Potential for Loss of NPSH Due to LOCA Debris Accumulation on PWR ECCS Sump Screens

Review of GSI-191 Industry Survey

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Review of GSI-191 Industry Survey - Overview

- Purpose of Survey
- LANL Review of Responses
- Parameters for Use in Parametric Evaluation
- Needed Parameters Not in Survey
- Key Findings from LANL Review of Survey Responses
- Survey Response Examples
- Limitations of Survey Information
- Summary

Purpose of GSI-191 Industry Survey

- Purpose
  - Provide Most Up-to-date Information on Insulation and Sump Configurations at Each Operating PWR
  - Collect Such Information to be Used in Design and Conduct of NRC GSI-191 Research
- Procedure
  - NRC Formulated Set of Questions Intended to Capture Information Needs and Forwarded to Licensees
  - Licensees Responses and Drawings Collected by Nuclear Energy Institute (NEI) – Information Forwarded to NRC
  - Total of 59 Responses Received by January 2000
  - LANL Reviewed Survey Responses for Use in Parametric Evaluation

LANL Review of Industry Responses

- Determine if Sufficient Information Available to Assess Effects of Debris Accumulation on Sump Screen Performance
- Plant Features that Affect:
  - Debris Generation
  - Debris Transport
  - Debris Accumulation on Sump Screen
  - Head Loss Across Screen During ECCS Recirculation
- Did NOT Attempt to Interpret Responses – However, Did Look for Obvious Inaccuracies or Missing Info.
- Looked for Consistency v. Variability over Industry for Various Plant Characteristics

Parametric Evaluation Parameters

- Identified Needs for Parametric Evaluations
  - Insulation Types in Containment
  - Relative Insulation Quantities (i.e., % of each)
  - Sump Screen Surface Area
  - $NPSH_{Margin}$ for HPSI, LPSI
  - Containment Water Pool Depth (switchover/max)
  - Sump Screen Height (to determine submergence)
  - ECCS/Spray Recirculation Flow Rates
  - Containment Spray Setpoint
- Other Information Not Used Explicitly In Parametrics
  - Sump Screen Mesh Size
  - Time of Switchover to Recirculation
  - Sump Location
  - Others

Needed Parameters Not In GSI-191 Survey

- Some Parameters Not Available from GSI-191 Survey Responses
  - NPSH Margin
  - Expected Recirculation Flow Rates
  - Containment Spray Setpoints
  - "Missing Responses"
  - "Missing Units"
- Sources Used to Obtain Missing Information
  - Plant FSARs, IPEs, Drawings & EOPs
  - Plant System Notebooks
  - Plant Responses to NRC Generic Letter 97-04
  - NUREG/CR-5640
  - Plant Visits

Key Findings from LANL GSI-191 Survey Review

- Wealth of Information on Plant Characteristics that Affect Sump Screen Debris Accumulation and Subsequent Performance
- Information from Survey and Supplemental Sources Not Sufficient to Perform Detailed Assessment for Individual Plants within GSI-191 Scope
  - High Variability Across Industry for Individual Parameters Makes Grouping of Plants for Vulnerability Assessment Difficult (screen area, insulation types, etc.)
  - Missing or Unclear Responses Made Assumptions Necessary in Parametric Evaluation (e.g., Question 3e: How Much Screen Area is Available?, Response: "All of it.")
  - Less Complete Information Available for SLOCA

Key Findings (Continued) – Sump Design

- Nearly 1/3 of Operating PWRs Have NPSH Margin < 2 ft-water & Nearly 2/3 Have NPSH Margin < 4 ft-water
  - In General, PWR Sumps Have Low NPSH Margin Compared to Potential Head-Loss Impacts from Debris Accumulation on Sump Screen
- Sumps Have Various Configurations and Locations
  - Combined with Wide Variability in Other Reported Parameters, Makes Firm Assessment of Individual Unit Vulnerability Difficult, Based on Generic Study
- Sump Screens Will Not Be Fully Submerged in 19 PWR Units at Switchover to Recirculation
  - Mode of Failure Strongly Influenced by Submergence
  - Note this result may be a reflection of licensing basis assumptions regarding water holdup, water sources, etc.
- Sump Screen Clearance Size Varies from 0.125” to 0.6” (two units report no fine mesh screen)

Key Findings – Debris Sources

- Most Plants Reported Potential Fibrous Debris Sources
  - Insulation Reported Includes: Nukon, Jacketed Nukon, Fiberglass Blanket, Jacketed (cloth or metallic) Fiberglass, Mineral Wool, Temp-Mat, Kaowool
  - Other Potential Fibrous Debris Sources Present (e.g., fire barrier materials and filters), But Not Considered in Parametric Evaluation
- Significant Majority of Plants Report Cal-Sil Insulation
  - Plants Reported Both Jacketed and Unjacketed Insulation
  - Some Report Min-"K", Asbestos, Unibestos Mass-Type Insulations
- Other Insulation Types Reported That Are Not Assumed to Affect Sump Screen Performance (In General)
  - Reflective Metallic Insulation (RMI) – Aluminum and Stainless Steel
  - Armaflex
  - Neoprene
  - Vinylcell
  - Foamglass

