ANSI/HI 4.1–4.6-2010

American National Standard for

# Sealless, Magnetically Driven Rotary Pumps

for Nomenclature, Definitions, Application, Operation, and Test

ANSI/HI 4.1–4.6-2010

Hydraulic Institute

6 Campus Drive
First Floor North
Parsippany, New Jersey
07054-4406
www.Pumps.org

This page intentionally blank.

ANSI/HI 4.1–4.6-2010

American National Standard for

# Sealless, Magnetically Driven Rotary Pumps

## for Nomenclature, Definitions, Application, Operation, and Test

Sponsor

**Hydraulic Institute**

**www.Pumps.org**

Approved June 24, 2010

**American National Standards Institute, Inc.**

# American National Standard

Approval of an American National Standard requires verification by ANSI that the requirements for due process, consensus and other criteria for approval have been met by the standards developer.

Consensus is established when, in the judgement of the ANSI Board of Standards Review, substantial agreement has been reached by directly and materially affected interests. Substantial agreement means much more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that a concerted effort be made toward their resolution.

The use of American National Standards is completely voluntary; their existence does not in any respect preclude anyone, whether he has approved the standards or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standards.

The American National Standards Institute does not develop standards and will in no circumstances give an interpretation of any American National Standard. Moreover, no person shall have the right or authority to issue an interpretation of an American National Standard in the name of the American National Standards Institute. Requests for interpretations should be addressed to the secretariat or sponsor whose name appears on the title page of this standard.

**CAUTION NOTICE:** This American National Standard may be revised or withdrawn at any time. The procedures of the American National Standards Institute require that action be taken periodically to reaffirm, revise, or withdraw this standard. Purchasers of American National Standards may receive current information on all standards by calling or writing the American National Standards Institute.

Published By

**Hydraulic Institute**
**6 Campus Drive, First Floor North**
**Parsippany, NJ 07054-4406**

**www.Pumps.org**



Printed in the United States of America

ISBN 978-1-935762-00-3

Recycled paper

## Contents

Page

Figures



Tables

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

### Scope

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 publication or an answer provided by the Institute to a question such as indicated above, the point in question shall be sent in writing 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.

## 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 for this standard was achieved by use of the Canvass Method

The following organizations, recognized as having an interest in the standardization of vertical pumps, 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.

A.W. Chesterton Company
Baldor Electric Company
Bechtel Power Corporation
Brown and Caldwell
ekwestrel corp
GIW Industries, Inc.
Healy Engineering, Inc.
Kemet Inc.
Las Vegas Valley Water District
Leistritz Corporation
Malcolm Pirnie, Inc.
Pentair Water - Engineered Flow GBU
Weir Floway, Inc.

## 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 the standard was approved, the committee had the following members:

Chair – John W. Owen, IMO Pump
Alan G. Wild, Consultant – Moyno, Inc.

| Committee Members | Company |
|---|---|
| Randolph K. Bennett | Leistritz Corporation |
| Todd E. Brown | Moyno, Inc. |
| James B. Casey | Milton Roy Americas |
| Trygve Dahl | Intelliquip, LLC |
| David G. McKinstry | IMO Pump |
| Michael L. Mueller | Flowserve Pump Division |
| Manor M. Parikh | Siemens Water Technologies |
| John E. Purcell | Roper Pump Company |
| James K. Simonelli | Roper Pump Company |
| Fred F. Walker | Weir Floway, Inc. |

| Other Contributors | Company |
|---|---|
| Fred Buse | Consultant |
| Michael Mulcahy | Tuthill Pump Group |
| Kathy Parry | formerly of Tuthill Pump Group |
| Dan Ross | formerly of Tuthill Pump Group |

# 4 Sealless, magnetically driven rotary pumps

## 4.0 Scope

This standard covers the unique features of sealless, magnetically driven rotary pumps and includes sections on types and nomenclature; definitions; design and applications; installation, operation, and maintenance; and test. Because of the variety of rotary pump configurations available and the broad range of applications, familiarization with Hydraulic Institute Standards ANSI/HI 3.1–3.5 *Rotary Pumps for Nomenclature, Definitions, Application and Operation* and ANSI/HI 3.6 *Rotary Pump Tests* is recommended. This standard does not apply to the flexible member/peristaltic rotary pump type.

## 4.1 Types and nomenclature

### 4.1.1 Objective

To clearly outline information necessary to define, apply, operate, and maintain sealless rotary pumps.

### 4.1.2 Introduction

This standard covers magnetically coupled rotary pumps (sometimes called *magnetic drives* or *magnetic couplings*), which eliminate the shaft seal. These pumps use permanent magnets to drive an internal rotating assembly through a magnetically permeable containment shell (canister). There are no openings or leak paths through the shell, and the rotor and bearings are completely submerged in the fluid. There are static seals in the pump.

The coupling referred to is the radial synchronous magnetic type. Other means of eliminating the shaft seal are axial magnetic couplings, eddy current (slip) drives, and canned motors. Although concepts within this standard apply, these devices have not been included because they are considered to be currently in limited distribution and focused information on the synchronous magnetic coupling is of greater importance.

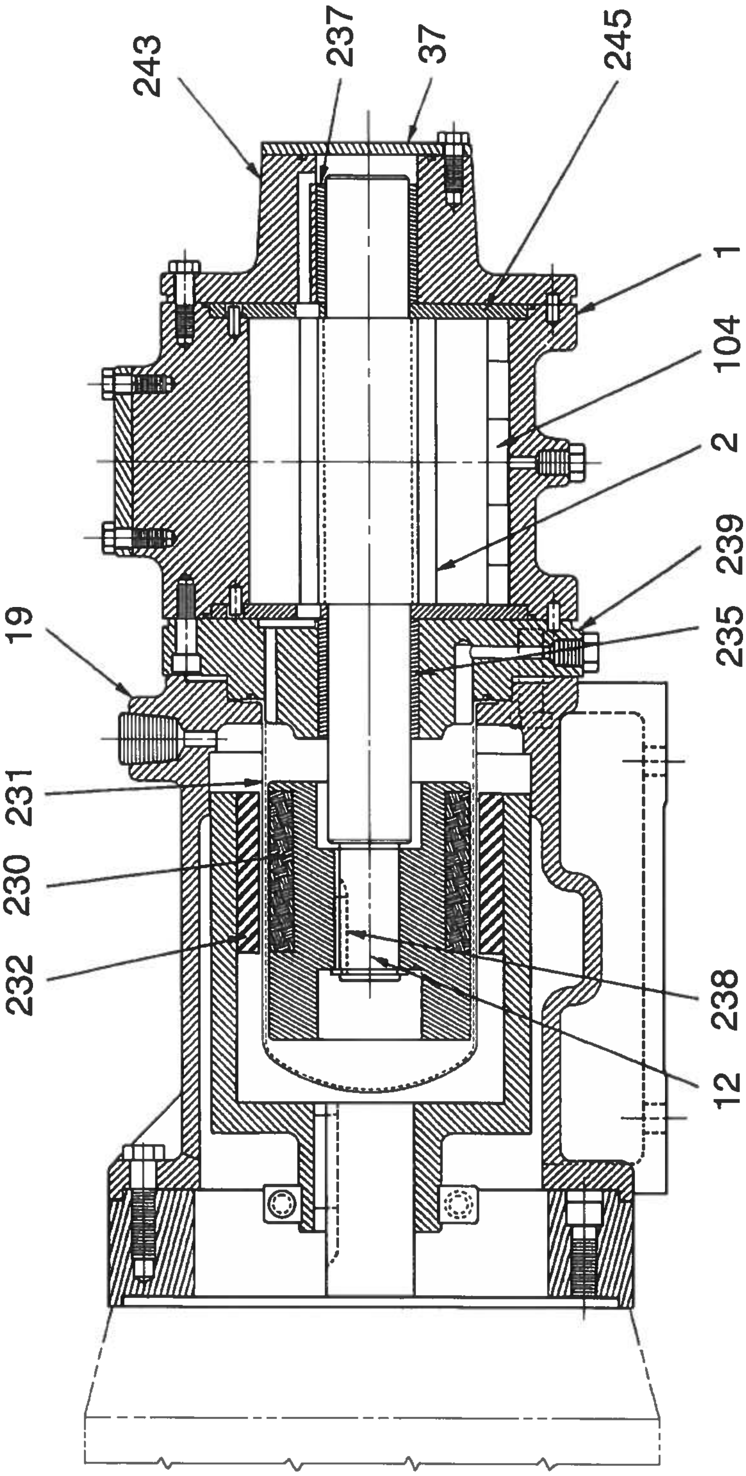
### 4.1.3 Types of magnetic drive configurations

ANSI/HI 3.1–3.5 *Rotary Pumps for Nomenclature, Definitions, Application and Operation*, Figure 3.1, provides a diagrammatic breakdown of types of rotary pumps. Because this family of products is so broad, this standard does not attempt to provide guidance or figures with each type in a sealless configuration.

