

Application Solutions Guide

COAL TO OLEFINS (CTO) / METHANOL TO OLEFINS (MTO) API PRODUCTION



Experience In Motion



TABLE OF CONTENTS

THE GLOBAL CTO/MTO INDUSTRY LANDSCAPE 3

- Market Overview 3
- A Closer Look at CTO/MTO Processes and Technologies 6
 - Coal Gasification..... 7
 - Dry Coal Gasification Process 8
 - Conversion of Syngas Into Methanol 9
 - MTO..... 10
 - MTO by Honeywell UOP..... 11
 - D-MTO by Dalian Institute of Chemical Physics, Chinese Academy of Sciences (DICP)..... 12
 - S-MTO by Sinopec 13
- CTO/MTO Industry Project Route to Market 14

THE CTO/MTO INDUSTRY-FLOWSERVE INTERFACE 15

- Business Impact and Focus Areas 15
 - The Big Picture 15
 - The Flowserve Fit in the CTO/MTO Industry . . 15
- Products for the CTO/MTO Industry—At a Glance 16
 - Pumps 16
 - Valves 19
 - Seals 21

FLOWSERVE OPPORTUNITIES IN THE CTO/MTO INDUSTRY — PRODUCTS AND CAPABILITIES 22

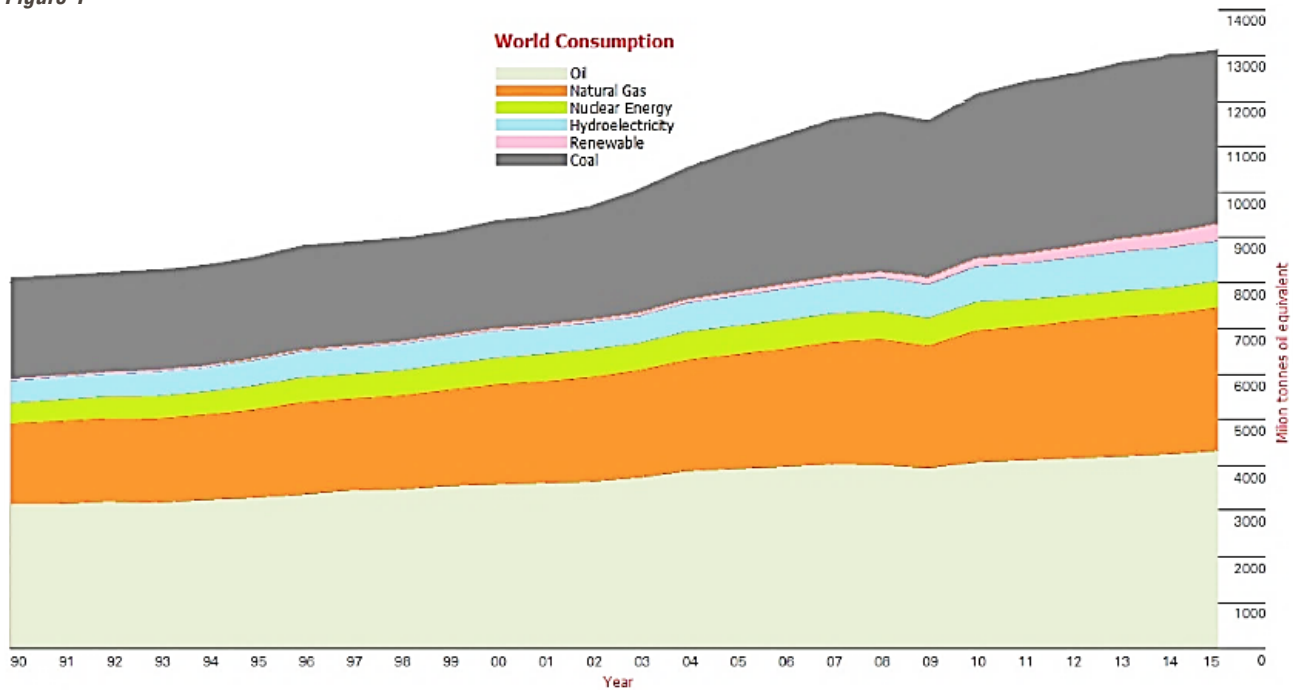
- Flowserve Products and Capabilities in Coal Gasification (Syngas) 22
 - Overview..... 22
 - Products 23
- Flowserve Products and Capabilities in Conversion of Syngas Into Methanol..... 28
 - Overview..... 28
 - Products 29
- Flowserve Products and Capabilities in MTO 31
 - Overview..... 31
 - Products 32
- Flowserve Products for CTO/MTO Processes..... 34
 - Pumps 34
 - Valves and Actuators 39
 - Seals 43
- Key Advantages for Flowserve in the Aftermarket 46
- COMMUNICATING OUR VALUE..... 47**
- Flowserve Value Proposition in CTO/MTO..... 47
 - Innovative Ways Flowserve Addresses Customer Challenges 48
- GLOSSARY 49**

THE GLOBAL COAL TO OLEFINS (CTO) / METHANOL TO OLEFINS (MTO) INDUSTRY LANDSCAPE

Market Overview

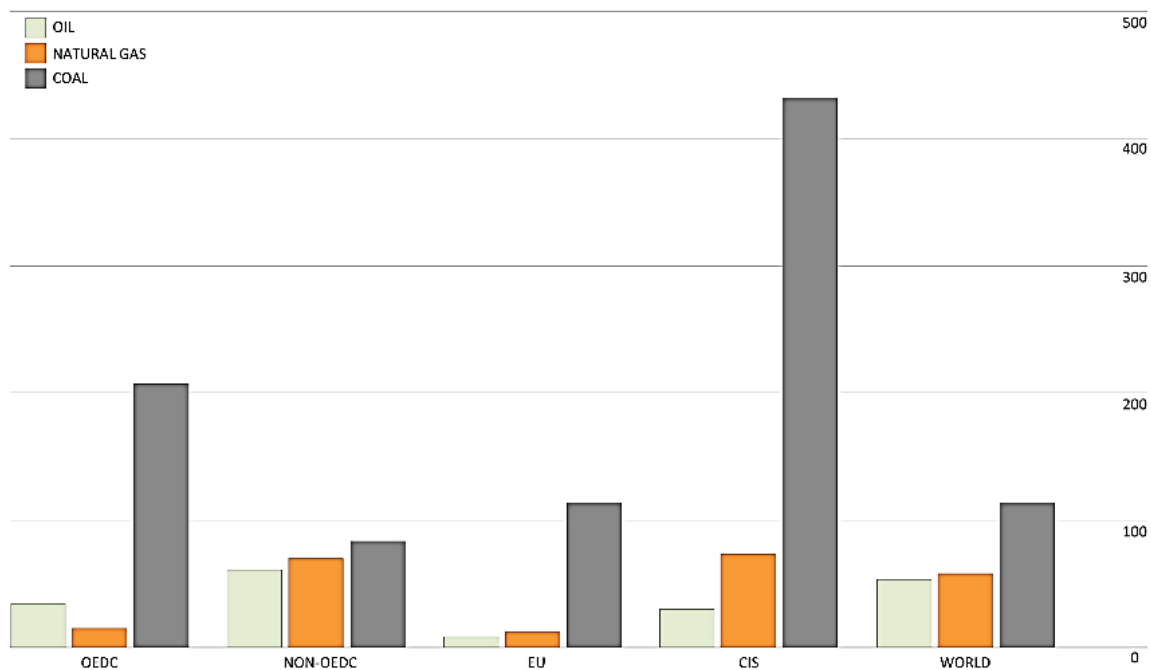
The CTO/MTO process produces olefins which can be reacted to produce polyolefins (polymers), which in turn are used to make many different plastic materials. The CTO/MTO process is used to produce ethylene and propylene, which are two of the most consumed raw materials in the petrochemical industry. Methanol can first be obtained from coal or natural gas, or it can be synthesized through CTO/MTO technology, now considered as an alternative process to the production of ethylene and propylene from petroleum.

