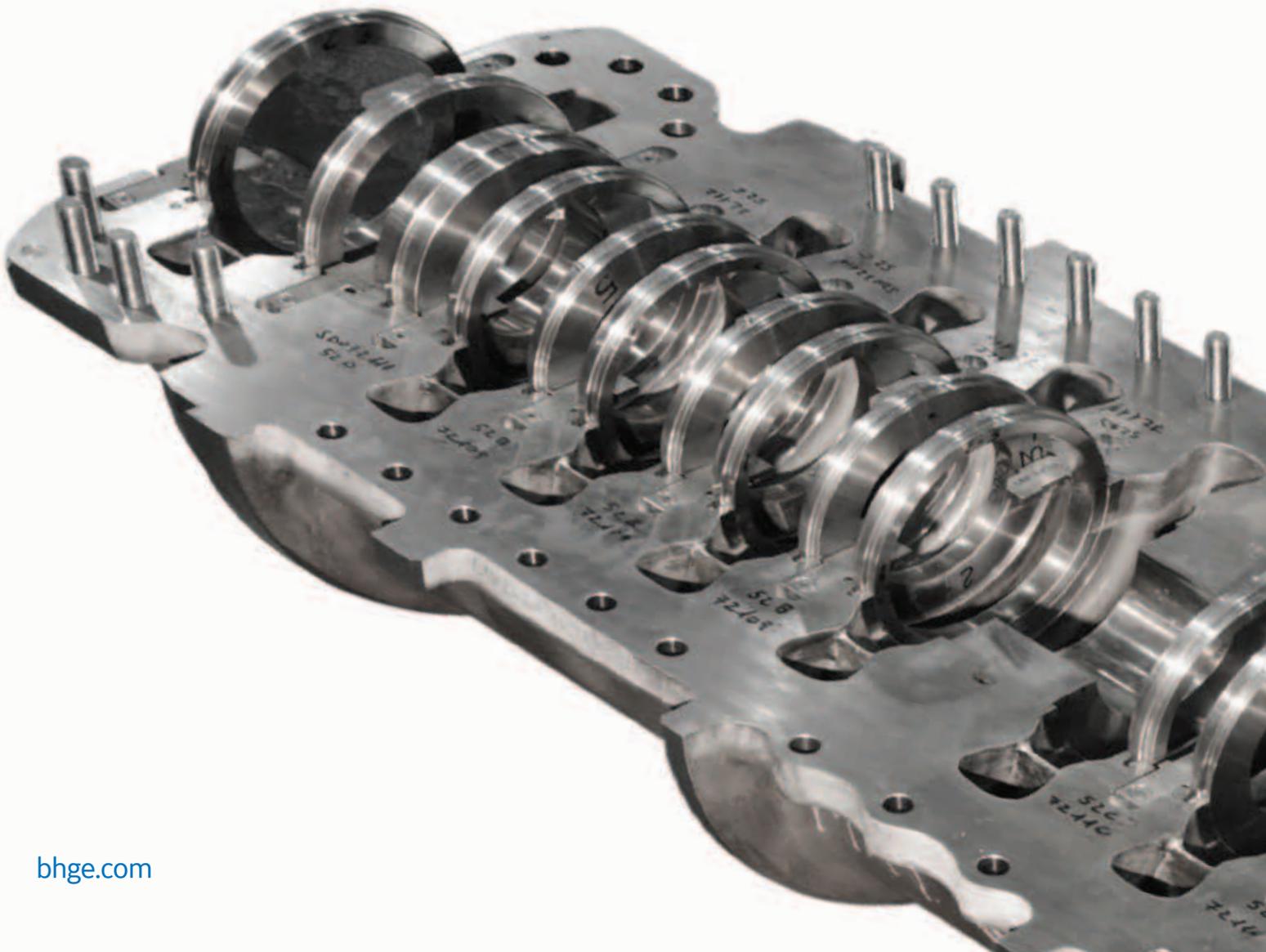


Pumps, valves, and systems

Advanced service solutions for the
oil and gas and power generation
industries



Baker Hughes, a GE company (BHGE), is a leading global supplier of compressors, turbines, pumps and valves for refineries, petrochemical plants, power generation plants, and pipelines. With over 20,000 units installed worldwide, and over 35 patents issued globally, BHGE's Pumps, Valves and Systems department (PVS) has been designing and manufacturing high-technology centrifugal pumps since the 1960s, while leveraging BHGE's vast experience in the field of rotating equipment. We also design and manufacture ASME-qualified control and safety valves for severe applications as well as turn-key fuel gas systems.

Today, operational efficiency, improved throughput and reduced downtime are a top priority for the energy industry. To support this effort, BHGE continues to invest in research and innovative technologies that allow our customers to operate more efficiently and profitably, while complying with regulatory mandates. With a covered area of more than 40,000 m², BHGE's Pumps and Valves Center of Excellence is headquartered in Bari, Italy where products are designed, manufactured, and thoroughly tested.

