ANSI/HI 9.8-1998

American National Standard for

# Pump Intake Design

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Approved November 17, 1998

**American National Standards Institute, Inc.**

# American National Standard

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## **Foreword** (Not part of Standard)

### Purpose and aims of the Hydraulic Institute

The purpose and aims of the Institute are to promote the continued growth and well-being of pump manufacturers and further the interests of the public in such matters as are involved in manufacturing, engineering, distribution, safety, transportation and other problems of the industry, and to this end, among other things:

a) To develop and publish standards for pumps;

b) To collect and disseminate information of value to its members and to the public;

c) To appear for its members before governmental departments and agencies and other bodies in regard to matters affecting the industry;

d) To increase the amount and to improve the quality of pump service to the public;

e) To support educational and research activities;

f) To promote the business interests of its members but not to engage in business of the kind ordinarily carried on for profit or to perform particular services for its members or individual persons as distinguished from activities to improve the business conditions and lawful interests of all of its members.

### Purpose of Standards

1) Hydraulic Institute Standards are adopted in the public interest and are designed to help eliminate misunderstandings between the manufacturer, the purchaser and/or the user and to assist the purchaser in selecting and obtaining the proper product for a particular need.

2) Use of Hydraulic Institute Standards is completely voluntary. Existence of Hydraulic Institute Standards does not in any respect preclude a member from manufacturing or selling products not conforming to the Standards.

### Definition of a Standard of the Hydraulic Institute

Quoting from Article XV, Standards, of the By-Laws of the Institute, Section B:

“An Institute Standard defines the product, material, process or procedure with reference to one or more of the following: nomenclature, composition, construction, dimensions, tolerances, safety, operating characteristics, performance, quality, rating, testing and service for which designed.”

### Comments from users

Comments from users of this Standard will be appreciated, to help the Hydraulic Institute prepare even more useful future editions. Questions arising from the content of this Standard may be directed to the Hydraulic Institute. It will direct all such questions to the appropriate technical committee for provision of a suitable answer.

If a dispute arises regarding contents of an Institute publication or an answer provided by the Institute to a question such as indicated above, the point in question shall be referred to the Executive Committee of the Hydraulic Institute, which then shall act as a Board of Appeals.

## Revisions

The Standards of the Hydraulic Institute are subject to constant review, and revisions are undertaken whenever it is found necessary because of new developments and progress in the art. If no revisions are made for five years, the standards are reaffirmed using the ANSI canvas procedure.

Over the past several decades, long-term performance results for many different centrifugal and axial flow pumping facilities have become available. Based on some less than satisfactory results, the industry has recognized a need for updating the standard approaches to designing pump intake structures and suction piping. In response to this evolving need, the Hydraulic Institute has improved and expanded its recommendations for designing intake structures for centrifugal, vertical turbine, mixed-flow, and axial-flow pumps and added intake designs for solids-bearing liquids.

This standard is a result of the combined efforts of a balanced committee that was formed to reflect the perspectives of sump designers, hydraulic researchers, pump manufacturers, and end users. It replaces ANSI/HI 1.1-1.5-1994 Section 1.3.3.6 and ANSI/HI 2.1-2.5-1994 Section 2.3.5.

The intent of this current edition of the pump intake design standard is to provide designers, owners and users of pumping facilities a foundation upon which to develop functional and economical pumping facility designs. The material has been prepared with the deliberate goals of both increasing understanding of the subject and establishing firm design requirements.

## Scope

This standard provides intake design recommendations for both suction pipes and all types of wet pits. While specific intake design is beyond the scope of the pump manufacturer's responsibility, their comments may be helpful to the intake designer.

## Units of Measurement

Metric units of measurement are used; and corresponding US units appear in brackets. Charts, graphs and sample calculations are also shown in both metric and US units.

Since values given in metric units are not exact equivalents to values given in US units, it is important that the selected units of measure to be applied be stated in reference to this standard. If no such statement is provided, metric units shall govern.

## Consensus

Consensus for this standard was achieved by use of the canvas method. The following organizations, recognized as having interest in the pump intake designs were contacted prior to the approval of this revision of the standard. Inclusion in this list does not necessarily imply that the organization concurred with the submittal of the proposed standard to ANSI.

