September 1982
Revision No. 1
Draft No. 1
Task MS 203-4

NOTE: This proposed revision is provided in comparative text format. Additions are underlined, deletions are crossed out.

U. S. Nuclear Regulatory Commission

Office of Nuclear Regulatory Research

Proposed Revision No. 1 to:
Regulatory Guide 1.82

Sump for Emergency Core Cooling and Containment Spray Systems

A. INTRODUCTION

General Design Criteria 35, "Emergency Core Cooling," 36, "Inspection of Emergency Core Cooling System," 37, "Testing of Emergency Core Cooling System," 38, "Containment Heat Removal," 39, "Inspection of Containment Heat Removal System," and 40, "Testing of Containment Heat Removal System," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Licensing of Production and Utilization Facilities," require that a system be provided to remove the heat released to the containment following a postulated design basis accident (DBA) and that this system be designed to permit appropriate periodic inspection and testing to assure its integrity, capability, and operability. General Design Criterion 1, "Quality Standards and Records," of Appendix A to 10 CFR Part 50, requires that structures, systems, and components important to safety be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety function to be performed. This guide describes a method acceptable to the Regulatory staff for implementing these requirements with regard to design, fabrication, and testing of sump or suction inlet conditions for pumps in the emergency core cooling and containment spray systems. This guide applies to pressurized water reactors. ~~The Advisory Committee on Reactor Safeguards has been consulted concerning this guide and has concurred in the regulatory position.~~

B. DISCUSSION

Sumps or pump intakes serve the emergency core cooling system (ECCS) and the containment spray system (CSS) by providing for collection of reactor coolant and chemically reactive spray solution and allowing its recirculation for additional cooling and fission product removal.

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For optimum use of the available coolant, the sumps should be placed at the lowest level practical. There may be numerous places within the containment structure where coolant could accumulate during containment spray application, and these areas should be provided with drains or flow paths to the sump location to minimize coolant holdup in areas away from the sumps. This guide does not address design of the drains. Because of certain amount of debris may flow toward the sump, the drains entering the sump area should terminate in such a manner that the emerging flow would not tend to impinge upon the coolant sump.

Debris resulting from a loss-of-coolant accident has the potential for blocking the sump screens; the corresponding increase in head loss could result in a loss of net positive suction head (NPSH) margin. The debris generation and transport should be analyzed to determine screen blockage and attendant head losses. Appendix A provides guidelines for evaluating insulation debris effects; References (1) and (2) provide additional information.

The debris resulting from a loss-of-coolant accident (LOCA) may be divided into two categories: (1) the pieces that by virtue of weight and volume will tend to float or sink slowly and (2) the heavy pieces that will drop to the floor surface. Every effort should be made to prevent either category of debris from accumulating at the sump location. Because the small drainage sump for collecting and monitoring normal leakage within the containment is separate from the coolant sump intended to serve the ECCS and CSS pumps, the floor would normally slope down toward the drainage sump. These sumps for routine building drainage should be at a slightly lower elevation than the coolant sumps so that water from minor leaks and spills cannot enter the ECCS-CSS sumps. The coolant sump location should be away from the drainage sump, so that the normal floor slope would assist in preventing heavier debris from accumulating at the coolant sump. In addition, the floor around the coolant sump should slope down and away from that sump to discourage debris from collecting on any part of the sump structure.

Pump intakes should be protected by screens and trash racks (coarse outer screens) of sufficient strength to resist impact loads that could be imposed by missiles that may be generated by the initial LOCA or by trash. Isolation of the coolant sump from high-energy pipe lines is an important consideration in missile protection; the sump screens and trash racks should be adequately shielded from impacts from ruptured high-energy piping. The screen and trash rack structures should be located above floor level to minimize the adverse effects from debris collecting on the screen structure. Redundant coolant sump screens and pump suction pipes should be separated as much as practical to reduce the possibility that a partially clogged screen or missile damage to one screen could adversely affect other pump circuits. In addition, the design of suction intakes should consider the avoidance of flow degradation by vortex formation.

Sump and suction intake placement should consider the avoidance of undesireable hydraulics effects, such as vortex formation. It has been experimentally determined that air ingestion can be minimized or eliminated if the guidelines provided in Appendix A are followed. References (1), (3), (4), (5), (6), and (7) provide further technical information relevant to sump hydraulic performance and design findings.

In addition, design of sump suction intakes should consider avoidance of vortex formation which could lead to air ingestion. However, for small amounts of air ingestion, the recirculation pumps can still be considered operable provided sufficient NPSH margin is demonstrated. Appendix A provides guidance for correcting NPSH margin if estimated levels of air ingestion are low (i.e., < 2%). References 1 and 8 provide additional technical findings relevant to pump operation and NPSH effects.

It is expected that the water surface will be above the top of the screen structure after completion of the safety injection. However, the uncertainties about the extent of water coverage on the screen structure, the amount of floating debris that may accumulate, and the potential for early clogging do not favor the use of the horizontal top screen. Therefore, no credit should be taken in computation of the available surface area for any top horizontal screen, and the top of the screen structure should preferably be a solid deck designed to provide for the removal of trapped air.

Slowly settling debris which is small enough to pass through the trash rack openings could clog the inner screens if the coolant flow velocity is too great to permit the bulk of the debris to sink to the floor level. The inner screen should be vertically mounted to minimize settling of debris on the screen surface, and sufficient unblocked screen area should be provided to keep the coolant flow velocity at the screen approximately 6 cm/sec (0.2 ft/sec). Such a velocity will allow debris with a specific gravity of 1.05 or more to settle before reaching the screen surface.

