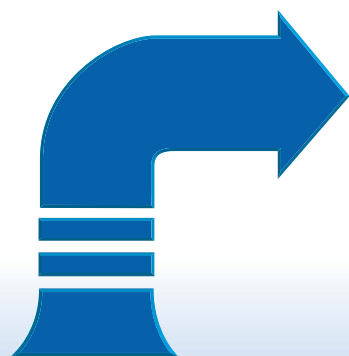
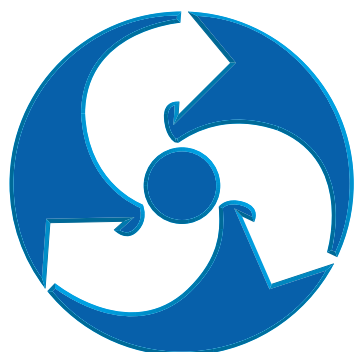




American National Standard for

Rotodynamic Pumps

for Vibration Measurements and
Allowable Values

ANSI/HI 9.6.4-2009



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Rotodynamic Pumps

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Allowable Values

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Approved May 13, 2009
American National Standards Institute, Inc.

American National Standard

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Foreword (Not part of Standard)

Purpose and aim of the Hydraulic Institute

The purpose and aims of the Institute are to promote the continued growth of pump knowledge for the interest of pump users and manufacturers and to 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 sent to the Technical Director of the Hydraulic Institute. The inquiry will then be directed to the appropriate technical committee for provision of a suitable answer.

If a dispute arises regarding contents of an Institute standard or an answer provided by the Institute to a question such as indicated above, the point in question shall be sent to the Technical Director of the Hydraulic Institute, who shall initiate the Appeals Process.

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 canvass procedure.

Major revisions

This standard, ANSI/HI 9.6.4-2009 *Rotodynamic Pumps for Vibration Measurements and Allowable Values*, was last published as ANSI/HI 9.6.4-2000. This updated edition is essentially a complete rewrite as compared to the previously published standard. In order to assist users of the standard in recognizing the changes, major revisions to the standard are provided as follows.

Tutorial information regarding dynamic analysis has been removed. This topic will be covered in a new document that is planned to be published as new guideline, ANSI/HI 9.6.8 *Dynamics of Pumping Machinery*. The new document was in the development stage at the time of this writing and a precise publication date is not known.

The scope of application of the standard has been clarified to identify pump types that are excluded from the standard.

Metric units are now primary, with US customary units secondary. For speeds above 600 rpm, the measurement quantity to be used for measuring the vibration of nonrotating parts of rotodynamic pumps is velocity in millimeters per second RMS or inches per second RMS.

Additional requirements have been added for operational speeds 600 rpm and lower. For speeds 600 rpm and below, measurement of the overall peak-to-peak displacement is required in addition to overall RMS velocity.

The Hydraulic Institute standard pump type nomenclature provided in ANSI/HI 1.1-1.2 *Rotodynamic (Centrifugal) Pumps for Nomenclature and Definitions* and ANSI/HI 2.1-2.2 *Rotodynamic (Vertical) Pumps for Nomenclature and Definitions* has been incorporated, with a new system of icons introduced to assist the user in recognizing the pump types and identifying the measurement locations.

Although this standard requires that the vibration test location is in the field by default, levels are provided for optional factory tests for most pump types.

The allowable vibration requirements have been updated to reflect acceptable performance both for field and factory tests, based on hundreds of data points obtained in surveys conducted since the publication of the previous edition. The revised allowable values have been compared with those presented by other standards organizations, including ISO and API, and can be considered as commensurate.

Values are presented for preferred operating region (POR) and allowable operating region (AOR).

To assist the user of the standard, a suggested vibration test report form is provided in an appendix.

Recommended default initial field alarm and trip settings are provided in an appendix.

A vibration troubleshooting chart is provided in an appendix.

Information on transducer types, mounting, and sensitivity is provided in two appendices.

