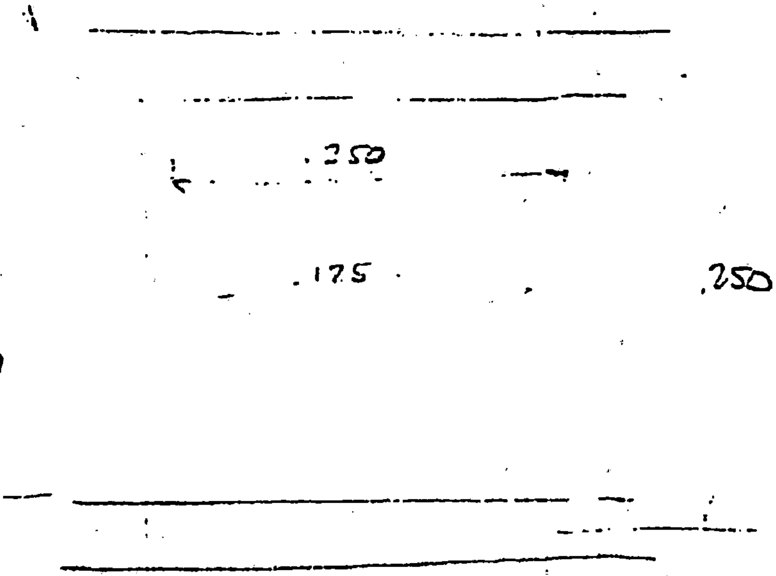
In Reference Manual?: N Format: HC Quantity of Pages: 0007
(Including Coding Forms)

Proprietary: N Document Text File: .

Abstract:
File Location: BOOK 13 TAB 16

Recirculation Sump Screen (As-Built)
(Upper Screen)





.250
.125
.125
2 .0625

.125

$(.250)^2 - (.125)^2 = .0469$

.0625
.0156
.0469

$\frac{.0469}{.0625} = 75\%$

∴ Open area = 25%

Screen Area = $(4.25 \times .75) + (4.5 \times .75) + (9 \times .75) + (11 \times .75)$

$$= \begin{array}{r} 3.18 \\ 3.38 \\ 6.75 \\ 8.25 \\ \hline 21.56\ ft^2 \end{array} \times .25 = 5.36\ ft^2$$

