White Paper

Slurry Pumps: Not Just for Mining Anymore

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Executive Summary

The American Petroleum Institute (API) was established in 1919, as the First World War was winding down, as a way for Congress and the domestic oil and natural gas industry to work together to help the Allied effort. Besides collecting industry statistics on crude oil production, the group focused on the standardization of oil field equipment.

During the war, drilling delays were caused by shortages of equipment at a drill site. The industry tried to resolve the problem by pooling equipment; however, because there was no uniformity of pipe sizes, threads and coupling, this effort was not successful. As a result, API shifted gears to focus on developing industry-wide standards for equipment used for the oil and gas industry. In fact, today API maintains more than 500 standards covering all segments of the industry, promoting reliability, safety and best practices for equipment.

Since single-stage, between-bearings and vertically suspended pumps comprise the vast majority of centrifugal pumps used in the industry, API standards have been developed to specifically cover these products:

- The API 610 standard, currently in its 11th edition, covers single-stage overhung pumps (types OH2, OH3, and OH6); between-bearings pumps (Types BB1, BB2, BB3 and BB5); and vertically suspended pumps (types VS1 though VS7).
- This standard sets specific design, test and other requirements for these types of pumps.

It is only recently that pump manufacturers have created guidelines for slurry pumps, which are beginning to prove especially useful in oil-and-gas refining operations. In 2005, the Hydraulic Institute published its first American National Standard for Rotodynamic (Centrifugal) Slurry Pumps (HI 12.1 – 12.6). This first-of-its-kind standard provides nomenclature and definitions along with guidelines for application and operation of slurry pumps.

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While used primarily in mining applications, slurry pumps now can provide benefits to oil refineries as well. Refineries can look to new slurry-pump offerings from ITT Goulds Pumps, a leading manufacturer of pumps, controls and monitoring systems, for a wide range of industrial markets.

Slurry Pumps vs. API Pumps

Slurry pumps are a different type of pump than those covered by API specifications. Both pump types are designed to maximize safety and reliability, but from very different perspectives.

- API pumps are designed for use in high-temperature and high-pressure applications where clean liquids are normally pumped. Safety and reliability are paramount as failure can be catastrophic.

- Slurry pumps are utilized in lower-temperature, lower-pressure applications where wear-life and ease of maintenance are key considerations, along with reliability and safety. Slurry pumps are designed to handle abrasive solids, so the design criteria are vastly different from API pumps that handle clean liquids. Wear is the key consideration for slurry pumps.

These differences result in very different design approaches to the two pump styles.

Slurry Pump Features for Less Wear, Longer Life

The wet ends of a slurry pump are designed for erosive duty, so larger wear allowances are required. API pumps typically have a casing thickness of one-quarter inch (6mm) to three quarters of an inch (19mm) with a one-eighth inch (3mm) corrosion allowance. Slurry pumps will typically have casing thickness of three quarters of an inch (19mm) to two inches (50mm) and greater, with a wear allowance of half an inch (12mm) or more. The extra material is required to extend the life of the pump.

In slurry pumps, casings are semi-volute as opposed to a true volute in API pumps. This results in a blunter, more robust cutwater and increased distance from the impeller to the cutwater. These compromises reduce the efficiency of the pump slightly but increase the wear-life.

Oversized, large-diameter impellers are used for slurry pumps operating at 1800 rpm (4-pole speeds) or less. Experiences and lab tests show that wear due to pumping abrasives is approximately the cube of the speed. Therefore, reducing the speed from 1800 rpm to 900 rpm, for example, will provide approximately *eight times* the wear-life. It is not uncommon to operate API pumps with smaller impeller diameters at 2-pole speeds.

Impellers for slurry pumps have thicker vane sections and large vane passage for extended wear and to allow larger solids to pass. Front and/or rear pump-out vanes are used to reduce recirculation of abrasives on the suction side and to reduce the pressure and presence of solids in the stuffing box.

Impellers are threaded onto the shaft rather than keyed, with an impeller nut used on OH2 API pumps. This is the preferred method for slurry pumps, as an impeller nut would be subject to abrasive wear, causing more frequent and difficult maintenance.

Replaceable wear plates/liners are used in slurry pumps, whereas close tolerance radial wear rings are used in API pumps. There is no adjustment capacity to renew clearances in API pumps. Due to this, slurry pumps utilize front-wear plates, and in some cases, back-wear plates. The impeller and/or a suction seal ring can be adjusted to maintain clearance axially, which maintains efficiency and extends pump-life. Radial wear rings in an API pump would quickly wear in the presence of abrasives resulting in greatly reduced efficiency and frequent maintenance.

Along with design considerations, wet-end materials differ between API and slurry pumps. The API 610 standard includes material specifications for all critical components in the pump. The pump's materials are called out by API codes, such as S-4 for carbon steel, C-6 for 12 percent chrome and D-1 for duplex alloy.