Size of openings in the fine screens should be determined by the physical restrictions, including spray nozzles, that may exist in the systems which are supplied with coolant for the emergency sump. As a minimum, consideration should be given to building spray nozzles, coolant channel openings, and pump running clearances in sizing the fine screen. If the coolant channel openings in the core represent the smallest flow restriction, the minimum opening in the core channels which will allow unblocked design operation of the ECCS should be used in sizing the fine screen mesh size.

Consideration should also be given to partial screen blockage in sizing the fine screen in order to assure an adequate margin of conservatism on free flow area.

A significant consideration is the potential for degraded pump performance which could be caused by a number of factors, including the loss net positive suction head (NPSH) margin. If he NPSH available to a pump is not sufficient, cavitation may significantly reduce the capability of the system to accomplish its safety function. For the recommended design velocity at the fine inner screens considered in this guide, a negligible pressure drop is anticipated across the screens. The effect of partially blocked screens should be considered in the evaluation of the overall NPSH.

To assure the readiness and integrity of the rack and screens, access openings should be provided to permit inspection of the inside structures and pump suction inlet openings. Inservice inspection for trash racks, screens, and pump suction inlet openings should be performed on a regular basis at every refueling period downtime, and it should include visual examination for evidence of structural distress or corrosion. Inspection of the coolant sump components should be made late in the refueling program and thus help to ssure the absence of construction debris in the coolant sump area. Any requirements for preoperational or periodic substantiation of adequate NPSH should be considered in the location and layout of the sump.

C. REGULATORY POSITION

Reactor building sumps which are designed to be a source of water for the emergency core cooling system (ECCS) and/or the containment spray system (CSS) following a loss-of-coolant accident (LOCA) should meet the following criteria:

1. A minimum of two sumps should be provided, each with sufficient capacity to service one of the redundant halves of the ECCS and CSS systems.

2. The redundant sumps should be physically separated from each other and from high-energy piping systems by structural barriers, to the extent practical, to preclude damage to the sump intake filters by whipping pipes or high-velocity jets of water or steam.

3. The sumps should be located on the lowest floor elevation in the containment exclusive of the reactor vessel cavity. At a minimum, the sump intake should be protected by two screens: (1) an outer trash rack and (2) a fine inner screen. The sump screens should not be depressed below the floor elevation.

4. The floor level in the vicinity of the coolant sump location should slope gradually down away from the sump.

5. All drains from the upper regions of the reactor building should terminate in such a manner that direct streams of water, which may contain entrained debris, will not impinge on the filter assemblies.

6. A vertically mounted outer trash rack should be provided to prevent large debris from reaching the fine inner screen. The strength of the trash rack should be considered in protecting the inner screen from missiles and large debris.

7. A vertically mounted fine inner screen should be provided. The design coolant velocity at the inner screen should be approximately 6 cm/sec (0.2 ft/sec). ~~The available surface area used in determining the design coolant velocity should be based on one half of the free surface area of the fine inner screen to conservatively account for partial blockage~~. The available screen surface area used in determining the design coolant velocity should be calculated to conservatively account for sump screen blockage which might result from debris generation and transport. Only the vertical screens should be considered in determining available surface area.

8. An evaluation of: (a) sump design effects (e.g., geometric effects, air ingestion, etc.), (b) LOCA generated debris effects (e.g., debris transport and screen blockage), and (c) pump NPSH margin requirements should be performed to ensure that long-term recirculation cooling can be accomplished. Any increases, due to sump hydraulic performance or debris considerations, with respect to NPSH margin should be considered in the sump pump performance evaluation.

~~8.~~ 9. A solid top deck is preferable, and the top deck should be designed to be fully submerged after a LOCA and completion of the safety injection. The solid deck should be designed to ensure the removal of air trapped underneath.

~~9.~~ 10. The trash rack and screens should be designed to withstand the vibratory motion of seismic events without loss of structural integrity.

~~10.~~ 11. The size of openings in the fine screen should be based on the minimum restriction found in systems served by the pump. The minimum restriction should take into account the requirements of the systems served.

~~11.~~ 12. Pump intake locations in the sump should be carefully considered to prevent degrading effects such as vortexing on the pump performance.

~~12.~~ 13. Materials for trash racks and screens should be selected to avoid degradation during periods of inactivity and operation and should have a low sensitivity to adverse effects such as stress-assisted corrosion that may be induced by the chemically reactive spray during LOCA conditions.

~~13.~~ 14. The trash rack and screen structure should include access openings to facilitate inspection of the structure and pump suction intake.

~~14.~~ 15. Inservice inspection requirements for coolant sump components (trash racks, screens, and pump suction inlets) should include the following:

a. Coolant sump components should be inspected during every refueling period downtime, and

b. The inspection should be a visual examination of the components for evidence of structural distress or corrosion.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants regarding the NRC staffs plans for using this regulatory guide. Except in those cases in which the applicant proposes an acceptable alternative method for complying with the specified portions of the Commission's regulation, the methods described herein will be used by the NRC staff in the evaluation of all construction permit applications and all operating license applications under review by the staff for which an NRC Safety Evaluation Report (SER) has not been issued at the time of implementation of this Regulatory Guide. With respect to operating plants and near term operating license (NTOL's) applicants, a generic letter will be sent to licensees and operating license applicants whose SER's have already been issued requesting that an assessment of sump screen blockage and associated impact on pump NPSH margin be performed utilizing the guidelines provided in Appendix A of RG 1.82. If the determination is made that excessive screen blockage or inadequate NPSH could occur using the guidelines in Appendix A, the respondee should also indicate what corrective actions will be pursued.

This draft regulatory guide has been published to encourage public participation in its development.

REFERENCES

(1) NUREG-0897, "Containment Emergency Sump Performance," Technical Findings Related to USI A-43, September 1982-"For Public Comment."

(2) NUREG/CR-2791, "Methodology for Evaluating of Insulation Debris," September 1982.

(3) NUREG/CR-2758, "A Parametric Study of Containment Emergency Sump Performance," July 1982.