Figure 1



Viewing the reserves to production (R/P) ratio of fossil energies, coal remains one of the largest reserves, with the Middle East and South America having the highest oil R/P ratios, while Europe and the Euro-Asian continent hold the largest coal reserves and the highest coal R/P ratio, respectively.

Figure 2: BP statistical review of world energy – 2016



All over the world, petrochemicals based on crude oil and oil field-associated gas is the mainstream. The crude oil production in the Middle East was 30.3M b/d in 2016. But coal is another way to produce chemical materials.

CTO technology produces methanol from coal instead of oil, and then to ethylene, propylene, polyolefin and other industrial chains in the downstream development. The use of CTO technology, rather than oil-based olefin technology, can reduce the over-reliance on oil resources in some poor countries, and is of great importance in promoting industrial development as well as the balanced utilization of oil-poor countries.

In the early 1980s, Mobil Corporation discovered and developed MTO processes in the study of methanol-based gasoline (MTG) processes. Mobil's fluidized

bed-based process demonstrator operated from the end of 1982 to the end of 1985, successfully demonstrating that the fluidized bed reaction system can be applied to the MTO process.

Currently, the mainstream MTO-developed technology around the world was by Honeywell International, Inc. (UOP). In 1995, UOP built a demonstration device, which ran well for 90 days with a methanol treatment capacity of 0.75 CJP tons/day.

At the end of 2008, Total Petrochemicals used Honeywell UOP-developed MTO technology to build the world's first MTO/OCP PDU in Feluy, Belgium, with a methanol capacity of 10 tons/day. Eurochem Company chose UOP MTO technology to build a 1 MTO/OCP facility in Nigeria, producing an annual capacity of 1.3 million metric tons of ethylene and propylene.

Some developing countries have large reserves of coal, while their oil and gas reserves are limited or expensive to extract; however, coal conversion presently costs more than conventional crude oil conversions. Coal conversion technologies can produce various chemicals as well as gas and liquid fuels. So far, these technologies are very limited in developing countries, and any large coal conversion project requires many coal sources for the candidates. About 12 developing countries or newly industrialized countries in four regions have a promising future in developing coal chemicals and coal-to-gas technologies. But because of the volatility and uncertainty of the investment environment, such prospects may not be realized.

1. Africa: South Africa, Mozambique, Zimbabwe

- Coal to liquid (CTL) is the most popular coal conversion technology in Africa.
- South Africa: more than 99% of coal reserves in Africa (60 billion tons) are located in the Southern African Development Community (SADC) region, and are located mainly in South Africa.
- Mozambique: coal resources are estimated at 23 billion tons.
- Zimbabwe: coal resources are estimated at 10 billion tons.

2. Asia: China, India, Indonesia, Mongolia, Vietnam

- China: matured CTO/MTO commercial operation.
- India: coal resources are estimated to be 248 billion tons. Due to the coal quality, India prefers CTG technology.
- Indonesia: coal resources are estimated to be 100 billion tons. But because of poor infrastructure and a complex regulatory environment, it makes it much harder to attract investments from overseas.
- Mongolia: coal resources are estimated to be 160 billion tons. Because of inadequate crude oil resources, a preference is to develop CTL or CTG technology.
- Vietnam: coal resources are estimated to be 210 billion tons.

3. Europe: Kazakhstan, Russia, Turkey, Uzbekistan

- Kazakhstan: coal resources are estimated to be 160 billion tons.

- Russia: coal resources are estimated to be 3.928 trillion tons. Russia has plenty of crude oil and natural gas resources. Coal is mainly used for power or export businesses.
- Turkey: coal resources are estimated to be 12 billion tons. So far, government has only started to develop CTG technology.
- Uzbekistan: coal resources are estimated to be 5 billion tons.

4. South America: Brazil

- Brazil: coal resources are estimated to be 6–7 billion tons. So far, they still mainly focus on crude oil and natural gas development.

Nurturing development in CTO technology will be an important advancement for a country that can realize its national energy strategy which encourages utilization of coal rather than oil, thus ensuring its energy security.

So far among these areas, Asia has become an important CTO/MTO market in the world because of its fast economic development and large requirement of raw chemical materials. Such a large requirement demonstrates the critical need for CTO to secure a chemical materials supply in key sectors of CTO projects and technological environments. Especially in China, there is a large scale of commercialized CTO/MTO business. We believe in the near future, perhaps because of energy diversification, other BRIC regional countries may also step up to develop CTO/MTO technology.



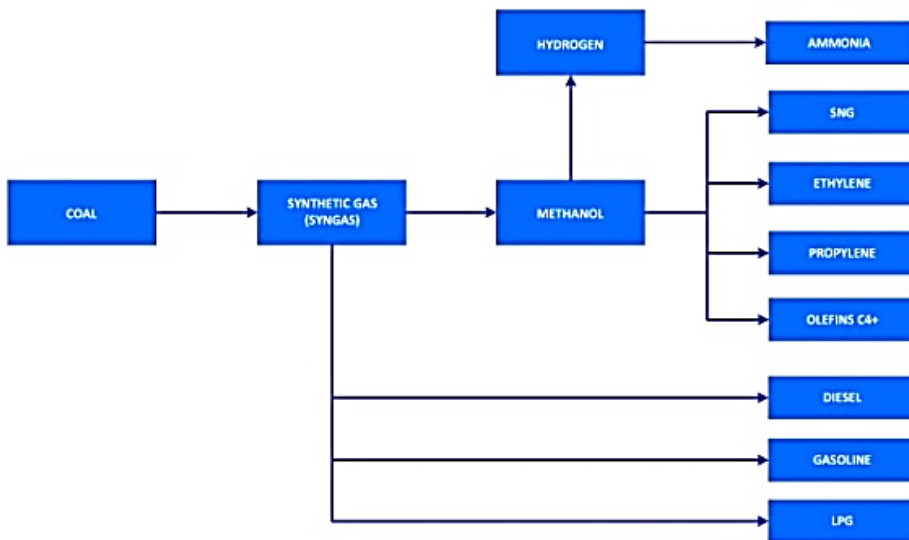
A Closer Look at CTO/MTO Processes and Technologies

The CTO process is both a high-temperature and pressure process. The coal gasification process produces CO and H₂ (synthesis gas), then the methanol is synthesized and the low-carbon olefins (ethylene and propylene) are produced by means of a fluidized bed reaction, similar to that of a catalytic cracking unit. The whole process consists of three technologies: coal-to-synthesis gas, synthesis gas-to-methanol, and methanol-to-olefins technologies.

Examples of process licensor for CTO/MTO include Shell's Pulverized Coal Gasification, GE Texaco's Coal-Water Slurry Gasification, Siemens GSP and Honeywell UOP's Methanol-to-Ethylene, etc.

At present, the key methanol-to-olefins technologies used worldwide are UOP's Methanol to Low-Carbon Olefins technology (MTO), Dalian Institute of Chemical Physics of Chinese Sciences Academy's Methanol to Low-carbon Olefins (D-MTO) technology, and China Sinopec's S-MTO technology.

Figure 3: Chemicals processed from coal



Summary:

- Approximately 1 ton of coal is needed to produce 55 mcf of syngas;
- Approximately 77 mcf of syngas is required to produce 1 ton of methanol;
- Approximately 1.4 tons of coal (feedstock) are required to produce 1 ton of methanol.

