July 11, 2011

Ms. Brenda Edwards
U.S. Department of Energy
Building Technologies Program
Mailstop EE-2J
RFI for Commercial & Industrial Pumps
EERE-2011-BT-STD-0031 and/or RIN 1904-AC54
1000 Independence Avenue, SW
Washington, DC 20585-0121

Dear Ms. Edwards:

Subject: DOE 10 CFR, Part 431; Docket EERE-2011-BT-STD-0031; RIN 1904-AC54

---- Hydraulic Institute (HI) Response to DOE Request for Information ----

This letter is a preliminary response to the U.S. DOE's referenced Request for Information, as published in the Federal Register on June 13, 2011.

The Hydraulic Institute requests the opportunity to provide the DOE with such additional information as HI and the pump industry can reasonably provide, noting that the thirty-day response deadline to the June 13, 2011 Request for Information, as published in the Federal Register, was insufficient notice to gather and provide a complete response.

Further, HI requests the opportunity to meet, in person, with representatives of the DOE and their contractors, and national labs (as may be assigned to work on this issue) for the purpose of conveying first-person input into the issues associated with the proposed rule-making. Such a meeting should be established at a mutually convenient location and time during this process, such that pump industry representatives can participate without un-due burden and that adequate additional time is provided to prepare for such a meeting.

The Hydraulic Institute, established in 1917, represents the pump manufacturing industry in North America. We are a recognized authority with regard to pumps and pumping systems and are an ANSI accredited standards developing organization. HI represents a total of 97 members that are pump manufacturers and leading suppliers to the pump industry.

While more detail is provided in this letter, HI has led the pump industry in its approach to energy savings associated with systems optimization, consistent with the strategic goals of the Department of Energy's Energy Efficiency and Renewable Energy and its Industrial Technology Program (ITP) and Superior Energy Performance (SEP) initiatives, focused on energy savings of systems optimization. HI and other leading energy efficiency stake-holders (the U.S. DOE included) helped create the "Pump Systems Matter" organization, the leading 501(c) 3 education/training organization focused on pump systems energy, efficiency and economics.

PSM is a subsidiary of the Hydraulic Institute, and more information can be found at: www.PumpSystemsMatter.org.

In response to the five specific issues (Section B of Public Participation) whereby the DOE seeks information, the Hydraulic Institute offers the following information and comment:

1.) **Definition(s) of pumps, pump product classes, and diversity of pump types within the pump industry:**

The Hydraulic Institute is the nation's recognized authority on the subject of pumps and pumping systems. HI has been writing pump standards since its founding in 1917, and fundamental areas of the Institute's expertise has been pump definitions, nomenclature, and cross-sectional diagrams that are incorporated into HI pump standards that are approved by the American National Standards Institute (ANSI).

ANSI/HI standards are widely referenced by other organizations, commercial, non-profit and government agencies, with such terminology also used by pump end-users, engineering consulting firms, pump manufacturers and distributors, and in guidelines and publications, including those published by the Hydraulic Institute.

More recently HI has re-purposed its pump definitions for evolving use in commercial transactions associated with electronic data exchange (EDE). In this regard, trading partners who are specifying, selecting and purchasing pumping equipment will be able to do so using HI EDE-compliant protocols and definitions, adopted and incorporated into a new HI EDE standard that was published in 2010. More information about the EDE standard, associated XML compliant data sheets, definitions, etc. can be found at: www.Pumps.org/EDE.

HI acknowledges that the "potential definitions" as identified in Section 5 of the June 13, 2011 Request for Information are fundamentally consistent with HI's definitions in published in HI standards. It does appear that the U.S. DOE has adopted HI pump definitions as published by the Hydraulic Institute and, and with the exception of minor editorial changes made in the Federal Register publication, these terms are essentially HI terminology without any technical edits.

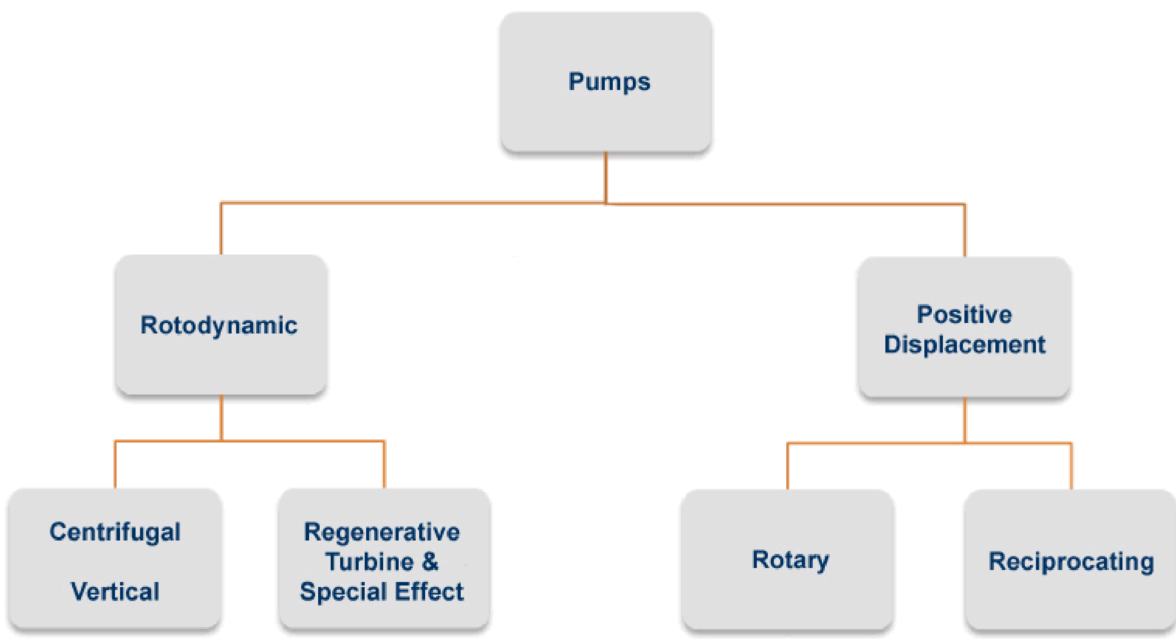
Recommendation: HI recommends that the U.S. DOE, in all future references to pump terms and definitions, use Hydraulic Institute Standards as the authoritative reference. For more information see: www.Pumps.org/Standards

Recommendation: HI recommends that the U.S. DOE, its national labs or contractor organizations, use HI standards as well-established authoritative references. In such instances where DOE has the need for a new definition (should it not be addressed by the Hydraulic Institute) we recommend that DOE consult with HI in this regard. The Institute creates standards and guidelines through a number of technical committees of subject matter experts, including pump and supplier OEMs, engineering consulting firms and others to develop and/or modify existing standards.

The DOE has also requested information on pump product classes and the diversity of products within the pump industry.

The Hydraulic Institute, and its technical committees, have defined a pump taxonomy that is also published and, as required with changes in technology, regularly updated in HI pump standards. HI defines the relationship(s) of pump types in major categories, such as Rotodynamic and Positive Displacement, followed with technology-specific details that are typically associated with the nature and/or construction of the pump.

The types of pump equipment are extensive, by type, function/application, geometry, standard product or custom engineered product. The HI classification system provides a means of organizing the industry's and the end-users understanding of product types.
The following is a high-level overview of the HI-defined pump universe, in a family-tree format:



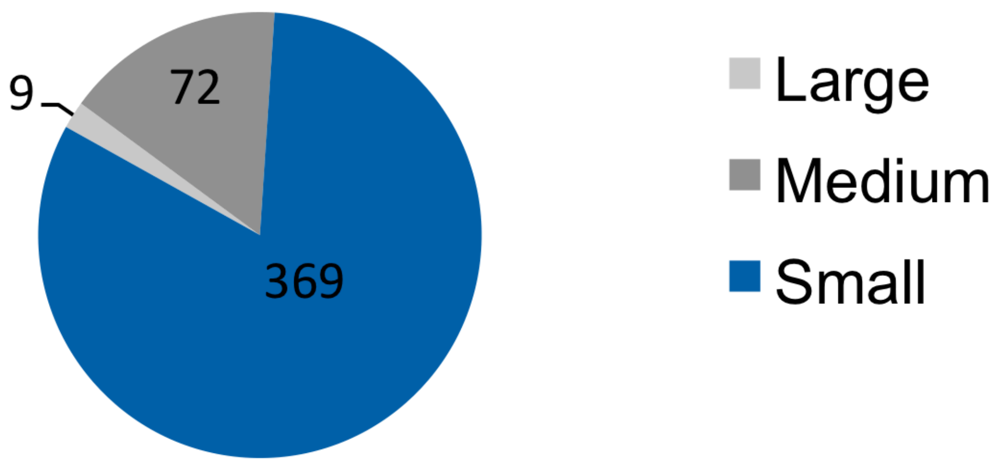
While this view of the "pump universe" may appear to be straightforward, pumps don't traditionally segregate into standard categories or easily definable cells. Understanding pump family trees requires a user to apply individual application/service requirements to understand the proper pump to select, and match it to the specific requirements of the system and the fluid, including viscosity and many other characteristics, to be pumped. Pump efficiency is one of many variables in this complex commercial process.