The figures included in this standard are to illustrate the fundamental magnetic drive configurations and those components that are typically applicable to various types of rotary pumps:

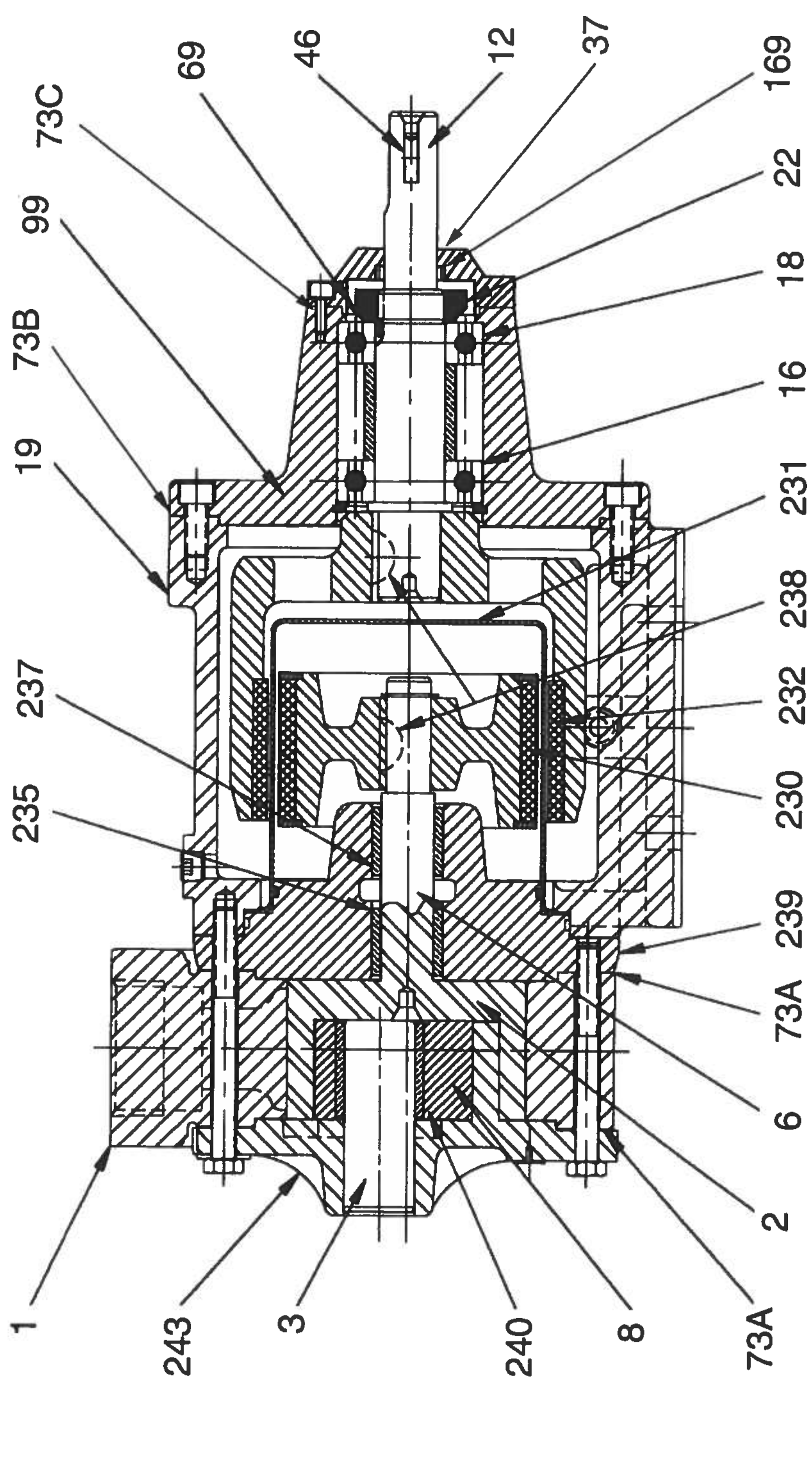
- Figure 4.1.3a Close-coupled, vane-type, magnetic drive pump
- Figure 4.1.3b Separately coupled, internal gear, magnetic drive pump with secondary control
- Figure 4.1.3c Separately coupled, screw-type, magnetic drive pump

The definitions of component parts are included in Table 4.1.3 — Nomenclature.



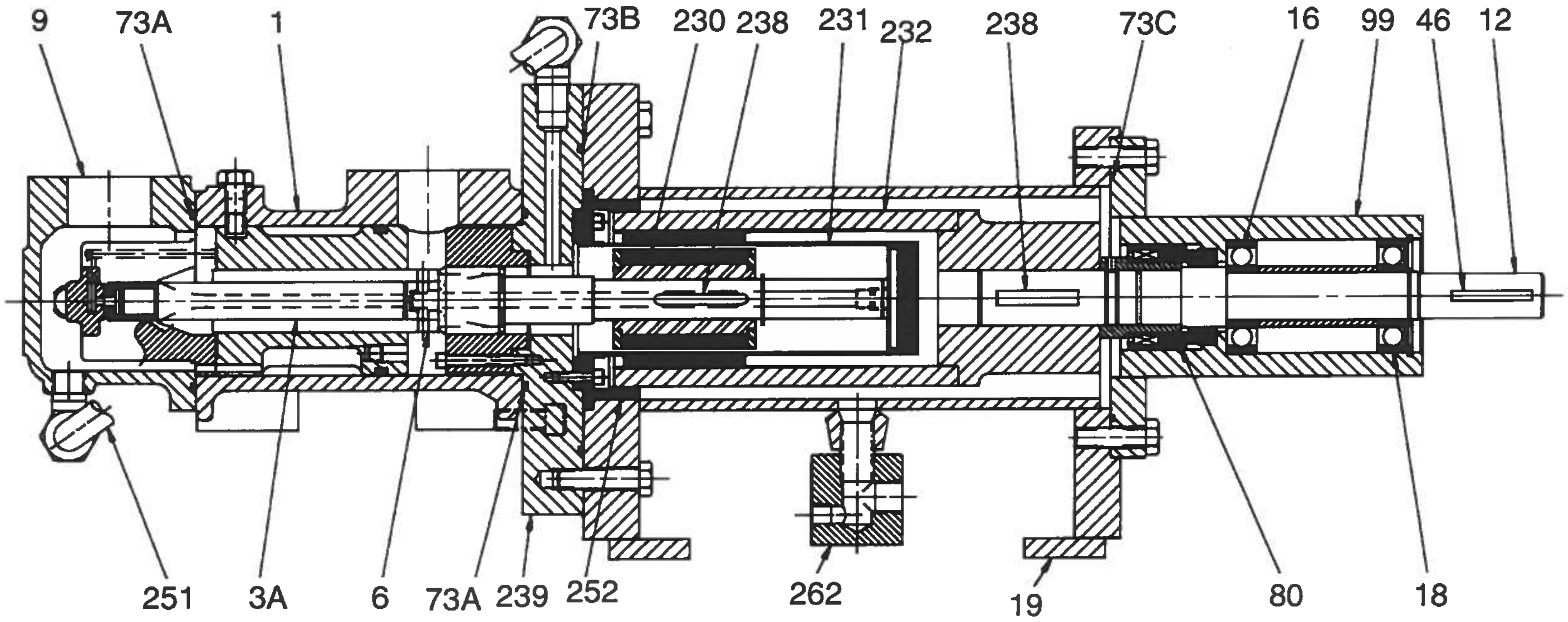

| | | | |
|---|---|---|---|
| 1 | Casing | 237 | Bushing, bearing, outboard |
| 2 | Rotor | 238 | Key, shaft |
| 12 | Shaft, drive | 239 | Cover, casing, inboard |
| 19 | Frame | 243 | Cover, casing, outboard |
| 37 | Cover, bearing, outboard | 245 | Disc |
| 104 | Vane | | |
| 230 | Magnet assembly, inner | | |
| 231 | Shell, containment | | |
| 232 | Magnet assembly, outer | | |
| 235 | Bushing, bearing, inboard | | |

**Figure 4.1.3a — Close-coupled, vane-type, magnetic drive pump**




| | | | | | |
|---|---|---|---|---|---|
| 1 | Casing | 22 | Locknut, bearing | 230 | Magnet assembly, inner |
| 2 | Rotor | 37 | Cover, bearing, outboard | 231 | Shell, containment |
| 3 | Idler pin | 46 | Key, coupling | 232 | Magnet assembly, outer |
| 6 | Shaft, pump | 69 | Lockwasher | 235 | Bushing, bearing, inboard |
| 8 | Idler gear | 73A | Gasket, casing | 237 | Bushing, bearing, outboard |
| 12 | Shaft, drive | 73B | Gasket, adapter | 238 | Key, shaft |
| 16 | Bearing, inboard | 73C | Gasket, bearing cover | 239 | Cover, casing, inboard |
| 18 | Bearing, outboard | 99 | Housing, bearing | 240 | Bushing, idler |
| 19 | Frame | 169 | Seal, bearing housing | 243 | Cover, casing, outboard |