The benefits that BHGE PVS offers are:

- Single source responsibility
- Optimized system performance through product synergy
- Advanced technical services
- Project management interface
- Global assistance for commissioning and startup

Product lines

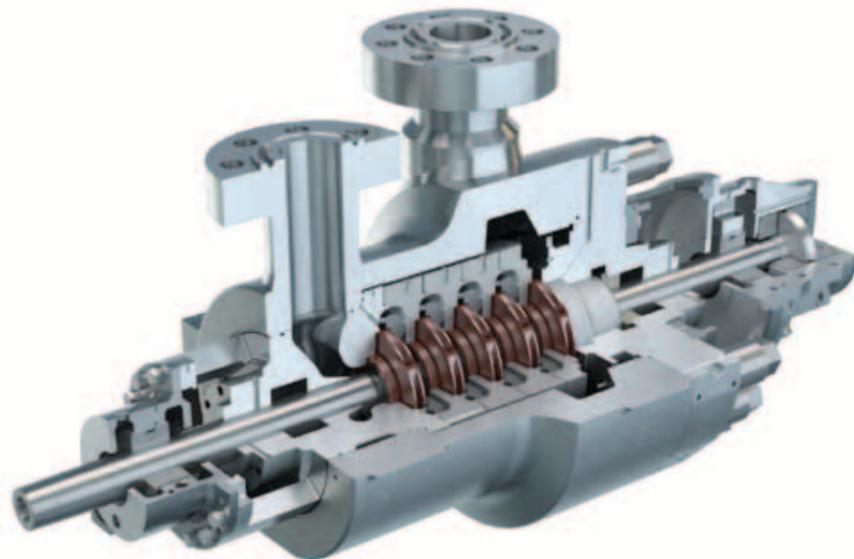
Centrifugal pumps

Manufactured since 1959, originally under United Centrifugal Pumps (UCP) license, and since 1997 under Nuovo Pignone patented design, throughout the years the pump designs have been improved based on our experience with rotating machinery.

For over 50 years, BHGE has manufactured a wide range of API 610/ISO13709-compliant centrifugal pumps for hydrocarbon processing, refineries, water injection, and pipeline services.

By leveraging our vast experience with refinery and petrochemical pumps as well as the research and design practices applied to high-pressure sour gas centrifugal compressors, BHGE has executed centrifugal pump projects in upstream applications whose complexity was particularly related to the adoption of special materials like super duplex and nickel alloys, and high discharge pressure.

All our pumps are API 610 compliant.