Number of Units Reporting Fibrous Insulation Types

- Low-Density Fiberglass
  - Nukon (12)
  - Jacketed Nukon (9)
  - Nukon w/wire wrap (1)
  - SS Jacketed Transco (1)
  - Encapsulated Transco (1)
  - Transco Blanket (1)
  - SS Covrd Transco w/fill (1)
- Mineral Wool (MW)
  - Mineral Wool (9)
  - Encapsulated MW (5)
  - Encapsulated MW Block (2)
  - SS Jacketed MW (2)
  - Mineral Fiber Blanket (1)
- High-Density Fiberglass
  - Temp-Mat (7)
  - SS Jacketed Temp-Mat (1)
  - Thermoglass Covered Temp-Mat (2)
  - Temp-Mat w/Silicon Cloth (1)
  - SS Covered Temp-Mat w/rubberized cloth (2)
  - Temp-Mat Blankets (2)
- Others Reported Various Miscellaneous Fiberglass, Cellular Glass, & Ceramic Fiber

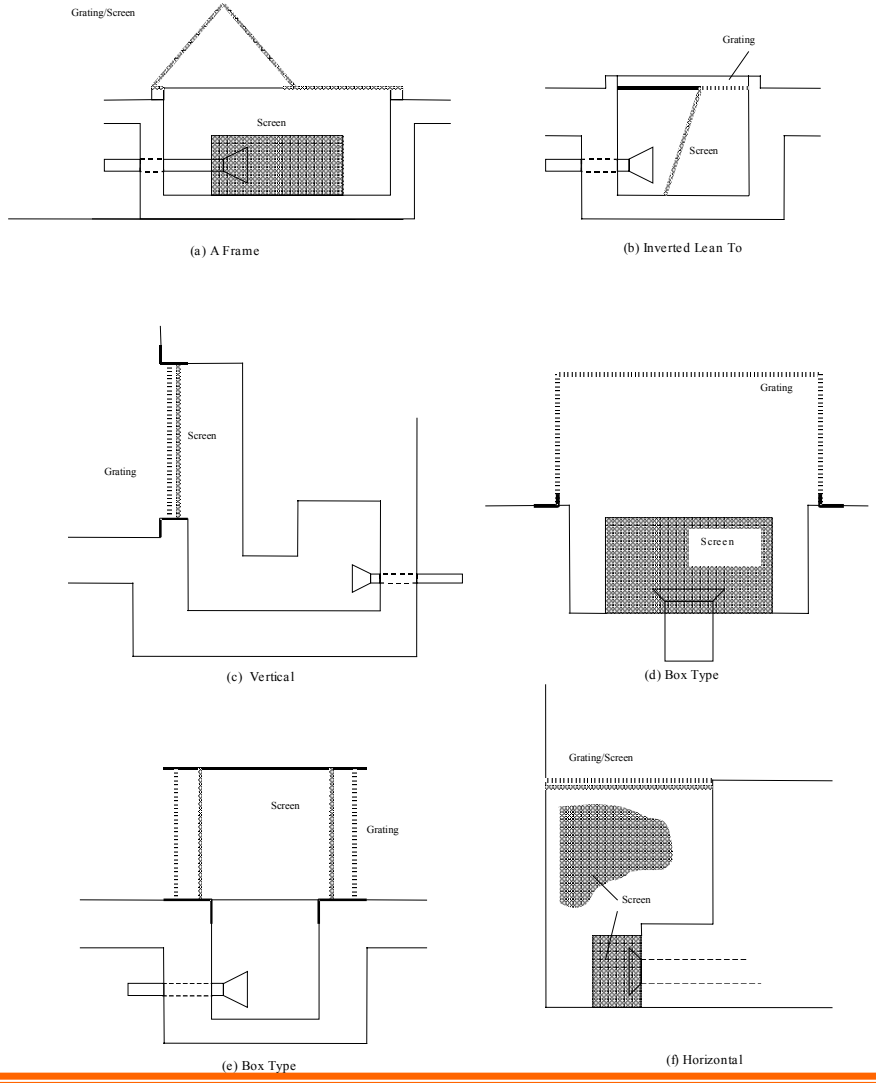
High-Pressure Pump Flow for SLOCA Mitigation

- Data Primarily Gathered From NUREG/CR-5640
- Based on These Data, Representative SLOCA Flow of 2500 gpm Assumed in Parametric Evaluation