Flow = 15000 gpm

$$\frac{15000\ gal/min}{7.48\ gal/ft^3} = 2010\ ft^3/min$$

$$\frac{2010}{5.36} = 374\ ft/min = 6.25\ ft/sec$$

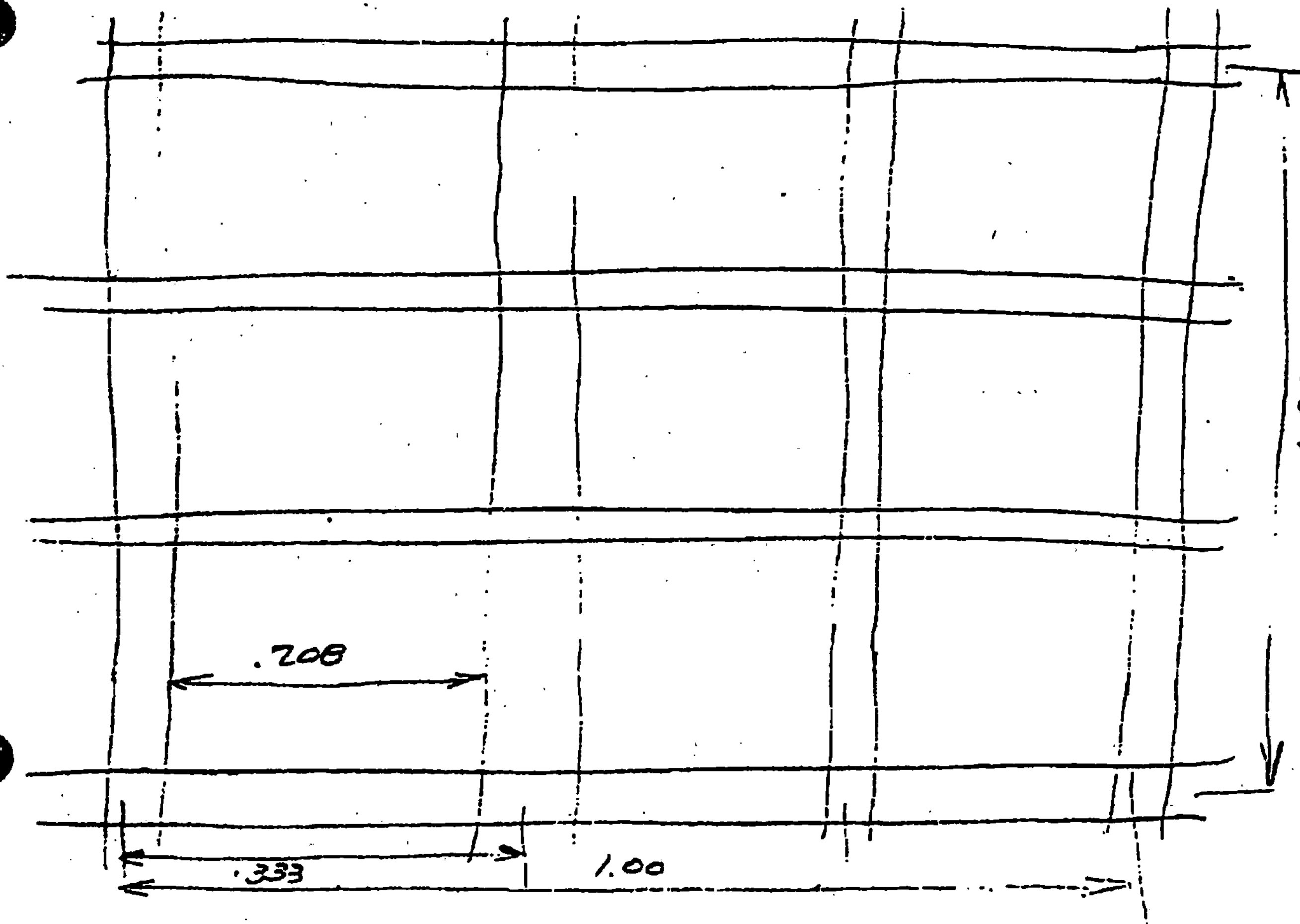
$$\Delta H = K\frac{V^2}{2g}$$

From S&L Standard ME-2.16 pg 16

$K = 10$ for $\frac{A_0}{A_2} = .25$

$$\Delta H = \frac{10(6.25)^2}{64} = 6.1\ ft.$$

Assume 3/8" Sq. wire mesh 14GA



$$(.333)^2 - (.208)^2 = 0.068$$

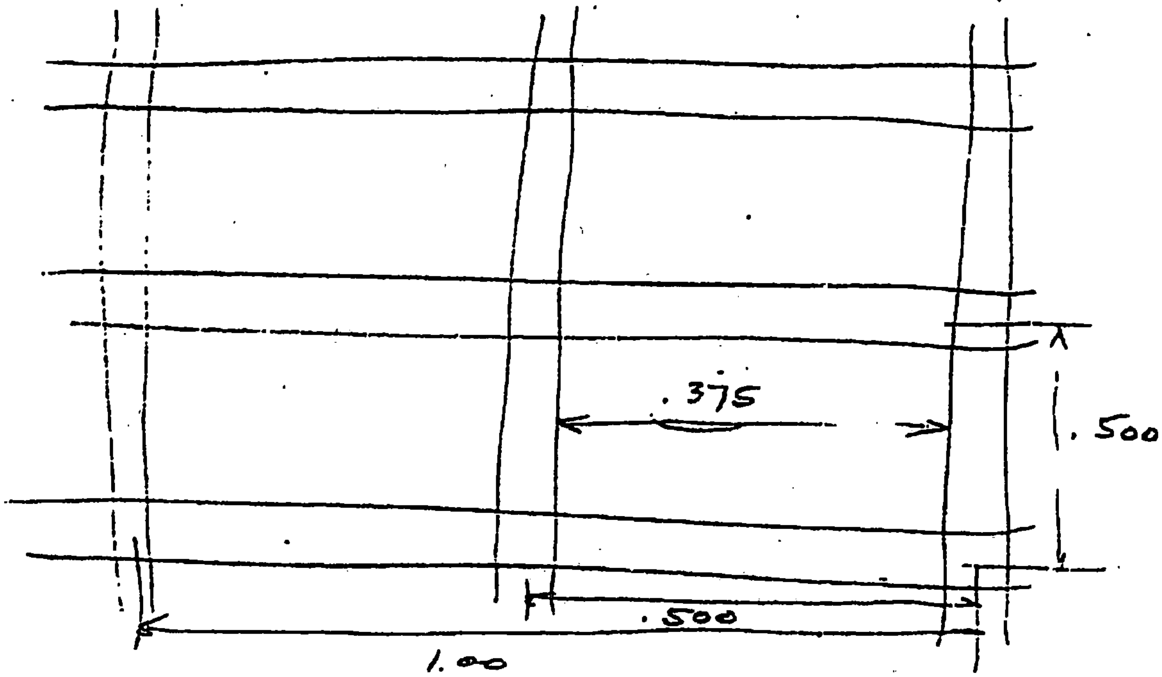
$$\begin{array}{r} .111 \\ .043 \\ \hline .068 \end{array} \qquad \frac{0.068}{.111} = .61 \qquad \text{Open area} = 39\% \qquad (K = 3)$$