**Figure 4.1.3b — Separately coupled, internal gear, magnetic drive pump with secondary control**




| | | | | | |
|---|---|---|---|---|---|
| 1 | Casing | 46 | Key, coupling | 232 | Magnet assembly, outer |
| 3A | Idler rotor (driven screw) | 73A | Gasket, casing | 238 | Key, shaft |
| 6 | Shaft, pump | 73B | Gasket, adapter | 239 | Cover, casing, inboard |
| 9 | Cover, suction | 73C | Gasket, bearing cover | 251 | Tube, circulation |
| 12 | Shaft, drive | 80 | Seal, secondary, mechanical | 252 | Ring, rub |
| 16 | Bearing, inboard | 99 | Housing, bearing | 262 | Port, instrumentation |
| 18 | Bearing, outboard | 230 | Magnet assembly, inner | | |
| 19 | Frame | 231 | Shell, containment | | |

**Figure 4.1.3c — Separately coupled, screw-type, magnetic drive pump**

**Table 4.1.3 — Nomenclature**

| Part name | Number | Definition |
|---|---|---|
| Bearing, inboard | 16 | Rolling element bearing in the frame nearest the pump. |
| Bearing, outboard | 18 | Rolling element bearing in the frame closest to the motor. |
| Bushing, bearing, inboard | 235 | Sleeve-type bearing in the drive section, closest to the liquid chamber, which is lubricated by the pumpage. |
| Bushing, bearing, outboard | 237 | Sleeve-type bearing in the drive section, closest to the magnets, which is lubricated by the pumpage. |
| Bushing, idler | 240 | Sleeve-type bearing in the idler, closest to the magnets, which is lubricated by the pumpage. The bushing rides on the idler pin. |
| Casing | 1 | The external part that surrounds the periphery of the pumping chamber. In some designs, the casing and liner (housing) are integral and form part of the pumping chamber. |
| Cover, bearing, outboard | 37 | An enclosing plate for the outboard end of the bearing housing. |
| Cover, casing, inboard | 239 | The end portion of the magnetic drive assembly that houses the driven magnet assembly, shaft, and containment shell. |
| Cover, casing, outboard | 243 | A body in which the outboard bushing is mounted. |
| Cover, suction | 9 | A removable piece that allows the inlet nozzle to be used to enclose the suction side of the casing. |
| Disc | 245 | Replaceable element to maintain close clearance along the rotor sideface. |
| Frame | 19 | A member of a pump to which is assembled the rotating outer magnet assembly and the drive motor or bearing housing. |
| Gasket | 73A, B and C | Resilient material of proper shape and characteristics for use in joints to prevent leakage. |
| Housing, bearing | 99 | A body in which the bearing is mounted. |
| Idler gear | 8 | The driven element in internal gear rotary positive displacement pumps. |
| Idler pin | 3 | Part on which the idler gear rotates. Unique to internal gear rotary positive displacement pump configurations. |
| Idler rotor | 3A | The driven element in three-screw rotary positive displacement pumps. |
| Key, coupling | 46 | A parallel-sided piece used to prevent the shaft from turning in a coupling half. |
| Key, shaft | 238 | A parallel-sided piece used to prevent the shaft from turning in the magnet assembly. |
| Locknut, bearing | 22 | Locking device used to fix a bearing position on a shaft. |
| Lockwasher | 69 | A device to prevent loosening of a nut. |
| Magnet assembly, inner | 230 | The permanent magnet or induction device assembly attached to the pump shaft, located within the containment shell, and driven by outer magnet assembly. |

**Table 4.1.3 — Nomenclature (*continued*)**

| Part name | Number | Definition |
|---|---|---|
| Magnet assembly, outer | 232 | The permanent magnet assembly attached to the power drive shaft, located outside of the containment shell, and driven by a driver. |
| Port, instrumentation | 262 | Access port to secondary casing for instrumentation required for detection of primary containment shell leakage. |
| Ring, rub | 252 | A replaceable ring mounted in or on the bearing housing and/or outer magnet assembly. It is used to prevent the outer carrier from hitting the containment shell if the rolling element bearings in the power end fail. |
| Rotor | 2 | A rotor rotates in the pumping chamber and is the primary element through which drive power is applied. Within some types of rotary pumps, it may be given a unique part name, such as *gear* or *screw*. |
| Seal, bearing housing | 169 | A contact seal for a bearing housing. |
| Seal, secondary, mechanical | 80 | A device mounted on the drive shaft to maintain the secondary pressure boundary in a secondary containment system. |
| Shaft, pump | 6 | The cylindrical member on which the rotor is mounted and through which power is transmitted to that rotor. |
| Shaft, drive | 12 | The cylindrical member that transmits power from the driver to the outer magnet assembly. |
| Shell, containment | 231 | The member that separates the inner and outer magnet assemblies. It also forms the barrier between the pumpage and the secondary containment. |
| Tube, circulation | 251 | A tube through which process liquid is piped for cooling of drive section. |
| Vane | 104 | Element in a rotary vane pump that is housed by the rotor and extends into the pumping chamber. In cooperation with the casing and endplate, it carries the liquid and provides continuous sealing. |

## 4.2 Definitions

This section provides definitions for terms for sealless pumps that are driven by radial synchronous magnetic couplings.

### 4.2.1 Close coupled

A coupling arrangement in which the driver is supplied with a flange adapter that mounts directly to the casing, body of the pump, or flange adapter of the magnetic coupling.

### 4.2.2 Coercive force

The value of the demagnetizing force.

### 4.2.3 Containment shell

The shell or canister that separates the inner and outer magnet assemblies. It forms the primary barrier between the pumped liquid and the environment at the point of power input. Materials may be metallic or nonmetallic.

### 4.2.4 Cooling liquid flow path

Due to inherent eddy current losses in metallic containment shells, cooling liquid may be necessary in the bearings and/or in the area between the inner magnet and containment shell for heat dissipation.

### 4.2.5 Curie temperature

The transition temperature above which the magnetic material permanently loses its magnetic properties.

### 4.2.6 Decoupling

The result of demanding more torque from a magnetic coupling than it is capable of transmitting. This results in the driven shaft coming to a stop while the drive shaft continues to rotate.

### 4.2.7 Demagnetization

Loss of magnetic properties. It can be caused by age, temperature, vibration, exposure to alternating current, modification of field, or decoupling.

### 4.2.8 Dephase

When the magnet coupling between two opposed magnets in a synchronous coupling is broken (see Decoupling).

### 4.2.9 Eddy current

Electric currents generated in a conductive material when the material passes through a magnetic field.

### 4.2.10 Eddy current drive

A nonsynchronous magnetic coupling consisting of a permanent outer magnet ring and an inner torque ring containing a network of conductive rods supported on a mild steel core. The rotating outer magnet ring generates eddy currents in the conductive rods, which convert the core to an electromagnet. The electromagnet tries to follow the rotating outer magnet ring, but at a slightly slower speed due to slip.

### 4.2.11 Eddy current losses

Power loss due to random electrical current generated in a conductive material when a magnetic field is rotated around it. These currents are normally dissipated as heat due to the electrical resistance of the material.

### 4.2.12 Encapsulation

Protective covering on magnet assembly to hold the magnets in position and/or reduce or prevent corrosive attack on the magnets.

### 4.2.13 Flux

The rate of transfer of energy (magnetic field) across a given surface (maxwell).

#### 4.2.14 Flux density

A term to describe the strength of a magnetic field (e.g., a very powerful magnetic field within a small magnet has a high flux density) (gauss).

#### 4.2.15 Gap

##### 4.2.15.1 Air gap

The radial distance between the inside diameter (ID) of the outer magnet assembly and the outside diameter (OD) of the containment shell.

##### 4.2.15.2 Liquid gap

The radial distance between the ID of the containment shell and the OD of the inner magnet assembly.

##### 4.2.15.3 Total gap

The radial distance between the ID of the outer magnet assembly and the OD of the inner magnet assembly. This is the sum of the air gap, liquid gap, and containment shell thickness.

#### 4.2.16 Gauss

Unit of flux density. Unit of magnetic induction in the metric electromagnetic system. One gauss is equal to one maxwell per square centimeter.

#### 4.2.17 Gilbert

The unit of magnetizing force.

#### 4.2.18 Hydraulic parasitic losses

Also called *hydraulic drag* – energy loss due to liquid friction within the containment shell.

#### 4.2.19 Hydrostatic test pressure

The pressure necessary to verify the integrity of the pressure-containing components.

#### 4.2.20 Hysteresis

A loss of magnetization in a magnetic material due to a change in magnetic force. The failure of a property of a substance that has been changed by an external agent to return to its original value when the cause of the change is removed. It is analogous to mechanical inertia, and the energy lost is analogous to that lost in mechanical friction.