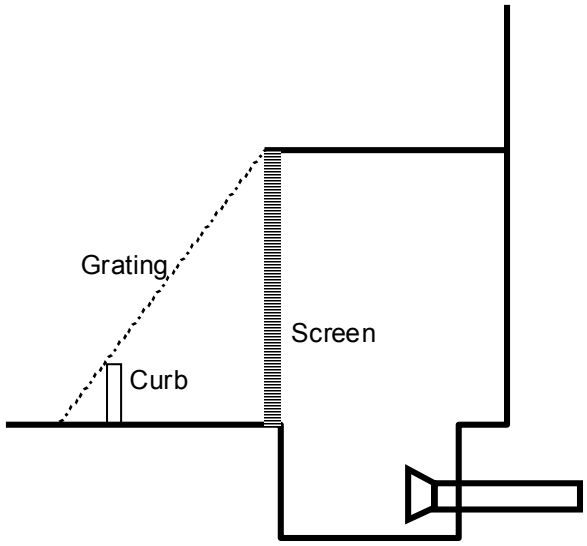
Plant	No. of Centrifugal Pumps	Centrifugal Pump Flow Rate at Pressure Listed at Right-Hand Column (gpm)	Centrifugal Pump Pressure (psig)	Centrifugal Pump Flow at 500 psig (per pump, runout flow)	No. of PD Pumps	PD Pump Capacity (gpm)	No. of HPSI Pumps	HPSI Pump Flow Rate at Pressure Listed at Right-Hand Column (gpm)	HPSI Pressure (psig)	HPSI Pump Flow at 500 psig (per pump, runout flow)	Total ECCS Flow at 500 psig
Beaver Valley 1 & 2	3	150	2514				**				?
Braidwood 1 & 2	2	150	2526		1	98	2	400	1106		?
Byron 1 & 2	2	150	2526		1	98	2	400	1106		?
Callaway	2	150		550	1	98	2	425	1162	650	2498
Catawba 1 & 2	2	150	2800		1	98	2	400	1750		?
Comanche Peak 1 & 2	2			550	1	unknown	2			650	2400
DC Cook 1	2	150	2800	550	1	98	2	400	1700	650	2498
DC Cook 2	2	150	2800	550	1	98	2	400	1700	650	2498
Diablo Canyon 1 & 2	2	150	2514	550	1	98	2	425	1084	650	2498
Farley 1 & 2	3	150	2800	700			**				2100
Ginna					3	60	3	300	1170	550	1830
Indian Point 2	3			650	3	98			1180		2244
Indian Point 3	3			650	3	98			1180		2244
Kewaunee					3	60.5	2	700	1082	850	1881.5
McGuire 1 & 2	2	150	2514		1	55	2	400	1106		?
Millstone 3	3	150	2800				2	425	1500		?
North Anna 1 & 2	3	150	2500	650			**				1950
Point Beach 1 & 2					3	60.5	2	700	1750	1100	2381.5
Prarie Island 1 & 2					3	60.5	2	700	1082	850	1881.5
Robinson					3	77	3	375	1750		?
Salem 1 & 2	2	150	2800	600	1	98	2			650	2598
Seabrook	2	150	2800	550	1	98	2	425	1750	650	2498
Sequoyah 1 & 2	2	150	2514	550	1	55	2	425	1084	650	2455
Shearon Harris 1	3	150	2514				**				?
South Texas 1 & 2	2	150	2513	?	1	35	3	800	1235	1600	4835
Summer	3	150		650	3	150	**				2400
Surry 1 & 2	3	150	2485				**				?
Turkey Point 3 & 4					3	77	2	300	1750		?
Vogtle 1 & 2	2	150	2514	550	1	98	2	425	1162	650	2498
Watts Bar 1 & 2	2	150	2514		1	98	2				??
Wolf Creek	2	150	2514	550	1	98	2	425	1161	650	2498

Table Notes:
* Does not include contribution from charging pumps.
** Same as charging pumps.