Product types

- Single or multistage
- Horizontally or radially split
- Single or double case type

Technical features

- Speed range: 1,500-7,500 rpm
- Flow range: up to 20,000 m³/h
- Power range: up to 15 MW
- Pressure range: up to 670 bar

Typical markets/segments

- Upstream: water injection, CO₂ re-injection, oil gathering (onshore and FPSO)
- Midstream: oil and water pipelines
- Downstream: refinery, petrochemical, fertilizers, hydrocracking auxiliaries, gas treatment
- Power generation: boiler feeding, cooling water, Condensate extraction, desuperheater
- Mining

Control and safety valves

BHGE has designed, manufactured, and installed control and safety valves since 1962. The original product line dedicated to liquids has been expanded to also serve gas and steam applications. We combine application knowledge, engineering, and manufacturing expertise, with BHGE's Research and Development Centers, and Six Sigma quality rigor to provide technologically advanced valves that meet the needs of the most critical applications.

All our safety valves are manufactured in line with ASME standards.



Product types

- Self-regulating control valves
- Turbine by-pass control valves
- Cold/hot gas by-pass valves
- Anti-surge control valves
- Cryogenic control valves
- Low-noise control valves
- Safety valves
- Back pressure valves for centrifugal pump and HPRT

Technical features

- Size range: 1 in. to 44 in. std.
- Rating class: 150# - 2500#; API 10,000 - 15,000
- Globe and angle valves
- Cast and forged body
- Temperature range: -196°C to 570°C

Typical market/segments

- Upstream: compressor anti-surge systems
- Midstream: compression and pumping stations, gas metering and pressure reducing stations, natural gas, and air separation plants
- Downstream: cryogenic, low emission, fertilizer plants
- Power generation: water injection

Fuel gas systems

BHGE provides design, detail engineering, material procurement, assembly, test, and commissioning of complete fuel gas system packages globally. We supply complete modules for the provision of filtering, heating, pressure reducing, and metering gas at the required pressure and temperature. The units are normally skid mounted, which significantly reduces the onsite assembly time. All packages are designed and built according to national and international regulations.

Other specifications

- Materials: API 6D
- Piping and fittings: ANSI, API
- Pressure vessels: ASME sect. VIII
- Heat exchangers: TEMA, HEI
- Instrumentation: IEC, IEE, ISA, NEMA
- Sour gas: NACE
- Flow meter: ISO 5167, AGA

Typical markets/segments

- Oil and gas pipeline
- Oil production
- Gas treatment
- Power generation
- Sour gas



PVS service solutions

BHGE offers tailored solutions to enhance equipment efficiency and performance, contractual service agreements to maintain equipment at peak reliability and availability, genuine OEM spare parts, maintenance, repairs, multivendor solutions, e-services, as well as other advanced services. BHGE's worldwide pool of field service engineers can be deployed to support unit installation, commissioning, and on-going operation and maintenance. BHGE's global footprint enables the delivery of services, technologies, and expertise when and where our customers need them. Access to state-of-the-art repair and service facilities is available globally, backed by BHGE's OEM warranty to provide the confidence required.

Service shops

We can leverage a global network of repair facilities in strategic locations to be closer to customers, operators, and end-users worldwide.

Our service shops are equipped with state-of-the-art tools and skilled technical advisors to provide first class technical sales support and to reduce the project cycle time.

Our local presence helps to create a more productive relationship by sharing a common culture and language.

Our services include:

- Machine overhaul
- Parts repair
- Proposal generation
- Field technical support

	OH2 DSTC TC	OH4 VP	BB1 DVE DVS	BB2 THF DSTHF DVSHF	BB5 DDHF DDM	BB3 MSN MSND	BB1 BF	VS7 VCMS VMS	VS6 VCD VD VDA
Performance optimization									
Impeller diameter/trim/pattern	●	●	●	●	●	●	●	●	●
De-staging/re-staging					●	●	○	●	●
Decase and volute modification and coating	●	●	●	●	●	●	●	●	●
Non-metallic wear ring	●	●	●	●	●	●	●	●	●
New rotor design									
New rotor design						●			
Pumps rejuvenation	●				○	○		●	●
Bearing housing modification	○	○	●	●	●	●	●	○	○
Mechanical seal upgrade	●	●	●	●	●	●	●	●	●

Feasibility: ● Yes ○ To be evaluated case by case

Repair and spare parts

We supply both standard and customized spare parts as well as upgrades that are designed to increase performance or improve reliability, based on our proven field experience. We custom develop special tools for specific applications. By defining specific tables of interchangeability, we can identify common parts used on different machines and equipment thus allowing lower stock quantities.