Coal Gasification (Coal to Syngas)

Coal gasification is a mature technology that is widely used, and it is also the core of the coal chemical industry. In an oxygen-deficient condition, coal is not completely burned into synthesis gas, which mainly contains CO, H₂ and CO₂, etc., and these can be used as chemical raw materials.

Syngas is synthesized from coal. It is a mixture of carbon monoxide (c.63% by volume) and hydrogen (c.27% by volume), with trace amounts of argon/nitrogen (c.7.0%), carbon dioxide (c.1.5%), sulfur-containing compounds (c.1.4%) and methane (c.0.03%). It serves as a building block for the production of olefins (ethylene and propylene). The synthesis gas from coal water slurries or dry coal dusts was partially oxidized to the synthetic gas (CO + H₂).

Presently, the main advanced coal gasification technologies — Shell's Pulverized Coal Gasification, GE Texaco's Coal-Water Slurry Gasification, Siemens GSP Pressurized Gasification and Lurgi technology, have already been widely used in many developed and developing countries, for example, the U.S., Germany, Japan, South Africa, etc.

According to the Gasification and Syngas Technologies Council, a U.S. trade association, there are globally 272 operating gasification plants, with 686 gasifiers and 74 plants, of which 238 gasifiers were constructed in 2014, mainly using coal as feedstock.

The process of the coal-to-syngas reaction is developed via two routes of technology: coal slurry gasification and dry coal gasification:

- Coal slurry route with GE Energy Texaco process
- Dry coal route with Shell, Lurgi and Siemens GSP processes

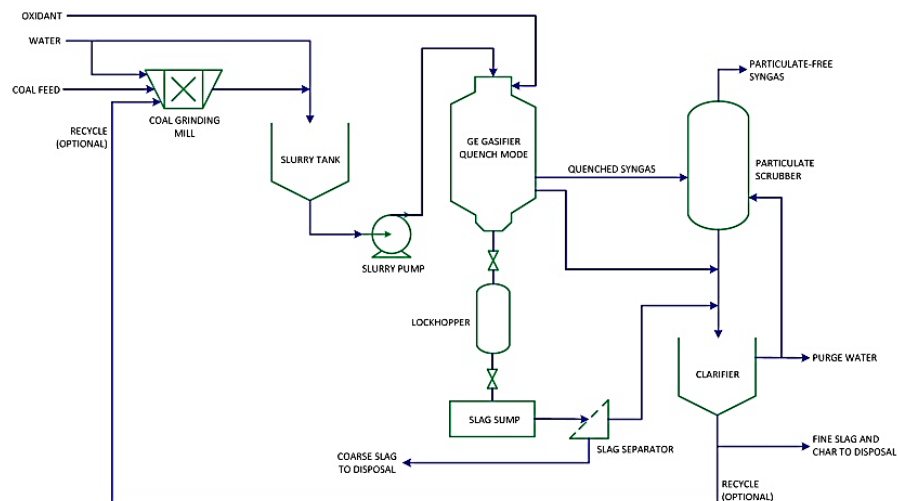
The coal slurry gasification process possesses advantages such as: it's a simple process with no environmental pollution; better coal adaptability; large production capacity; yielding good, quality high-pressure gasification synthesis gas; convenient startup/stop; and loads faster due to its simple structure of gasifier and stable operation. It accounts for a large market share around the world.

The coal slurry gasification process consists of three stages: coal water slurry production; pressurized gasification; and ash water treatment, with the gasification section being the core part of the total process.

Figure 4 is an example of the typical process for the GE Texaco technology.

The gasification furnace temperature is at 1200°C. Production scale gasification furnace will have three pressure levels at 4 MPa, 6.5 MPa and 8.5 MPa.

Figure 4: TCGP – coal, methanol to olefin (2)



Dry Coal Gasification Process

Coal power is fed into a gasifier by high-pressure N_2 gas. At a pressure of 4.1 MPa and a temperature of 1500 to 1600°C of the gasifier, a series of physical and chemical processes of volatilization, cracking, combustion and transformation is completed by coal powder and combining oxygen and water vapor. Gasification products are crude syngas.

Figures 5 and 6 depict the typical Shell technology and GSP processes.

So far only Shell, Siemens GSP, Lurgi and GE Texaco possess licensed gasification systems. All four of these coal gasification systems have proven to be effective.

Figure 5: Shell's CGP – coal, methanol to olefin (3)

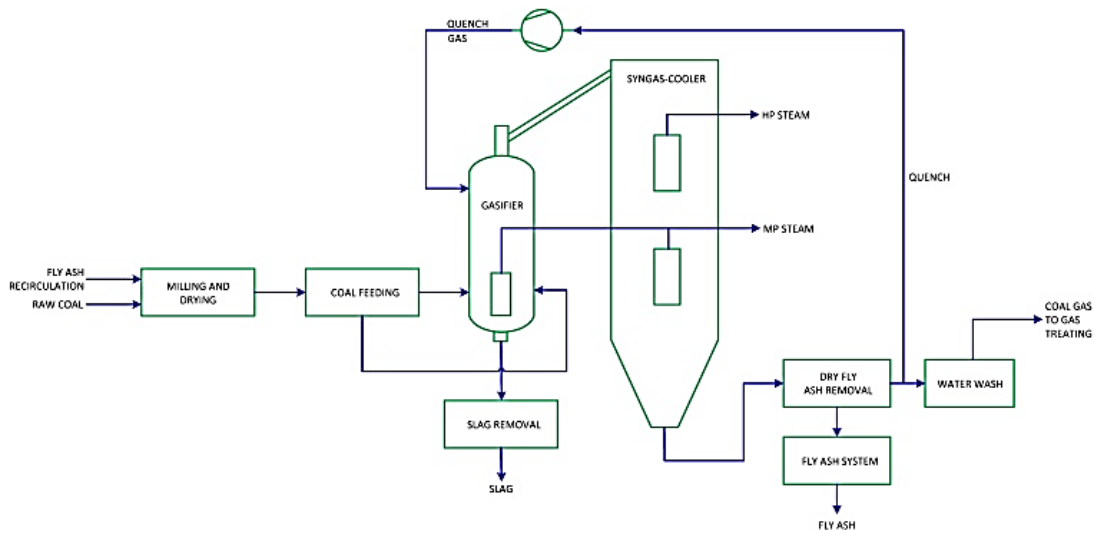
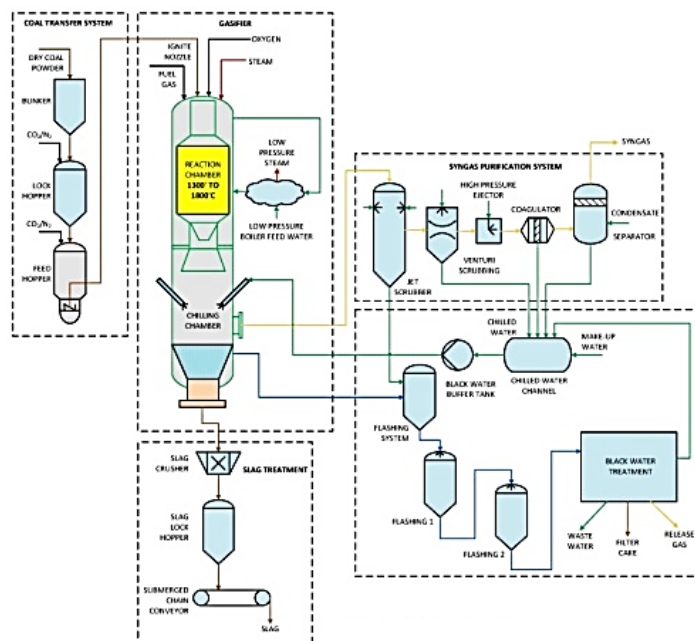


Figure 6: GSP gasification process



Conversion of Syngas Into Methanol

A methanol synthesis system includes the synthesis gas purification, methanol synthesis and methanol distillation processes.