These materials are applied based on the specific service involved. With slurry pumps, wear is the critical component in material selection. As such, high-chrome white iron (ASTM A532 Class III Type A hardened) is the primary material used for slurry pumps. This material, which provides the optimum wear performance, has a hardness of 600 BHN (Brinell hardness), or greater. ITT Goulds Pumps designates this material as HC600.

Due to the material's hardness, items such as casing drains and suction and discharge connection are not provided. Along with the difficulty of drilling and taping the hardened material,

interruptions in the volute surface create standing vortices, which become accelerated wear points. Impellers trims are also avoided. Trimming an impeller increases recirculation, which accelerates wear. While these items are common on API pumps, they lead to a decrease in MTBM (mean time between maintenance) and higher costs on slurry pumps.

The power end for slurry pumps must be robust to handle loads created by high specific gravity fluids, the passage of large solids, and the loading and imbalance created by uneven erosive wear. Along with this, slurry pumps are typically V-Belt driven, which creates additional loading. As a result, heavy-duty, large-diameter shafts and spherical or tapered roller bearings with an oversized oil sump are employed to compensate for these loads. Though they have robust power ends for intended use, API Pumps are direct-driven and are not subject to the loads created by erosive wear that occur in slurry pumps.

Lastly, slurry pumps must be designed for ease of maintenance and safe handling. Due to the wear experienced, slurry pumps must be maintained on a frequent basis to replace worn components. Features employed in slurry pumps to ease maintenance include front pull-outs to access high-wear components, replaceable suction liners, lifting lugs for the major components, release collars to aid in impeller removal, and replaceable bearing cartridges.

Higher-Performing Slurry Pumps

To make slurry pumps more efficient and effective in the API, mining and minerals, power, and other industries, ITT Goulds Pumps conducted extensive "voice of the customer" research. The research identified a number of key attributes needed in slurry pumps, including:

- Better performance
- Higher reliability
- Easier maintenance
- Lower conversion costs
- Improved safety

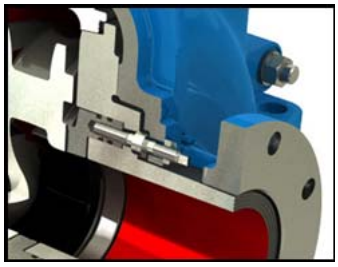
XHD Extra Heavy Duty Lined Slurry Pump

ITT used the data collected to create the XHD Extra Heavy Duty Lined Slurry Pump—the next generation slurry pump that was recently named the Technical Innovation of the Year at the 2012 Pump Industry Awards.

Designed to work optimally on both Service Class III (heavy) and Class IV (very heavy) slurries as defined by the Hydraulic Institute, the pump is currently available in six discharge sizes ranging from 80 mm (3 inches) to 300 mm (12 inches), and in four power frames. Its flow range extends to 2,950 cubic meters per hour or 13,000 gallons per minute, and discharge pressures to 85 meters or 280 feet.

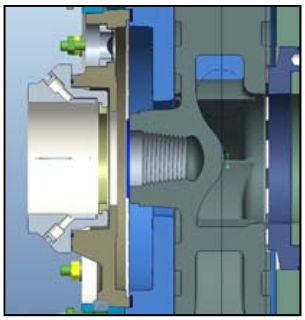
The XHD delivers a unique combination of performance, reliability and safety to meet customers' needs. Fully lined for maximum safety, it employs a ductile iron outer shell composed of hard-metal wear components, providing higher maximum allowable working pressure and protection from liner wear-through that is unavailable on unlined pumps.

As wear is a critical concern of any slurry pump, the XHD was designed with a patent-pending adjustable suction seal ring. This seal ring allows easy access and axial-clearance adjustment from the front of the pump. This means the axial clearance between the impeller and the seal ring can be adjusted while the pump is operating, resulting in greater pump efficiency while extending the wear-life of the unit. The XHD also employs a wear pin to allow simple visual monitoring.

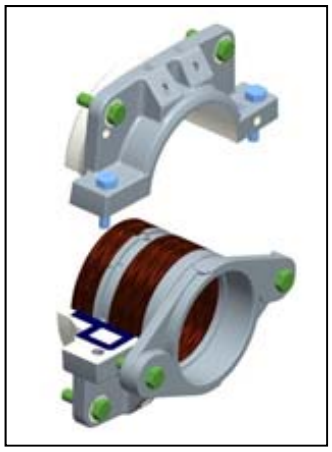


Adjustable Seal Ring

To provide safe, fast and easy pump maintenance, the XHD utilizes a patent-pending tapered shaft thread, which is self-aligning, to facilitate assembly and disassembly.