Units of measurement

Metric units of measurement are used, and corresponding US customary units appear in brackets. Charts, graphs, and sample calculations are also shown in both metric and US customary units. Since values given in metric units are not exact equivalents to values given in US customary 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 canvass method. The following organizations, recognized as having interest in rotodynamic pumps for vibration measurements and allowable values, were contacted prior to the approval of this revision of the standard. Inclusion in the list does not necessarily imply that the organization concurred with the submittal of the proposed standard to ANSI.

Anspach Consulting
Baldor Electric Company
Bechtel Power Corporation
Black & Veatch
Budris Consulting

Buse, Fred – Consultant
Flowserve Pump Division
Grundfos Pumps Corporation
Healy Engineering
ITT - Industrial Process

ITT - Residential & Commercial Water
Malcolm Pirnie
National Pump Company, LLC
Patterson Pump Company
Peerless Pump Company
Pentair Water

Powell Kugler, Inc.
Sulzer Pumps (US) Inc.
Weir Floway, Inc.
Weir Minerals North America
Weir Specialty Pumps

Committee List

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

Chair – Jack Claxton, Patterson Pump Company
Vice-Chair – Michael Cropper, Sulzer Pumps (US) Inc.

Committee Members

Stefan Abelin
Graeme Addie
Thomas Angle
John Anspach
Julian Atchia
Allen Behring
James Bonifas
Charles Cappellino
James Healy
Thomas Hendrey
Greg Highfill
Michael Hiscock
Allen Hobratschk
Al Iseppon
Garr Jones
Dimitar Kalchev
Mika Kaplan
Yuri Khazanov
Zan Kugler
William Marscher
Tony Radcliff
James Roberts
Mark Rosebraugh
Aleksander Roudnev
Arnold Sdano
Ernest Sturtz
Roger Turley
Fred Walker
Brett Zerba

Alternate

Charles Allaben
Edward Allis
Lech Bobowski
Randal Ferman
Mark Jaminet
John Kelly
Gary Leander
Patrick Moyer

Company

ITT - Water & Wastewater
GIW Industries, Inc.
Weir Specialty Pumps
John Anspach Consulting
SJE-Rhombus®
A.G. Behring Company
Emerson Motors/US Motors
ITT - Industrial Process
Healy Engineering
Whitley Burchett & Associates
A.R. Wilfley & Sons, Inc.
South Florida Water Management District
National Pump Company, LLC
Pentair Water
Brown and Caldwell
Peerless Pump Company
King County Wastewater Treatment Division
InCheck Technologies Inc.
Powell Kugler, Inc.
Mechanical Solutions, Inc.
Grundfos Pumps Corporation
ITT - Residential & Commercial Water
Yeomans Chicago Corporation
Weir Minerals North America
Fairbanks Morse Pump Corporation
CDM
Flowserve Pump Division
Weir Floway, Inc.
TACO, Inc.

Company

CDM
Peerless Pump Company
Peerless Pump Company
Flowserve Pump Division
ITT - Water & Wastewater
Yeomans Chicago Corporation
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William A. Beekman
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9.6.4 Rotodynamic Pumps for Vibration Measurements and Allowable Values

9.6.4.1 Introduction and scope

9.6.4.1.1 Introduction

This standard pertains to evaluation of vibration when the vibration measurements are made on nonrotating parts (bearing housings) of rotodynamic pumps. It provides specific maximum allowable vibration values measured on bearing housings of rotodynamic pumps in field and factory test environments.

For certain vertical pump types, the vibration probes shall be located near the top of the motor support (refer to Figure 9.6.4.2.3.1, Measurement locations and directions). For vertical pump types, the reference to “bearing housing” refers to this location.

Vibration measurements can be useful for many purposes, such as acceptance tests, diagnostic or analytic investigations, and operational monitoring.

A general description of the principles to be applied for the measurement and assessment of vibration on rotodynamic pumps is given for vibration on nonrotating parts.

This standard is based on experiences from pump users and manufacturers as well as vibration measurements by many companies. Vibration data from both factory test and field test environments have been incorporated into the maximum allowable vibration values. Values are applicable when the pump is installed per Hydraulic Institute Standards or the manufacturer’s specifications.