(4) NUREG/CR-2759, "Results of Vertical Outlet Sump Tests," September 1982.

(5) NUREG/CR-2760, "Assessment of Scale Effects on Vortexing, Swirl and Inlet Losses in Sarge Scale Pump Models," June 1982.

(6) NUREG/CR-2761, "Results of Vortex Suppressor Tests, Single Outlet Sump Tests and Miscellaneous Sensitivity Tests," September 1982.

(7) NUREG/CR-2772, "Hydraulic Performance of Pump Suction Inlets for Emergency Core Cooling Systems in Boiling Water Reactors," June 1982.

(8) NUREG/CR-2792, "An Assessment of Residual Heat Removal and Containment Spray Pump Performance Under Air and Debris Ingesting Conditions," September 1982.

APPENDIX A TO RG 1.82

CONTAINMENT EMERGENCY SUMP REVIEW GUIDELINES

1. General

The containment emergency sump should be evaluated to determine design adequacy for providing a reliable water source to the ECCS and CSS pumps during a post-LOCA period. Both sump hydraulic performance under adverse conditions, and potential LOCA-induced insulation debris effects require adequate technical assessment to assure that long-term recirculation can be maintained. Technical considerations can be subdivided into: (a) Sump Hydraulic Performance, (b) LOCA-Induced Debris Effects, and (c) Pump Performance Under Adverse Conditions. Specific considerations and the combining thereof are shown in Figure A-1.

2. Sump Hydraulic Performance

Sump hydraulic performance can be evaluated on the basis of submergence level (or water depth above the suction outlets) and required pumping capacity (or sump suction outlet velocity). The water depth(s) and suction pipe velocity (V) parameters can be combined as a Froude number:

$$\text{Froude number} = V/\sqrt{gs}$$

where g is the gravitational constant. The Froude number concept has been shown to be an acceptable correlation for determining sump hydraulic performance.

Sump hydraulic performance can be judged on the basis of:

(a) zero air ingestion, thus avoiding pump cavitation

(b) air ingestion $\leq$2%, a conservative level where degradation of pumping capability is not expected

(c) use of vortex suppressors to reduce air ingestion effects to a negligible level.

Zero air ingestion can be assured by use of the design criteria set forth in Table A-1. Determination of air ingestion levels $\leq$2% can be obtained using Table A-2, and the attendant envelope, placement and screen guidelines contained in Tables A-3, A-4, and A-5. Table A-6 presents design guidelines for vortex suppression devices which have shown the capability to reduce air ingestion to zero. These guidelines (Tables A-1 through A-6) have been developed from extensive full scale sump hydraulic tests and provide a concise means to assess sump hydraulic performance. If the sump design deviates significantly from the boundaries noted, then similar performance data should be obtained for verification of sump hydraulic performance.

3. LOCA-Induced Debris Effects

Determination of LOCA debris generation and the effect of debris migration is complex and plant specific. Thus debris assessments require consideration of the initiating mechanisms (pipe break locations, orientations, and break jet energy content), evaluation of the amount of debris that can be generated, short- and long-term transport, the potential for sump screen blockage, and head loss that could degrade available NPSH. Table A-7 outlines considerations requiring evalutions to determine potential screen blockage and attendant head loss.

The evaluation of debris generation and screen blockage requires a systematic evaluation similar to that shown in Figure A-2. Types, quantities and locating of insulation employed, along with plant layout (or design) have been shown to result in plant specific results, thus the need for calculations as described in Figure A-2. References (1) and (2) provide more information relevant to assessment of debris effects.

4. Pump Performance Under Adverse Conditions

The pump industry historically has determined net positive suction head requirements for pumps on the basis of a percentage degradation in performance. The percentage has been at times arbitrary, but generally in the range of 1-3%. A 2% limit on allowed air ingestion is recommended since higher levels have been shown to initiate degradation of pumping capacity.

The 2 percent limit on sump air ingestion and the NPSH requirement act independently. However, air ingestion levels less than 2 percent can also affect NPSH requirements. Figure A-3 is, therefore, provided as a guide for evaluating conditions at the pump inlet, commencing at the sump. IF air ingestion is indicated, correct the NPSH requirement from the pump curves by the following relationship:

$$NPSH_{required}(air/water) = NPSH_{required}(liquid) \times \beta$$

where:

$$\beta = 1 + 0.50\alpha_p$$

and α_p is the air ingestion rate (in percent by volume) at the pump inlet flange.

5. Combined Effects

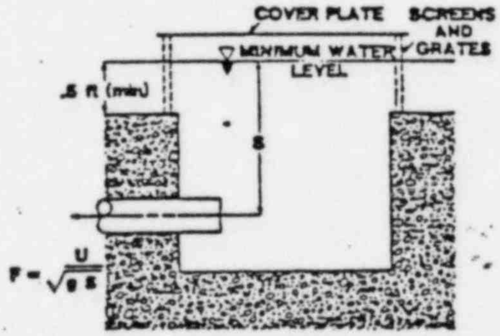
As introduced in Figure A-1, these three effects (e.g., sump hydraulic considerations, debris effects and pump performance) require combination for determining long-term recirculation capability.

The combined interactions of these effects is shown in Figure A-4. Use of this guidance and criteria provided can be used to determine sump design acceptability. If the proposed design falls outside of the data constraints noted, the applicant will need to address the need for additional data, or calculations to arrive at a sump evaluation position.

TABLE A-1

Zero Air Ingestion
Hydraulics Design Findings

Item	Horizontal Outlets		Vertical Outlets	
	Dual	Single	Dual	Single
Minimum Submergence, s (ft)	10		10	
Maximum Froude Number, F	0.25		0.25	
Maximum Pipe Velocity, U(ft/s)	4		4	



Aspect Ratio: 1-5

Minimum Perimeter: $\geq$ 16 ft
B - e_y/d: $\geq$ 3 ft
C/d: $\geq$ 1.5 for Horizontal Outlets, $\leq$ 1 for vertical inlets

Minimum Screen Area: $\geq$ 34 ft^2

NOTE: See Tables A-3 and A-4 for definition of dimensions noted above.