Tapered Shaft Thread



Split Stuffing Box

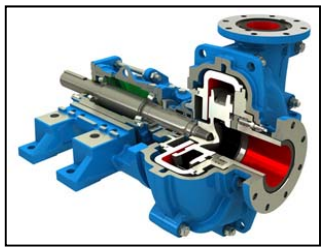
A split two-piece stuffing box with identical halves is another unique feature of the XHD. The stuffing box is typically one of the highest maintenance areas on a slurry pump. Open, easy access to this area is crucial for ease of maintenance. The XHD not only provides easy access, but the split box is easy to install. It allows users to inspect the shaft sleeve without disassembling the pump, and enables simple conversion from packing to mechanical seals or vice versa.

The XHD's power end is designed with numerous features to provide safe, reliable operation with reduced conversion costs.

- A compact frame allows for installation on any existing foundation and alignment with existing suction piping, greatly reducing change-out

costs.

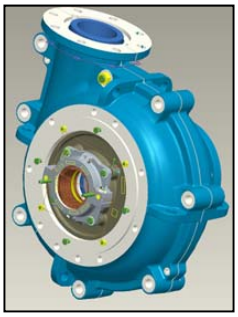
- Through bolt construction, no blind taps provide easy removal without the binding of pedestal threads.
- Dual-rod impeller adjustment enables fast, easy access.
- Heavy duty shaft and bearings are designed to handle loads, due to high specific gravities and imbalance due to wear.
- Flat-bottom bearing cartridge assembly design allows for easy realignment of the bearing frame and shaft versus a more common saddle fit. Bearing cartridges may be removed as a unit to allow maintenance in the shop.
- Standard, on-board temperature and vibration monitoring is provided by the patented *i-ALERT*™. In normal conditions, this blinks green, but it will flash red if there is a vibration or temperature issue.



Model XHD

i-ALERT™

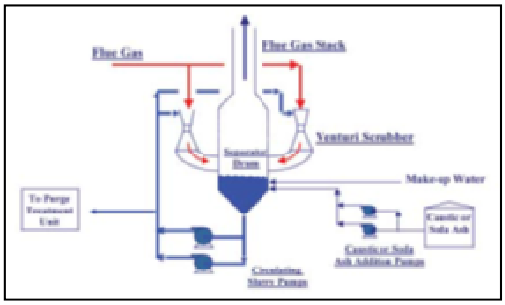
Another unique feature of the XHD is the quick change wet and bearing cartridge. Due to its design, the XHD allows you to clamp the impeller between the back wall of the volute liner and the seal ring for removal of the entire wet end of the pump as a unit. This same feature allows you to remove the bearing cartridge and shaft (with packing or mechanical seal) while leaving the wet end in place. No longer do you have to tear down the wet end of the pump to replace a shaft sleeve or mechanical seal, and for critical services, an assembled wet end can be stocked for fast replacement with minimal downtime.



Wet End removed as unit

Choose a Slurry Pump for Reliability, Maximum MTBM

ITT Goulds knows that even one hour of refinery downtime can result in significant costs. That fact, along with customer feedback, is what inspired us to completely redesign the slurry pump for a new level of reliability. The XHD Extra Heavy Duty Lined Slurry Pump stands up to the harshest conditions, while setting new standards in serviceability. Many parts now are more accessible and adjustable than ever before in a slurry pump.



FCCU – Wet Gas Scrubber Process

While the API 610 standard was created to maximize reliability, it does not cover all pumps and an API pump may not be suitable for every application. One such application is the Wet Gas Scrubber in the FCCU (Fluid Catalyst Cracking) process unit. The purpose of the service is to circulate spray water from the wet gas scrubber to remove Flue gas particulate and SO_2 emmissions. Due to the presence of abrasive solids in the pumped fluid, and specific gravities of up to 1.15 or greater, an API type pump is not ideal and will require increased maintenance. In this instance–and in many others–a non-API type slurry pump is the right choice to save money though lower maintenance and replacement part costs, and to keep the process running with maximum MTBM.

When selecting a pump for a refinery operation, the application must be reviewed for factors such as pressure, temperature, erosive and corrosive properties in order to select the correct type of pump. As demonstrated an API may not always be the right pump for the service. A slurry pump may be the right choice to maximize reliability, wear life, minimize downtime and provide the lowest total cost of ownership.

About ITT and ITT Goulds Pumps

ITT is a diversified leading manufacturer of highly engineered critical components and customized technology solutions for the energy, transportation and industrial markets. Building on its heritage of innovation, ITT partners with its customers to deliver enduring solutions to the key industries that underpin our modern way of life. Founded in 1920, ITT is headquartered in White Plains, N.Y., with employees in more than 35 countries and sales in a total of approximately 125

countries. The company generated 2012 revenues of $2.2 billion. For more information, visit www.itt.com.

ITT Goulds Pumps is a leading manufacturer of pumps for a wide range of industrial markets—including chemical, mining, oil & gas, power generation, pulp and paper, and general industry. As the first manufacturer to make digital monitoring standard on every process pump, ITT's Goulds Pumps continues to lead the industry in both mechanical pump design and the adoption of smart technologies.