$$21.56 \times .39 = 8.4\ ft^2$$

$$\frac{2010}{8.4(60)} = 4.0\ ft/sec$$

$$\Delta H = \frac{3(4.0)^2}{64} = 0.75\ ft.$$

Assume 1/2" sq. wire mesh 14GA
DIA = 0.080



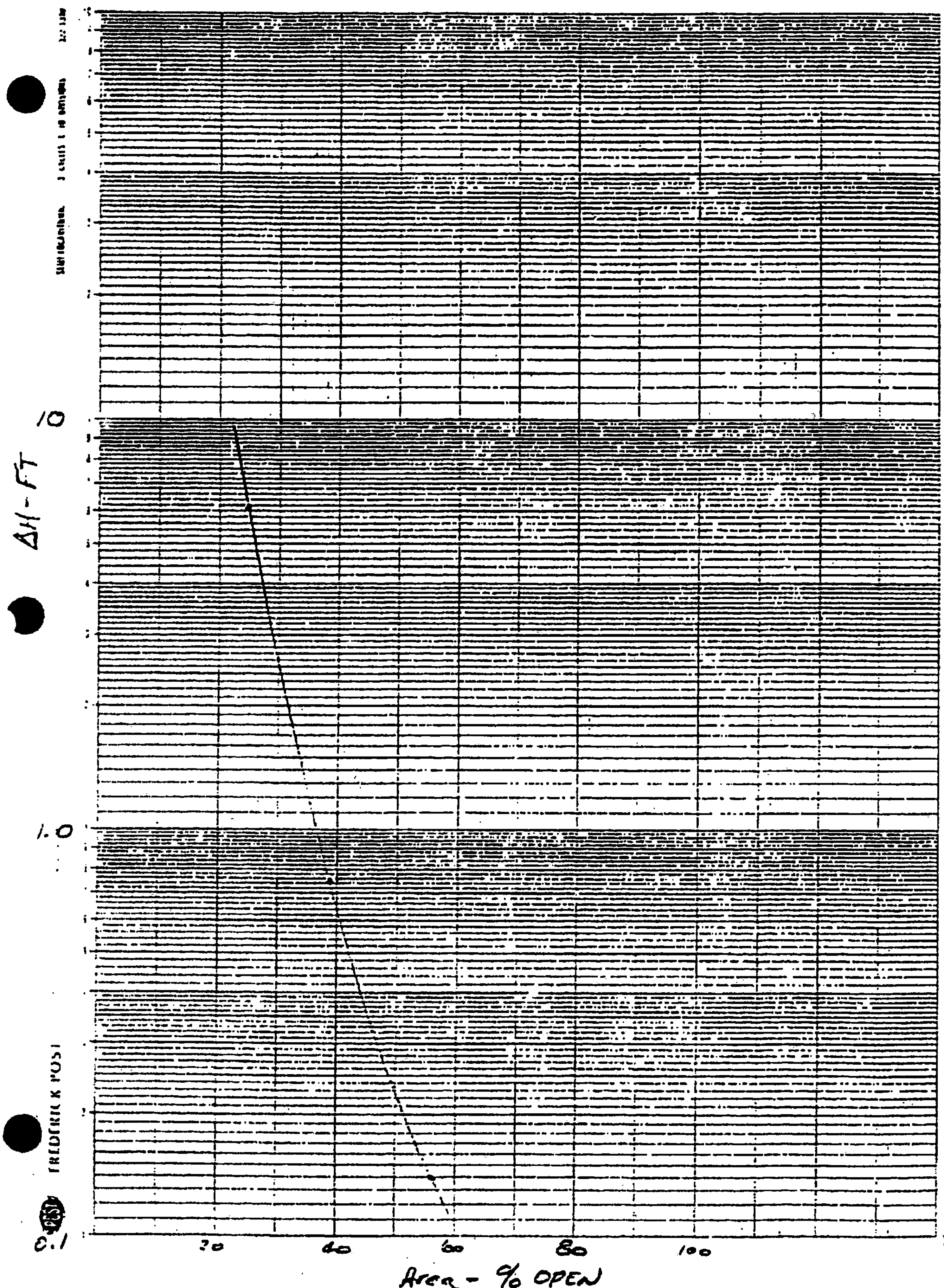
$(.500)^2 - (.375)^2 = .109$

$$\begin{array}{r} .250 \\ .141 \\ \hline .109 \end{array} \qquad \frac{.109}{.250} = .435 \qquad \text{open area} = 56.5\% \ (K = 1.2)$$