#### 4.2.21 Inner magnet assembly (driven)

This assembly includes magnets and conducting material that mechanically supports the magnets while providing the necessary flux path for the magnetic circuit. It may be encapsulated (see Encapsulation). Located on the driven shaft and within the containment shell.

#### 4.2.22 Intrinsic induction

The flux density produced by the magnet alone.

#### 4.2.23 Magnet (permanent)

A material that exhibits a considerable amount of magnetism with minimal loss at normal temperatures over a long period of time.

#### 4.2.24 Magnetic coupling

A device that transmits torque through the use of magnets attached to the drive and driven shafts.

#### 4.2.25 Magnetic drive pump/magnetic coupling pump

See Introduction (page 1).

#### 4.2.26 Magnetic materials

Those currently in use are typically alnico, ferrite, neodymium, and samarium cobalt. Note: Temperatures at the magnet can be significantly higher than those in the pump.

##### 4.2.26.1 Alnico

Aluminum, nickel, cobalt – A permanent magnet made from aluminum, nickel, and cobalt. Usually considered the weakest of the magnets in pump applications. Depending on the grade, these magnets can tolerate temperatures up to 515 °C (960 °F).

##### 4.2.26.2 Ceramic

See Ferrite.

##### 4.2.26.3 Ferrite

Also known as *ceramic*. A permanent magnet made from barium or strontium and iron. Their strength and temperature limitations are similar to alnico.

##### 4.2.26.4 Neodymium

Neodymium, iron, boron (NdFeB): A rare earth magnet usually considered to have the greatest strength, depending on the grade.

##### 4.2.26.5 Samarium cobalt

(Sm Co): A rare earth magnet typically of considerable strength. Rated for higher temperature application than neodymium.

#### 4.2.27 Maximum working pressure

The maximum working pressure is the maximum operating pressure the pump may be subjected to under any circumstance in the application.

#### 4.2.28 Maxwell

Unit of magnetic flux in the metric electromagnetic system. One maxwell is one line of magnetic flux.

#### 4.2.29 Negative thrust

Axial thrust away from the pump casing (toward the motor).

### 4.2.30 Oersted

Unit of field strength in the metric electromagnetic system. One oersted equals a magnetomotive force of one gilbert per centimeter of flux path.

### 4.2.31 Outer magnetic assembly (driver)

This assembly includes magnets and conducting material that mechanically supports the magnets while providing the necessary flux path for the magnetic circuit. It may be encapsulated (see Encapsulation). Located on a drive shaft attached to the motor.

### 4.2.32 Permeability (magnetic)

A measure of the property of a material that determines the degree it changes the flux in a magnetic field. A measure of how much flux is produced in a material by the application of a given magnetizing field.

### 4.2.33 Permeance

A measure of how easy it is for the flux to pass from one pole through the air gap to the other pole; the higher the permeance, the higher the flux density. It is the reciprocal of the reluctance *R*, measured in maxwells per gilbert.

### 4.2.34 Pole

Magnets exhibit the ability to repel and attract. One pole (+) would repel the like pole (+) of an identical magnet but would attract the opposite pole (–).

### 4.2.35 Positive thrust

Axial thrust away from motor.

### 4.2.36 Reluctance (*R*)

The resistance to magnetic flow. It is the reciprocal of permeance.

### 4.2.37 Secondary containment

The confinement of the pumped liquid within a secondary pressure casing in the event of failure of the primary containment shell.

### 4.2.38 Secondary containment system

A combination of devices that, in the event of leakage from the primary containment shell, confines the pumped liquid within a secondary pressure casing that includes provision to indicate a failure of the primary containment shell.

### 4.2.39 Secondary control

The minimization of release of pumped liquid in the event of failure of the containment shell.

### 4.2.40 Secondary control system

The combination of devices (including a secondary pressure casing) that, in the event of leakage from the containment shell, minimizes and safely directs the release of pumped liquid. It includes provision(s) to indicate failure of the containment shell.

#### 4.2.41 Separately coupled

An arrangement in which the motor shaft is attached to the power frame of the pump by means of a flexible or rigid coupling; thus the motor is mounted on the same base and must be aligned with pump driving components.

The outer magnet assembly is mounted on a separate shaft and supported by rolling element bearings.

#### 4.2.42 Shell

See Containment shell (canister).

#### 4.2.43 Slip, hydraulic

Recirculation of liquid within the pump through the internal leakage paths.

#### 4.2.44 Slip, magnetic

The speed differential between the inner magnet ring and the outer magnet ring in an eddy current drive pump.

#### 4.2.45 Synchronous drive

The drive shaft and driven shaft rotate at the same speed without slip. Banks (rows) of magnets on the outer magnet assembly and inner magnet assembly follow each other without slip.

## 4.3 Design and application

### 4.3.1 Scope

This section covers background information, design features, and general selection guidelines for application in liquid handling systems of sealless rotary pumps of the synchronous magnetic drive type.

The pumping portion of rotary sealless pumps is similar to units having shaft seals. There are differences, however, in design and application considerations that concern the drive portion of sealless pumps. This section concentrates on application considerations that are unique to sealless pumps, and presumes that the reader has background knowledge relative to the more general subject of rotary pumps.

For general application information on rotary pumps, refer to Design and Application in ANSI/HI 3.1–3.5.

#### 4.3.1.1 Reasons for use

Sealless rotary pumps are typically used when there is a need to contain toxic, dangerous, or valuable liquids to reduce maintenance cost, or where specific applications warrant. Application may be dictated by environmental, safety, or economic concerns.

#### 4.3.1.2 General precautions

Even though the pumps described by this section are sealless, leakage could occur as a result of certain types of wear, misoperation, or misapplication. Also the purchaser should take appropriate supplemental precautions to avoid dry running, to ensure a satisfactory environment for liquid-lubricated bearings as well as for cooling the magnetic coupling areas.

Proper selection and application requires a detailed understanding of operating conditions and the specific design being considered to ensure that safety and reliability can be achieved.

#### 4.3.2 Sealless pump overview

The term *sealless* refers to a pump design having no dynamic shaft seals between the wetted pump elements and the surrounding environment. The rotary pump may be one of several configurations, but common to all types of sealless pumps covered in this section is a driven shaft completely contained in a magnetically permeable vessel containing the pumped liquid and a set of permanent magnets to drive the internal rotating assembly. Sealless pumps, however, retain the characteristic advantages of rotary pumps, including the following:

- Fixed displacement per revolution
- Flow proportional to rotational speed
- Constant flow over a wide viscosity range
- High efficiency at low rates of flow
- Self-priming capability
- Capability to handle liquids with limited gas or entrained vapor
- Stripping capability
- Ability to handle high viscosities and pressures
- Ability to handle shear-sensitive liquids

##### 4.3.2.1 Operating principles of sealless pumps

Two methods are used for transmitting power to the pump shaft through a containment shell. One is the canned motor type, which consists of an induction motor where the rotor is mounted on the drive end of the pump shaft inside the containment shell with the stator outside the containment shell. The second method uses permanent magnets to transmit torque through the containment shell, and these are driven by a standard motor or drive shaft. There are two types of magnetic pump couplings: synchronous and eddy current. Guidelines in this standard are limited to synchronous magnetic couplings.

###### 4.3.2.1.1 Synchronous magnet coupling

In this design, permanent magnets inside and outside the containment shell rotate the pump shaft in synchronized motion with the driver shaft. The coupling has high-efficiency torque transmission capability.

Synchronous couplings do not slip; the pump shaft turns at the same speed as the outer magnet assembly unless the unit is overloaded and decouples.

###### 4.3.2.1.2 Eddy current magnetic coupling

The eddy current type coupling consists of a permanent outer magnet ring and an inner torque ring containing a network of copper rods supported on a mild steel core. The rotating outer magnet ring generates eddy currents in the copper rods, which convert the core to an electromagnet. The electromagnet tries to follow the rotating outer magnet ring but at a slightly slower speed. The difference between the driven shaft speed and drive shaft speed is defined as *magnetic slip*. This design may be preferred in some high-temperature pumping applications because the materials used in the torque ring are less sensitive to heat than permanent magnets.

##### 4.3.2.2 Basic design features

The unique features of sealless, synchronous, magnetically coupled pumps are discussed in this section.

#### 4.3.2.2.1 Containment shell

The containment shell serves as the primary barrier between the process pumpage inside the pump and the surrounding environment. Containment shell thickness is usually optimized between pressure capability and efficiency because the magnet's ability to transmit torque decreases as the square of the gap between the outer magnet and inner magnet. Shell metal thickness also affects eddy current losses, which generate heat.

Containment shells may be formed from a variety of materials, not all of which are metal. See the material section 4.3.3.8.1 for additional information on shell materials.

#### 4.3.2.2.2 Magnet assembly

Synchronous magnetic drive sealless rotary pumps use permanent magnets on the outer magnet assembly to drive an inner magnet assembly.