Syngas purification: After desulphurization and decarburation, the synthesis gas produced by the coal gasification process can then remove the excess CO₂, H₂S, cosines, etc.

Methanol synthesis: The purified gas from the compressor and the circulating gas from the circulation machine are mixed and heated as they enter the methanol reactor. With the help of the catalyst, the methanol synthesis reaction obtains crude methanol. The main reactions are as follows:
 $CO + 2H_2 - CH_3OH$.

Methanol distillation: After the crude methanol enters the flash evaporating tank to obtain the refined methanol, it is then sent to a methanol distillation tower to purify the methanol.

Figures 7 and 8 depict the typical process for the conversion of synthetic gas to methanol.

The typical methanol synthesis processes used in the world are mainly Lurgi process, Germany Linde and the Mitsubishi Gas Chemical Company (MCC) process. At present, the new process of liquid phase methanol synthesis has the advantages of high investment rate, high thermal efficiency and low production cost, especially LPMEOH (liquid phase methanol synthesis) process, which has a favorable price when competing with natural gas raw materials.

Figure 7: Synthetic gas to methanol (1)

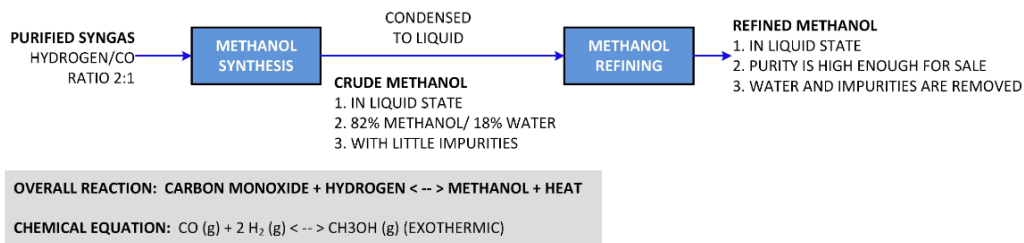
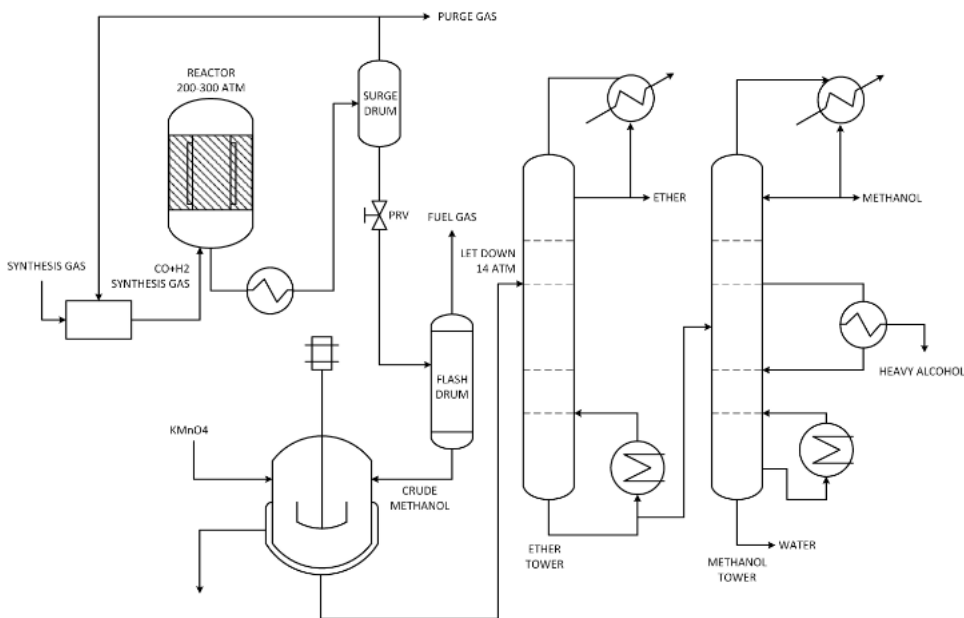


Figure 8: Synthetic gas to methanol (2)



MTO (Methanol to Olefins Process)

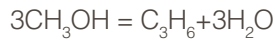
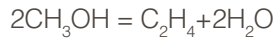
The MTO process includes reaction regeneration, quench fractionation, gas compression, flue gas energy utilization and recovery, heat reaction and heat regeneration, as indicated in Figure 9 below.

Worldwide, there are three main methanol-to-olefin technologies. All three are being used widely:

1. MTO by UOP
2. D-MTO
3. S-MTO

And, UOP is the first one to invent this technology and complete small methanol to olefins test devices.

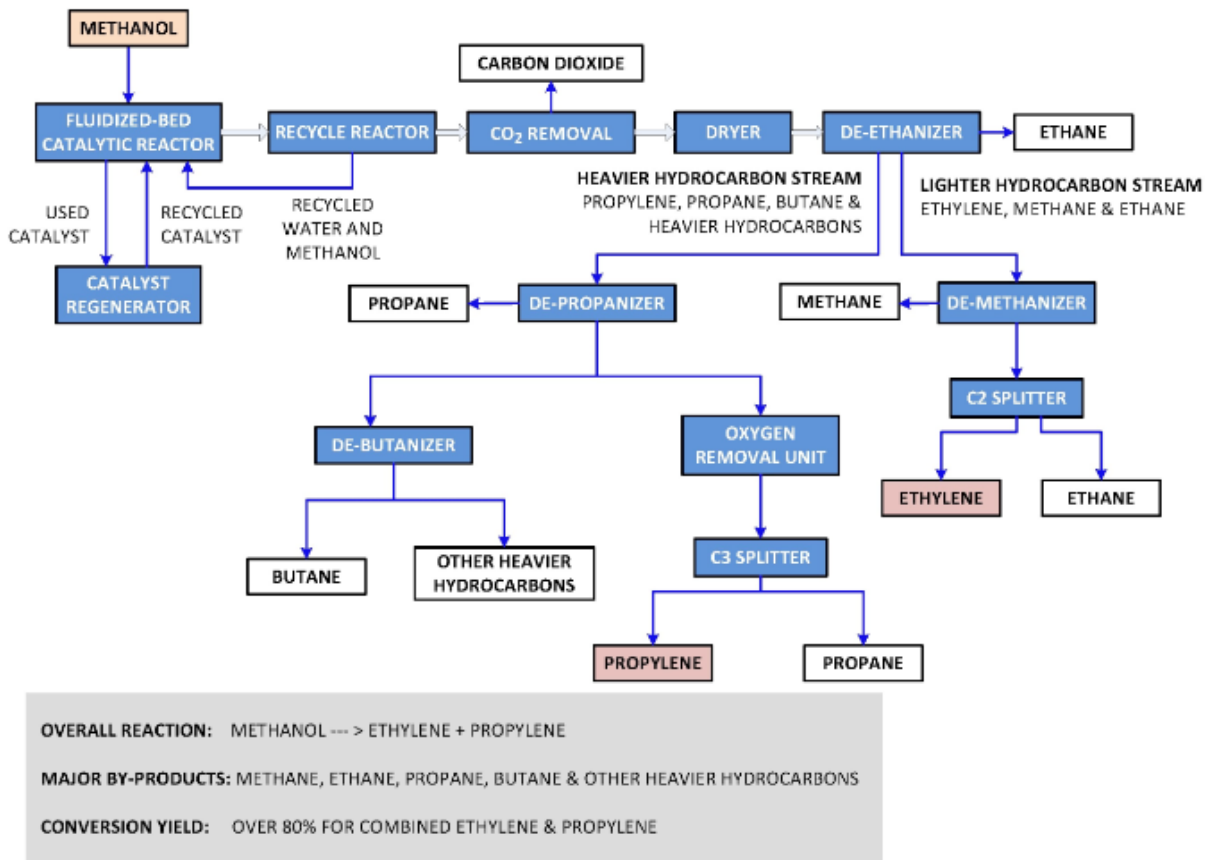
MTO:



“D-MTO” and “S-MTO” are technologies developed in China by Chinese companies/institutes. The D-MTO technology has the largest market share in China because of the government’s localization policy.