$21.56 \times .565 = 12.2\,ft^2$

$$\frac{2010}{12.2(60)} = 2.75\,ft/sec$$

$$\Delta H = \frac{1.2(2.75)^2}{64} = 0.14\,ft$$

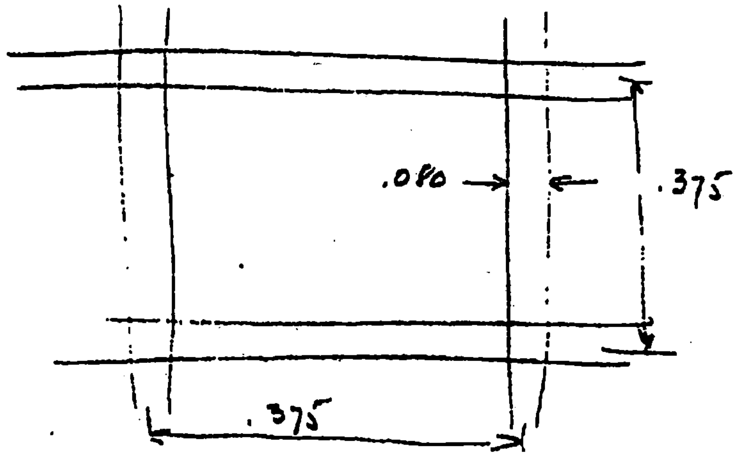

ΔH - FT
10
1.0
0.1
20
40
60
80
100
Area - % OPEN
FREDERICK POST

(Lower Screen)

$3(3 \times 2\tfrac{3}{4}) + \tfrac{1}{2}(1\tfrac{1}{4})(3) + 3(\tfrac{3}{4}) =$

$24.8 + 1.87 + 2.25 = 28.92\ ft^2$

Assume 3/8" sq. wire mesh 14GA



$(.375)^2 - (.295)^2 = .054$

$$\begin{array}{r} .141 \\ .087 \\ \hline .054 \end{array} \qquad \frac{.087}{.141} = .62$$

Open area = 62%
(K = 1)

$28.92 \times .62 = 17.9\ ft^2$

$$\frac{2010}{17.9(60)} = 1.87\ ft/sec$$

$$\Delta H = \frac{(1)(1.87)^2}{64} = 0.055\ ft$$

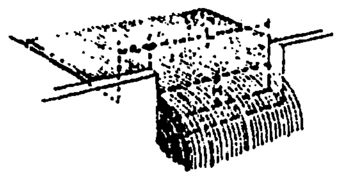
Total drop = 0.14 + 0.055 = <u>0.195 ft</u>