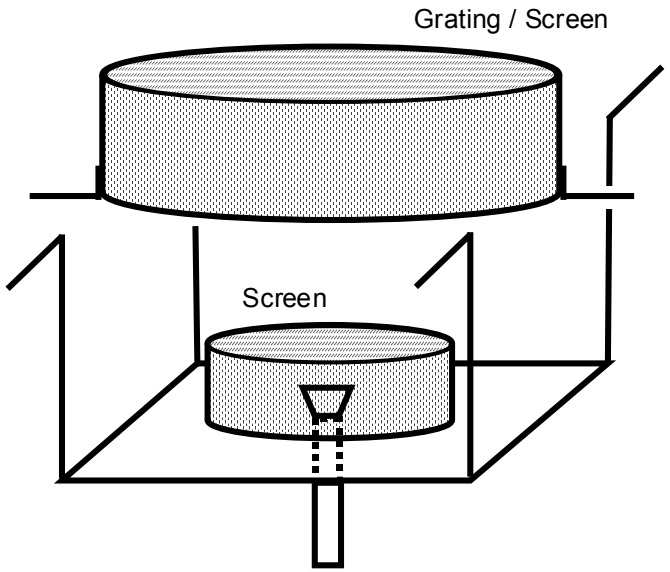
Sump Screen Configurations - Idealized



Sump Screen Configurations - Idealized

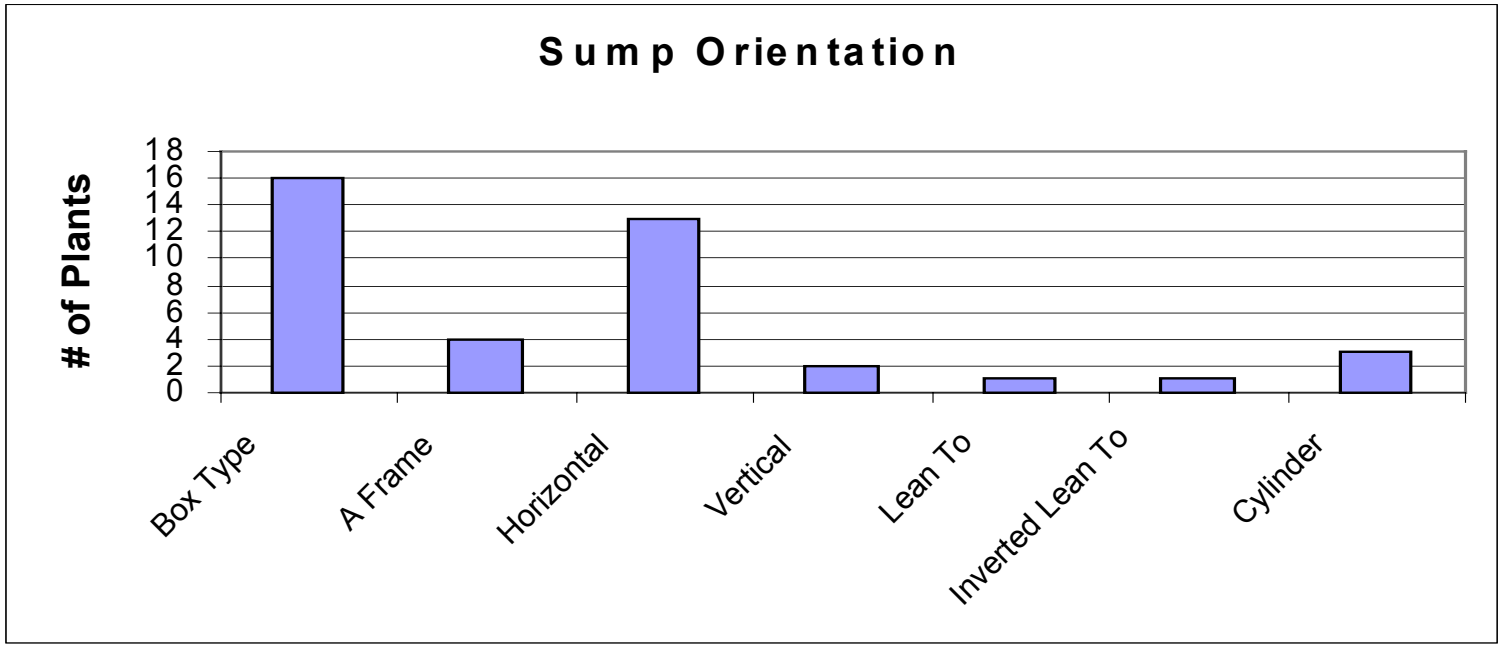


(a) Lean to Vertical

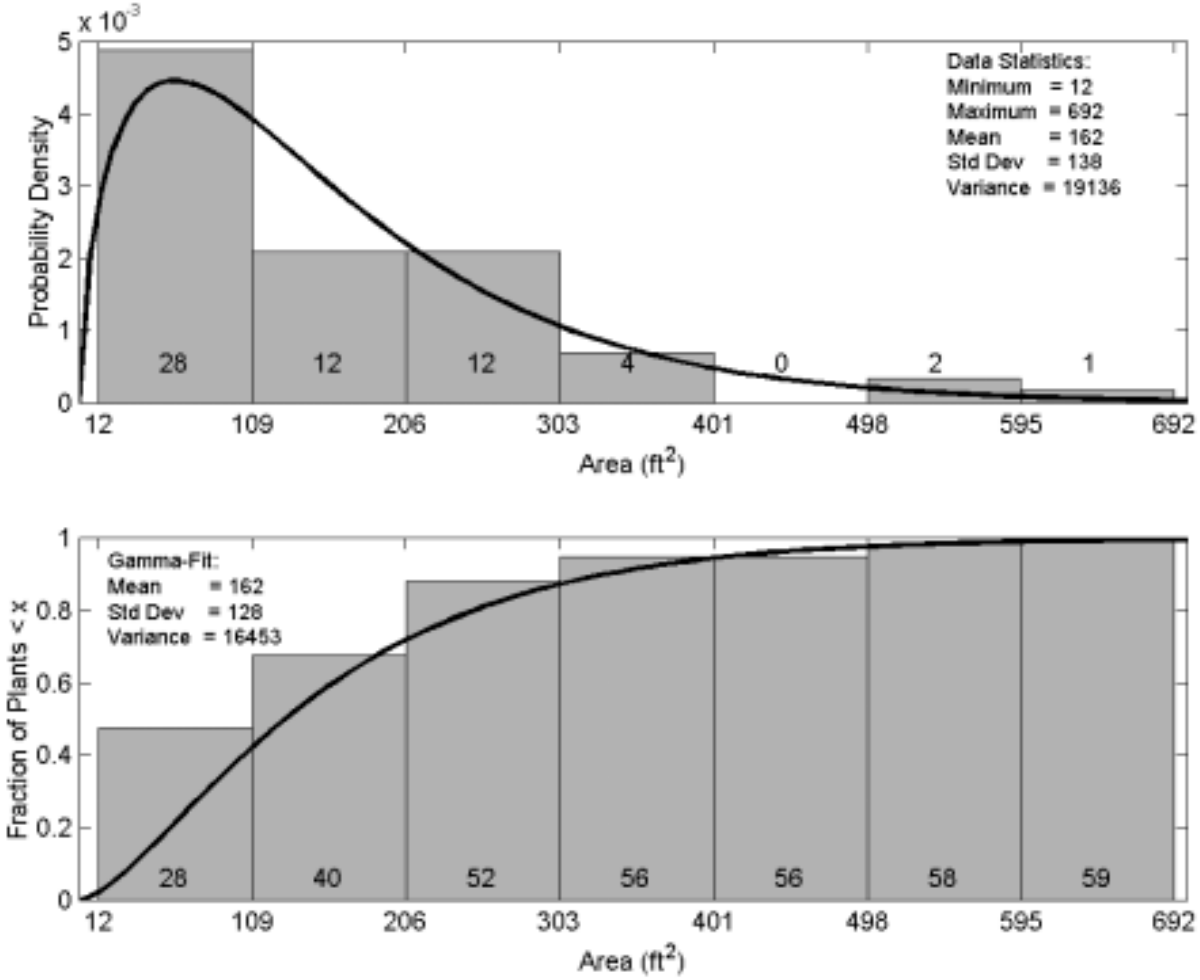