Our repair processes are built on several decades of experience and employ state-of-the-art technology including advanced metallurgy, welding, precision machining, and non-destructive testing methods including x-ray and ultrasonic inspection. These methods ensure the integrity of our repairs and the highest quality renovation of parts available in the industry. The repairs can be performed either in the field or at any authorized BHGE pumps and valves repair facility worldwide.

Our services include:

- High tech repairs
- Component testing
- Metallurgical services
- Residual life assessment
- Anti-fouling and anti-corrosion/erosion coatings

Multi-vendor services

To offer customers the benefits of a single point of contact for servicing a complete fleet of both rotating and static equipment, we will consider offering service capabilities for non-BHGE products in accordance with local laws and our policy of respecting the valid intellectual property rights of third parties.

Our single point fleet servicing may include providing spare parts, repairs, upgrades, re-rates, exchange, and field service to cover products developed by other OEMs. By avoiding changes to the piping or foundations, while achieving the desired performance and reliability improvements, we can increase output, efficiency, and run-times and help reduce emissions, all of which impact your facility's profitability.

Our multi-vendor services may cover:

- Centrifugal pumps
- Valves
- Fuel gas systems





e-Services

Digitization is one of the biggest steps forward we have taken in making it easier to do business with us while increasing speed and productivity. To this purpose, we have developed a variety of proprietary e-service tools such as our Customer Service Portal, through which our customers can access information that includes:

1. Spare parts management

- Graphical navigation through customer's fleet
- Recommended maintenance parts list
- Interchangeability parts across customer's fleet
- Inventory availability
- Obsolete parts management
- Order and quote status

2. Conversions, modifications, and uprates (CM&U)

- Reliability and availability improvement
- CM&U payback analysis
- Annual cashflow evaluation
- Payback

3. Plant maintenance information

- Operating condition reports
- Availability and reliability reports
- Performance assessment
- Maintenance and operation recommendations
- Technical documentation

Pump troubleshooting

Maintenance

We provide quick turnaround on a full range of services for circulating, vacuum, and centrifugal pumps including:

- Overhauling activities
- Anti-erosion and anti-corrosion coatings
- Dimensional check with coordinate measuring machines
- Machining of division planes of casing halves and internal diameter
- Impeller and rotor static balancing
- Performance test

Consultative service/outage pack

Early troubleshooting is key to ensure optimal equipment performance throughout the entire product lifecycle across a wide range of operating conditions. By performing rigorous onsite tests on key operating parameters such as suction and discharge pressure, bearing temperature, vibration levels, we can monitor customer equipment to prevent parts breakdown and other kinds of mechanical failures.

Customer training

Human capital is the key contributor to production, reliability, and efficiency; a well-trained and skilled workforce is the most valuable resource to face uncertain markets and the most complex company dynamics. Making the most of our assets and expertise, as BHGE customer training we are fully committed to supporting the growth of your workforce and helping you excel in the oil and gas value chain. Our dedication to develop human capital is based on a structured process aimed at building both technical and soft skills, pursuing the highest standards in everything that we do.

BHGE's oil and gas technical courses are taught by field-seasoned instructors who combine their understanding of theory with practical experience. Class-based courses are run in our training centers worldwide: Bari, Florence and Massa Italy; Ras Laffan, Qatar; Perth, Australia; Port Harcourt, Nigeria; Boufarik, Algeria; Ciudad del Carmen, Mexico. A set of e-training courses are also available to serve remote customers.

Digital solutions

BHGE is investing heavily in becoming a digital industrial partner. One of the ways we provide this service to you is through Remote Monitoring & Diagnostics. This service leverages data acquisition and connectivity systems to gather data from machinery installed in the field.