TABLE A-2

Hydraulics Design Findings

For Air Ingestion ≤ 2%

Item	Horizontal Outlets		Vertical Outlets	
	Dual	Single	Dual	Single
Minimum Submergence, s (ft)	7.0	8.0	8.0	10
Maximum Froude Number, F	0.53	0.40	0.41	0.33
Maximum Pipe Velocity, U(ft/s)	8.0	6.5	7.0	6.0
Maximum Screen Face Velocity (Blocked and minimum submergence) (ft/s)	3.0	3.0	3.0	3.0
Minimum Water Level (inside screens and grates)	Sufficient to cover 1.5 ft of open screen			
Maximum Approach Flow Velocity (ft/s)	0.36	0.36	0.36	0.36
Sump Loss Coefficient, C_L	1.2	1.2	1.2	1.2
Air Withdrawal, α_s, α_o	-2.47	-4.75	-4.75	-9.35
$\alpha_s = \alpha_o + \alpha_1 \times F$ (% air by Volume) α_1	9.38	18.04	18.69	35.95

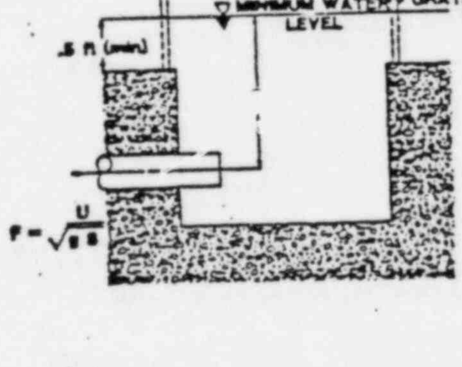
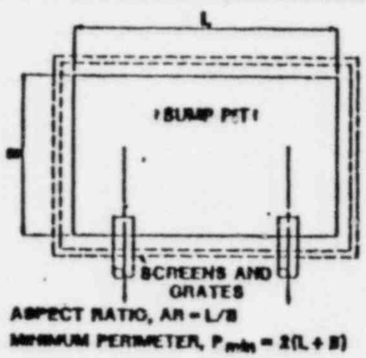


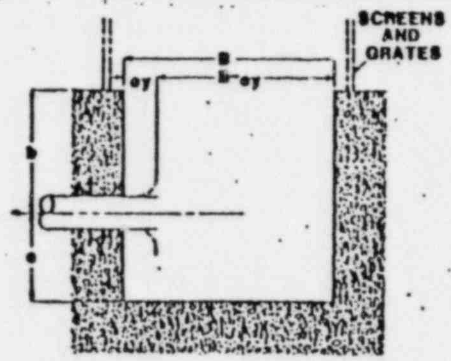
TABLE A-3

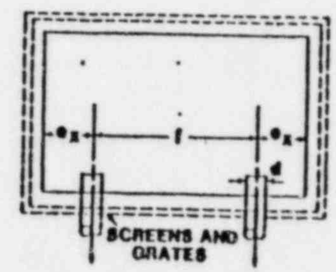
Geometric Design Experimental Envelop Contraints

		Size and Placement		Inlet Position**						Screens & Grates
		Aspect Ratio	Min. Perimeter	e_y/d	$(B-e_y)/d$	c/d	b/d	f/d	e_x/d	Min. Screen Area (Plane face)
Horizontal Outlets	Dual	1 to 5	36 ft	≥ 0	≥ 3	≥ 1.5	≥ 1	≥ 4	1.5* or	75 ft^2
	Single	1 to 5	16 ft	≤ 1				-	> 1.5	35 ft^2
Vertical Outlets	Dual	1 to 5	36 ft	1.5* or	≤ 1	≥ 0	≥ 1	≥ 4	1.5* or	75 ft^2
	Single	1 to 5	16 ft	> 1.5		≤ 1		-	> 1.5	35 ft^2

Definitions





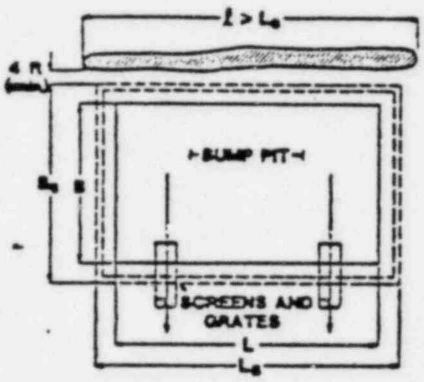


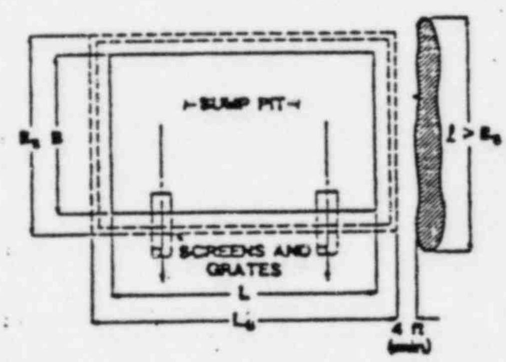
**Preferred location.

*Dimensions are always measured to pipe centerline.

TABLE A-4

Additional Considerations Related To Sump Size and Placement*





1. Aspect Ratio, see Table A-3

2. Minimum Sump Perimeter, see Table A-3.

3. Sump clearance of 4 ft between the screens/grates and any wall or obstruction of length ℓ equal to or greater than the adjacent screen/grates length (B_s or L_s).

