Select Hydraulic Institute Standards:
Pump Operations, Efficiency, Testing & Systems

Allowable Operating Region – ANSI/HI 9.6.3 (Currently being updated. New version anticipated 3Q2012)

This guideline discusses the effects of operating a rotodynamic pump at rates of flow that are greater than or less than the rate of flow at the pump's best efficiency point (BEP). These effects influence the power consumption and life of pump components and, therefore, considering the operating rate of flow is essential to reliable, efficient pump operation.

Design characteristics for both performance and service life are optimized near a rate of flow designated as the BEP. At BEP the pump operates with maximum hydraulic efficiency. The pumped liquid passes through the impeller vanes, casing diffuser (discharge nozzle), or vaned diffuser with minimal losses. Flow through the impeller and diffuser vanes (if so equipped) is relatively uniform and matched to the pump hydraulic geometry.

When the operating rate of flow moves far enough away from BEP, the flow through the pump is no longer uniform. Areas of flow recirculation and separation develop increasing hydraulic losses. Nonuniform flow and uneven pressure distributions in the pump result in increasing hydraulic loads and vibration.

Pumps operating in the presence of fibrous materials and at low speeds and flows, can lead to pump clogging. The minimum rate-of-flow, used to define the AOR, may need to be increased to reduce the risk of clogging for these types of applications.

NPSH Margin – ANSI/HI 9.6.1 (Currently not available for sale. Standard is being updated by HI Committee. New version anticipated 4Q2012)

A net positive suction head (NPSH) margin may be required for several reasons related to pump performance and service life, to cover the uncertainties of what the NPSH available (NPSHA) will be over the range of operation, and to provide for adequate pump reliability and performance.

NPSH is the liquid's energy, above the vapor pressure, at the inlet of the pump. By Hydraulic Institute definition (see ANSI/HI 1.1-1.2 *Rotodynamic (Centrifugal) Pumps for Nomenclature and Definitions* and ANSI/HI 2.1-2.2 *Rotodynamic (Vertical) Pumps for Nomenclature and Definitions*), the required NPSH of a pump is the NPSHA that will cause the total head (first-stage head of multistage pumps) to be reduced by 3%, due to flow blockage from cavitation vapor in the impeller vanes. The required NPSH (NPSHR) defined by this criterion will be referred to as *NPSH3*.

The full published pump head will not, however, be achieved when the NPSHA equals the NPSH3 of the pump. The first-stage head will be 3% less than the fully developed value. The 3% head drop referred to throughout this guideline refers to the head drop in a single-stage pump. For a multistage pump it refers to the head drop in the first stage only, not the total head of the pump.

It is therefore important to note that the NPSHR curves historically provided by pump manufacturers may not show sufficient NPSH values to provide zero head loss or to eliminate cavitation. The manufacturer's curve, if produced in accordance with HI definitions, gives the NPSH required such that cavitation will occur to the point where 3% of the first-stage pump head is lost through cavitation.

Rotodynamic (centrifugal and vertical) pump efficiency prediction – HI 20.3 (Available for sale)

The major influences on rotodynamic pump efficiency are pump size, specific speed *ns* (*Ns*), and the type of pump selected to meet the service conditions. The efficiency prediction charts (see Figures 20.3a, b, c, and d) relate to industrial-class pumps designed, manufactured, and tested in accordance with recognized industry standards.

The following can influence efficiency deviations:

a) Types of pumps:
b) Surface roughness
c) Internal clearances:
d) Mechanical losses:
e) Pumpage
f) Special impeller designs
g) Impeller diameter trim
h) thrust balance

Hydraulic performance acceptance tests – ANSI/HI 14.6 (Currently available for sale)

This standard covers hydraulic performance tests for acceptance of rotodynamic pumps (centrifugal, mixed flow, and axial flow pumps), in this document referred to as *pumps*.

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.

Information in the standard may be applied to pumps of any size and to any pumped liquids behaving as clear water.

The standard includes three grades of accuracy of measurement: grade 1 for higher accuracy, and grades 2 and 3 for lower accuracy. These grades include different values for tolerance factors for allowable fluctuations and uncertainties of measurement.

This standard applies to a pump by itself without any fittings. The pump may also be tested with a combination of upstream and/or downstream fittings by prior agreement and agreed on contractually.