These components are typically either ceramic, ferrite, or rare earth magnets. Typically, neodymium-iron-boron or samarium cobalt rare earth magnets are used, which allow for compact design due to their high flux density.

The outer steel portion of the outer magnet assembly shall be coated with a corrosion/heat-resistant paint or coating, with the exception of any close-clearance register fits. If the outer magnets are neodymium, and are in a corrosive environment, then they should also be coated or painted to prevent corrosion. The outer magnet assembly shall be designed to be easily cleaned of stray ferrous particles during assembly.

#### 4.3.2.2.3 Internal sleeve bearings

Internal sleeve bearings in sealless pumps are cooled and, in most cases, lubricated by the pumpage. The durability and wear life of the bearing is therefore dependent on the characteristics of the pumpage, as well as operating conditions such as speed, temperature, and pressure. Internal sleeve bearings are widely used in conventionally sealed rotary pumps, but the purchaser should be aware that most of the eddy current heat from the canister is dissipated to the pumpage; if the pumped liquids can vaporize, then this could result in accelerated wear of the bearings due to loss of liquid film or localized cavitation in the bearings.

A variety of materials is available for bearing construction to handle the various liquids encountered in rotary pump services. See Section 4.3.3.8.2.

#### 4.3.2.2.4 Cooling liquid flow

Due to heat generation, almost all sealless pumps require some flow of cooling liquid to remove heat from the magnetic coupling area. Typically, this cooling flow is developed by recirculating a portion of the pumpage internally through the containment shell and bearings. There are several satisfactory means of providing recirculation cooling flow, but the most common is the discharge-to-inlet method in which a portion of the flow is diverted from the high-pressure side of the pump and recirculated through the containment shell and bearings back to the lower-pressure inlet section.

Temperature control is vital because liquid flashing or vaporization can result in loss of cooling flow and resultant damage to the containment system magnets and/or bearings.

### 4.3.3 Application considerations

The factors that should be considered when selecting a rotary sealless pump for a given application are addressed in this section.

#### 4.3.3.1 Coupling selection

A magnetic coupling is a constant torque device rated by its torque transmission capability.

It is important to apply magnetic drive pumps carefully, because if misapplied, the coupling magnets may become permanently demagnetized and require replacement. Factors that must be watched to prevent demagnetization are decoupling and high temperature.

When a synchronous magnetic coupling is incapable of transmitting the pump torque required, it completely decouples. The pump will stop, and motor load will normally be substantially reduced from rated conditions. Higher than specified temperatures, pressures, or viscosities can cause decoupling, as can improper coupling selection. If the pump unit continues to run in a decoupled state, it may vibrate excessively and heat will rapidly build up in the magnetic drive area due to eddy currents and lack of cooling flow.

Magnetic couplings are not meant to run decoupled, and operation in this condition will lead to reduced magnetic strength and even complete demagnetization (along with bearing failure). However, some materials can tolerate decoupling for longer periods than others.

#### 4.3.3.2 Temperature

Eddy currents in the containment shell are one source of heat in the sealless pump. Heat is also generated by liquid friction as the inner magnet moves through the liquid inside the containment shell.

Magnetic couplings undergo some loss of torque capability with increasing temperature. Additionally, each permanent magnet material has a unique Curie point, which is the temperature at which the material loses all magnetism. Below the Curie point, there are two ranges referred to as *reversible* and *irreversible temperature*. Reversible losses naturally occur in the normal rated temperature range of the coupling and will return to full strength when the coupling cools down to ambient. Between the rated temperature of the coupling and the Curie point is a range where the magnets lose a percentage of their strength permanently as a function of time and temperature. The manufacturer should be consulted for specific information about coupling torque versus temperature prior to sizing the magnetic coupling for a given application. The generally recognized useful temperature limits vary with the magnet type and grade.

Always check with the manufacturer before using magnetic couplings close to these limits, because magnet temperatures are higher than the pumpage or environment. When pumping liquids that are particularly sensitive to temperature, or when operating near the vaporization point, it is recommended that the internal temperature rise profile be obtained from the manufacturer.

#### 4.3.3.3 Liquid properties

This section provides an overview of various liquid properties that have unique effects on the performance of rotary sealless pumps, so the purchaser will be equipped to make informed application selections and understand the background of the general precautions outlined in Section 4.3.1.2.

##### 4.3.3.3.1 Viscosity

Viscosity of the pumped fluid will affect the input power and magnetic coupling torque required. Primary considerations in basic magnetic coupling selection are the maximum pressure differential, speed, and viscosity at which the pump will operate, which determine the input power and torque required by the pump. In addition, the torque required to overcome viscous friction between the inner magnet and the containment shell must also be known and added to the pump input torque to determine the torque requirement of the magnetic coupling. Other effects of viscosity on magnetic couplings are discussed in Sections 4.3.3.3.2, 4.3.3.3.3, and 4.3.3.3.4 below.

##### 4.3.3.3.2 High viscosity

There are traditional considerations that must be addressed when handling high-viscosity liquids. These include concerns about suction lift, port size, friction losses, and reduced pump speeds. In addition to the traditional considerations when selecting a sealless rotary pump, a user should also consider the effect that high-viscosity liquid has on the temperature rise of the magnetic coupling. With high-viscosity liquids, the amount of cooling flow at a given pressure may be reduced, resulting in diminished cooling and increased temperature rise within the coupling. The user should carefully consider the effects of high viscosity with respect to both increased torque required and potentially elevated magnetic coupling temperature.

Starting torque for a pump previously primed with viscous pumpage can be a problem unless appropriate consideration has been given to coupling sizing. The use of a soft-start device may avoid decoupling on start-up with a high-viscosity pumped liquid.

#### 4.3.3.3.3 Low viscosity

Traditional concerns when pumping low-viscosity liquids are poor lubricating qualities and slippage. In addition, purchasers should carefully consider the vaporization point when applying a rotary sealless pump. The temperature of the liquid in the coupling should be maintained well below the vaporization point of the liquid being pumped.

#### 4.3.3.3.4 Variable viscosity

The viscosity of many liquids changes with shear and temperature. If viscosity increases, additional torque could be required to pump the liquid, and increased heat buildup in the drive section may occur.

#### 4.3.3.3.5 Liquid vapor pressure

Liquids having a large vapor pressure rate of change with temperature typically have a low flash point temperature. When a liquid flashes in the bearing area or containment shell, it may result in loss of lubricating film and cooling flow. Whether or not a specific liquid will flash depends on the liquid properties, such as flash point, liquid vapor pressure, and heat capacity, as well as pump design and application-specific features, such as amount of cooling flow, temperature rise, and pressures developed in the recirculation flow path. The manufacturer should be consulted regarding applications for pumping such liquids.

#### 4.3.3.3.6 Specific heat

The liquid's specific heat, also known as the *specific heat capacity*, is a measure of the liquid's ability to absorb heat. The specific heat of a given liquid can be used to confirm the ability to remove heat from the magnetic coupling when the manufacturer's test liquid (typically water or oil) varies significantly from the service liquid.

#### 4.3.3.3.7 Specific gravity

Low specific gravity liquids frequently have a high rate of change in vapor pressure per unit temperature, and precautions outlined in above Section 4.3.3.3.5 apply.

#### 4.3.3.3.8 Entrained air or gas

Traditionally, rotary pumps have handled liquids with entrained air or gases; however, if the entrained or dissolved gases are a large percentage of the pumpage, they may result in loss of flow rate or reduce coupling cooling flow.

#### 4.3.3.3.9 Particles

Particles may be magnetic or nonmagnetic materials. If the particles are magnetic, then they will be attracted to the magnet and build up within the clearance area of the containment shell. This could lead to poor circulation and create the possibility of contacting and wearing the containment shell, which may result in failure of the shell.

If the particles are nonmagnetic, then the size and percentage of the particles must be kept small to prevent binding. The abrasive nature of the particles and the resulting effect on wear should be considered as well.

If particles are present in the pumpage, the cooling flow path may become obstructed, leading to excessive heat buildup and possible damage to magnets or internal sleeve bearings, as well as increased potential for flashing and vaporization with some liquids.

The manufacturer should be consulted for the allowable particle concentration and size for its pump design.

#### 4.3.3.3.10 Lubricating liquid

Lubricating liquids are any of a variety of liquids capable of reducing friction, heat, and wear when introduced between solid surfaces, and are ideal for rotary sealless pump applications.

#### 4.3.3.3.11 Nonlubricating liquid

When the pumpage is nonlubricating, bearing lubrication may be impaired, and a reduction in maximum pressure to maintain a satisfactory service life is required. In certain applications, input power requirements may also increase significantly due to the inability to avoid boundary lubrication conditions.