4. A solid wall or large obstruction may form the boundary of the sump on one side only, i.e., the sump must have three (3) sides open to the approach flow.

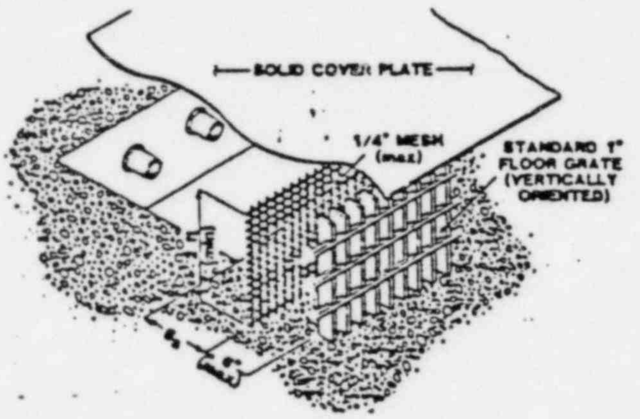
*These additional considerations are provided to ensure that the experimental data boundaries (upon which Tables A-2 and A-3 are based) resulting from the experimental studies at Alden Research Laboratory are noted.

TABLE A-5

Screen, Grate, and Cover Plate Design Findings*

1. Minimum plane face screen area, see Table A.2.

2. Minimum height of open screen should be 2 feet.



3. Distance from sump side to screens, g_s; g_s may be any reasonable value.

4. Screens should be 1/4 inch mesh or finer.

5. Gratings should be vertically oriented 1 to 1-1/2 inch standard floor grate or equivalent.

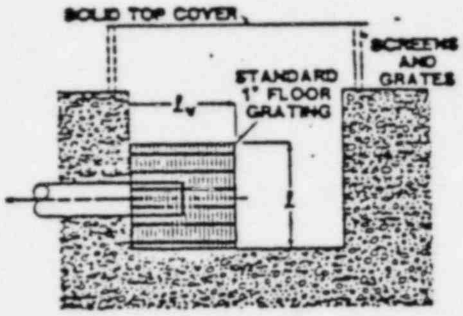
6. The distance between the screens and grates shall be 6 inches or less.

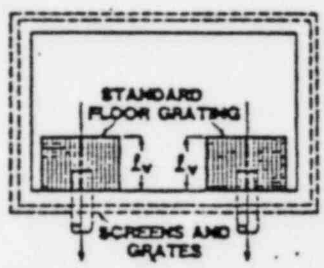
7. A solid cover plate above the sump and extending to the screens and grates is required; the cover plate must be designed to ensure the release of air trapped below the plate (a cover plate located below the minimum water level is preferable).

*These additional details are pertinent to the Alden Research Laboratory's full scale tests and were found to yield satisfactory sump hydraulic performance.

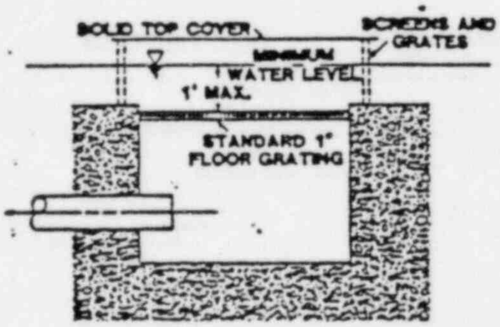
TABLE A-6

Findings For Selected Vortex Suppression Devices*





1. Cubic arrangement of standard 1-1/2 inch or deeper floor grating (or its equivalent) with a characteristic length, ℓ_v, that is ≥ 3 pipe diameters; the top of the cube must be submerged a minimum of 6 inches below the minimum water level. Non-cubic designs, where ℓ_v is ≥ 3 pipe diameters for the horizontal upper grate, satisfying the depth and distances to the water minimum water surface given for cubic designs are acceptable.



2. Standard 1-1/2 inch or deeper floor grating (or its equivalent) located horizontally over the entire sump and containment floor inside the screens and located between 3 inches and 12 inches below the minimum water level.

*These types of vortex suppressors were tested at Alden Research Laboratory and have demonstrated the capability to reduce air ingestion to 0%, even under the most adverse conditions simulated.

TABLE A-7

Debris Assessment Considerations

CONSIDERATION	EVALUATE
1) Debris Generator (Pipe Breaks & Location as identified in SRP Section 3.6.2)	o Major Pipe Breaks & Location o Pipe Whip & Pipe Impact o Break Jet Expansion Envelope (This is the major debris generator)
2) Expanding Jets	o Jet Expansion Envelope o Piping & Plant Components Targeted (i.e., steam generators) o Jet Forces on Insulation o Insulation Which Can Be Destroyed or Dislodged by Blowdown Jets. o Sump Structure (i.e., screen) Survivability Under Jet Loading
3) Short-Term Debris Transport (transport by blowdown jet forces)	o Jet/Equipment Interaction o Jet/Crane Wall Interaction o Sump Location Relative to Expanding Break Jet
4) Long-Term Debris Transport (transport to the sump during the recirculation phase)	o Containment Layout & Sump Location o Heavy (or "Sinking") Debris o Floating Debris o Neutral Buoyancy Debris
5) Screen Blockage Effects (impairment of flow and/or NPSH margin)	o Screen Design o Sump Location o Water Level Under Post LOCA Conditions o Flow Requirements

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Key Elements for Assessment of Debris Effects:

- o Estimated Amount of Debris That Can Reach Sump
- o Screen Blockage
- o ΔP Across Blocked Screens