The installation reference in the Appendix includes methanol-to-olefin projects, both in operation and in the planning stage.

Figure 9: MTO process – methanol to olefin (MTO)



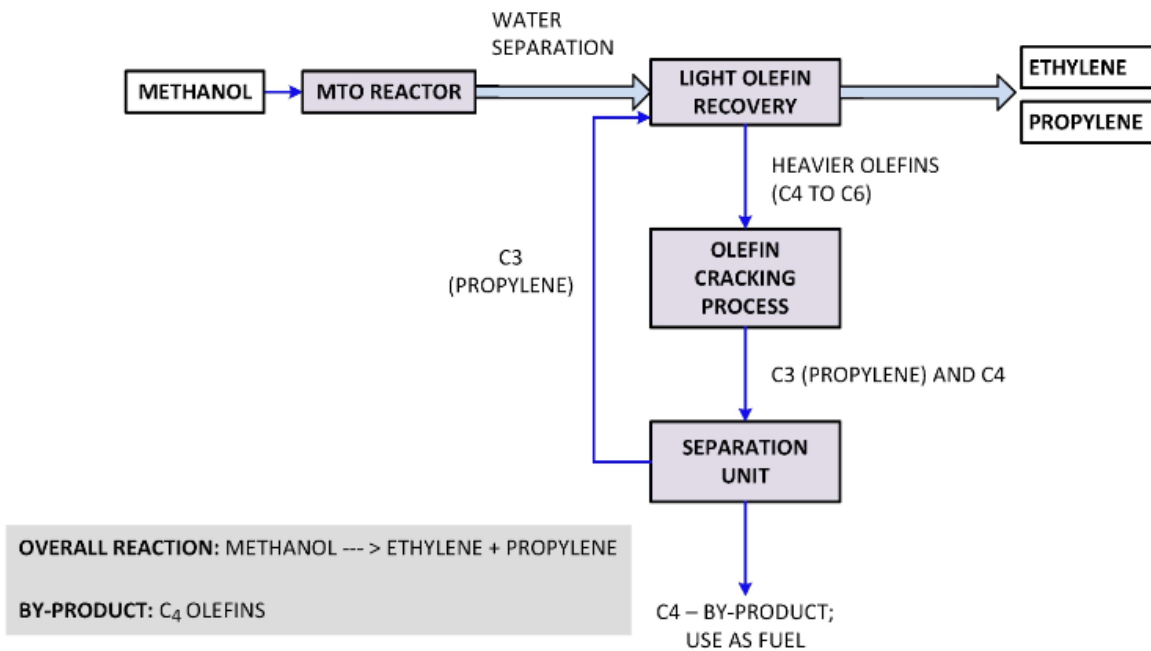
MTO by Honeywell UOP

This process produces ethylene/propylene by using methanol as the raw material and employing the use of a fluidized bed reactor. The catalyst MTO-100 is used in the reaction process to improve the conversion rate of methanol. In 1995, UOP built a demonstration unit that ran well for 90 days with methanol treatment capacity of 0.75 tons/day.

At the end of 2008, Total Petrochemicals using UOP MTO technology built the world's first MTO/OCP PDU

in Feluy, Belgium, with a total investment of 45 million euros. It would verify the reliability of its integration of process as well as magnification to millions of tons of industrial scale based on long-term operation, including methanol to olefins, olefins separation, heavy olefins cracking, olefins polymerization and polyolefin products. Since May 2010, the unit has produced high standards of polypropylene and polyethylene products. To produce one million tons of low-carbon olefins, it only needs 2.6 million tons of methanol feed.

Figure 10: MTO process by UOP



D-MTO by Dalian Institute of Chemical Physics, Chinese Academy of Sciences (DICP)

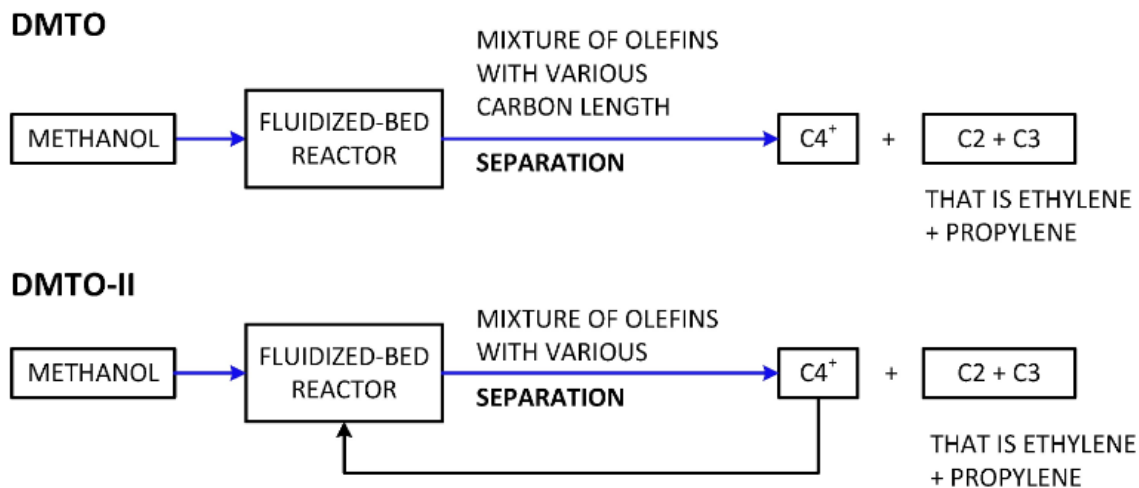
DICP, Chinese Academy of Sciences D-MTO technology takes methanol as raw materials to produce polyolefins and other high value-added chemicals from basic chemical raw materials such as ethylene, propylene and other low-carbon olefins through catalytic conversion.

SYN Energy Technology Co., Ltd. (SYN) is a Sino-foreign joint venture formed by DICP and Shaanxi Coal Industry Group and Thailand's Chia Tai Energy and Chemical Group. SYN and Luoyang

Petrochemical Engineering Corporation/Sinopec (LPEC) form a complete commercial capacity of the D-MTO technology, and they are one of the professional patented technology suppliers in the field of CTO and related fields in China and abroad.

Up to the end of 2014, a total of 20 sets of large-scale industrial installations were implemented by D-MTO technology (including DMTO-II), with a total olefin production capacity of 11.26 million tons/year.