### 4.3.3.4 Liquid classification

A wide variety of liquids are handled by rotary pumps, and classification is considered to be the purchaser's responsibility. The Hydraulic Institute does not classify specific liquids. Specific liquids, however, may be regulated by local, state, or federal agencies through implementation of health, safety, and emission control environmental legislation. A commonly used hierarchy of liquids follows:

1) Nonhazardous, nonflammable.

2) Hazardous (flammable) volatile.

3) Hazardous (environmental) corrosive, toxic.

All of the liquid classifications based on material of construction requirements may be candidates for sealless pumps for a number of reasons, including regulatory requirements, environmental practices, plant maintenance policies, risk-avoidance determinations, standardization, or specific economics.

### 4.3.3.5 Shear sensitivity

When a shear-sensitive liquid is to be handled, it is recommended that discussions be held with the pump manufacturer to obtain specific recommendations. Drive-end operation could modify shear performance as compared to a standard conventionally sealed or packed pump.

### 4.3.3.6 Stripping applications

Rotary pumps are frequently used in stripping services where pipes or vessels are pumped clear of liquids. This application may involve interrupted flow, and consideration of instrumentation to detect no-flow conditions and to monitor drive-end temperatures is recommended.

### 4.3.3.7 Off-design rating procedures

Off-design operating conditions should be specified so magnetic couplings can be sized appropriately. This includes rating for the maximum torque required for the relief valve setting at maximum viscosity. A safety factor should be applied to ensure adequate torque when viscosity is variable.

#### 4.3.3.8 Materials

Material selection depends on the operating stress; effects of corrosion, erosion, abrasion, temperature, entrained vapors, and solids content; and compatibility with the pumped liquid's chemical composition. For rotary sealless pumps, the materials used in the magnetic drive section are uniquely important.

##### 4.3.3.8.1 Containment shell

The containment shell thickness is normally kept to a minimum for the rated operating pressure because the magnet's ability to transmit torque decreases with increasing magnet gap distance. With metal shells, as the shell thickness increases, eddy current losses and resultant heating increase as well. Typical containment shell materials available are high-grade stainless steel, "alloy C," and ceramics.

##### 4.3.3.8.2 Bearings

The internal sleeve bearings in sealless pumps are cooled and, in most cases, lubricated by the pumpage. The durability and wear life of the bearings is therefore dependent on characteristics of the pumpage, and operating conditions such as speed, temperature, and pressure. A variety of materials are available for bearing construction. Typical materials used are silicon carbide, carbon (graphite), and plastic or polymer. The limitations and advantages of each type should be weighed against process conditions prior to making a selection.

Silicon carbide bearings are very hard and consequently wear-resistant but may not tolerate dry-running conditions without rapid destructive heat buildup. They may also be sensitive to poor lubricating liquids.

Carbon bearings allow for longer dry running and have excellent chemical compatibility; however, due to the inherent softness of the material, they decompose rapidly if large abrasive solids are allowed to enter the bearing area.

Plastic or polymer bearings must be chemically compatible with the liquid pumped and tend to collect any abrasives that are present, resulting in rapid wear of rubbing shaft surfaces.

Properly selected bearings should be compatible with the pumpage in terms of corrosiveness, lubricity, and viscosity.

##### 4.3.3.8.3 Magnets

See Sections 4.3.3.1 and 4.3.3.2.

##### 4.3.3.8.4 Pump

The purchaser shall specify any corrosive chemicals that need specific consideration for the particular design or application involved. In addition to rated liquids, the purchaser should fully specify all flush-cycle liquids and the corresponding operating conditions.

Materials shall be as stated on the data sheet. If the materials are selected by the purchaser but the pump manufacturer considers other materials to be more suitable, these shall be offered as alternatives. The manufacturer shall inform the purchaser regarding selection of materials that are particular to the design involved, such as containment shell and inner magnet assembly encapsulation. Careful consideration of corrosion is important.

#### 4.3.3.9 Safety consideration

Sealless pumps hold the potential for significant improvement in environmental and safety aspects when properly applied. When they are used for hazardous services, consideration of potential application hazards should be reviewed by the purchaser to define and specify any additional protection required. Recognized systems that are designed to provide further levels of protection are secondary control and secondary containment.

Secondary control minimizes the release of pumpage in the event of failure of the containment shell. A secondary control system is a combination of devices used to minimize and safely direct the release of pumpage in the event of failure of the containment shell. Such systems include a secondary pressure casing with a flow-restriction device around the drive shaft and controlled drain provisions (Figure 4.1.3b).

Secondary containment confines the pumpage within a pressure casing in the event of failure of the containment shell. A secondary containment system is a combination of devices that confine the pumpage within a pressure casing and includes a provision to indicate failure of the containment shell. These systems usually include a secondary pressure casing and an auxiliary shaft seal on the drive shaft (Figure 4.1.3c).

#### 4.3.3.10 Mechanical safety considerations

Jacking screws and special precautions may be recommended by the manufacturer for assembly and disassembly of magnetic couplings because magnets exert considerable force when approaching each other.

#### 4.3.3.11 Monitoring devices

Monitoring protection available for sealless pumps includes devices for monitoring temperature of the containment shell, leak sensors, and sensors that monitor motor current, power, flow, and pressure. Such devices are optional. Consideration of the liquid properties outlined in Section 4.3.3.3 may lead to selection of one or more of these devices.

In secondary control or secondary containment systems, certain devices may be mandatory to meet the required operational intent. In such systems, coordination of interfaces between manufacturer and purchaser is required. The purchaser should determine if systems should simply activate alarms or if they should shut down equipment.

### 4.3.4 Life cycle cost evaluation

There is a substantial first-cost premium for sealless rotary pumps. Depending on the type, this cost is a multiple of a similar pump with a conventional mechanical seal. The expense associated with magnetic drive pumps is primarily associated with the cost of the magnets required to transmit torque.

There are many applications where sealless pumps may be selected based on a life cycle cost analysis. Each application is subject to individual review, but general areas that may be considered in a life cycle cost analysis follow:

a) Negative for sealless pumps:

- Initial capital cost
- Additional instrumentation, if required
- Lower drive efficiency

b) Variable cost elements based on user experience:

- Cost of maintenance differential (numerous surveys have shown mechanical seal failure to be the dominant cost of pump maintenance)
- Cost of production loss associated with system reliability
- Reduced cost of instrumentation compared to complex seal systems

c) Positive for sealless pumps:

- Monitoring exemption for fugitive emissions under Clean Air Act
- Cost of liquid disposal as a result of seal failure
- Risk cost associated with personnel or fire incident loss
- Cost of alternate sealing systems to meet environmental emissions control requirements, such as double seal and compliance
- Value of extended operating periods between unit turnaround
- Space reduction as opposed to complex seal systems
- Cooling water costs

Economics may initially be difficult to assess until operating, maintenance, and monitoring expense experience has been assembled. Records of these considerations are valuable to the pump-type selection process.

#### 4.3.5 Selection guideline

It is necessary to have good communication on the details of any application for successful operation. The following application specifications and attached data sheet are designed to serve as a communication vehicle between purchaser and supplier.

##### 4.3.5.1 Specifications

###### 4.3.5.1.1 Pump and system ratings

- Rate of flow
- Discharge pressure
- Suction pressure (or lift)
- Operating temperature

###### 4.3.5.1.2 Pumped liquid characteristics

- Viscosity – range or high, low, and rated
- Temperature – range
- Vapor pressure (and rate of change with temperature)
- Specific gravity
- Specific heat
- Percent entrained air or gas
- Percent solids and size and hardness
- Material compatibility

#### 4.3.5.1.3 Pump and drive characteristics

- Speed
- Power/torque required
- Starting torque characteristics of driver
- Duty cycle
- Service
- Magnet temperature limit
- Pump and drive materials compatible with pumped liquid

#### 4.3.5.1.4 Safety characteristics

- Leak protection – secondary control or containment measures
- Sensors – rate of flow, low current or power, bearing wear, temperature, leak detectors

### 4.3.6 Data sheet

(See next page.)

## 4.4 Installation, operation, and maintenance

### 4.4.1 Installation

When rotary positive displacement pumps are magnetically driven, special precautions must be taken. However, the basic reference, ANSI/HI 3.1–3.5 *Rotary Pumps for Nomenclature, Definitions, Application and Operation*, remains applicable for installation, operating, and maintenance information.

#### 4.4.1.1 Special requirements

Magnetic drive pumps may have special requirements that set the limits for pump operation, thus close attention to application details is important. Among these details are high-temperature considerations, viscosity effects, eddy current loss considerations, liquid flash point, and dry-running protection. A general discussion of these application limitations can be found in Section 4.3. The user must discuss these items in detail with the manufacturer before installation.