9.6.4.1.2 Scope

This standard applies to the evaluation of vibration on rotodynamic pump applications absorbing more than 2 kW (3 hp) and of the types as indicated in Figure 9.6.4.2.3.1. It pertains to evaluation of vibration when the vibration measurements are made on nonrotating parts (bearing housing vibration).

The general evaluation criteria are included for acceptance tests in field environments or at the manufacturer’s test facility, as appropriate and as defined in the standard.

The following types of pumping equipment and associated equipment are **excluded** from this standard:

- Submersible pumps (refer to ANSI/HI 11.6)
- Submersible vertical turbine pumps
- Wet pit cantilever belt-driven pumps with overhung motors
- API 610 or ISO 13709 pumps (refer to API 610 or ISO 13709)
- Reciprocating engine-driven pumps
- Separately mounted drivers (i.e., vertical motors on separate floors)
- Right-angle gear drives
- Maritime applications

For these pumping equipment types, refer to other industry standards, if available, or the pump manufacturer.

Torsional vibration is not dealt with in this standard.

Information for assessing shaft vibration measured on rotating shafts is **excluded** from the scope of this document. The user is referred to the ISO 10816-7 standard for information on this topic.

This standard applies to tests conducted within the rated speed $\pm 10\%$. Tests conducted at speeds exceeding these limitations (such as variable-speed pumps or 50-cycle pumps tested with 60-cycle power for factory tests) shall be mutually agreed upon by the user and manufacturer due to the possibility of objectionable resonance effects.

This standard is applicable to solids-handling pump types. A solids-handling pump is defined as a pump designed to ensure maximum freedom from clogging when handling liquids containing organic solids or stringy materials.

This standard is applicable to slurry pump types. A *slurry pump* is defined as a pump suitable for pumping a mixture of abrasive solids with specific gravity greater than 1 and concentration by volume greater than 2% in a liquid carrier, usually water. For more information on slurry pump types, refer to the latest edition of ANSI/HI 12.1–12.6 *Rotodynamic Slurry Pumps for Nomenclature, Definitions, Applications, and Operation*. If an ASME B73.1-type pump is used as a slurry pump, the acceptable vibration levels for slurry pumps as provided herein shall be used.

9.6.4.2 Bearing housing vibration measurement

9.6.4.2.1 Measurement units and procedure

For rotodynamic pumps operating at all speeds greater than 600 rpm, the measurement quantity to be used is overall velocity in millimeters per second root mean square (RMS) (inches per second RMS), measured on nonrotating parts in accordance with Section 9.6.4.2.3. Additionally, for rotodynamic pumps operating at speeds equal to or less than 600 rpm, the measurement readings of overall displacement shall be recorded in millimeters (inches) peak-to-peak, also measured on nonrotating parts in accordance with Section 9.6.4.2.3.

9.6.4.2.1.1 Speeds above 600 rpm

For speeds above 600 rpm, the sole measurement quantity to be used for measuring the vibration of nonrotating parts of rotodynamic pumps is velocity in millimeters per second RMS or inches per second RMS.

A velocity or acceleration probe is used to measure vibration at various frequencies, and the measurements are integrated in an electronic circuit as agreed upon by the user and the pump manufacturer to determine the overall RMS vibration in the appropriate units.

Overall RMS vibration is a measure of the total RMS vibration magnitude obtained using instruments that integrate the vibration within a fixed frequency range over a fixed period of time.

Measurement of vibration filtered to discrete frequencies is not applicable for acceptance testing of pumps according to this standard. Such methodologies, including complete frequency analysis, may be useful in diagnosing vibration problems, should they occur.

9.6.4.2.1.2 Speeds of 600 rpm and below

For speeds 600 rpm and below, measurement of the overall peak-to-peak displacement is required in addition to overall RMS velocity.

9.6.4.2.2 Vibration measurement instrumentation and transducers

9.6.4.2.2.1 General

For all speeds, a 6-dB per octave filter shall be used to filter out frequencies outside the measurement range to reduce the electronic noise. This filter is typically built into dedicated vibration data collection instruments. The filter may not be present when using software processing alone.