Figure 11: DMTO/DMTO-II

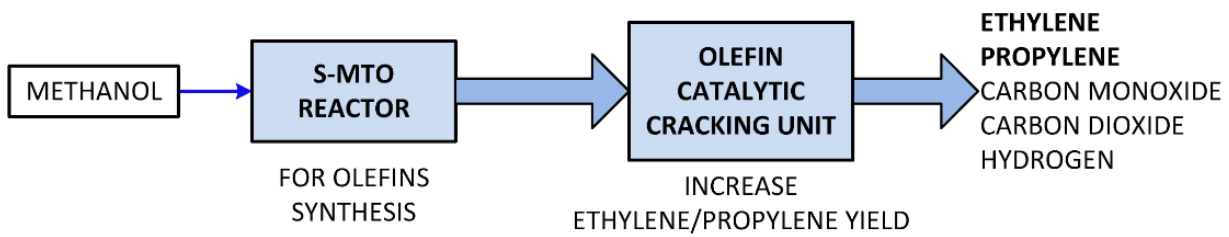


OLEFINS WITH MORE THAN 4 CARBON ATOMS WILL BE SEPARATED, COLLECTED AND FED BACK TO THE FLUIDIZED-BED REACTOR UNTIL C4⁺ (THE HEAVIER OLEFINS) FINALLY CONVERTS TO C2 (ETHYLENE) OR C3 (PROPYLENE)

S-MTO by Sinopec

Sinopec's S-MTO technology was jointly developed by Sinopec Shanghai Petrochemical Research Institute, Sinopec Engineering Construction Company (SEI) and Beijing Yanshan Petrochemical Company. In 2007, Yanshan Petrochemical Company completed 100 tons/day of methanol-to-olefins industrial test plant, and completed the 1.8 million tons of methanol feed in 2008. The catalyst was produced by the Sinopec Shanghai Branch.

Figure 12: S-MTO process by Sinopec



OVERALL REACTION: METHANOL --- > ETHYLENE + PROPYLENE
BY-PRODUCTS: CARBON MONOXIDE, CARBON DIOXIDE, HYDROGEN
PRODUCT YIELD: UP TO 85 – 87% (COMBINED ETHYLENE AND PROPYLENE)

CTO/MTO Industry Project Route to Market (RTM)

Crude oil and natural gas-based petrochemicals are common around the world. But when some countries are faced with abundant coal and oil/gas deficient situations, there would be a push to develop coal-based oil/gas substitutes.

Countries with large coal reserves but without coal conversion technologies will require huge investments for any large coal conversion project. However, due to volatility and uncertainty of the investment environment, such CTO/MTO industry is unable to be realized thus far.

In Europe, there are no known plants currently looking to use coal as the source for feedstock. The depressed oil price would make any plants expensive today, but for the longer term, it remains a potential source.

Presently in the global coal chemical industry, only South Africa and the United States have built commercial CTL and coal to SNG projects, respectively. In the new “coal chemical industry” now prominent in Asia, CTO/MTO has become well developed, especially in China, where they have huge reserves of coal but limited oil reserves. So, the justified use of coal reduces their dependence on other external sources. However, the CTO/MTO process is still more expensive than conventional petrochemical processes; as such, continued improvements and enhancers will be needed over the next few decades.

Over the past few years, China has become an important CTO/MTO market in the world, with most of the CTO/MTO projects being built in China. As such, China by default was used as an example of a typical RTM model. And, this model can be scalable to any other global CTO/MTO market in the future.

CTO/MTO plants are built under many different commercial investment scenarios involving different key buying influencers and decision makers. This section summarizes the primary project models.

Fixed Engineering Procurement and Construction (EPC) Projects

The conventional plant construction contract used by EPC is very common around the world. For CTO/MTO projects, most models are for EPC, which accounts for 70% of the market.

- EPC is a prominent form of contracting agreement in the construction industry. An engineering and construction contractor will carry out the detailed engineering design of the project, procure all the equipment and materials necessary, and then construct to deliver a functioning facility or asset to their client. Companies that deliver EPC projects are commonly referred to as EPC contractors.
- Normally, the EPC contractor has to execute and deliver the project within an agreed upon time and budget, commonly known as a Lump Sum Turn Key (LSTK) contract.
- Key EPC players in the CTO/MTO include: Wison-UOP, China Chengda, China Hualu Engineering, Sinopec Engineering Incorporation (SEI), and Sinopec Luoyang, etc.

In China, most of the owners are state-owned companies/or enterprises (SOEs). As such, in the beginning, many projects were awarded to their affiliated engineering arm within the group. However, as the market matures, all projects started to use the open-bidding process for their projects to all participating companies, in order to solicit the most competitive price with the best terms and conditions, thus exercising control over the investment budget.

Non-Engineering Procurement and Construction (Non-EPC) Projects

Non-EPC projects mostly happen in developing countries, especially in APAC, as more owners choose to execute projects on their own to reduce budgets and control costs. Such projects account for about 30% of the CTO/MTO market.

- The project is divided into separate packages. An engineering company will normally be responsible for the design only. The owner will procure all the equipment themselves. Construction is then outsourced to the contractor.
- The owner will set up a Project Management Team (PMT) to manage the whole project. The PMT will oversee the EPC contractor. The PMT will also ensure the contractor carries out the project in accordance with the agreed upon scope of works stipulated in the contract.

THE CTO/MTO INDUSTRY-FLOWSERVE INTERFACE

Business Impact and Focus Areas

The Big Picture

The global production of olefins is mostly from natural gas and oil. However, high prices and limited reserves of natural gases in certain geographical areas such as Asia and Africa have stimulated interest in unconventional feedstock for the production of olefins. Thus, coal comes across as a sustainable alternative raw material for large-scale olefin production owing to its abundance, low cost and available efficient coal gasification technology. The coal chemical industry in Africa is mainly focusing on CTL, while in Asia it is mainly focused on CTO.

The global methanol market demand is projected to reach 95 million tons by 2020, registering a CAGR of 5% between 2016 and 2020. This growth is fueled by the use of methanol as fuel in the automotive industry, increasing olefin production from MTO, and also increasing the global demand for petrochemicals. MTO as one end use of methanol accounts for 18% of the total market.

According to the “Mitsubishi Chemical report 2017”, only 2% of the world’s olefins are produced from coal. And nearly all projects are located in Asia, predominantly in China.

China had laid out an aggressive strategy for the development of its CTO and MTO industries. By 2016, the capacity achieved 12.75 million tons/year, and it is forecasted that by the end of 2020, the gross capacity will reach 16 million tons/year. The total investment for CTO/MTO during 2016–2020 is about USD10 billion.

The Flowserve Fit in the CTO/MTO Industry

CTO/MTO is one of many coal chemical processes. As the leading supplier of engineering [pumps/valves/seals](#), Flowserve can provide a wide range of products. Compared to hydrocarbon processes, CTO/MTO involves similar operating pressures and temperatures, but often with significantly more slurry liquids. The difference from normal chemical process is that CTO/MTO processes require more API standard pumps for virtually all applications in separation, conversion and treatment.

Flowserve is a leading player in the [basic chemicals industry](#), including all sub-segments of the CTO/MTO process comprised of coal to synthesis gas, synthesis gas to methanol, and methanol to olefins.

Products for the CTO/MTO Industry — At a Glance

There are many different scales for a CTO/MTO plant. The products Flowserve typically delivers for CTO/MTO projects will vary accordingly. At a high level, the Flowserve products and services offerings for CTO/MTO applications can be categorized as follows:

Pumps

Flowserve offers the industry’s most extensive line of API/ISO pumps for virtually all applications in separation, conversion and treatment. Further attesting to its capabilities, Flowserve has been a leader in the development of more specialized — even unique — pumps for proprietary processes and advanced process technologies.

Below are the key pumps for major process.