#### 4.4.1.2 Cautions

The magnets in magnetic drive rotary pumps are usually rare earth elements. The extremely strong magnetic fields and strong mechanical forces developed by rare earth magnets may create hazards to personnel through chipping, shattering, or pinching as the magnets snap together. Always make sure that rare earth magnets are under mechanical control when they come in contact with each other or with ferrous materials. Some additional special cautions regarding these magnetic fields include the following:

##### 4.4.1.2.1 Pacemakers

Magnets from these pumps can upset the timing of pacemakers and make them malfunction. The magnets must be kept away from all pacemakers.

| | | |
|---|---|---|
| **Application data** | | |
| Name: | | Type services: |
| Location: | | Duty cycle: |
| Elevation: | | |
| **Liquid data** | | |
| Liquid: | | Vapor pressure: |
| Temperature, normal/maximum: | | Specific heat: |
| Chemical compatibility: | Metals: | Elastomers: |
| **Normal operational point** | | |
| Liquid: | Viscosity: | Specific gravity: |
| Suction pressure, rated/max: | | Discharge pressure: |
| Rate of flow: | | NPIPA: |
| **Upset condition (low viscosity and/or flushing)** | | |
| Liquid: | Viscosity: | Specific gravity: |
| Suction pressure, rated/max: | | Discharge pressure: |
| Rate of flow: | NPIPA: | Duration/time: |
| **Upset condition (high viscosity)** | | |
| Liquid: | Viscosity: | Specific gravity: |
| Suction pressure, rated/max: | | Discharge pressure: |
| Rate of flow: | NPIPA: | Duration/time: |
| **Specific materials of construction** | | |
| Case: | | |
| O-Rings: | | |
| **Mounting** | | |
| Orientation: | ☐ Horizontal | ☐ Vertical |
| **Connections** | | |
| Inlet: | ☐ Flange ☐ Pipe thread | ☐ Other |
| Discharge: | ☐ Flange ☐ Pipe thread | ☐ Other |
| **Additional comments** | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

#### 4.4.1.2.2 Credit cards/magnet tape

All magnets must be kept away from credit cards or magnet tape. If not done, the information on the credit card or magnet tape can be scrambled.

#### 4.4.1.2.3 Computers, computer tapes, and computer discs

These magnets must be kept away from computers, computer tapes and discs, or any computer memory device, or the information may be scrambled.

#### 4.4.1.2.4 Watches

When handling these magnets, all watches should be removed. These magnets can and have affected the workings of traditional mechanical spring-driven watches as well as chip and electronically controlled watches.

#### 4.4.1.2.5 Electronic instruments

Sensitive electronic instruments and devices may change calibration or be damaged by a powerful magnetic field. Always keep rare earth magnets a safe distance away from such sensitive electronic instruments.

#### 4.4.1.2.6 Explosive atmosphere

Rare earth magnets and magnetic materials may create sparks through contact in handling. Never handle rare earth magnets in explosive atmospheres where sparking may ignite that atmosphere.

#### 4.4.1.2.7 Freight

When shipping bare magnet assemblies, especially by air, special precautions may be necessary. Usually the shipment of an assembled pump is not a problem. Consultation between the pump manufacturer, the user, and the freight company is advisable.

### 4.4.2 Operation

#### 4.4.2.1 Standard operation of magnetically driven rotary pumps

The operation of these pumps is similar to the operation of standard rotary pumps; however, special considerations are required. The user should refer to ANSI/HI 3.1–3.5 for information on the operation of rotary pumps.

#### 4.4.2.2 Prevention of operation without liquid flow

Magnetically driven pumps must not run dry. Reference to running dry is made in the design and application section of this standard. Heat buildup is a major concern. Also, the bearings in most magnetic drive pumps must be lubricated by the pumped liquid. If run dry, these bearings can wear quickly or fail, depending on design. Some manufacturers may make pumps that have dry run capability. Consult your supplier if this is a concern.

#### 4.4.2.3 Problems with air entrainment

Liquids with air entrained can also cause bearings to wear or fail due to heat buildup or the lack of lubrication. If entrained air or gases are anticipated, this condition should be noted and discussed with the manufacturer. Special designs to operate with this condition may entail special flush systems; however, specific determination is dependent on type of entrainment, operating conditions, and percent of gas entrainment.

#### 4.4.2.4 Air in containment shell

Air or gases trapped in the containment shell may cause the bearings to wear or be destroyed after a very short period of operation. Most designs require the pump casing and containment shell to be fully primed and properly vented. The user must follow the manufacturer's recommendations on these procedures. This is one of the most common failures of this type of pump at start-up.

#### 4.4.2.5 Temperature limits of magnets

It is important to emphasize that the magnet temperature can be significantly higher than the pump operating temperature or recommended practice for the pumped liquid. The pump user must carefully review the cautions and temperature limits from the manufacturer, and consider liquid properties. In addition to liquid considerations, excessive temperatures can cause damage to the magnet, containment shell, or static seals and result in failure of containment integrity.

Some stable liquids are commonly handled at elevated temperatures by applying prevailing industry safety practices. Common magnet materials used in these applications, in order of increasing temperature capability, are neodymium, samarium cobalt, and alnico.

Magnets retain most of their strength up to the manufacturer's maximum temperature. Magnet temperature limits, as opposed to pump operating temperature limits, are established by the type and grade magnet material used, and is defined as that temperature beyond which the materials become permanently demagnetized. As the temperature approaches its Curie temperature, the magnet will lose some force and this loss could result in the decoupling of the pump. For magnet life and proper operation, the user should establish a maximum operating temperature with an appropriate safety margin.

#### 4.4.2.6 Internal temperature rise

Pumps with metallic containment shells have heat developed in the shell during operation due to eddy currents that are generated by rotating a magnetic field around the conductive material of the shell. This heat is dissipated to the atmosphere and the pumped liquid. Caution must be taken to ensure that the liquid temperature stays within allowable limits.

Certain liquids could ignite, flash, or have property changes due to temperature. All pumps, therefore, should be applied in accordance with the manufacturer's temperature recommendation and published liquid physical property data. Since liquid flow is used to dissipate the generated heat, the temperature and pressure profile of liquid in the coupling should be discussed with the manufacturer to ensure safe performance at all operating conditions.

The manufacturer's published temperature limits are normally based on the assumption that liquid inlet temperature and ambient temperature are in the same range. If ambient and liquid inlet temperatures are substantially different, then the temperature rise of the shell may vary from the published data. This condition should be noted in application criteria provided to the manufacturer so that proper limits and temperature detection devices can be mutually discussed.

#### 4.4.2.7 Pump monitoring devices

Instrumentation recommendation should be made based on the criticality of the pump service, the danger associated with liquid leakage, and an evaluation of specific risks of the pump running dry. If needed at all, some applications may be satisfied with a simple current or kilowatt sensor, which can detect operational malfunctions arising from low suction pressure, decoupling jamming for overloads due to rubbing, viscosity changes, or air slugging. Other more complex systems may need to have instrumentation that includes a temperature probe of liquid in the containment shell, suction vessel low-level alarm and shut-down devices, pressure gauges across the suction strainer and discharge, vibration monitors for pump casing, and rotor or acoustical devices to measure change in the pump's operation. Consultation with the manufacturer concerning the extent of instrumentation is recommended.

#### 4.4.2.8 Demagnetization

Rare earth magnets may become demagnetized permanently if misapplied or improperly operated. Increased temperature is the normal cause of demagnetization. When this happens, the magnetic components must be replaced. Magnet temperature rise is a result of operating environment, liquid temperature, and decoupling.

When a magnetic coupling slips, it may completely decouple. The pump will stop, and motor load will normally be substantially reduced from rated conditions. (For most applications, a current- or power-sensing warning device is recommended to indicate this condition. These devices may have limited effectiveness where the pump operates at low-load conditions.) If the magnet is not damaged, it will pick up the load again by stopping the motor, correcting the pump overload problem, and restarting. The magnetic coupling cannot pick up the pump load while the motor is running.

A high-temperature environment and/or liquid temperature above the manufacturer's recommendation reduces the life of, or permanently damages, the magnetic coupling.

Magnet materials vary in their tolerance for decoupled operation and temperatures. Care should be taken to specify the material suitable for your application, and appropriate warning or shut-down devices should be incorporated into your system. (Refer to Section 4.4.2.7.)

#### 4.4.2.9 Humidity effects on magnets

Samarium cobalt magnets are not affected by humidity or water. Neodymium magnets are affected by humidity and water, and will corrode. Consult the manufacturer or instruction manual for the type of magnets provided by the manufacturer.

### 4.4.3 Maintenance

#### 4.4.3.1 Rotary magnetic drive pump maintenance

The maintenance of these pumps is similar to the maintenance of standard rotary pumps. Use of the ANSI/HI 3.1–3.5 section on maintenance is recommended. Because of the special characteristics of magnet drive pumps, additional precautions must be taken in maintaining these pumps. The user is advised to become knowledgeable about the special characteristics of the pumping system, and with disassembly and assembly of the pump for required maintenance. Refer to the manufacturer's maintenance manual frequently to become familiar with the specific maintenance requirements of your pump.