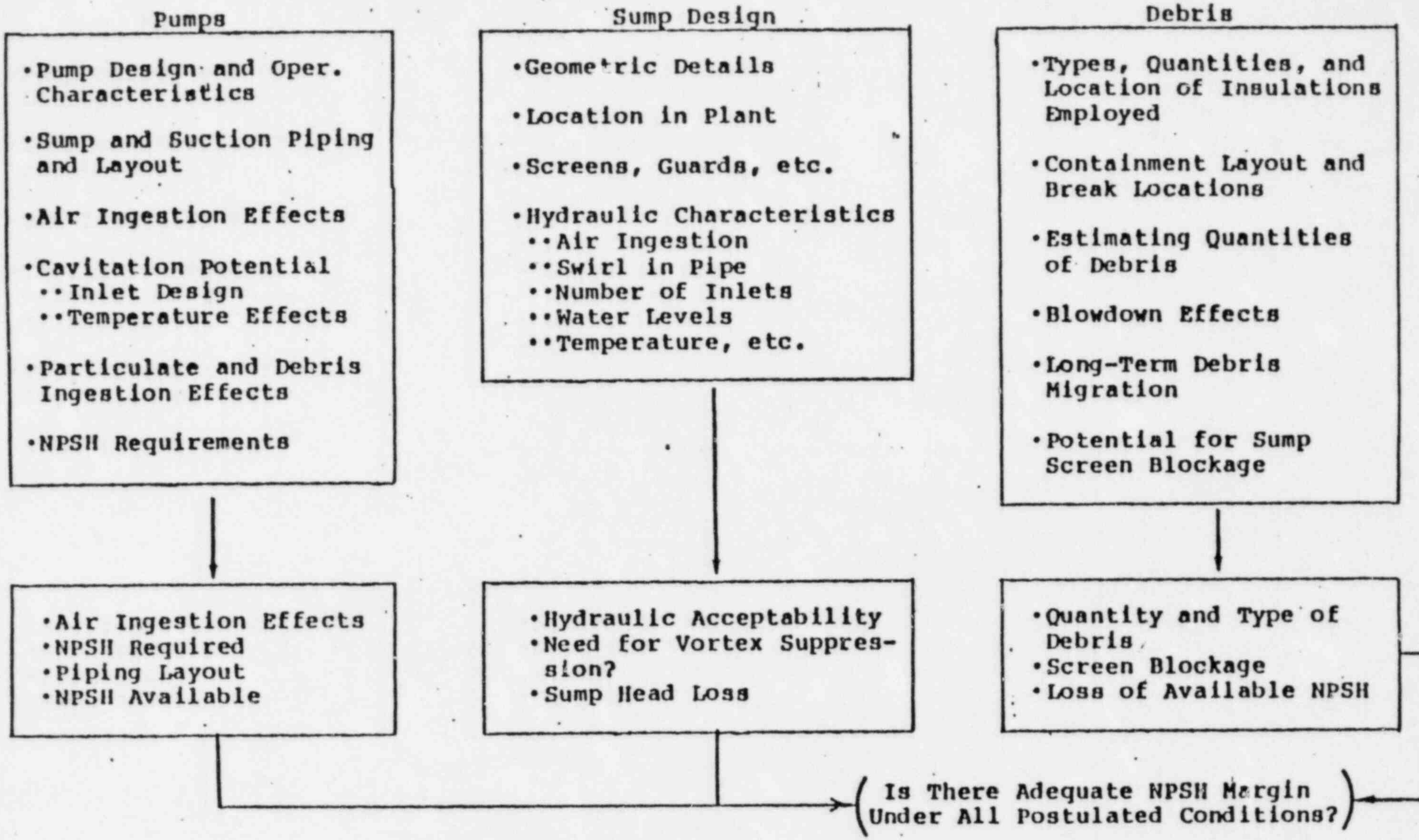
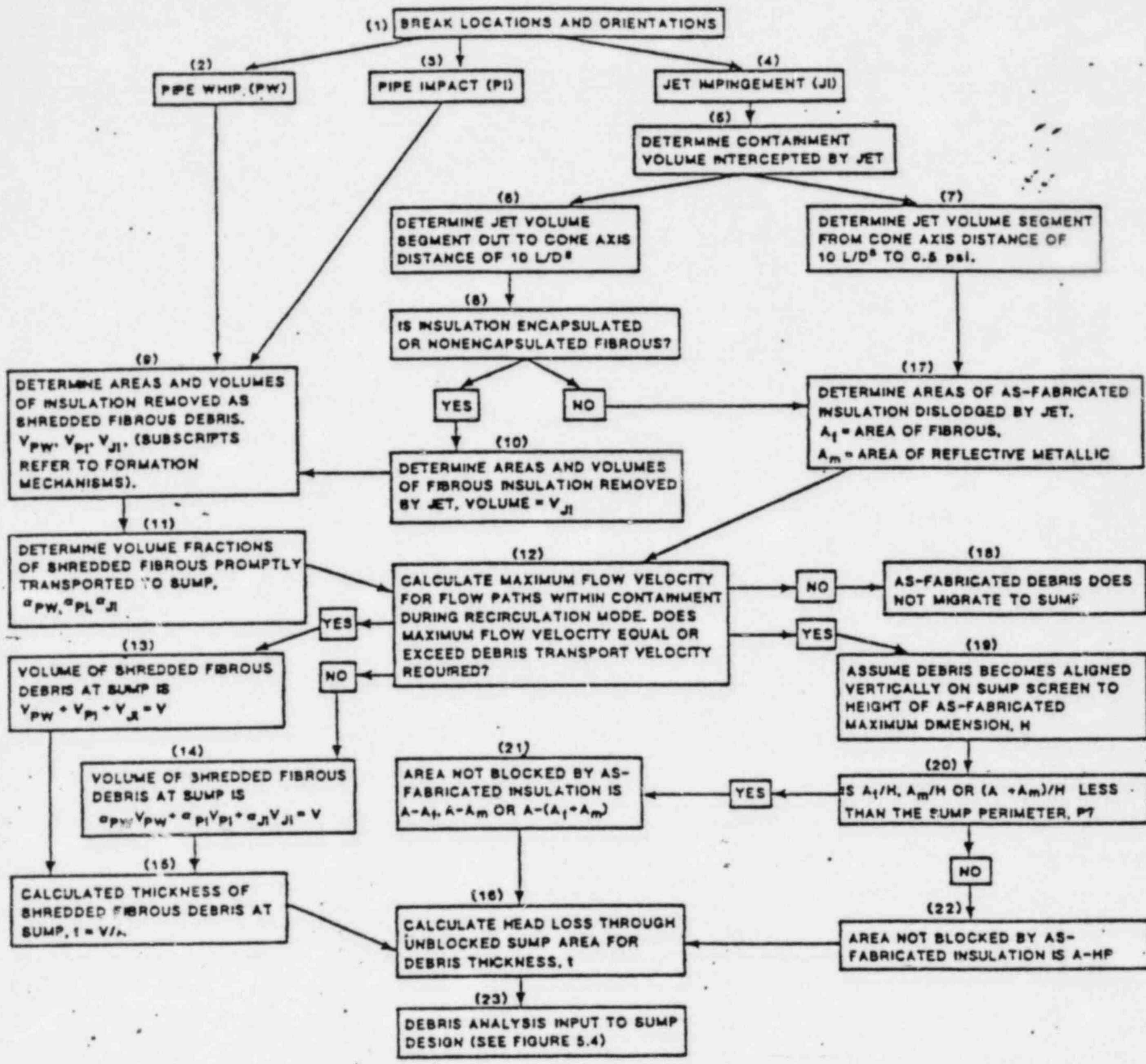