Coal gasification (coal to syngas) process:

- | | |
|--------------------------------------|----------------------------|
| • High- and low-pressure slurry pump | Hose diaphragm piston pump |
| • Burner cooling water pump | OH2 pump, HPX/ERP |
| • Bucket pump | OH2 pump |
| • Slag pump | OH2 pump |
| • Chilled water pump | OH2 pump |
| • High- and low-pressure ash pump | OH2 pump |

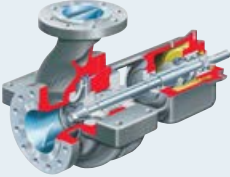
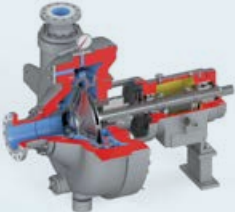

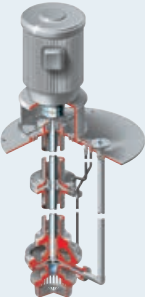

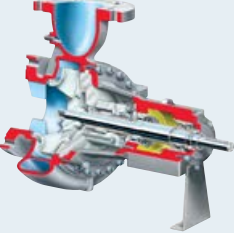
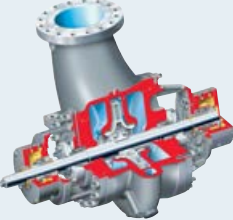



Conversion of syngas into methanol (synthetic gas to methanol) process:

- | | |
|--|------------------------------|
| • H ₂ S concentrated tower discharging pump | HDX |
| • CO ₂ absorption tower feed pump | DMX |
| • Semi-methanol pump | DMX |
| • Methanol regenerating column feed pump | HPX |
| • Methanol/water separating column feed pump | HPX |
| • Methanol regenerating column reflux pump | HPX |
| • Underground methanol pump | ESP |
| • Tail gas washing tower bottom pump | HPX |
| • Vacuum pump | LPHX/LPH/SIHI ^{dry} |

MTO (methanol to olefins) process:

• Quench tower bottom pump	HDX
• Catalyst/cocatalyst regenerator waste pump	HPX
• Quench oil pump	HDX
• Dry tower bottom pump	Mark 3™
• Separator top transport pump	HDX
• C ₂ green oil tank bottom pump	HPXM
• C ₂ green oil extraction pump	HPX
• C ₃ separator reflux pump	HDX
• C ₂ separator reflux pump	ERPNI
• Wash tower bottom pump	HDX
• Deethanizer reflux pump	HPX
• HP depropanizer reflux pump	HPX
• Demethanizer reflux pump	HPX
• Ethylene fractionator tower reflux pump	HPX
• Ethylene rectification tower side line extraction pump	HPX
• Propylene distillation tower bottom pump	HDX
• Propylene fractionator reflux pump	HDX
• Propylene fractionator bottom fluid transporting pump	HDX
• Ethylene transfer pump	WUC
• Propylene transfer pump	WUC
• Disqualified ethylene deliver pump	HPX
• Recycle ethane pump	WUC
• Demethanizer intercooler pump	HPX

Table 1





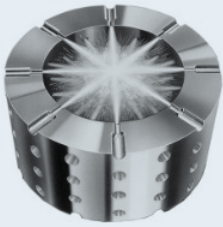



HPX	HPX 6000	DMX	ESP3	WUC
Flows to 2000 m ³ /h (8800 gpm)	Flows to 3409 m ³ /h (15 000 gpm)	Flows to 5620 m ³ /h (24 750 gpm)	Flows to 1300 m ³ /h (5700 gpm)	Flows to 500 m ³ /h (2200 gpm)
				
ERP	HDX	Durco® Mark 3 ISO	SIHI Vacuum Pump	SIHI ^{dry}
Flows to 1100 m ³ /h (4800 gpm)	Flows to 4100 m ³ /h (18 000 gpm)	Flows to 1400 m ³ /h (6160 gpm)	Flows to 10 700 m ³ /h (4800 gpm)	Flows to 1000 m ³ /h
				

Valves

There may be more than 10 000 valves in a typical CTO/MTO plant. A large share of these is small, general service valves, which are not discussed in this guide. Flowserve targets the severe service and control valve applications. These account for as much as 20% of the total valve capital budget, even though the quantity of valves may be fairly small. Typical Flowserve valves used in the different streams of CTO/MTO process are as follows:

• Oxygen valve	Valtek® Mark One™
• Black water valve	Valtek Survivor
• Gray water valve	Valtek DiamondBack
• Syngas/steam vent valve	Valtek Mark One
• Quench water valve	Valtek Mark One
• Oxygen on-off valve	Argus™ FK76
• Nitrogen on-off valve	Argus FK76
• Lock-hopper, on-off valve	Argus FK76
• Slurry on-off valve,	Argus FK76
• Black/gray on-off water valve	Argus FK76
• Rectisol device control valve	Valtek Mark One
• Rectisol device on-off valve	Argus FK76
• Refrigerating station control valve	Valtek Mark One
• Compressor cutoff valve	Argus FK76
• Pneumatic on-off valve	Argus FK76

Table 2



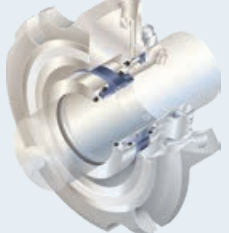
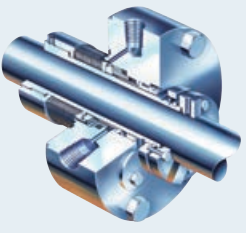

Argus FK76	Survivor	Valtek Mark One	Valtek Mark 100
Size: DN 65 to 900 mm (DIN); NPS 2½ in to 36 in (ASME)	Size: DN 25 to DN 350; 1 in to 14 in	Size: DN 15 to DN 915; 0.5 in to 36 in	Size: DN 150 to DN 750; 6 in to 30 in
			
CavControl	DiamondBack	Automax™ RG Series Heavy-Duty Actuator	Limitorque® MX
Size Range: 1 in to 24 in	Size Range: 1.5 in to 36 in	Torque Rating Range: up to 248 000 Nm (2.2 million in-lb)	Torque Rating Range: From 20 to 1700 ft lbs output torque
			

Seals

For chemical process applications, high-temperature, heat transfer oil, acid and caustic chemical services, shaft mechanical seal solutions along with the appropriate piping plans are selected to enable longer and trouble-free operations or mean time between failure (MTBF)/or planned maintenance (MTBPM). Flowserve mechanical seals are not only used in Flowserve pumps, but also in other pump brands, as per purchaser's specifications. Almost all of the known operational conditions can be handled with the following sealing solutions:

- UHTW/DHTW: Custom designed cartridge seals for heavy-duty pumps, especially high-pressure conditions.
- QBW/QBW: API 682 Type A Category 2 and 3, conventional pusher seals for the conversion of syngas into methanol (synthetic gas to methanol) process and rectisol device.
- ISC2-682: API 682 Type A Category 1, standard cartridge seals normally used for general applications with cost competition.
- BRCS: Welded metal bellows seals are exceptionally robust and designed for high-temperature hydrocarbons, heat transfer fluids and severe services in hydrocarbon processing plants. The BRC series is fully compliant with API 682 Type C requirements and features thick-plate Alloy 718 bellows convolutions for superior NACE corrosion resistance.
- BXRH/BXHH: Provide sealing capability at extreme temperatures in challenging petrochemical services. When pumping services push beyond the temperature limits of elastomers, BXHHS and BXRH seals offer reliable sealing in both single and dual seal configurations. BXHHS and BXRH seals are fully compliant with API 682 Type C requirements.