Ahlstrom Pumps, LLC
Alden Research Laboratory, Inc.
Bechtel Corporation
Black & Veatch
Brown & Caldwell
Camp Dresser & McKee
CH2M Hill
Chas S. Lewis & Co., Inc.
Crane Pump & Systems
David Brown Union Pump Company
DeWante & Stowell
Dow Chemical

Electric Power Research Institute
ENSR Consulting & Engineering
Equistar L.P.
Essco Pump
Fairbanks Morse Pump
Florida Power Corporation
Floway Pumps
Flowserve Corporation
Ingersoll-Dresser Pump
ITT A-C Pump
ITT Fluid Technology
ITT Goulds Pump
Iwaki Walchem Corp
J.P. Messina Pump and Hydraulics Consultant
John Crane, Inc.
Johnston Pump Company
Lawrence Pumps, Inc.
M. W. Kellogg
Malcolm Pirnie, Inc.
Marine Machinery Association
Montana State University
Montgomery Watson
MWI
National Pump Company
PACO Pumps
Patterson Pump Company
Price Pump
Raytheon Engineers & Constructors
Robert Bein, William Frost & Assoc.
Sewage & Water Board of New Orleans
Skidmore
Solutia, Inc.
South Florida Water Management District
Southern Company Services, Inc.
Sta-Rite Industries
Stone and Webster
Sulzer Binhham Pumps, Inc.
Summers Engineering, Inc.
Systecon, Inc.
Tennessee Valley Authority
US Bureau of Reclamation

### Committee List

Although this standard was processed and approved for submittal to ANSI by the canvas method, a working committee met many times to facilitate the development of this standard. At the time it was approved, the committee had the following members:

| NAME | COMPANY | CATEGORY |
|---|---|---|
| Jack Claxton, Chairman | Patterson Pump Company | Producer |
| Stefan Abelin, Vice Chair. | ITT Flygt Corp. | Producer |
| William Beekman | Floway Pumps | Producer |
| Thomas Demlow | ENSR Consulting & Engineering | General Interest |
| Thomas Duncan | Southern Company Services, Inc. | User |
| Peter Garvin | Bechtel Corporation | General Interest |
| Herman Greutink | Johnston Pump Company | Producer |
| James Healy | Stone and Webster | General Interest |
| George E. Hecker | Alden Research Laboratory Inc. | General Interest |
| Joseph Jackson | Yeomans Chicago Corp. | Producer |
| Garr Jones | Brown & Caldwell | General Interest |
| Zan Kugler | South Florida Water Management District | User |
| James Leech | US Army Corps of Engineers | User |
| Frederick Locher | Bechtel Corporation | General Interest |
| Wilbur Norwood (Alternate) | Yeomans Chicago Corp. | Producer |
| Robert Sanks | Montana State University | General Interest |
| Gerald Schohl | Tennesse Valley Authority | User |
| Arnold Sdano | Fairbanks Morse Pump | Producer |
| G. Joseph Sullivan | Sewerage & Water Board of New Orleans | User |
| Zbigniew Czarnota (Alternate) | ITT Flygt Corp. | Producer |

## Major Revisions

Past Hydraulic Institute intake design standards have been based on the rated flow rate of the pump, while several other pump intake guidelines are based on dimensions determined from multiples of the inlet bell diameter.

Recognizing that a balance between these concepts may optimize the intake design, this edition is based upon:

- the pump intake bell outside diameter called "design diameter" or simply "D"
- an acceptable average velocity range across D (see Table 9.8.3)
- verification that the approach velocity does not exceed specified limits
- submergence "S" of pump intakes as a function of Froude number "$F_D$" and D

This edition consists of the "standard," Section 9.8, Intake Design Standards, and several appendices. These appendices are included as educational information and are not part of the standard. Illustrations of "Not Recommended" designs have been eliminated, as they are too numerous to document properly.

Other major changes introduced by this standard are given below under each subject heading.

### *Rectangular Intakes*

The dimensioning for rectangular plan intakes has been changed from a flow-based design to one based on D, as determined by the inlet bell velocity. A partitioned intake design is recommended over an open intake design.

Reference sections (*9.8.2.1 and 9.8.3.4*)

### *Formed Suction Intakes*

This standard introduces recommendations for the formed suction inlet.

*Reference sections (9.8.2.2)*

### *Circular Intakes*

This standard introduces recommendations for the appropriate use of circular wet wells for both clear and solids-bearing liquids, and it suggests specific configurations.

*Reference sections (9.8.2.3 and 9.8.3.3)*

## Trench-Type Intakes

This standard introduces geometry for trench-type wet wells for both clear and solids-bearing liquids.

*Reference sections (9.8.2.4 and 9.8.3.2)*

### *Suction Tanks*

Guidelines are provided for suction tank applications.

*Reference section (9.8.2.5)*

### *Barrel or Can and Submersible Vertical Turbine Intakes*

Recommendations for barrel or can-type intakes and submersible vertical turbine intakes designs are introduced.