Our diagnostic engineers and sophisticated proprietary algorithms leverage GE's **PREDIX™ software platform** to analyze this data and provide suggestions for optimizing performance and scheduling and executing maintenance. This can be achieved by tracking machine performance during plant operation with the aim of sustaining overall efficiencies and maximizing machinery productivity. Smart management of equipment data gathered at your site is key to provide assistance in machinery troubleshooting, extending product life, and maximizing its value.

Installation and field service

The installation and field service organization is our worldwide customer support for all oil and gas industrial plant onsite services from installation and startup to inspection and field maintenance. This activity is performed by over 200 highly trained service engineers and technical advisors available at our service shops worldwide.

Our worldwide services include:

- Technical advisory service
- Remote and onsite technical assistance
- Troubleshooting
- Installation

Performance optimization

Our customers' most frequent requests relate to matching new plant operating points with existing machines originally designed for different conditions.

The BHGE approach starts from a detailed analysis of the existing pump configuration and margins for matching the new target. We use a variety of tools for simulating modifications to the pump design in order to validate potential modifications to match the new target point.

Tools such as rotor dynamic software, computational fluid dynamics (CFD) software, and our proprietary Centrifugal Pump Configurator, a web-based application integrated with a centralized database that provides pump curves based on both CFD calculations and field tests on the existing fleet.

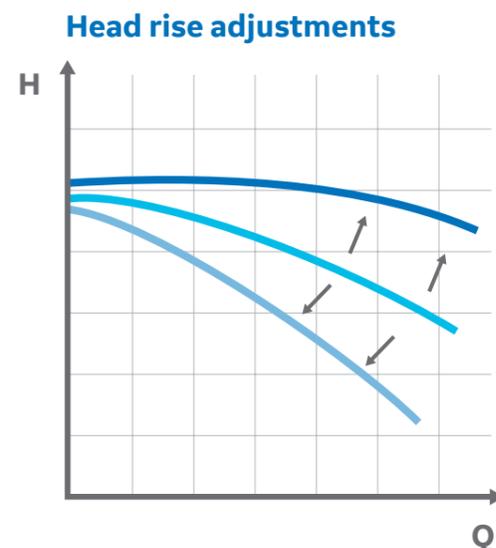
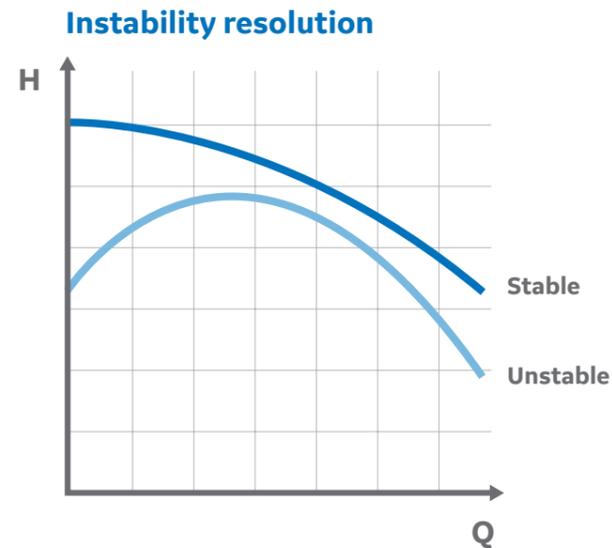
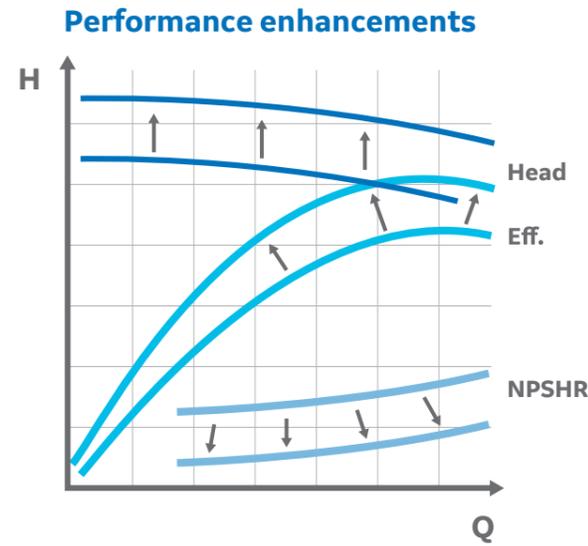
The most frequent customer needs are:

- Increasing flow rate
- Increasing mean time between failure (MTBF)
- Reducing vibrations
- Revision of operating point
- Increasing efficiency

We can increase overall performance by:

- Changing the impeller diameter to define a new best efficiency point (BEP)
- Modifying the impeller design with a new pattern in the original pump case
- De-staging or re-staging multistage pumps by adding or removing impellers
- Modifying the volute cross-sectional area and the position of the volute cutwater
- Cleaning the volute and coating the casing with ceramic paint
- Installing pressurized throttle bushings and/or modifying clearances
- Using composite materials as wear components

All the above activities are performed in line with API requirements.



Technology focus

Vertical pumps

Upgrade kit

One example of our effort to maximize asset performance throughout its lifecycle is the introduction of an upgrade kit for vertical pumps that do not have an oil lubricated thrust bearing. During operation, a whipping motion of the shaft occurs which can lead to vibrations and consequent rubbing of the rotating and stationary components as well as seal damage.

The kit includes: an oil-lubricated axial thrust bearing, a new bearing bracket, a new longer shaft, and a flexible coupling to replace the rigid coupling. Non-metallic wear rings can be installed upon demand to increase the pump efficiency and to enhance the pump rotor stability by reducing the shaft diametrical clearance. The benefits of this solution are increased efficiency and improved maintainability.

Improved configuration

Another example of the relentless research and innovation that is at the core of our products is the recent introduction of an improved configuration to avoid counter-rotation of vertical pumps, especially those working in parallel mode and with a common suction/discharge header.

This is obtained thanks to a freewheel applied directly onto the pump instead of the driver. In addition to furnishing the backstop, the cover and the coupling hub are also replaced. This solution helps minimize mechanical seal damage thus reducing maintenance time while increasing reliability.

API 682 compliant sealing system

The API 682 standard provides a set of design criteria with the mission to give a "high probability of operating for three years of uninterrupted service while meeting or exceeding environmental emission regulations." The implementation of the new standards provides a sealing system that improves reliability, maintainability, and standardization, strongly increasing interchangeability of the components, and resulting in a consistent reduction in lifecycle costs.

The three main standard arrangements defined as per API 682, are:

- Single mechanical seals: one rotating face per seal chamber; internally balanced
- Unpressurized dual mechanical seals: two rotating flexible elements and two mating rings in series; internally balanced with a buffer fluid that separates the seals
- Pressurized dual mechanical seals: two rotating flexible elements and two rotating mating rings in series; internally balanced with a barrier fluid that separates the seals

Typical scope of supply includes:

- Technical studies
- Sealing system
- All necessary parts required to modify the existing pump (including bearing bracket, stuffing box, throat bushing, shaft sleeve and seal, and gaskets)
- Field installation and testing

Application of a standard mechanical seal can require modification of some components. This could include:

- Redesign of the shaft sleeve
- Machining or redesign of the stuffing box in order to meet API 682
- Machining or redesign of the throat bushing
- Machining of the bearing housing to introduce new standard flush planes to meet API 682

Low emission packings

Emissions have become a key parameter in the evaluation of the quality of a valve. Attention to the environment is a requirement in every industry, and reducing emissions also relates to safety issues, since contaminants can be hazardous. For valves, one of the solutions to control emissions is a new packing design, which also reduces the friction between the packing and the stem.

There are two principle types of packing rings, which are described below.

Universal seal-type packing rings

These high-performance self-energized rings are capable of handling extreme service conditions such as ultra-low friction, chemical compatibility, and resistance to extreme temperatures.