Further, depending upon an end-users preference(s), there are typically several pump types that will satisfy a particular pumping application. Very sophisticated software selection programs have been created and are commonly used in the industry to specify, configure and select pump equipment. Industry participants know that the variables in pump applications range from 10 to 20 times greater than motor applications, making the complexities of this proposed rule-making very challenging, at best.

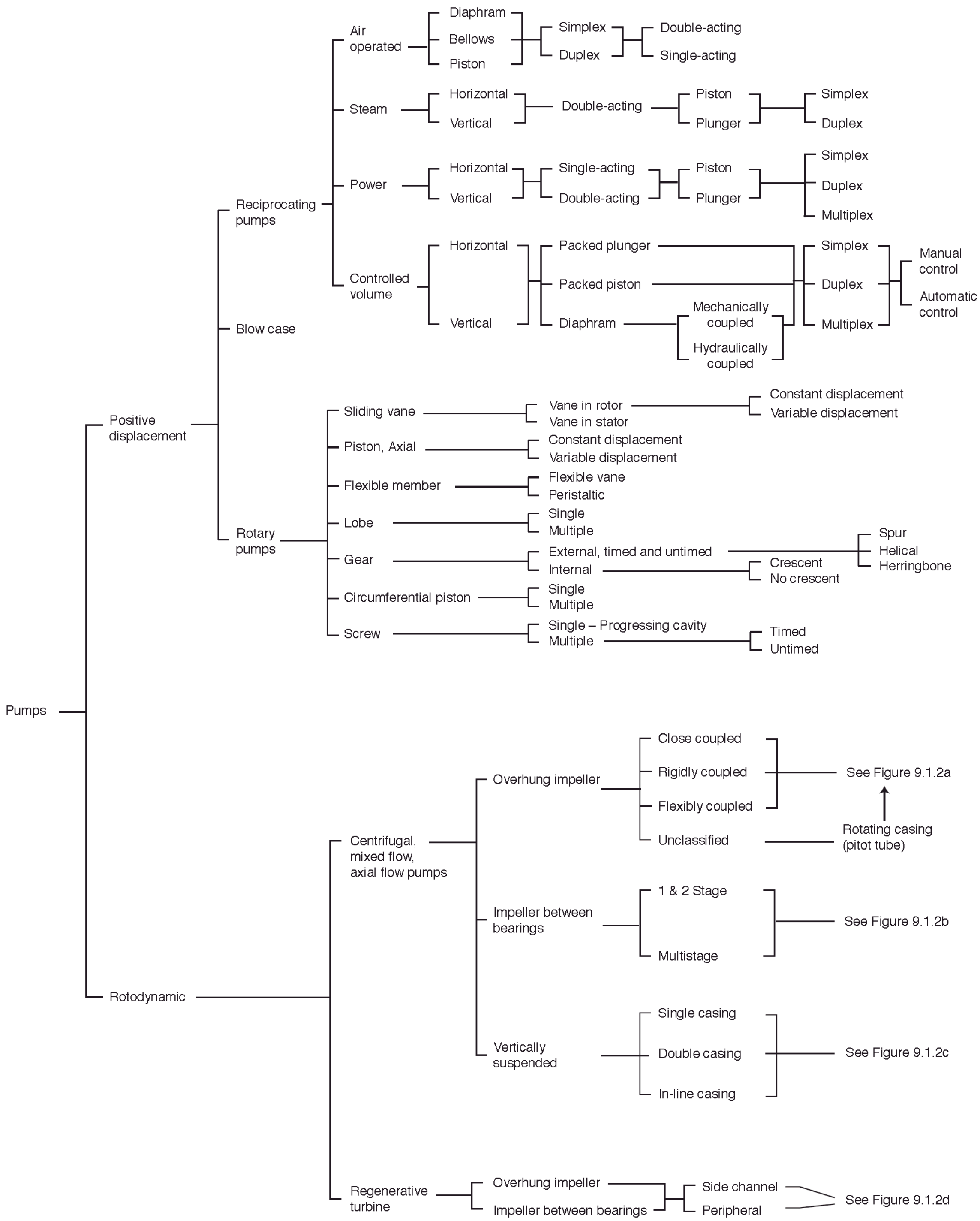
The industry is composed of an estimated 450 pump manufacturers in the United States with an overwhelming majority being small to medium-sized manufacturers.

HI estimates, in that regard, are based on size ranges being defined as: 1.) Large = $1B+; 2.) Medium = $100M - $999M and Small = below $100M.

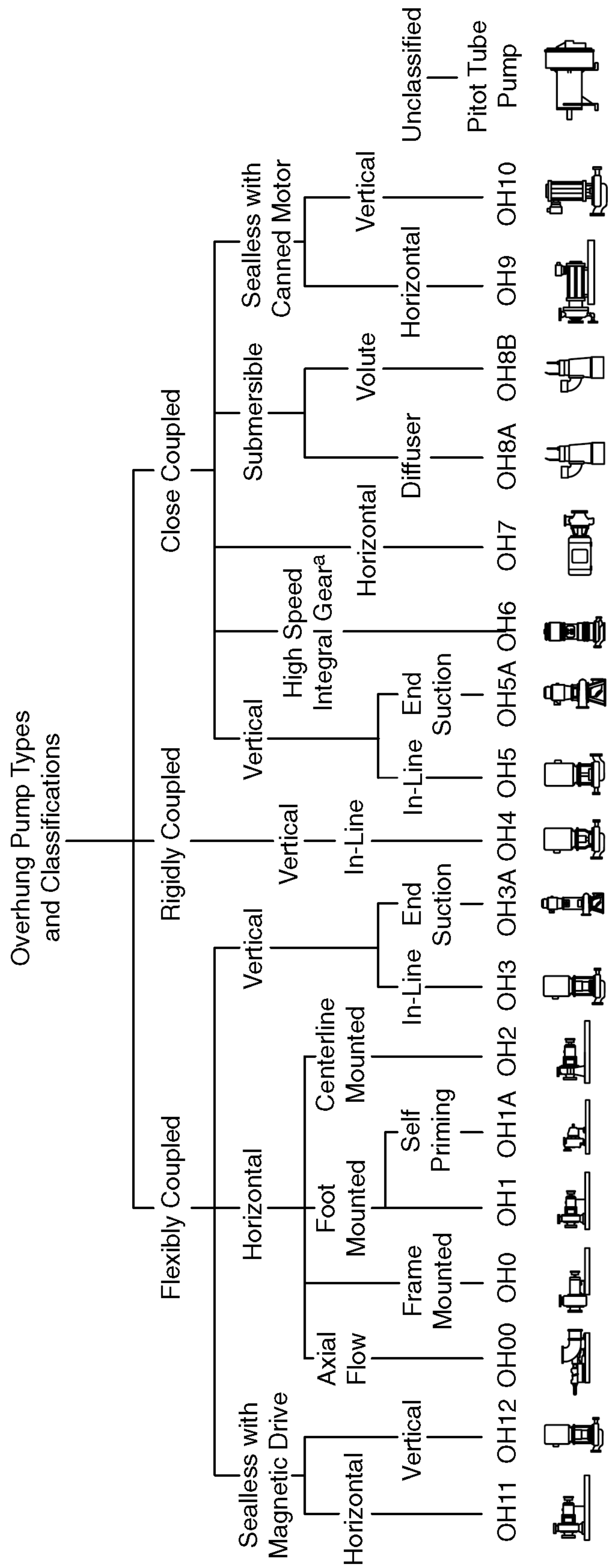
Profile of Pump Manufacturers in the United States
(Based on Hydraulic Institute estimates)



Another view of the complexity of pump types, with greater details of technology-specific functionality, is the following HI pump family tree from ANSI/HI pump standards:



To further, although not fully, illustrate the complexity of the Rotodynamic pump family tree, the following provide additional details:



[a] Refer to Section 1.1.3.1.5 for high-speed integral gear definition.