Pump Systems Energy Optimization Standard (In early stage of committee development)

Purpose

The purpose of the HI Systems Section Sub-group is to create an informative standard for energy efficient Rotodynamic pump systems. This standard will provide the user with a collection of tools and metrics that will provide guidance for the development and evaluation of high efficiency pump systems.

Such standards are intended to facilitate optimization of pumping systems to achieve higher energy savings than by addressing pump efficiency alone.

Scope:

This standard is intended to be used as a tool in the design and retrofitting of rotodynamic pump systems to optimize the energy efficiency of clean water applications potentially reduce life cycle costs.

Pump Selection

The pump must be selected within the Preferred Operating Region (POR) as defined in ANSI/ HI 9.6.3. Selection of the pump outside this range causes efficiency and reliability problems.

Specific Energy can be used to compare pump systems to determine which system is the most energy efficient. To date we do not have a method to determine what constitutes a good specific energy vs. a poor specific energy rating.

Indicators of Poor System Energy Optimization:
The following are a list of conditions that may indicate possible system efficiency improvement opportunities. While a system that only exhibits one of these indicators may not have poor system efficiency, systems that have two or more of these symptoms may have poor overall system efficiencies and high specific energy levels.

1. Throttle valve controlled Systems (Throttling valve is being used to control flow rate through pump & system)
    1.1. Systems that use the resistance of a control or throttle valve are an inherent waste of energy. The friction dissipated across the valve is wasted as heat and turbulence. The energy loss for a valve can be calculated using the following equation.
2. Bypass Line in normally open (continuous bypass of liquid back to the suction)
    2.1. Bypass lines that are normally open allow the pressured liquid on the discharge side (high energy side) of the system to flow back to the inlet side (low energy side) of the system. Not only does this dissipate the energy that was added by the pump but it also requires that that fluid be re energized as it passes through through the pump for a second time. The amount of energy wasted through a bypass line can be determined by the following equation.
3. Multiple parallel pumps in a system, always running the same number of pumps even as flow demand changes.
    3.1. Often parallel pump systems are used to to allow the pump system to accommodate a range of flow rates in static dominated systems.
4. Pumps are in continuous operation in a batch process.
    4.1. This can be an indicator that the pump is undersized for the process.
5. Pumps cycle on and off in a continuous process
    5.1. This is often an indication that the pump is oversized for the process. The on off operation can cause a variety of reliability problems.
6. Cavitation
7. High levels of system maintenance, not only pumps but valves etc.
8. Systems that have undergone a change in function.
    8.1. Often over time systems are changed to increase or decrease the flowrate.

Minimum Efficiency Performance Standard (MEPS) for Extended Products (In early stage of committee development)

Purpose**:**
It is HI’s focus and advocacy to optimize the energy usage of the “pump system”, which is being defined as the “Extended Product”. An Extended Product consists of a pump configured with an electric motor, an electronic variable speed drive and a closed-loop feedback control system enabling the pump to operate at variable speeds. This maintains efficient performance of the pump close to its BEP over a broad range of operating load conditions, and is applied in applications with variable-flow operating requirements and in which the static head is 25% or less of the total system head loss.

Scope:
The scope is to develop the conceptual direction and the basis for defining a standard to evaluate the MEPS for Extended Products that are of a certain type, operate within the following operating parameters, and are included in the following markets:

- Irrigation / Agriculture
- Building (Including HVAC applications)
- Water treatment
- Water utility (Distribution)

The scope of this document will cover the extended products that operate within the following criteria:

- Extended Products that consist of a pump (wet-end); driver (electric motor); variable frequency drive unit (VFD); and feedback control loop to operate the VFD and motor.
- Extended Products pumping clean water (Clean water is defined as water with a maximum free solid content less than 0.25 kg/m^3, and a maximum dissolved solid content of 50 kg/m^3)
- Extended Products with rated flow rates equal to or above 25 gpm.
- Extended Products with discharge pumping head values equal to or below 295 ft
- Extended Products using motors equal to or below 200 HP
- Extended Products with pumps and drivers that operate at equal to or below 3,600 rpm
- Extended products that operate between -10^{o} C and 120^{o} C

This standard will not apply to Extended Products that utilize the following pumps:

- Fire
- Positive Displacement
- Self-Priming
- Solids handling

For more information visit: www.Pumps.org/Standards or www.Pumps.org/Subscriptions