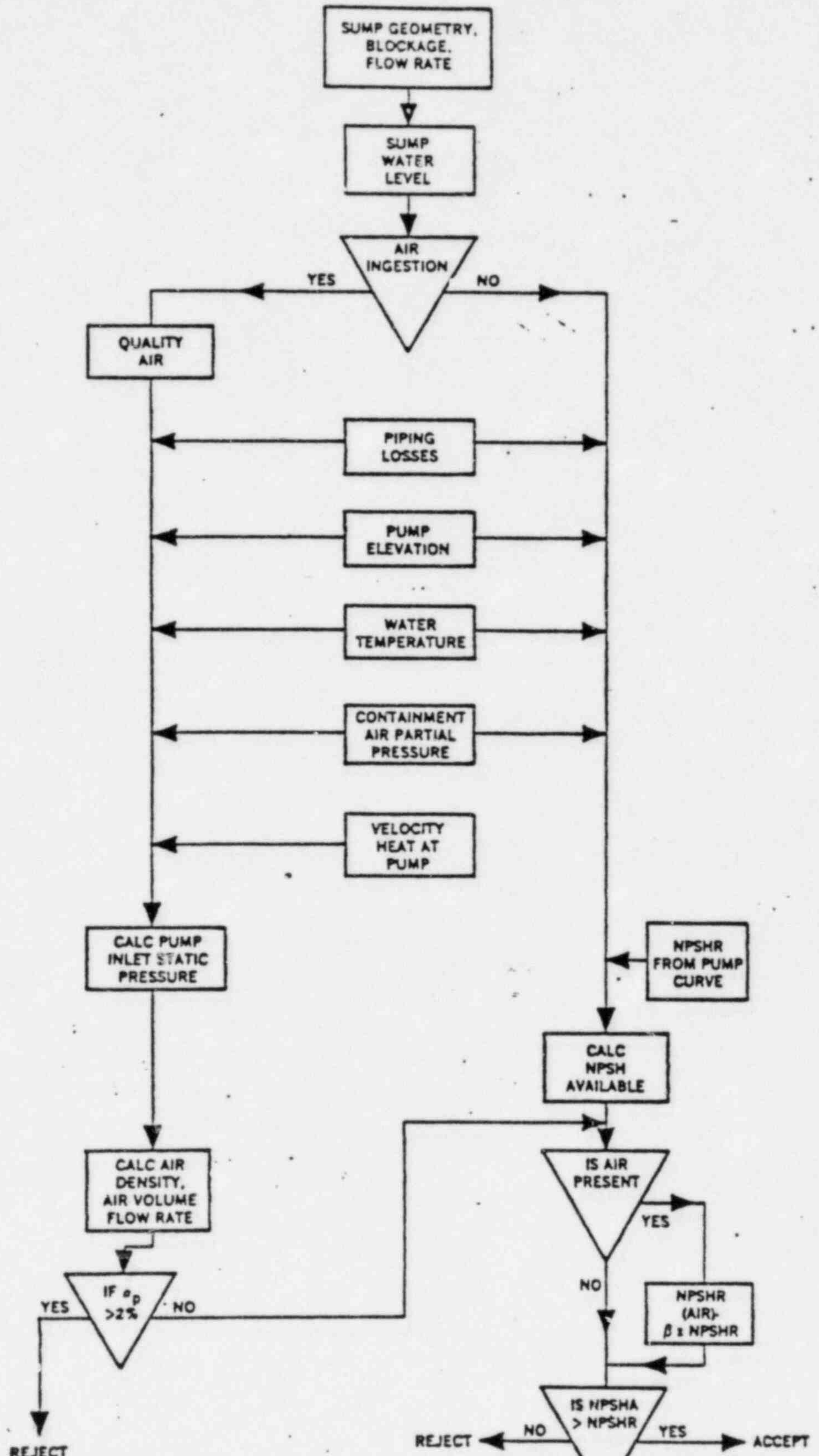
Figure A-1 Performance Considerations Relevant to Containment Emergency Sump Performance