Figure 9.1.2a — Rotodynamic pump types - overhung

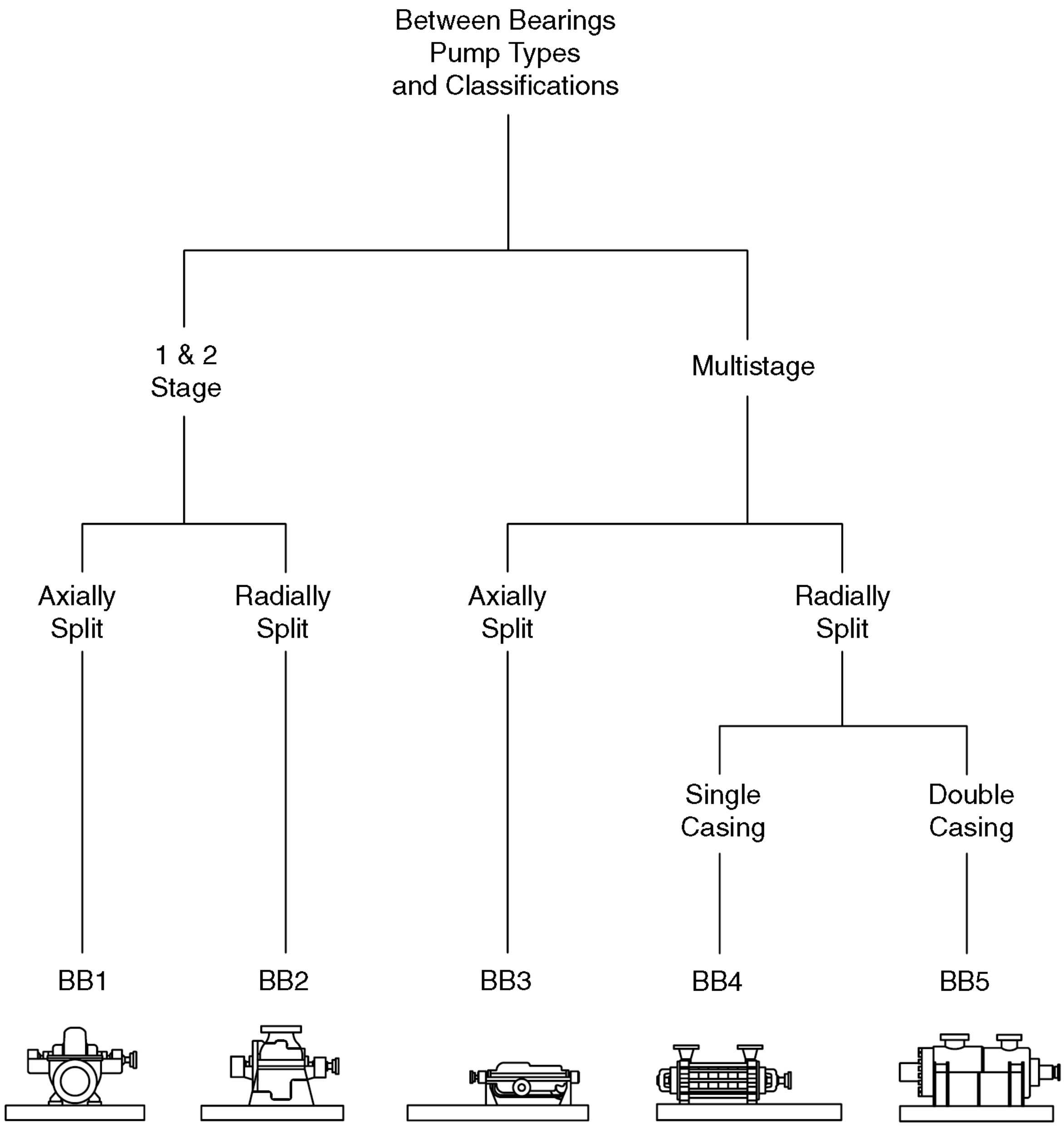


Figure 9.1.2b — Rotodynamic pump types - between bearings

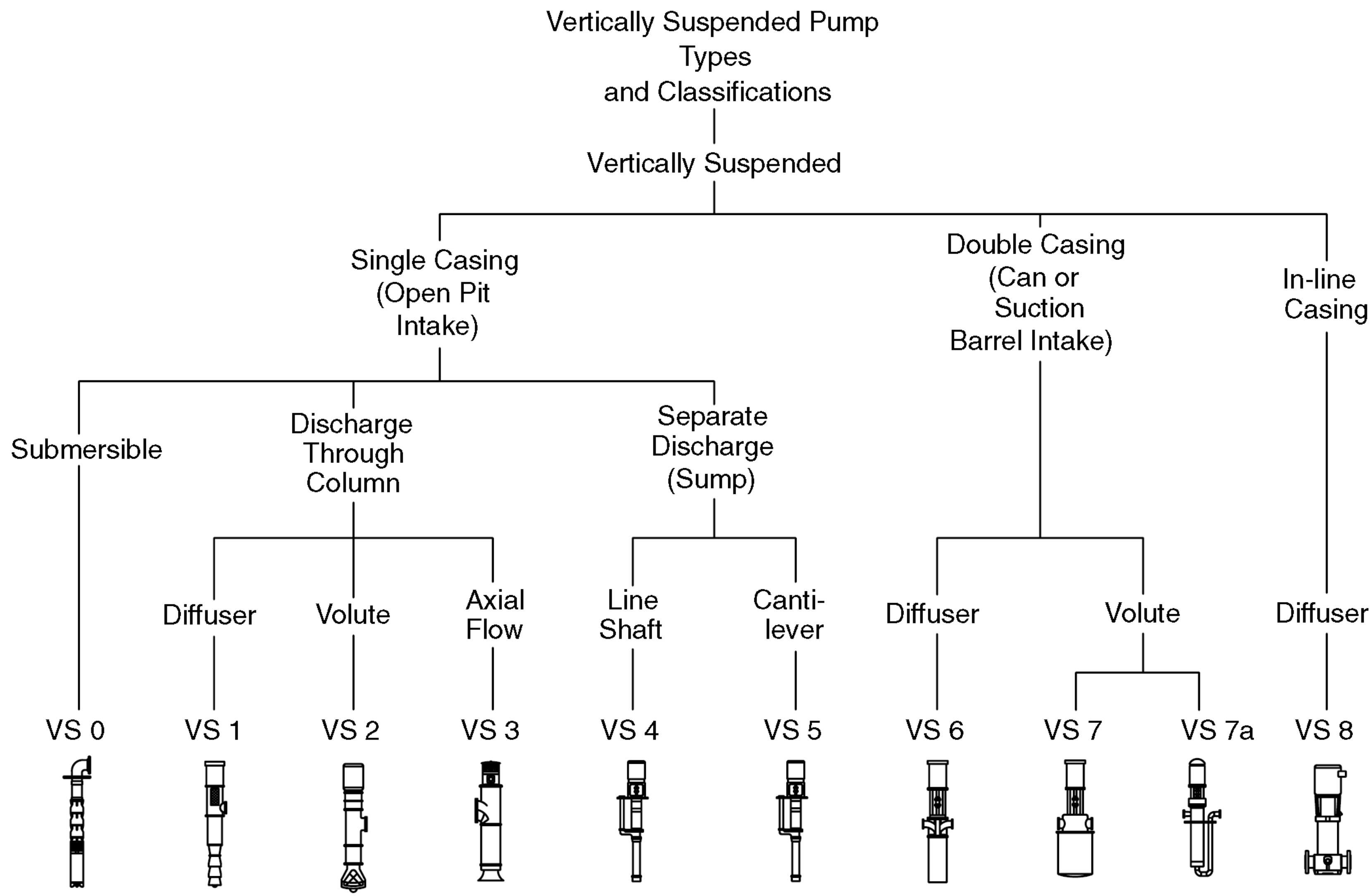


Figure 9.1.2c — Rotodynamic pump types - vertically suspended

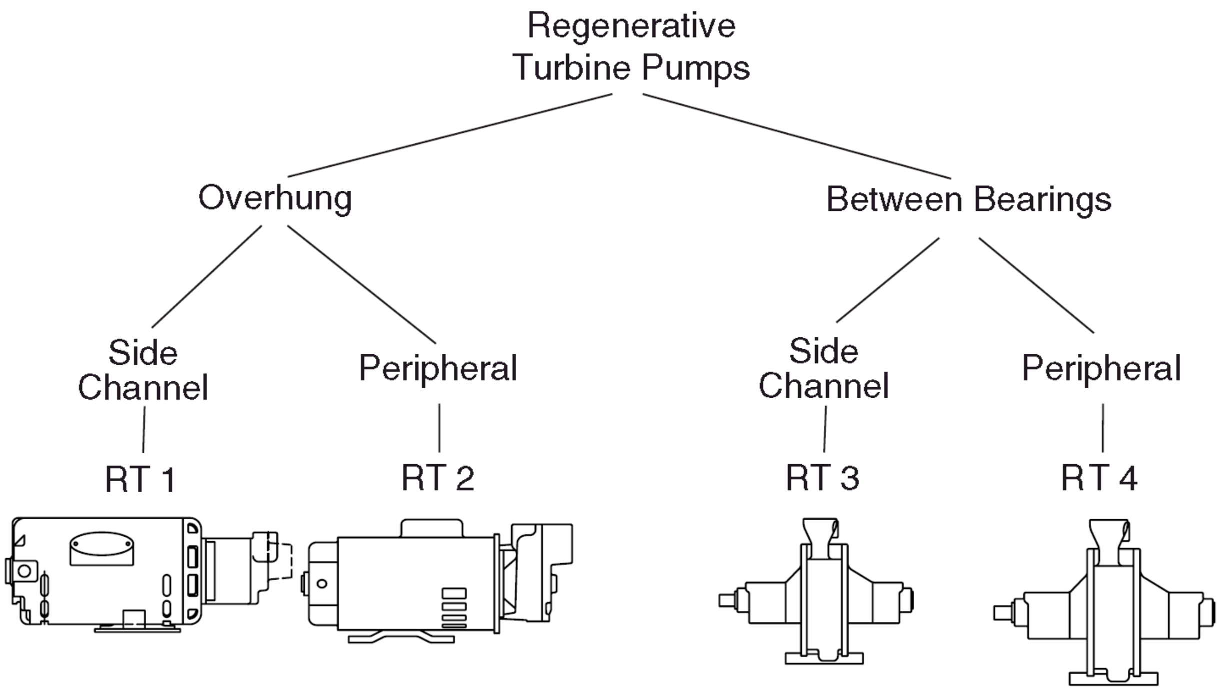


Figure 9.1.2d — Rotodynamic pump types - regenerative turbine

ANSI/HI pump standards, as previously noted, provide a pump family tree for each of major categories of pumps, and these details (including definitions and cross-sectional diagrams) are available in HI pump standards, available at: www.Pumps.org/Standards. These are detailed in the following ANSI/HI pump standards:

- Rotodynamic (Centrifugal) Pumps (ANSI/HI 1.1-1.2)
- Rotodynamic (Vertical) Pumps (ANSI/HI 2.1-2.2)
- Rotary Pumps (ANSI/HI 3.1-3.5)
- Sealless Rotary Pumps (ANSI/HI 4.1-4.6)
- Sealless Rotodynamic Pumps (ANSI/HI 5.1-5.6)
- Reciprocating Pumps (ANSI/HI 6.1-6.5)
- Controlled-Volume Metering Pumps (ANSI/HI 7.1-7.5)
- Direct Acting Pumps (ANSI/HI 8.1-8.5)
- Air-Operated Pumps (ANSI/HI 10.1-10.5)
- General Guidelines (ANSI 9.1-9.5)

In addition to the pump type or product descriptions the Hydraulic Institute Standards listed above provide nomenclature and definitions for pump components which are widely used in the pump industry, and among pump users, distributors, engineering consulting firms, etc.