(b) Cylindrical

Reported Sump Screen Configurations

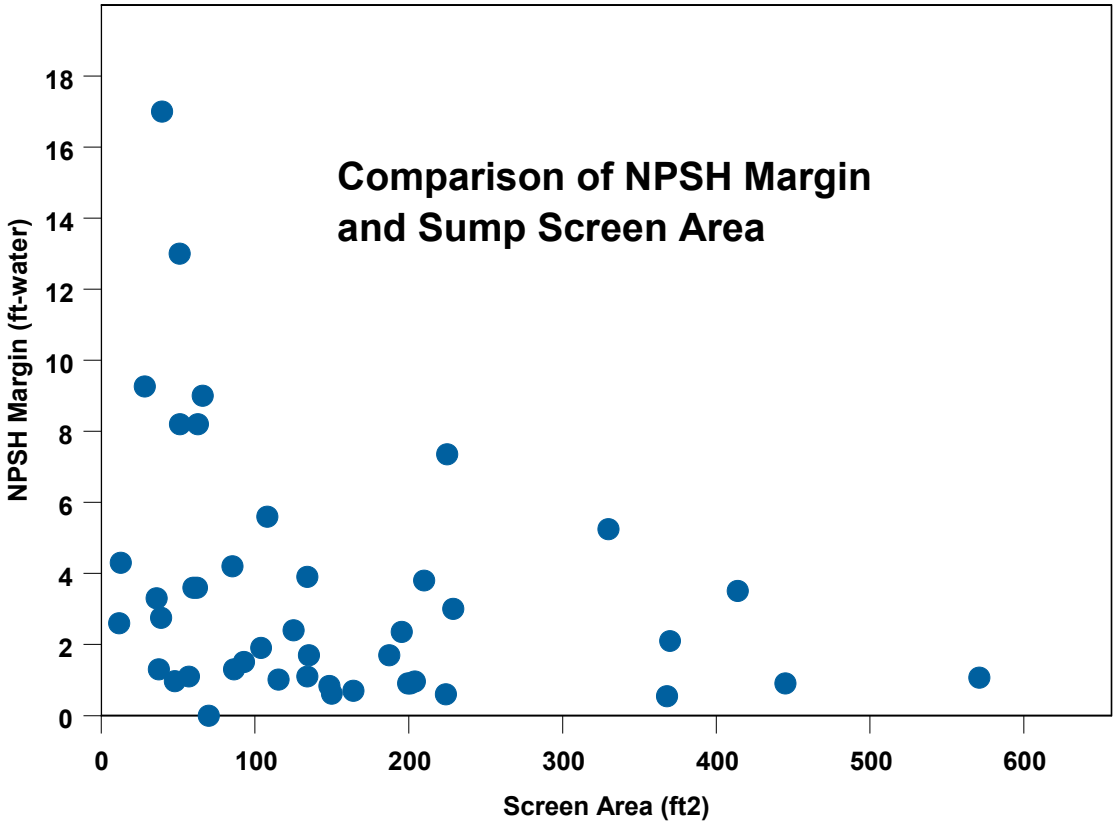


Sump Screen Area

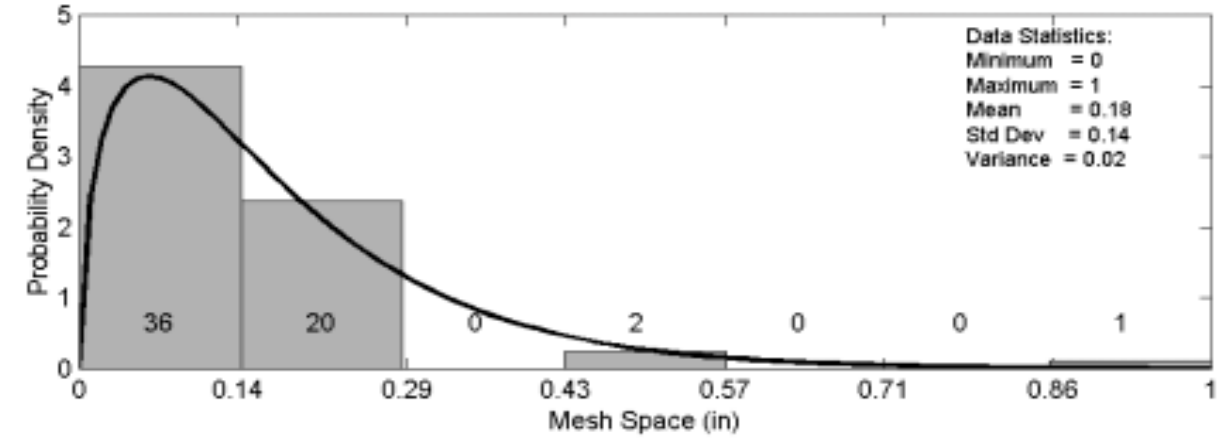


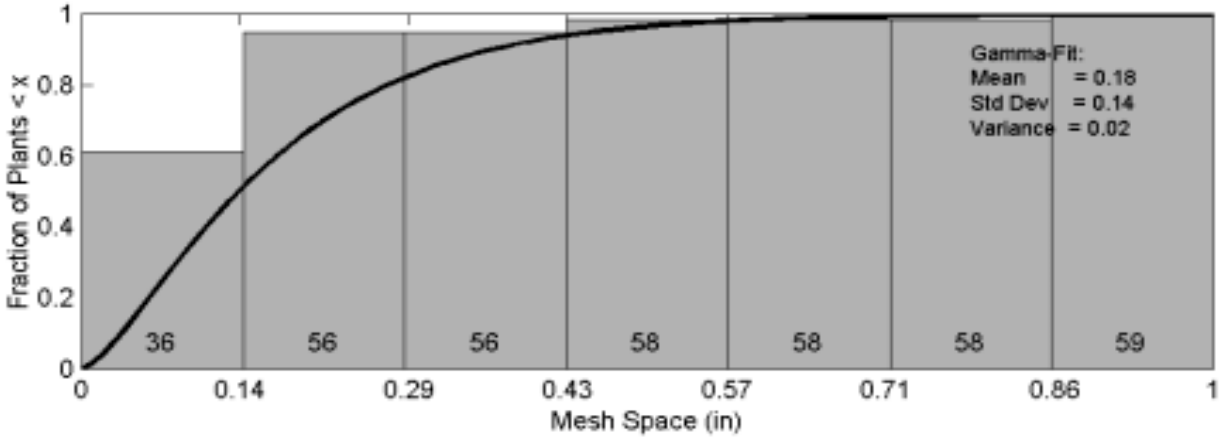
Reported NPSH Margin v. Sump Screen Area

- Low $NPSH_{margin}$ for LPSI and CS pumps
  - 1 to 10 ft-water
- Higher $NPSH_{Margin}$ for HPSI pumps
  - 10 to 25 ft-water
- Median Sump screen area of 125 ft^2