*Reference section (9.8.2.6)*

### *Unconfined Intakes*

Guidelines are provided for unconfined intake applications.

*Reference section (9.8.2.7)*

### *Solids-Bearing Liquids Applications*

In past editions of this standard, discussions of solids-bearing liquids were limited to advising designers to obtain specific recommendations from pump manufacturers. This standard provides recommendations for pump sump designs intended for solids-bearing liquids. It addresses the special considerations of keeping wet wells clean and maintaining minimum velocities. Specific recommendations for wet well geometries are provided.

*Reference section (9.8.3)*

### *Pump Suction Piping*

The section on suction piping has been rewritten and condensed. It provides information and specific recommendations for suction piping design, suction headers, and design recommendations for solids-bearing liquids.

*Reference section (9.8.4)*

### *Model Testing*

The discussion of sump model testing has been expanded to include:

- factors for determining when a model test is necessary
- scaling criteria for determining adequate model size and proper flow rates
- recommended instrumentation and testing methods
- acceptance criteria for wet well and suction piping hydraulic performance

*Reference section (9.8.5)*

### *Inlet Bell Diameter*

When the bell diameter "D" has not been established, the standard uses a "Design Bell Diameter" based on an acceptable velocity range for determination of sump geometry.

*Reference section (9.8.6)*

### *Submergence*

The submergence "S" of pump intakes is determined as a function of inlet bell Froude number "$F_D$" and D.

Submergence requirements for the bell or pipe intake, as calculated with this standard, are generally less than the values specified by the 13th edition, but more than those required by the 14th edition of the Hydraulic Institute standards.

*Reference section (9.8.7)*

### *Appendix*

**These appendices are not part of this standard, but are presented to help the user in considering factors beyond the standard sump design.**

Appendices have been added to include:

a) Remedial Measures for Problem Intakes

b) Sump Volume (calculations with considerations given for cyclical operation of constant speed pumps)