Further to the issue of establishing definitions, the Hydraulic Institute lead an ISO TC 115 Work Groups 5 to define nomenclature for "Pump Systems." These definitions are now contained in the ISO 17769-2 Standard and are used by HI in its publications and related programs.

2.) **Energy use by pumps as summarized in Table 3.1:**

The Hydraulic Institute notes that there is no "Table 3.1" in the Federal Register as published on June 13, 2011. In that specific regard, therefore, we cannot comment.

While the Hydraulic Institute is aware of various estimates of energy usage made by the U.S. DOE and other organizations, it is not clear that there is any reliable or verifiable data on energy use by pumps because of the significant impact of system variables in the way pumps are used and the significant variables associated with systems loads and demands in the use of pumps.

Even a U.S. DOE commissioned report, prepared by Argonne National Laboratory, under Contract Number W-31-109-ENG38, published in 1980, stated "*Only a small fraction of pumps operate under steady or easily predictable head and flow conditions. Most pumps in industrial applications must accommodate varying conditions. Hence a pump of maximum efficiency under a set of nominal operating conditions will operate at lower efficiencies as requirements change*."

The Hydraulic Institute is very concerned with the acceptance of any energy savings data summarized by ignoring the impact of application variables and the interaction of system components. The integration of pump system components, and duty cycles of each application, has a dramatic effect on the resulting energy use. Overall efficiency delivered by the pumping system may vary by 30% points or more. It is unreasonable to make assumptions that in any way ignores or attempt to smooth this variation. This process cannot provide meaningful data that would be acceptable to estimate the value of establishing a stand-alone efficiency standard covering commercial and industrial pumps.

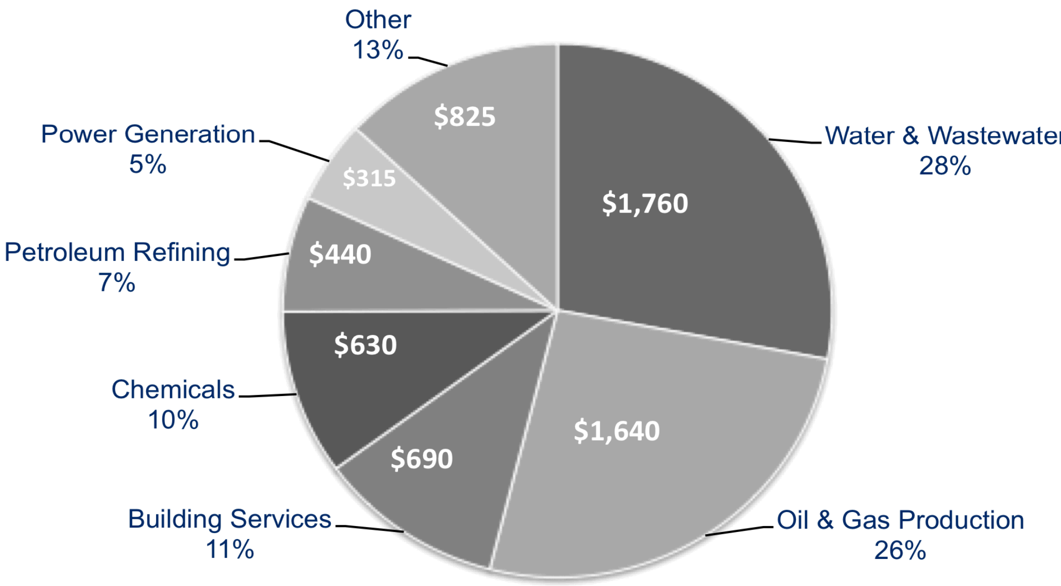
Development of standards must rely on sound technical evaluation and acknowledge the effects of system integration which do not have linear relationships and are not scalable. If standards are limited to individual components, without addressing the application and component integration effect, the regulation cannot be quantified and the necessary economic justification requirement will not be met by DOE.

The Hydraulic Institute has no independent data available on this subject, and at this time is not able to comment further in this regard.

3.) **Overview of the industrial and commercial pump market, including shipments and efficiency ranges:**

Based on industry estimates, as well as published reports (such as the World Pump Outlook Report by EIF), which is made available through the Hydraulic Institute, the U.S. market for pumps is estimated at $6.3B in annual sales, of which member companies of HI represent 70-80% of this total. Estimated market share(s) follow, associated with the leading end-use markets:

U.S. Market Sales ($ Million)



HI also notes that the DOE RFI does not make mention of the significant water/wastewater markets in the United States. There are well-documented opportunities associated with improving pumping systems operations in these markets by many different organizations, including AWWA, ASE, CEE, WEF, WRF and others.

It is estimated that 3-4% of electricity in the United States is consumed by the water and wastewater industry (*Raucher, R. S.; Cromwell III, J.E.; Cooney, K.; Thompson, P.; Sulluvan, L.; Carrico, B.; MacPhee, M.; and Wilkinson, R., 2008. Risk and Benefits of Energy Management for Drinking Water Utilities. AWWA Research Foundation, Denver).* Energy savings potential in water and wastewater utilities has been estimated to be 31 billion kWh. (*CEC (2005) California's Water-Energy Relationship. CEC-700-20050-011-SF. www.energy.ca.gov/2005publications/CEC-700-2005-011/ CEC-700-20050-011-SF.pdf*)

Several U.S. Government statistical sources provide data on pump manufacturing and shipments in the United States.

Pump manufacturing is classified in the North American Industry Classification System (NAICS) under the following headings:

- 333911 "Pumps and Pumping Equipment Manufacturing"
- 333912 "Air and Gas Compressor Manufacturing"
- 333913 "Measuring and Dispensing Pump Manufacturing"
- 333996 "Fluid Power Pump and Motor Manufacturing"

Pump shipment data is collected and published by the U.S. Department of Commerce, Bureau of Census in the Current Industrial Report, MA333P - *Pumps and Compressors,* found at: www.census.gov/manufacturing/cir/historical_data/ma333p/index.html

Additional data can be found in the Current Industrial Report, MA333N report - *Fluid Power Products for Motion Control (Including Aerospace)."* Details are found at: *www.census.gov/manufacturing/cir/historical_data/ma333n/index.html*

U.S. international trade data on pumps in classified in chapter 84 of the Harmonized Tariff Schedule (HTS) of the United States, under the following four-digit headings:

- 8413 – "Pumps for liquids, whether or not fitted with a measuring device; liquid elevators; parts thereof"
- 8414 – "Air or vacuum pumps; air or other gas compressors or fans; ventilating or recycling hoods incorporating a fan, whether or not fitted with filters; parts thereof"

The HTS is maintained by the U.S. International Trade Commission: www.usitc.gov

Centrifugal pumps, also known as Rotodynamic pumps, are the most common type of industrial pumps. Industry estimates suggest that the majority of commercial/industrial pumps are centrifugal pumps.

Positive displacement (PD) pumps may be found almost anywhere and everywhere but it is a generally accepted view is that over 90% go into applications within these top six market segments:

- Oil and Gas;
- Water and Wastewater Treatment;
- Chemical;
- Food, Beverage and Pharmaceutical.
- Power; and,
- General Industrial (Marine / Medical / OEM).

Rotodynamic pumps have much greater flow rate capability than PD pumps. Within their operating envelope their efficiencies are best in the moderate to high flow range. Extremely high pressures can be achieved by multi-staging several impellers, each increasing the pressure of fluid being pumped. Rotodynamic pumps are capable of handling solids and abrasives and, in special designs, pump large diameter solids.

Hydraulic Institute Guideline, HI 20.3, Rotodynamic (Centrifugal and Vertical) Pump Efficiency Prediction, by pump type, flow and specific speed addresses this issue. The standard is available at: www.Pumps.org/Standards.