ENCLOSURE 4

Reference 5.5 of Calculation 22S-B-008M-092

ENCLOSURE 5

Table on page 2-10 of Reference 5.2 of Calculation 22S-B-008M-092



Discharge From Rectangular Weir with End Contractions

Figures in Table are in Gallons Per Minute

Head (H) in inches	Length (L) of weir in feet: 1	3	5	Additional gpm for each ft over 5 ft	Head (H) in inches	Length (L) of weir in feet: 3	5	Additional gpm for each ft over 5 ft
1	35.4	107.5	179.8	36.05	8	2338	3956	814
1¼	49.5	150.4	250.4	50.4	8¼	2442	4140	850
1½	64.9	197	329.5	66.2	8½	2540	4312	890
1¾	81	248	415	83.5	8¾	2656	4511	929
2	98.5	302	506	102	9	2765	4699	970
2¼	117	361	605	122	9¼	2876	4899	1011
2½	136.2	422	706	143	9½	2985	5098	1051
2¾	157	485	815	165	9¾	3101	5288	1091
3	177.8	552	926	187	10	3216	5490	1136
3¼	199.8	624	1047	211	10½	3480	5940	1230
3½	222	695	1167	236	11	3716	6355	1320
3¾	245	769	1292	261	11½	3960	6780	1410
4	269	846	1424	288	12	4185	7165	1495
4¼	293.6	925	1559	316	12½	4430	7595	1575
4½	318	1006	1696	345	13	4660	8010	1660
4¾	344	1091	1835	374	13½	4950	8510	1780
5	370	1175	1985	405	14	5215	8980	1885
5¼	395.5	1262	2130	434	14½	5475	9440	1985
5½	421.6	1352	2282	465	15	5740	9920	2090
5¾	449	1442	2440	495	15½	6015	10400	2165
6	476.5	1535	2600	528	16	6290	10900	2300
6¼		1632	2760	560	16½	6565	11380	2410
6½		1742	2920	596	17	6925	11970	2520
6¾		1826	3094	630	17½	7140	12410	2640
7		1928	3260	668	18	7410	12900	2745
7¼		2029	3436	701.5	18½	7695	13410	2855
7½		2130	3609	736	19	7980	13940	2970
7¾		2238	3785	774	19½	8280	14460	3090

This table is based on Francis formula.

$$Q = 3.33 (L - 0.2H)H^{1.5}$$

in which

Q = ft^3 of water flowing per second.
L = length of weir opening in feet (should be 4 to 8 times H).
H = head on weir in feet (to be measured at least 6 ft back of weir opening)
a = should be at least 3 H

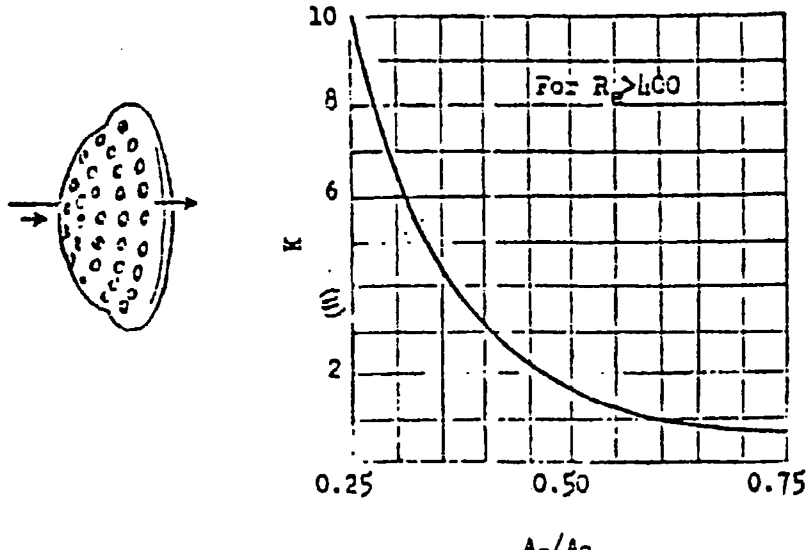
ENCLOSURE 6

Page 17 of Reference 5.17 of Calculation 22S-B-008M-092

FIGURE 9

RESISTANCE COEFFICIENT FOR STRAINERS AND COARSE FILTERS

("Local Resistance to Flow," Louis Dodge, Product Engineering - March 1974, Page 68)

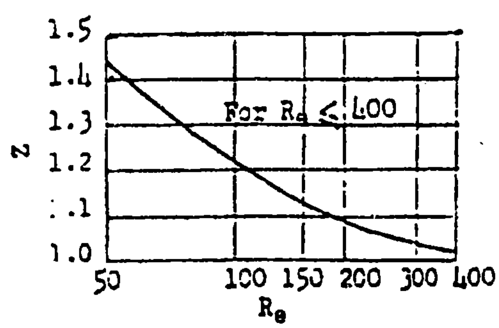


A_o = Open area, ft^2
A_2 = Total effective area, $A_2 = A_o$ + solid area, ft^2

FIGURE 10

RESISTANCE CORRECTION FACTOR

("Local Resistance to Flow," Louis Dodge, Product Engineering - March 1964, Page 68)



For $R_e \leq 400$
$K = Z \times K$ (for $R_e > 400$)

ENCLOSURE 7

Drawing of the Containment Sump

OVERSIZE
DOCUMENT
PAGE(S) PULLED

SEE APERTURE CARD FILES

APERTURE CARD/PAPER COPY AVAILABLE THROUGH NRC FILE CENTER
****

NUMBER OF OVERSIZE PAGES FILMED ON APERTURE CARD(S) 2
****

ACCESSION NUMBERS OF OVERSIZE PAGES:

9709170003

9709170005