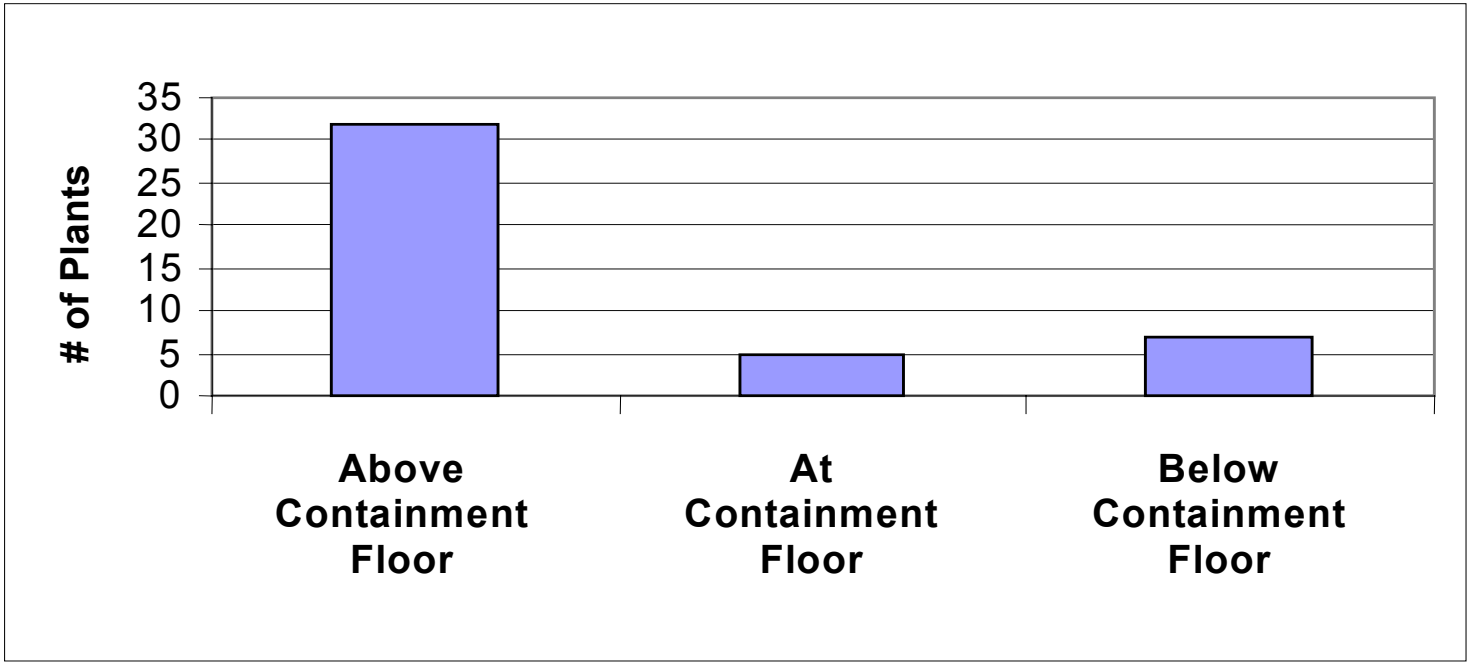


Sump Screen Mesh Size

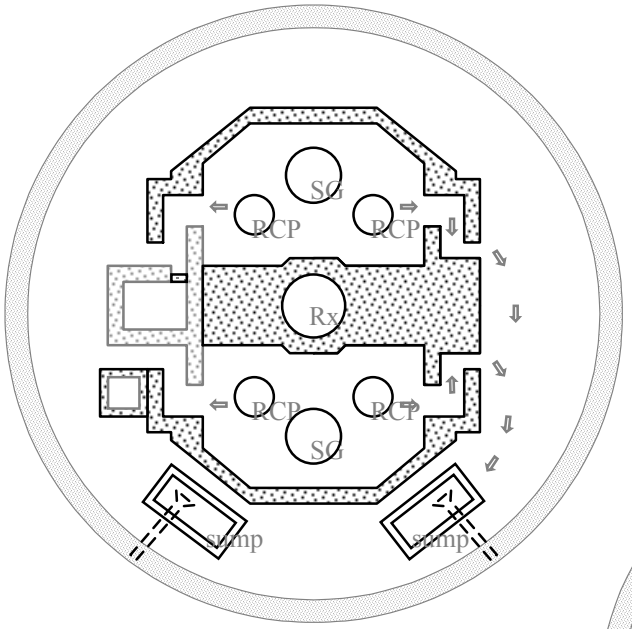




Reported Sump Screen Locations

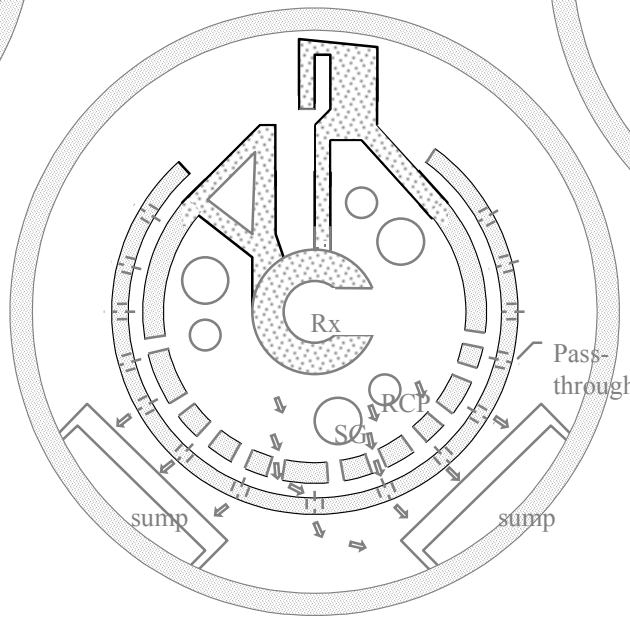


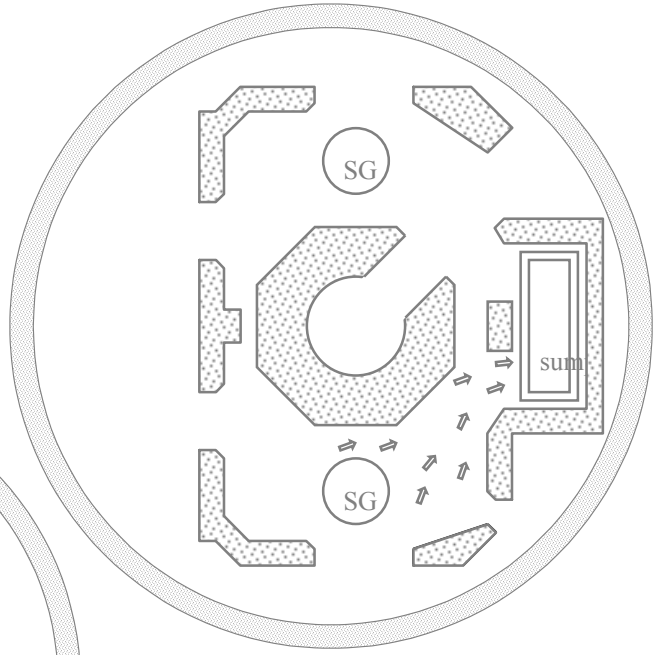
Example Sump Locations



Remote

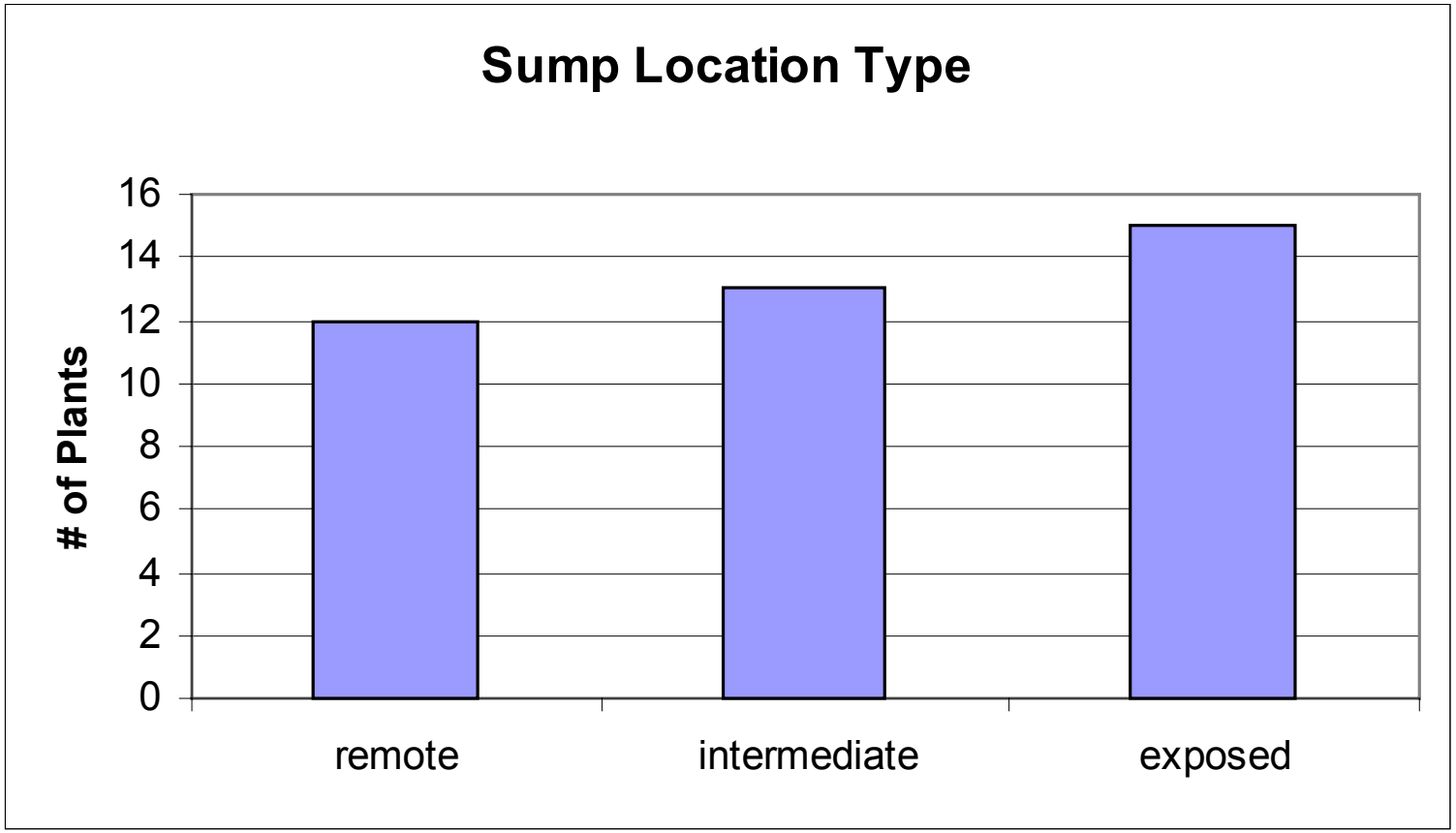
Intermediate





Exposed

Reported Sump Locations



Limitations of Survey Information

- Some Plant Characteristics Could Not Be Assessed With Survey and Supplemental Information
  - Location, Distribution of Debris Sources
  - Difficult to Characterize Containment Configuration in a Manner that Lends Itself to Direct Application to Parametric Evaluation
  - Actual Debris Quantities Not Provided in Most Cases
  - Cannot Assess Particulate Contribution to Head Loss Based on Information in Survey

Summary – LANL Industry Survey Review

- Industry Survey, Along with Supplemental Sources, Provided Much Information Related to GSI-191 Topic Not Previously Assembled
- Thorough QA Review of Information Used in Parametric Evaluation Performed by LANL
- High Variability Across Industry for Many Plant Characteristics
- Determination that Most Plants Contain Some Potential Fibrous and Cal-Sil Debris Sources
- Large Number of Plants Report Relatively Low NPSH Margin
- Configuration of Many Units May Result in Unsubmerged Sump Screens at Switchover
- Many Units Have Sump Screens With Mesh Openings > 1/8”