This guideline was developed to help pump users predict *normally attainable* efficiency levels at the Best Efficiency Point (BEP) for selected types of Rotodynamic pumps when the rate of flow, total head per stage, net positive suction head available (NPSHA), and the service conditions are known. The following types of pumps are addressed in the standard:

- Slurry, end suction
- Solids-handling, end suction pumps
- Submersible sewage, end suction
- Paper stock, end suction
- Horizontal multistage, axial split, segmented ring diffuser barrel
- ASME B73, API end suction, end suction – small
- End suction – large (greater than 0.3 m3/s (5000 gpm)
- API double suction
- Double suction, general service
- Vertical turbine, mixed-flow and propeller, single and multistage diffuser type

HI pump efficiency prediction charts have been incorporated into the U.S. DOE's Pump Systems Assessment Tool (PSAT), as algorithms, and this tool serves as the basis of training programs that the DOE has developed for pump systems assessments and will continue to serve as a basis of training/certifying professionals to do pump systems audits per ANSI/ASME EA-2-2009, Energy Assessment of Pumping Systems. DOE's EERE, and Industrial Technology Program, clearly recognize the benefits of systems optimization to achieve energy savings.

HI notes that the U.S. DOE has referenced, in its RFI, a "*European Guide to Pump Efficiency for Single Stage Centrifugal Pumps*." Most likely this is the same guide, created by Europump in working with a technical university, which was created to describe maximum attainable *theoretical* pump efficiency for this single type of pump. It is important to note that this is simply one type of pump, among hundreds of pump types, and the efficiency predication modeling was mathematically derived and is *theoretical*.

It is useful, therefore, to understand the complexities associated with pump efficiency, and the many factors that are associated its attainment. A brief discussion follows from ANSI/HI Standard 1.6, Rotodynamic Pump Tests:

1.6.3.13 Power (P)

1.6.3.13.1 Pump input power (P_p)

The power delivered by the driver to the pump input shaft. It is also called brake horsepower.

1.6.3.13.2 Electric driver input power (P_{mot})

The electrical input to the driver expressed in kilowatts (horsepower).

1.6.3.13.3 Pump output power (P_w)

The power imparted to the liquid by the pump. It is also called water horsepower.

(Metric) $$P_w = \frac{Q \times H \times s}{367}$$

(US units) $$P_w = \frac{Q \times H \times s}{3960}$$

1.6.3.13.4 Pump efficiency (η_p)

The ratio of the pump output power (P_w) to the pump input power (P_p); that is, the ratio of the liquid horse-power to the brake horsepower expressed in percent:

$$\eta_p = \frac{P_w}{P_p} \times 100$$

1.6.3.13.5 Overall efficiency (η_{OA})

The ratio of the pump output power (P_w) to the energy supplied to the driver (P_{mot}) expressed in percent. This efficiency takes into account losses in both the pump and the driver:

$$\eta_{OA} = \frac{P_w}{P_{mot}} \times 100$$

- Parameters that influence efficiency include:
  - Pump type and size
  - Type of service (e.g., liquid)
  - Quality of hydraulic design (hydraulic efficiency)
  - Mechanical design aspects, running clearances and tolerances
  - Casting quality
  - Surface finish
  - Material selection (surface degradation in service)

The pump industry uses advanced techniques to attain maximum hydraulic efficiency, often employing sophisticated software tools to design/model pump performance and attain best production quality in the manufacturing process. It is generally understood that pumps are inherently highly efficiency machines and if properly selected, operated and maintained they achieve their best efficient at their inherent Best Efficiency Point (BEP), when properly matched to the system requirements. Those who purchase pumps specify a number of criteria to be met by pump manufacturers, which are detailed in bid packages, pump specifications and related procurement practices, including commercial contracts, including pump efficiency. How a pump is eventually operated becomes the most critical issue to obtaining and maintaining its best efficiency, and energy savings potential. These are systems issues first and foremost.

We will discuss, in our response to question number four (4), how pumps are typically tested – including for efficiency – and what ANSI/HI standards are used in this process.

Pump performance losses, as a matter of record, are also based on a number of very complicated and inter-related factors which HI is willing to discuss further with DOE, such as:

- Part load operation: Power dissipated by recirculation
- Hydraulic losses
    - Mechanical design
    - Quality of hydraulic design
    - Casting quality
    - Quality of surface finish
    - Material selection (corrosion)
    - Mechanical losses
        - Bearings
        - Seals and Lips
        - Seals, mechanical
        - Packing
- Leakage losses
    - Mechanical design
    - Clearances
    - Wear ring material selection
    - Wear during service
    - Axial thrust balancing device
- Disk friction
    - Mechanical design
    - Casting quality
    - Quality of surface finish
    - Material selection (corrosion)

Pump performance is substantially impacted by the system in which pumps are used, how a pump is maintained, operator decisions, systems variables, type or nature and efficiency of the driver and other significant external factors.

In summary, regarding the issue of pump efficiency:

- Pumps are highly efficient in converting energy into flow and head (pressure)

- Pump design is a highly evolved technology, using state of the art computer simulation, Computational Fluid Dynamics (CFD) to achieve optimum performance
- Relatively small, but costly gains can be made with surface finish improvement and reduction of running clearances
- Proper selection, sizing and system design is where targeted energy reduction can be realized
- HI and Pump Systems Matter have been leaders in the area of educating the marketplace on pump systems efficiency and energy savings opportunities, and expanding this effort with proper support of the U.S. DOE would significantly leverage our collective success in achieving EERE's and SEP's goals of reducing energy intensity in industry by 25% over ten years.

Again, as a key reference, the U.S. DOE commissioned a report, prepared by Argonne National Laboratory, under Contract Number W-31-109-ENG38, which was published in 1980 and the recommendations remain instructive and directionally viable today as they were 31 years ago. In this regard the report said:

"*System inefficiencies appear to dominate the overall loss picture, as opposed to the intrinsic inefficiency of the pump itself, because:*

(1) End-users consistently select over-sized pumps and motors largely because (a.) calculating/estimating flow and head requirements is often difficult and uncertain as a result, for example, of having to estimate pipe corrosion and increased resistance to flow over time; and (b) there are essentially no penalties for selecting an oversized unit but severe penalties associated with under-sizing, namely complete failures.

(2) Most pumps cannot operate efficiently off their full-load design point, and excess power must be wasted in throttling valves or in bypassing flow."

These statements are as true today as they were in 1980, as the physics of pumping has not changed. The largest opportunities for energy efficiency gains remain in the system – not in the pump.

The Hydraulic Institute and Pump Systems Matter have been advocating for, and to whatever extent possible, working with the DOE Energy Efficiency and Renewable Energy (EERE) program and the Industrial Technology Program (ITP), to address pumping systems optimization issues. Historically, HI has been a Charter Sponsor of the DOE's Motor Challenge program, an Allied Partner with DOE and more recently has applied to become an ALLY with the DOE's Superior Energy Performance (SEP) program. HI and Pump Systems Matter continue to explore ways to collaborate and work with the U.S. DOE and reiterate our interest in doing so – to help achieve our common goals. We stand ready to be a strong corporate partner in that regard.

It is with systems improvement where very significant energy efficiency and energy savings improvements, of 20% - 40% or more, can be achieved. HI and PSM are willing to meet with DOE to explore this issue further, as a collaborative approach offers much to be gained by the nation, pump end-users, electric power utilities, energy efficiency NGOs and all other interested parties. This matter will be described further in our response to question number five (5).

4.) Availability and applicability of U.S. and international test procedures for pumps:

HI has an acknowledged U.S. leadership role in writing and publishing ANSI-approved pump test standards which includes the following widely-accepted standards currently available to pump end-users, OEMs, EC firms and other interested parties:

- Centrifugal Pump Tests: ANSI/HI 1.6
- Vertical Pump Tests: ANSI/HI 2.6
- Rotary Pump Tests: ANSI/HI 3.6
- Sealless Rotary Pump Tests: ANSI/HI 4.6
- Sealless Centrifugal Pump Tests: ANSI/HI 5.6
- Reciprocating Pump Tests: ANSI/HI 6.6
- Controlled Volume Metering Pump Tests: ANSI/HI 7.6 (pending review and publication)
- Air Operated Pump Tests: ANSI/HI 10.6
- Submersible Pump Tests: ANSI/HI 11.6
- Centrifugal Slurry Pump Tests: ANSI/HI 12.6
- Rotodynamic Pumps for Hydraulic Performance Acceptance Tests, ANSI/HI 14.6 (pending publication in 4Q 2011, to replace ANSI/HI 1.6 and 2.6)

HI test standards are widely referenced by other organizations, for a variety of pump types and markets, including: API, ASME B.73, AWWA, the Process Industry Practices (P.I.P.) organization and broadly accepted for inclusion within specifications developed by North American consulting engineering firms for their commercial and industrial building projects. HI is an ANSI accredited standards developer, accredited in 1986, with a scope defined as: "*Standards in regard to centrifugal, vertical, reciprocating, and rotary pumps*"

A summary of ANSI/HI test standards, with their scope and coverage, follows:

A.) ANSI/HI 1.6 - Centrifugal Pump Tests: This standard outlines tests to be performed on centrifugal pumps with clear water. It is intended to provide uniform procedures for hydrostatic, hydraulic, and mechanical performance testing and test result recording. The main test is the performance test, including power measurement and efficiency determination. The list of tests included in this standard is provided below.