V_{PW} - VOLUME OF SHREDDED FIBROUS INSULATION REMOVED BY PIPE WHIP. (FT^3)
V_{PI} - VOLUME OF SHREDDED FIBROUS INSULATION REMOVED BY PIPE IMPACT. (FT^3)
V_{JI} - VOLUME OF SHREDDED FIBROUS INSULATION REMOVED BY JET IMPINGEMENT. (FT^3)
α_{PW} - FRACTION OF VOLUME OF SHREDDED INSULATION CAUSED BY PIPE WHIP PROMPTLY TRANSPORTED TO SUMP.
α_{PI} - FRACTION OF VOLUME OF SHREDDED INSULATION CAUSED BY PIPE IMPACT PROMPTLY TRANSPORTED TO SUMP.
α_{JI} - FRACTION OF VOLUME OF SHREDDED INSULATION CAUSED BY JET IMPINGEMENT PROMPTLY TRANSPORTED TO SUMP.
L/D - RATIO OF PIPE LENGTH TO PIPE DIAMETER.
V - TOTAL VOLUME OF SHREDDED DEBRIS TRANSPORTED TO SUMP SCREEN. (FT^3)
A_f - AREA OF AS-FABRICATED FIBROUS INSULATION DISLODGED BY JET. (FT^3)
A_m - AREA OF AS-FABRICATED REFLECTIVE METALLIC INSULATION DISLODGED BY JET. (FT^2)
A - EFFECTIVE AREA OF SUMP SCREEN. (FT^2)
H - MAXIMUM LINEAR DIMENSION OF AS-FABRICATED INSULATION. (FT)
P - PERIMETER OF EFFECTIVE SUMP SCREEN. (FT)
t - CALCULATED THICKNESS OF SHREDDED DEBRIS MAT ON SUMP SCREEN. (IN)

*CALCULATIONAL METHODS ARE AS GIVEN IN REFERENCE 2

Figure A-2 Debris Generation, Transport and Sump Blockage Potential



FLOW CHART FOR CALCULATION OF PUMP INLET CONDITION

Figure A-3

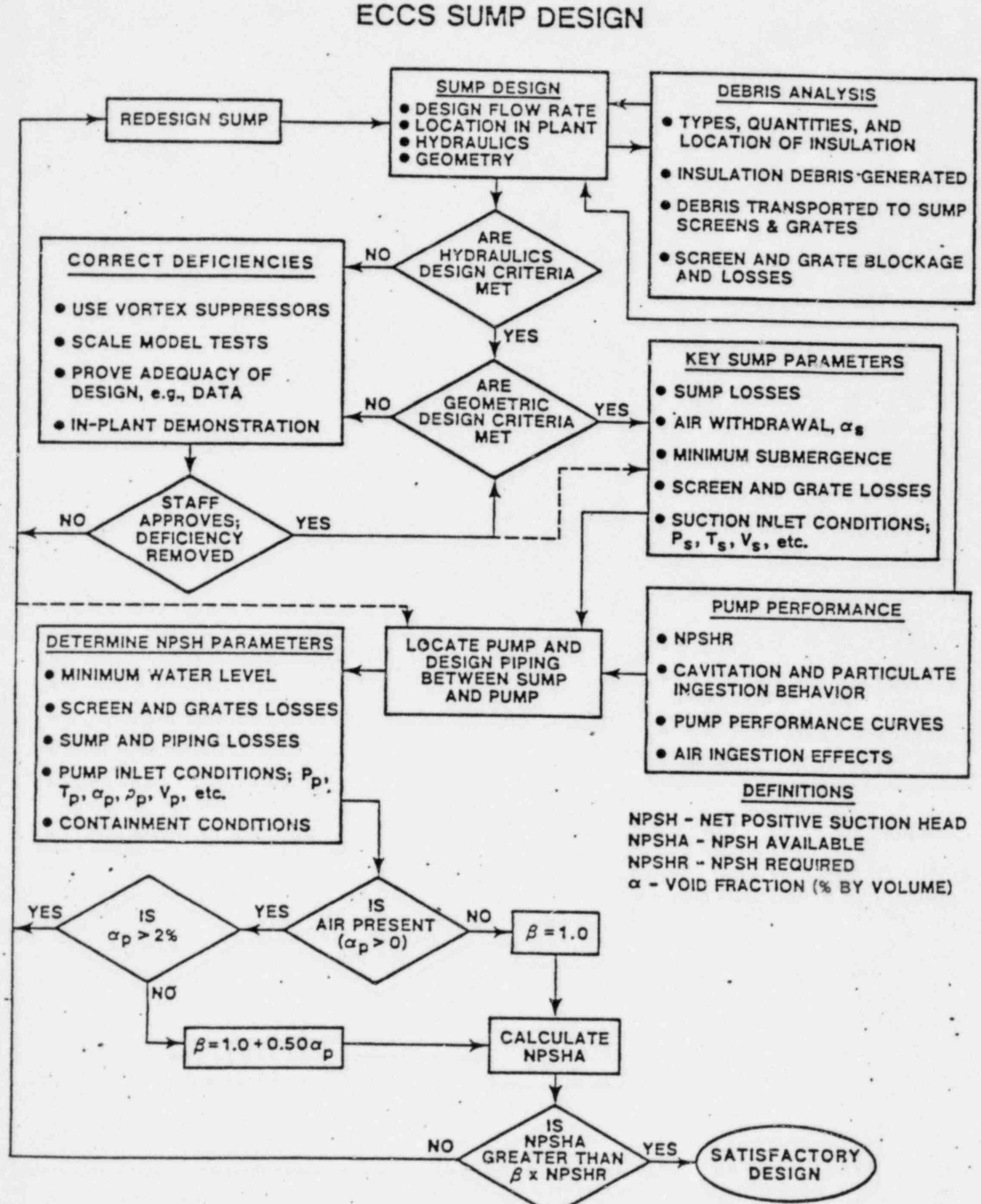


Figure A-4 Combined Technical Considerations for Sump Performance