#### 4.4.3.2 Draining the containment shell

Many magnetic drive pumps handle flammable, toxic, or hazardous liquids. A material safety data sheet (MSDS) is required. The user must be sure that all the liquid is drained from the containment shell before disassembly. Some designs may not fully drain the containment shell when the casing is drained. Reference to the manufacturer's manual is required. Proper draining procedures should be followed. When the pump is handling flammable, toxic, or hazardous liquids, the internals of the pump are to be properly decontaminated before disassembly. This normally is done by flushing the pump and system as recommended by the liquid manufacturer before disassembly.

#### 4.4.3.3 Caution on assembly of magnetic parts

Extreme caution should be used when reassembling a magnetic drive pump. The magnets can create hazards to personnel through chipping, shattering, or pinching as the magnets snap together. The magnets can cause parts and tools to slam together with force enough to injure persons handling parts. Always make sure that rare earth magnets are under control when they come in contact with each other or with ferrous materials. The user should refer to the manufacturer's maintenance manual for procedures, special tools, or fixtures. The use of nonmagnetic tools, while not absolutely necessary, is advised to prevent injury to workers and/or pump parts.

#### 4.4.3.4 Frequency of inspection

The manufacturer's manual may recommend a schedule of inspection or will recommend inspection of parts based on some abnormal event. However, the frequency of inspection mainly depends on the application. Hazardous liquids should be monitored or checked frequently. Containment shells, bearings, and magnets should be checked frequently for wear or contact marks that can cause the canister to fail, causing the liquids to be discharged to the environment. The user should set up an inspection schedule accordingly.

#### 4.4.3.5 Review of parts when disassembled

The manufacturer's manual details the method of review of individual parts to determine their wear and, therefore, their replacement or expected future life.

#### 4.4.3.6 Cautions on handling magnets

When disassembling or assembling a magnetic drive pump, the user must follow careful procedures to protect individuals and equipment from the effects of the magnets' magnetic field. Refer to the above cautions along with those in the installation section of this standard.

## 4.5 Reference and source material

### 4.5.1 Hydraulic Institute

ANSI/HI 3.1–3.5 *Rotary Pumps for Nomenclature, Definitions, Application and Operation*

ANSI/HI 3.6 *Rotary Pump Tests*

Hydraulic Institute
6 Campus Drive
First Floor North
Parsippany, NJ 07054-4406
www.Pumps.org

### 4.5.2 International Magnetics Association (IMA)

International Magnetics Association
8 South Michigan Avenue, Suite 1000
Chicago, IL 60603
www.intl-magnetics.org

## 4.6 Test

The user should refer to ANSI/HI 3.6 *Rotary Pump Tests* for detailed testing recommendations. In addition, an optional hermetic integrity test and/or optional torque confirmation test may also be performed on sealless rotary pumps as described in this standard when negotiated as part of the purchase contract.

The user should also refer to International Magnetics Association (IMA).

### 4.6.1 Hermetic integrity test (optional)

#### 4.6.1.1 Objective

The objective is to provide a procedure for a nonstructural test to demonstrate that a sealless rotary pump assembly, or a sealless rotary pump with secondary containment, has basic hermetic integrity when subjected to internal pressure.

This test may be performed in addition to hydrostatic component testing performed to confirm structural acceptance and pump unit performance testing.

#### 4.6.1.2 Test parameters

Tests shall be conducted on completely assembled pump units. The primary and secondary (if so equipped) containment boundaries shall be tested separately. Disassembly after test is not permitted.

##### 4.6.1.2.1 Test duration

Test pressure shall be maintained for a sufficient period of time to permit a complete examination of the parts under pressure. A minimum of 10 minutes is considered necessary for this examination.

##### 4.6.1.2.2 Test fluid

The test fluid shall be an inert dry gas. Where specified, there shall be no water or other liquid present in the test fluid.

##### 4.6.1.2.3 Test pressure

The test pressure shall not be less than 170 kPa (25 psi). Test pressure shall not exceed 75% of the maximum allowable working pressure of the containment boundary or 517 kPa (75 psig), whichever is lower. Because a compressible medium is being used for the test fluid, and the test is not conducted in an isolated safety chamber, adequate safety precautions must be taken.

**EXTREME CAUTION: COMPRESSED GAS IS HAZARDOUS WHEN USED AS A TEST MEDIUM. USE ADEQUATE SAFETY PRECAUTIONS TO PROTECT ALL PERSONNEL.**

##### 4.6.1.2.4 Test temperature

Tests shall be conducted at room temperature unless other arrangements are made between the manufacturer and purchaser. The temperature must remain constant during the test to avoid affecting test results.

#### 4.6.1.3 Test procedure

An inert dry gas medium shall be introduced into the primary and secondary containment boundaries. Each area shall be tested separately. The primary boundary shall be pressurized first. Once the primary boundary has been proven, the secondary boundary, if any, shall be pressurized. (Note: if pressurizing the secondary boundary could damage the primary boundary, then it is permissible to pressurize the primary boundary during the test of the secondary boundary.) After pressure and temperature have stabilized, one of the following three methods can be used to determine leakage:

1) Inert gas sniffer test.

2) Pressure decay observation at constant temperature.

3) Bubble test (immersed or joints coated with bubbling agent).

#### 4.6.1.4 Acceptance criteria/alternatives

One of the following criteria shall be used, depending on the test method selected in Section 4.6.1.3 above.

1) A leakage of no more than $1 \times 10^{-4}$ mL/s of gas shall be observed.

2) Pressure drop of no more than 0.4 kPa (0.06 psig) should be noted for a period of not less than 10 minutes or a measured pressure decay of not more than $7 \times 10^{-4}$ kPa/s ($1 \times 10^{-4}$ psi/s).

3) No observable leakage for a minimum of 10 minutes.

### 4.6.2 Torque confirmation test (optional)

#### 4.6.2.1 Object

The object is to demonstrate the torque transmission capability of a synchronous magnetic coupling supplied as an integral portion of a rotary positive displacement pump.

#### 4.6.2.2 Test scope

This test is designed to be conducted on assembled units in an operational mode. It is an optional test for units when a Type IV performance test has been conducted in accordance with ANSI/HI 3.6 *Rotary Pump Tests*. The method outlines procedures for establishing the magnetic coupling torque transmission capability.

When steady state decoupling torque is a goal, the suitability of this procedure is dependent on review by the manufacturer of the specific relationship between the available coupling torque and the rating of the pump. Sometimes the test may not be suitable because it would exceed the maximum pump or test stand operating capability. In such cases, the purchaser and manufacturer may agree on alternate test methods, including component testing or static unit tests. Such tests normally include use of torque test fixtures, and recommended procedures are contained in Magnet Material Producers Association publications.

#### 4.6.2.3 Test parameters

Because this test follows a Type IV power test, the setup, instrumentation, circuits, and applicable procedures of ANSI/HI 3.6 *Rotary Pump Tests* apply.

#### 4.6.2.4 Records

The following data shall be taken in addition to that listed in ANSI/HI 3.6 *Rotary Pump Tests*.

a) Outlet pressure at decoupling.

b) Recorded torque.

c) Calculated torque at maximum pressure achieved during test.

#### 4.6.2.5 Calculations

The formula for calculating torque is:

(metric units) $$\tau = \frac{9550 \times P}{n}$$

Where:

$\tau$ = Torque, in newton-meters (N•m)

$P$ = Power, in kilowatts (kW)

$n$ = Pump speed, in revolutions per minute (rpm)

(US customary units) $\tau = \dfrac{5250 \times P}{n}$

Where:

$\tau$ = Torque, in pound-feet (lb•ft)

$P$ = Power, in horsepower (hp)

$n$ = Pump speed, in revolutions per minute (rpm)

#### 4.6.2.6 Test procedure

The pump with its magnetic coupling shall be installed in an approved circuit, and a Type IV performance test shall be conducted. Test shall be conducted to meet the criteria selected in Section 4.6.2.8.

#### 4.6.2.7 Decoupling torque (optional)

Operation will then be established and circuit equilibrium achieved. The control valve located in the discharge line shall be closed gradually until the discharge pressure is within 5% of the calculated pressure necessary to meet the selected test criteria (see Section 4.6.2.8). Using the discharge control valve, pressure will then be increased in increments of 1% until the criteria is satisfied.

If testing for the decoupling torque (maximum torque capability), then that capability will be assigned as 101% of the last recorded torque value or the calculated torque value derived from the measurement of power.

#### 4.6.2.8 Acceptance criteria

Acceptance is a function of contractual criteria and is foreseen as being established as confirming that there is available torque that:

a) Meets or exceeds a published level.

b) Meets or exceeds a specified level.

c) Tests maximum torque capability of the drive.

d) Is a combination of the above.

Alternate acceptance criteria may correspondingly adjust test procedures.

# Appendix A

# Index

This appendix is not part of this standard, but is presented to help the user with factors referenced in the standard.

Note: an f. indicates a figure, and a t. indicates a table.



This page intentionally blank.