The original packing requires a greater sealing length, has higher friction, and is more sensitive to valve movement. The new universal seal packing can be installed in a much more limited space and provides tightness performance which is far superior to the previous types. Modification of BHGE valves involves the following substitutions:

- New universal seal packing
- Bonnet (new design)
- Stem (with chrome carbide coating for endurance)
- Gland (new design)
- Nuts and studs
- Sleeve

GIJ Packing

The patented GIJ packing is a recent innovation introduced by BHGE based on the physical principle of gas diffusivity in a fluid.

Compared to universal seal rings, this packing is more reliable over time, guarantees emission levels below the ISO standards, and is more "fault tolerant" because it is able to prevent stem damage as the fluid penetrates the scrap cavities better than plastic rings.

The valve has two packings (upper and lower) in order to balance the stem. Process gas energizes the packings and feeds the fluid stuffing boxes. The valve is also equipped with a safety system that alerts the operator to the need for packing re-pressurization in the event of a system failure. Liquid packings considerably decrease the friction on the upper and lower stems which improves the controllability of the valve. This kind of packing is also available for ANSI standard valves.

The integrity of the packing has been proven for up to 80,000 cycles.

New composite materials for pumps

In order to satisfy the increasing demand for pump reliability and performance, BHGE has introduced new PEEK-based (Poly-Ether-Ether-Ketone) composite materials with better performance for wear components. Polymer-based composite materials have excellent strength and wear properties, and do not cause galling or seizing. This permits a significant reduction in clearances between rotating and stationary wear parts, which result in greater pump efficiency by restricting internal leakage. Other performance advantages include lower vibration levels, extended wear life, and lower repair costs.

The API 610 11th edition recognizes and lists polymer-based composites as an acceptable option for replacing metal wear parts to improve pump performance in appropriate applications. BHGE offers two types of composites for centrifugal pumps, both of which meet API standards. These classes of polymer-based composites contain the same two base materials, PEEK thermoplastic and carbon fiber. The molding of the blended resin

allows the thermoplastic (PEEK) to flow around and encapsulate the filler (carbon fiber) creating a homogeneous material. The ratio between the polymer matrix and the filler is manipulated to yield materials with a desired range of properties and characteristics that match the requirements of the intended application. PEEK is a ductile material which absorbs shocks and vibrations, dampening the effects of resonating metal components.

It is important that pump users consider the use of this new material for pump components only under the advice of the pump original equipment manufacturers (OEM). Our engineering department will determine if the proposed composite has the necessary properties and characteristics to perform successfully in the customer's application and whether the mean time between maintenance (MTBM) of the pump will be improved rather than compromised.



API 610 11th ed. - Non-metallic wear part materials

Material	Temperature limits		Limiting pressure differential	Application
	Min	Max		
PEEK Chopped carbon, fiber filled	-30°C (-20°F)	135°C (275°F)	2,000 kPa (20 bar) (300 psi)	Stationary parts
PEEK Continuous carbon, fiber wound	-30°C (-20°F)	230°C (450°F)	3,500 kPa (35 bar) (500 psi) or 14,000 kPa (140 bar) (2,000 psi) if suitably supported	Stationary or rotating
Carbon graphite Resin impregnated, babbitt impregnated, nickel impregnated, copper impregnated	-50°C (-55°F) -100°C (-150°F) -195°C (-320°F) -265°C (-450°F)	285°C (550°F) 150°C (300°F) 400°C (750°F)	2,000 kPa (20 bar) (300 psi) 2,750 kPa (27.5 bar) (400 psi) 3,500 kPa (35 bar) (500 psi)	Stationary parts

Non-metallic wear part materials, which are proven to be compatible with the specified process fluid, may be proposed within the above limits.

Such materials may be selected as wear components to be mated against a suitably selected metallic component such as hardened 12% Cr steel or hardfaced austenitic stainless steel. Materials may be used beyond these limits if proven application experience can be provided, and if approved by the purchaser.



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