- Hydrostatic test demonstrating that the pump will not leak or fail structurally when subjected to hydrostatic pressures
- Performance test shows the pump's hydraulic and mechanical integrity. This test outlines two acceptance levels, marked as 'A' and 'B', based on quantitative values. 'A' is reserved for pumps designed for specific conditions of service, while 'B' is applied to pumps that are mass produced for stock
- Net positive suction head required (NPSHR) test determines the NPSH characteristic of the pump

- Mechanical test demonstrates the satisfactory mechanical operation of a pump, at the rated conditions, including: vibration levels; lack of leakage from shaft seals, gaskets, and lubricated areas; and free running operation of rotating parts
- Priming time test is only performed on pumps designed for self priming. This test shows the time it takes for the pump to self prime

B.) ANSI/HI 2.6 - Vertical Pump Tests: This standard outlines tests to be performed on vertical diffuser type centrifugal pumps with clear water. It is intended to provide uniform procedures for hydrostatic, hydraulic, and mechanical performance testing and test result recording. . The main test is the performance test, including power measurement and efficiency determination. The list of tests included in this standard is provided below:

- Hydrostatic test demonstrating that the pump will not leak or fail structurally when subjected to hydrostatic pressures
- Performance test shows the pump's hydraulic and mechanical integrity. This test is completed at a specified condition point only, not the entire performance curve. Acceptance levels require the pump to operate at or within the tolerance above the pump's ratings for the rate of flow and rpm
- Net positive suction head required (NPSHR) test determines the NPSH characteristic of the pump
- Mechanical test demonstrates the satisfactory mechanical operation of a pump, at the rated conditions, including: vibration levels; lack of leakage from shaft seals, gaskets, and lubricated areas; and free running operation of rotating parts

C.) ANSI/HI 3.6 - Rotary Pump Tests: There are 4 types of performance tests outlined in this standard. Tests 3 and 4 each have two acceptance levels. Level 'A' is the normal acceptance level, which applies unless the purchaser specifies level 'B':

1. Internal quality-assurance test
2. RPM; pressure; power
3. RPM; pressure; rate of flow
4. RPM; pressure; rate of flow; power

The pump efficiency is determined from the ratio of the pump output power (P_w) to the pump input power (P_p) and reported as a percent.

The following tests are also described in this standard, but are marked as optional:

- Hydrostatic test demonstrating that the pump will not leak or fail structurally when subjected to hydrostatic pressures. For purposes of this requirement, the containment of liquid means only prevention of its escape through the external surfaces of the pump, normally to atmosphere
- Net positive inlet pressure required (NPIPR) test determines the NPIPR, above liquid vapor pressure (bubble point), to fill each pumping chamber or cavity while open to the inlet chamber

D.) ANSI/HI 4.6 - Sealless Rotary Pump Tests: ANSI/HI 3.6 *Rotary Pump Tests* outlines the basic requirements and detailed testing recommendations for Sealless Rotary Pump tests. 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**.** ANSI/HI 4.6 outlines a test procedure designed to ensure a sealless rotary pump assembly (or a sealless rotary pump with secondary containment) has basic integrity when subject to internal pressure.

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

E.) ANSI/HI 5.6 - Sealless Rotodynamic Pump Tests: This standard applies to tests of the pump and magnetic coupling (magnetic drive pumps), or pump and motor unit (canned motor pumps). The Rotodynamic (Centrifugal) Pump Test Standards (ANSI/HI 1.6 and 14.6) are applicable to sealless Rotodynamic pumps, except for the tests listed below, which are unique to sealless pumps:

- Hermetic integrity test demonstrates that a sealless pump assembly does not leak when subjected to internal pressure. This test is usually a low-pressure gas (air) test and done after final assembly.
- Motor winding integrity test (canned motor pumps) verifies the integrity of the motor windings during manufacturing, and checks the integrity once the motor is installed in the field. This test is typically conducted by the manufacturer during the manufacture of the motor, or by the user if a motor is suspected of having a problem
- Secondary containment test verifies integrity of the secondary containment shell, welds, and electrical lead through connections at maximum working pressure. The pump user will consider specifying a secondary containment test, if it is absolutely critical to contain the process fluid in the event of a primary containment failure. This test would be specified in addition to a hydrostatic test of the primary containment shell (ANSI/HI 1.6 and 14.6)
- Motor winding temperature rise test (canned motor pumps). Verifies that motor windings do not exceed the maximum insulation temperature at design motor load and design motor liquid cooling temperature

F.) ANSI/HI 6.6 - Reciprocating Pump Tests: This standard outlines tests to be performed on reciprocating power pumps, including controlled volume metering pumps, which are driven by power from an outside source applied to the crankshaft. It includes procedures for testing such pumps. It is intended to provide uniform procedures for hydrostatic, hydraulic, and mechanical performance testing and test result recording.

The tests included in this standard are listed below. The main test is the performance test, which includes measurement of rate of flow, pressure, and input power and determination of pump efficiency. Other tests include the following:

- Hydrostatic test demonstrating that the pump will not leak or fail structurally when subjected to hydrostatic pressures. For the purpose of this requirement, “will not leak” means only prevention of escape of liquid through the external surfaces of the pump, normally to atmosphere.

- Net positive suction head required (NPSHR) test determines the NPSH characteristics of the pump

G.) ANSI/HI 10.6 - Air Operated Pump Tests: This standard outlines tests to be performed on air-operated diaphragms and bellows pumps only. The tests included in this standard are listed below. The main test is the mechanical integrity test, with the other tests being marked as optional:

- Mechanical integrity tests are performed at the manufacturer's specified operating conditions. The pump is monitored for abnormal noise, vibration, leakage, and proper valve operation. Test acceptance is based on visual and physical inspection to ensure that the pump meets the manufacturer's requirements.
- Performance tests measure discharge pressure, rate of flow (capacity), and air consumption. This test is to establish conformance with the manufacturer's published performance criteria.
- Net positive suction head required (NPSHR) test determines the NPSH/NPIP characteristic of the pump
- Suction lift tests are performed both on both dry and wet systems. They are the most accurate way to represent self-priming conditions in the field:
    - Dry suction lift: With the pump in an unprimed (dry) condition, the dry suction lift is defined as the vertical elevation in meters (feet) of water that can be lifted by the pump
    - Wet suction lift: With the pump and suction piping full of fluid, the wet suction lift is defined as the vertical elevation in meters (feet) of water that can be lifted by the pump
- Hydrostatic test demonstrating that the pump will not leak or fail structurally when subjected to liquid pressure. For the purpose of this requirement, the words "will not leak," mean only prevention of escape of liquid through the external surfaces of the pump, typically to atmosphere.
- Noise measurement tests test one of the following established sound pressure or sound power standards:
    - ANSI S 1.13 Measurement of Sound Pressure Levels in Air Pumps General Guidelines for Types, Definitions, Applications, Sound Measurement and Decontamination
    - ANSI/HI 9.1–9.5 Pumps - General Guidelines for Types, Definitions, Application, Sound Measurement and Decontamination
    - Other standards as agreed to by manufacturer and customer

H.) ANSI/HI 11.6 - Submersible Pump Test: This standard outlines tests to be performed on centrifugal submersible pumps driven by induction motors, unless stated otherwise. A centrifugal submersible pump is defined as a close-coupled impeller pump/motor unit designed to operate submerged in liquid. This definition includes submersible pumps operating in either a wet-pit or dry pit environment.

The tests included in this standard are listed below. This standard is being revised and is currently in the approval process. One of the notable updates is a wire-to-water efficiency test such that motor performance will be included in the package performance test. The main test is the performance test, with the other tests being marked as optional:

- Performance tests verify the hydraulic, electrical, and mechanical operation of a submersible pump relative to a specified condition point. The performance test serves three purposes:
  1. Document the hydraulic performance of the pump.
  2. Verify the electrical characteristics of the submersible motor during the performance test.
  3. Ensure the mechanical integrity of the pump while being tested.
- Hydrostatic test demonstrating that the hydraulic end, when connected to the motor, will not leak or fail structurally when subjected to hydrostatic pressures
- Net positive suction head required (NPSHR) test determines the NPSH characteristic of the pump
- Submersible motor integrity tests are designed to verify the sealing and electrical integrity of a submersible motor
- Vibration tests provide acceptance criteria for OEM factory vibration testing of submersible pumps

I.) ANSI/HI 12.6 - Rotodynamic (Centrifugal) Slurry Pump Test: This standard outlines tests to be performed on centrifugal slurry pumps while operating and pumping slurry. These tests should all be done in conjunction with ANSI/HI 1.6 (to be superseded by ANSI/HI 14.6).

The performance test of Section 12.6.1.2 is normally sufficient to ensure satisfactory operation on-site. Rarely, a very extreme application may fall outside the normal range of experience where there is no guidance for determining the equivalent clear-water rating. Excess power (larger driver) is normally provided in such cases and speed or impeller diameter changes are made in the field to obtain the needed performance. If this is not possible, a facility test on the actual slurry to be handled is sometimes considered. Slurry tests may not be practical depending on available facilities and the actual slurry to be handled. Slurry tests are expensive, therefore, should only be considered for extremely critical services where there is no other alternative.

J.) ANSI/HI 14.6 - Rotodynamic Pumps for Hydraulic Performance Acceptance Tests: *(Expected 4th Quarter 2011, replaces ANSI/HI 1.6 and ANSI/HI 2.6)*: This standard outlines tests that are applicable to Rotodynamic pumps (centrifugal, mixed flow, and axial flow pumps) that operate with any liquid behaving as clear water. It includes three grades of accuracy of measurement: grade 1 for higher accuracy, and grades 2 and 3 for lower accuracy.