c) Intake Basin Entrance Conditions

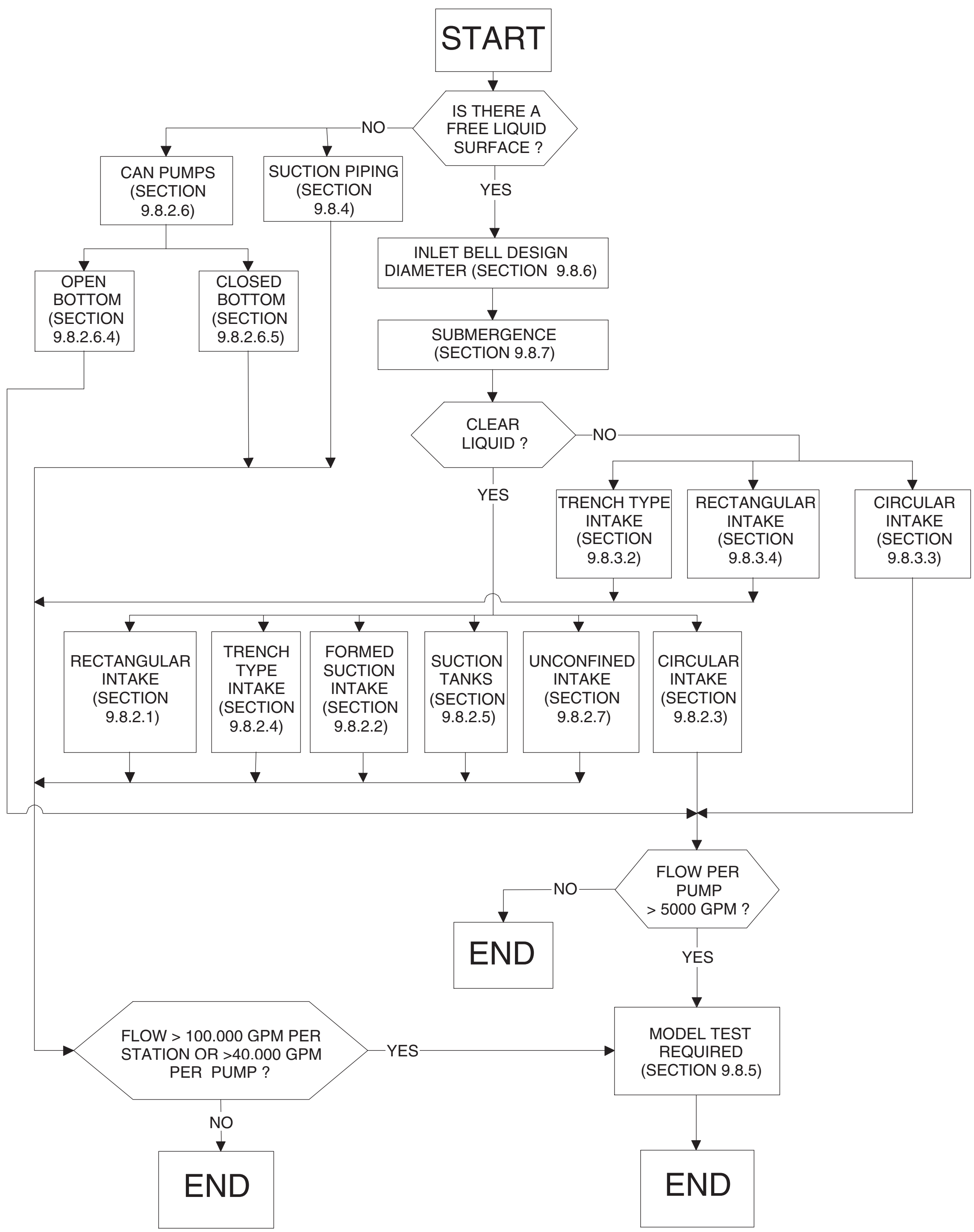
d) Bibliography

### Disclaimers

This document presents accepted best practices based upon information available to the Hydraulic Institute as of the date of publication. Nothing presented herein is to be construed as a warranty of successful performance under any conditions for any application.

### Flow Chart For Use Of Standard

NOTE: This flow chart is intended as a guide to the use of this standard and can be used to locate the appropriate sections in this standard. The chart is not a substitute for the understanding of the complete standard.



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# Pump Intake Design

## 9.8 Pump intake design

Metric units of measurement are used; and corresponding US units appear in brackets. Charts, graphs and sample calculations are also shown in both metric and US units.

Since values given in metric units are not exact equivalents to values given in US units, it is important that the selected units of measure be stated in reference to this standard. If no such statement is provided, metric units shall govern. See Section 9.8.8 for Glossary and Nomenclature.

In the application of this standard, the pump rated flow shall be used as the design flow for the basis of the intake design.

### 9.8.1 Design objectives

Specific hydraulic phenomena have been identified that can adversely affect the performance of pumps. Phenomena that must not be present to an excessive degree are:

- Submerged vortices
- Free-surface vortices
- Excessive pre-swirl of flow entering the pump
- Non-uniform spatial distribution of velocity at the impeller eye
- Excessive variations in velocity and swirl with time
- Entrained air or gas bubbles

The negative impact of each of these phenomena on pump performance depends on pump specific speed and size, as well as other design features of the pump that are specific to a given pump manufacturer. In general, large pumps and axial flow pumps (high specific speed) are more sensitive to adverse flow phenomena than small pumps or radial flow pumps (low specific speed). A more quantitative assessment of which pump types may be expected to withstand a given level of adverse phenomena with no ill effects has not been performed. Typical symptoms of adverse hydraulic conditions are reduced flow rate, head, effects on power, and increased vibration and noise.

The intake structure should be designed to allow the pumps to achieve their optimum hydraulic performance for all operating conditions. A good design ensures that the adverse flow phenomena described above are within the limits outlined in Section 9.8.5.6.

**If an intake is designed to a geometry other than that presented in this standard, and this design is shown by prototype or model tests, performed in accordance with Section 9.8.5, to meet the acceptance criteria in Section 9.8.5.6, then this alternative design shall be deemed to comply with this standard.**

### 9.8.2 Intake structures for clear liquids

#### 9.8.2.1 Rectangular intakes

This section is applicable to wet pit pumps. This section also applies to the intakes for dry pit pumps with less than five diameters of suction piping immediately upstream from the pump (see Section 9.8.4).

##### 9.8.2.1.1 Approach flow patterns

The characteristics of the flow approaching an intake structure is one of the most critical considerations for the designer. When determining direction and distribution of flow at the entrance to a pump intake structure, the following must be considered:

- The orientation of the structure relative to the body of supply liquid
- Whether the structure is recessed from, flush with, or protrudes beyond the boundaries of the body of supply liquid
- Strength of currents in the body of supply liquid perpendicular to the direction of approach to the pumps
- The number of pumps required and their anticipated operating combinations

The ideal conditions, and the assumptions upon which the geometry and dimensions recommended for rectangular intake structures are based, are that the structure draws flow so that there are no cross-flows in the vicinity of the intake structure that create asymmetric flow patterns approaching any of the pumps, and