ANSI/HI Standard 14.6 is intended to be used for pump acceptance testing at pump test facilities, such as manufacturers' pump test facilities or laboratories only. Industry experience shows that it is very difficult to perform measurements accurate enough to satisfy the acceptance requirements in this standard when testing is performed in the field.

The tests included in this standard are listed below. The main test is the performance test, with the other tests being marked as informative:

- Hydrostatic test demonstrating that the pump will not leak or fail structurally when subjected to hydrostatic pressures
- Performance test shows the pump's hydraulic and mechanical integrity. This standard outlines grades 1, 2, and 3 for pump acceptance criteria, which are subdivided into 6 acceptance grades, with Grade 1E aimed specifically at energy efficient products. Some of these grades allow for negative tolerance (bilateral), while others do not (unilateral).
- Mechanical test demonstrates the satisfactory mechanical operation of a pump, at the rated conditions, including: vibration levels; lack of leakage from shaft seals, gaskets, and lubricated areas; and free running operation of rotating parts

HI has an acknowledged international leadership role in writing/approving ISO pump standards through ISO/TC 115, with support/consent of the U.S. Technical Advisory Group (TAG) which HI administers on behalf of ANSI for the United States. HI holds the Secretariat role in ISO/TC 115 SC3 (Pumps – Installation and Special Application), and is a voting member of SC1 (Dimensions and Technical Specifications), SC2 (Methods of Measurement) and TC115 WG 7 (Pump system energy assessment).

HI has been working through the International Pump Industry Standardization Committee (IPSC), jointly with Europump (representing 18 national pump associations in 15 EU member states, plus Turkey, Russia, and Switzerland) and ISO/TC 115 WG2 to create a significantly updated global test standard, ISO 9906. This extensively updated standard incorporates and integrates both HI's test standards and the previous version of ISO 9906. After eight years of effort working with these organizations we anticipate that this updated standard will soon complete the approval process and be released for publication.

As noted above, HI will publish, by 4Q 2011, a new test standard for centrifugal pumps, ANSI/HI 14.6, that will be harmonized to the fullest extent possible, with ISO 9906 and provide pump end-users, OEMs, EC firms and other interested parties with a common global test standard – a significant effort by the members of HI and Europump to accomplish this goal.

In a decade long effort long activity within ISO TC 115, the Hydraulic Institute was a leader in global normalization of the Rotodynamic Test Standard ISO 9906. This effort is in the final stage of approval and ISO 9906 is in alignment on all key elements with ANSI/HI 14.6.

The Hydraulic Institute will begin, in the 4Q 2011, a series of education webinars for pump users, EC firms, pump and supplier OEMs and other interested parties:

i) on the new features of ANSI/HI 14.6 vs. ANSI/HI 1.6 and 2.6, which it will replace, in the 4Q 2011, and

ii) a series of market-specific educational webinars associated with the forthcoming ANSI/HI 14.6 in the 1Q 2012, or earlier.

While HI recognizes that there may be several areas associated with its test standards, such as "*rating requirements*," and "*conformance conditions*" identified that have not historically been addressed by HI, the Institute (given the DOE's Request for Information on pump efficiency rule-making) is willing to discuss the development of such procedures with DOE and amongst its members, the HI Standards Committee and the HI Board of Directors. Should HI, the energy efficiency community and DOE agreed to proceed, it will do so with the large community of pump OEMs, motor, seal and other manufacturers associated with the Hydraulic Institute.

In that regard, HI has already agreed to meet with members of the energy efficiency community, as interested parties and stakeholders, to explore common issues of concern regarding pump and pumping systems efficiency. HI, consistent with our historic role in representing the pump industry – and particularly pump test standards – welcomes the opportunity to explore revisions and modifications to HI test standards to maintain and enhance HI's acknowledged pump test standard leadership role.

Several concerns with a DOE pump efficiency rule-making is the availability of non-U.S. pumps imported as finished goods and as components within a system. HI has many concerns about how enforcement of any pump efficiency rules will adversely impact U.S. manufacturing jobs. Should HI members be regulated to a new standard that is not properly enforced, including on all imported products and systems, any new regulation will have a potential adverse impact on the pump industry and ultimately U.S. citizens. Further, the majority of pump OEMs in the U.S. are small to medium-size manufacturers and HI is concerned about the adverse impact of any new regulations on "small businesses."

5.) Assistance and resources available from stakeholders, states, local jurisdictions, and others

The Hydraulic Institute, and its nearly 100 member organization and associated energy efficiency NGOs and utilities are willing to work together to explore options associated with this issue and make specific additional recommendations to the U.S. DOE. The Institute anticipates meeting with representatives of the energy efficiency community in this regard, and finding common ground, will likely make a joint proposal to the DOE.

The Pump Systems Matter (www.PumpSystemsMatter.org) educational foundation and market transformation initiative, supported by HI and interested electric power utilities and energy efficiency NGOs, has the following stated Vision and Mission:

Vision: Assist North American pump users to gain a more competitive business advantage through strategic, broad-based energy management and pump system optimization.

Mission: Provide the marketplace with tools and collaborative opportunities, including energy efficiency education and training, to integrate pump system optimization and efficient energy practices into normal business operations.

HI and Pump Systems Matter have also developed an extensive number of invaluable educational resources for end-users to better understand pumps and pumping systems. A summary of these resources follows:

Resource	Description
American National Standards Institute (ANSI) / HI Pump Standards	Define the voluntary HI standards and designed to eliminate misunderstandings between the manufacturer, purchaser, and user.
Pump Systems Optimization Guide	Summarizes information on all aspects of pumping systems optimization, energy saving, and performance improvement.
Pumping Systems Optimization Course	This hands-on one-day course will help teams focus on pump systems optimization with a particular emphasis on energy savings and pump audits.
American Society for Mechanical Engineers (ASME) Energy Assessment for Pumping Systems Standard Webinar	Provides detailed instructions on how to conduct a pumping system energy assessment and report the results.
Energy Reduction in Pumping Systems Training Program	Helps users understand how to optimize pump system performance for energy savings.
Variable Speed Pumping Guide	Covers successfully employing variable speed pumping in an effort to solve problems, optimize system performance, and reduce energy costs.
Variable Speed Pumping Webinar	Introduces variable speed drives and describes when installation is appropriate.
Mechanical Seals Guide	Provides information on pump mechanical seals including proper selection for individual systems.
Mechanical Seals Energy Saving Webinar Series	This webinar discusses the significant energy savings associated with the proper selection of mechanical seals and the sealing plan.
Fundamentals of Mechanical Seals Webinar Series	This four-part webinar series, based on the HI/FSA Guidebook on Mechanical Seals, reviews proper selection of seals and seal plans and addresses diagnosis of mechanical seal issues.
Pump Life Cycle Cost Guide	HI has championed the cause of Life Cycle Cost (LCC) in an effort to bring increased attention upon the total cost of ownership. Energy consumption is one of the key components of LCC

Currently the Pump Systems Matter organization is offering the marketplace a well-regarded one-day course on "*Pump Systems Optimization: Energy Efficiency and Bottom-line Savings*." The course is designed to support host organizations and their attendees with gaining new skills to improve centrifugal pump system efficiency and to reduce energy and operating costs. Pump Systems Matter would welcome the support of the U.S. DOE to help promote this course, and others like it that PSM can develop, to state energy offices, major corporations associated with the U.S. DOE's Leader's program who are pledged to reduce energy intensity by 25% over ten years, to pump end-users, engineering consulting firms, ESCOs, interested associations of end-users and other parties. Details are available at www.PumpSystemsMatter.org/Training.

Pump Systems Matter has also been working to create additional education and training resources to address the dearth of high-quality pump and pumping systems knowledge. PSM seeks to partner with the U.S. DOE and others in the creation and deployment of such programs, to address training needed among technical engineering schools and programs, with pump end-users, engineering consultants and other professionals who select, install, operate and/or maintain pumps and pumping systems.

HI and Pump Systems Matter have also been working closely with DOE's Energy Efficiency and Renewal Energy (EERE) and Industrial Technology Program (ITP) staff to advance such initiatives as:

- Updating the Pump Systems Assessment Tool (PSAT), which incorporates HI's pump efficiency predication data
- Offering education webinars on such subjects as Pump Systems Assessments, and understanding the benefits of ASME's EA-2-2009 standard on doing energy audits of pumping systems
- Exploring an education/training role associated with a new DOE ITP program to educate, train and certify Pump Systems Assessment professionals
- Assisting the DOE, through ASME, in writing ASME's EA-2-2009 standard
- Promoting DOE's resources associated with the benefits of pumping systems energy savings

Pump Systems Matter has also been working with its Utility Rebate and Incentive Task Force to design models for pump systems optimization rebate and incentive programs that could be adopted in the United States to create market transformation benefits with pump systems optimization projects. PSM would welcome the participation of other interested parties, particularly electric power utilities and energy efficiency NGOs to help accelerate the development and deployment of this important initiative. Systems benefits charges, applied to creating incentives to optimize pumping systems would have significant market benefits.

Hydraulic Institute members and Pump Systems Matter sponsors have extensive pump expertise which can be offered to the U.S. DOE for selective projects. The HI and PSM resources, however, fundamentally rest upon volunteers and individuals participate as interested parties for the benefit of advancing the objectives of our organizations and in the interests of public and, specifically, end-users of pump products.

The Hydraulic Institute represents the best and brightest pump engineering talent in the North America. HI and PSM seek to apply that talent to help solve the nation's energy resource issues – by continuing to focus on pump systems efficiency, where significant energy savings potential exists. Energy efficiency improvements in pump systems are significant, and collaborative approaches between DOE, Pump Systems Matter and the Hydraulic Institute could serve to help transform the marketplace for energy efficient pumping systems. No one party, we believe, can do it alone.

As further background, the vision and mission of the Hydraulic Institute are:

Vision: To be a global authority on pumps and pumping systems

Mission: To be a value-adding resource to member companies and pump users worldwide by:

- Developing and delivering comprehensive industry standards
- Expanding knowledge by providing education and tools for the effective application, testing, installation, operation and maintenance of pumps and pumping systems
- Serving as a forum for the exchange of information

The HI Systems Section is currently developing a new Systems Standard, and seeks the input and collaboration with other subject matter experts in this regard. HI collaborates with engineering consulting firms, who serve as HI Standards Partners – and we welcome further interest in this regard. HI also uses the Canvass Method, approved by the American National Standards Institute (ANSI) to engage pump users and other interested parties in its standards review and approval process. HI welcomes more subject matter experts to express their interest in this process.

Another area for potential HI consideration is centrifugal pumping sizing standards (e.g., proximity to BEP). It is well known that pumping system designers often create designs utilizing a Rotodynamic pump across a broad range of flow rates. The reason behind this is to take advantage of the relatively large allowable operating envelope characteristic of Rotodynamic pumps in order to:

- Save initial cost,
- Reduce the pump station size or complexity; or,
- Meet clients' specific requests.

Recognizing that the systems design often results in operating conditions that are far from optimal in regard to energy usage, taking an approach to the educational problem with a new HI industry standard – and related HI/PSM/DOE programs, would serve to highlight this issue that focuses on the significant energy savings potential that exists with current systems that can be optimized and new systems that are properly designed.

While the lack of practicality of all pump applications operating at BEP is recognized, significant energy savings can be achieved by controlling the deviation from optimal conditions within reasonable limitations. The potential savings represented by sizing standards far exceed those from solely improving pump efficiency.

Another potential area for consideration is the development of a Variable Speed Pumping standard. Development of a formal Standard for Variable Speed Pumps in applications with varying flow and head conditions is under discussion within HI and with other energy efficiency organization stakeholders. HI sees substantial benefits associated with the DOE's support for this new initiative should we decide to move ahead, given limited resources currently available.

The following are key technical issues to consider with regard to variable speed:
1. It is not always the best solution for every application
2. Conditions of service vary, where the flow and/or pressure must be subject to change
3. Most pump installations do not have static conditions

The standard should be written to cover situations in which the flow rate varies and the pump is operating in a(n):
1. Closed loop piping system
2. Open loop piping system in which the static head is generally less than 50% of the Total Dynamic Head

The actual operating efficiency of fixed speed pumps will virtually always be lower than variable speed pumps and this will reduce overall power consumption by pumps.
- A fixed speed pump will typically operate at a **lower** efficiency rating. For example, a fixed speed pump that has an 80% BEP will often operate for much of its life at a less 50% efficiency.
- The variable speed pump will operate at a **higher** efficiency rating, since it can employ controls which virtually always allow it to operate at or near its BEP. For example, an 80% variable speed pump may seldom operate at less than 75% efficiency.

In summary, the Hydraulic Institute and Pump Systems Matter have offered to work with the U.S. DOE in areas where significant pump systems energy efficiency improvements and energy savings are possible, in the areas where we jointly address pumping systems energy savings improvements, through:

- Expanding education/training programs, with a collaborative DOE effort
- Creating new pump and pumping systems education programs
- Enhancing and expanding existing HI test standards, with a collaborative approach in needed areas
- Working on a pump systems and possibly variable speed pumping standards
- Creating utility rebate and incentive programs to leverage systems benefits funds with utility service territories

As the past is prologue to the future, once again quoting from the U.S. DOE commissioned report, prepared by Argonne National Laboratory, under Contract Number W-31-109-ENG38, published in 1980, it stated: "*Based on DOE's review of existing practices in the selection of pumps there does not appear to be significant potential for improving the availability of efficiency information by mandating of labeling requirements*."

HI and Pump Systems Matter welcome the opportunity to work with the U.S. DOE rule-making, EERE and ITP staff to explore this issue further, focusing on energy efficiency improvements in pumping systems that will deliver greater total pumps system energy savings at a lesser cost to the American people. A list of all HI members, in that regard, can be found in Attachment A.

HI believes that with additional funding for DOE to expand its scope to include additional market segments such as water and wastewater along with training greater numbers of pump energy specialists, the amount of energy saved will be much more than regulating the pump as a component and ignoring the system and its much greater potential.

HI is concerned with any pump regulation at the component level that will require very large amounts of federal funding to enforce. While HI represents a large portion of the US pump market there are thousands of pumps imported as finished goods or a components of equipment from non members that would need to be regulated, inspected and verified. The cost to the American people to adequately enforce a pump component standard must be included as part of any economic justification requirement. Without a stringent importation enforcement program the American worker will be unfairly exposed to foreign competition by his own government.

HI reserves the right to provide additional input to the U.S. DOE, in writing and/or in-person to supplement this preliminary submission.

Sincerely,

Robert K. Asdal
Executive Director

Cc: John Cymbalsky, Supervisor, Appliance Standards, Building Technologies Program, U.S. DOE Energy Efficiency and Renewable Energy

Charles Llenza, Project Manager/Engineer, Regulatory Program, DOE Energy Efficiency and Renewable Energy

Hydraulic Institute
Creating Pump Standards Since 1917

Attachment A

HI Member Companies

A.R. Wilfley & Sons, Inc.
*A.W. Chesterton Company
ABS/Cardo Flow Solutions USA
*AESSEAL Inc.
Afton Pumps, Inc.
All-Flo Pump Company, Inc.
Armstrong Limited
ARO Fluid Products, Ingersoll Rand Industrial Technologies
*Baldor Electric Company
*BigMachines, Inc.
*Blacoh Fluid Controls, Inc.
Buffalo Pumps Div. of Air & Liquid Systems Corp.
Carver Pump Company
Cascade Pump Company
Chempump, a Division of Teikoku USA Inc.
CLYDEUNION Pumps
Cornell Pump Company
Crane Pumps & Systems, Inc.
Dover Pump Solutions Group
  Blackmer
  Griswold Pump Company
  Neptune Chemical Pump Co., Inc.
  Wilden Pump & Engineering LLC
*EagleBurgmann Industries LP
Ebara International Corp., Fluid Handling Division
*Emerson Industrial Automation, Power Transmission Solutions
*Engineered Software, Inc.
Essco Pump Division, Engineers Sales Service Co.
Flowserve Corporation
FPI Pumps, Inc.
Franklin Electric Company, Inc.
*GE Energy - Motors
GIW Industries, Inc.
*Graphite Metallizing Corporation
Grundfos North America
  Paco Pumps, Grundfos CBS, Inc.
Hamilton Sundstrand Corporation, a United Technologies Company
  Milton Roy Americas
  Sundyne Corporation
Hydro, Inc.
IMO Colfax
  Warren/Colfax
*Intelliquip, LLC
ITT Corporation - Fluid & Motion Control
  ITT - Industrial Process
  ITT - Residential & Commercial Water
  ITT - Water & Wastewater
Iwaki America Incorporated
*John Crane Inc.
KSB, Inc.
Leistritz Corporation
LEWA, Inc.
Lewis Pumps
*Lovejoy
MET-PRO GLOBAL PUMP SOLUTIONS, Fybroc/Sethco Product Brands
MET-PRO GLOBAL PUMP SOLUTIONS, Dean Pump Product Brand
Metso Minerals Industries, Inc.
Moving Water Industries (MWI)
National Pump Company
*Nidec Motor Corporation
Patterson Pump Company
Peerless Pump Company
LaBour Pump
Pentair Water
Aurora Pump
Delta Environmental Products
Fairbanks Morse Pump Corporation
Hydromatic Pumps
Myers
Price Pump Company
ProMinent Fluid Controls Inc.
PumpWorks 610
Reddy-Buffaloes Pump, Inc.
Robbins & Myers - Fluid Management Group
Moyno, Inc.
*Schneider Electric - Square D
Scot Pump Division, Ardox Corp.
*Siemens Industry, Inc.
Simflo Pumps, Inc.
*SJE-Rhombus®
Smith & Loveless, Inc.
*SPP Pumps, Inc.
Sulzer Process Pumps (US) Inc.
Sulzer Pumps (US) Inc.
TACO, Inc.
Vertiflo Pump Co., Inc.
Warren Rupp, Inc.
*Waukesha Bearings Corporation
*WEG Electric Corp.
Weir Floway, Inc.
Weir Hazleton, Inc.
Weir Minerals North America
Weir Specialty Pumps
Wilo USA LLC
Yeomans Chicago Corporation