Table 3

UHTW/DHTW	QB	ISC2	BRCS	BXRH/BXHH
Pressure up to 207 bar (3000 psi)	Pressure up to 51.7 bar (750 psi)	Pressure up to 20.6 bar (300 psi)	Pressure up to 20.7 bar (300 psi)	Pressure up to 20.7 bar (300 psi)
				

FLOWSERVE OPPORTUNITIES IN THE CTO/MTO INDUSTRY — PRODUCTS AND CAPABILITIES

Flowserve Products and Capabilities in Coal Gasification (Syngas)

Overview

The gasifier is one of the most important pieces of equipment for coal-to-chemical projects, as it converts coal to syngas. So far, there are key two methods of coal gasification. Although the processes/technologies differ, the output is roughly the same.

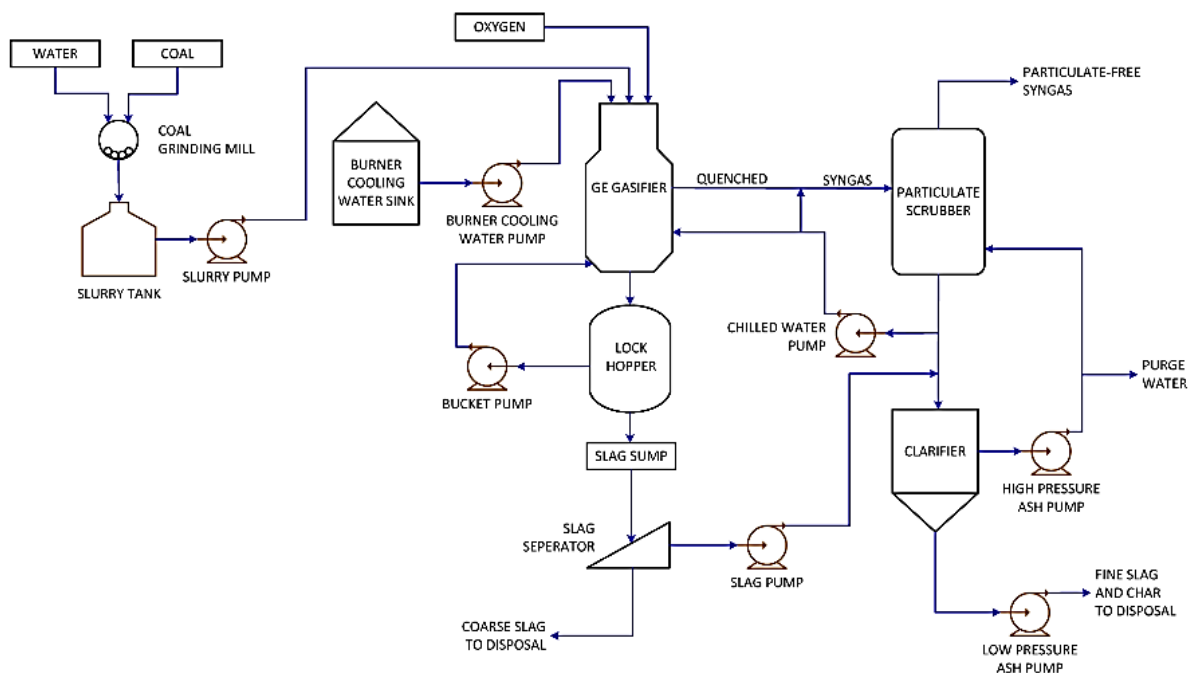
Coal Slurry: The coal slurry is fed into the gasifier. This main technology is from the GE Texaco process.

Dry Coal: Dry coal is pulverized in a milling unit and fed into a gasifier. The main technology is from Shell Coal Gasification Process (SCGP), Lurgi process and Siemens GSP process.

There is more pumping equipment used in the coal slurry gasification process, except that high- and low-pressure slurry pumps are not used in the dry coal process; other pumps in dry coal gasification are similar to those used for the coal slurry application.

Next, the GE Texaco process will be cited as an example for demonstration. Figure 13 shows a typical coal slurry gasification technology road map. The gasification furnace temperature is at 1200°C. According to the production scale and procedure requirements, the gasification pressure of the gasifier will normally use three levels of pressure: 4.0 MPa, 6.5 MPa and 8.5 MPa.

Figure 13: GE energy gasification process (coal slurry)



Products

Pumps

The key pumps used in coal gasification include the following services:

- High- and low-pressure slurry pump Hose diaphragm piston pump
- Burner cooling water pump OH2 (API 610) pump (HPX/ERP)
- Bucket pump OH2 (API 610) pump
- Slag pump OH2 (API 610) pump
- Chilled water pump OH2 (API 610) pump
- High- and low-pressure ash pump OH2 (API 610) pump

From pulping to gasification, the critical pumps in the unit are the high- and low-pressure coal slurry pumps. A low-pressure coal slurry pump is important for the preparation of coal slurry. It sends coal slurry from the coal mill into the coal slurry tank. The centrifugal double-shell slurry pump is applicable. A high-pressure coal slurry pump is the key equipment of coal gasification. Its function is to pressurize the coal water and send it to the gasifier. At present, for high-pressure coal slurry pump, “Hose diaphragm piston pump” is most suitable and widely used; however, this is not within the Flowserve product range.

Other key pumps used in the coal gasification process include burner cooling water pump, bucket pump, slag pump, low-pressure ash pump, high-pressure ash pump, etc.

Burner cooling water pumps send cooling water to the nozzle jacket, cooling the nozzle. In general, the standard chemical process pump is chosen for this service.

Bucket and chilled water pumps guarantee the safe and stable operation of the coal gasifier in the coal-water slurry gasification process. Bucket pumps return the water from the lock tank to the gasifier. Chilled water pumps return the water from the carbon scrubber to the gasifier. The two pumps have common characteristics: high water pressure; high working temperature; and transportation of water which contains a small amount of solid particles; as such, high-pressure resistant and wear resisting are key success factors. At present, single-stage cantilever centrifugal pumps generally use dual-phase steel material.

Slag pumps draw water and ash from a slag pool. The scouring of ash and other corrosive substances will accelerate wear, so Ni-hard material is usually used for double-shell slurry pumps.

High-pressure gray water pumps send gray water from a gray water tank to the carbon scrubber through the flash heat exchanger. Due to the duty condition with mass flow and high head and liquid with a certain amount of ash, multi-stage axially split centrifugal pump is preferred.

Valves

Key valves used in coal gasification include the following services:

Control Valves

- Oxygen valve/special material (Inconel or Monel) Valtek Mark One
- Black water valve/high flashing valve/Survivor Valtek Survivor
- Pump gray water/Multi-Z/globe valve Valtek DiamondBack
- Syngas or steam vent valve Valtek Mark One
- Quench water valve (high-pressure globe valve) Valtek Mark One

ON/OFF Valves

- Oxygen on-off valve/special material (Inconel or Monel) Ball valve Argus/FK76
- Nitrogen on-off valve Ball valve Argus/FK79
- Lock hopper on-off valve Ball valve Argus/FK76
- Slurry on-off valve Ball valve Argus/FK76
- Black/gray on-off water valve Ball valve Argus/FK76

With reference to Figure 14, an oxygen control valve in a gasifier has three valves, which have different roles: the main line of oxygen control valve, the oxygen vent valve, and the central oxygen control valve.

The most critical valve is the central oxygen control valve, which requires precise regulation to control the flow of oxygen into the gasifier in order to achieve a reasonable ratio of oxygen, steam and coal in the gasifier. It is necessary to achieve full reaction and the best synthesis gas production rate. The working condition is mainly oxygen, easy to deflagration, so that the material of valve and the adjustment accuracy requirements are high. The main product is Mark One series globe control valve.

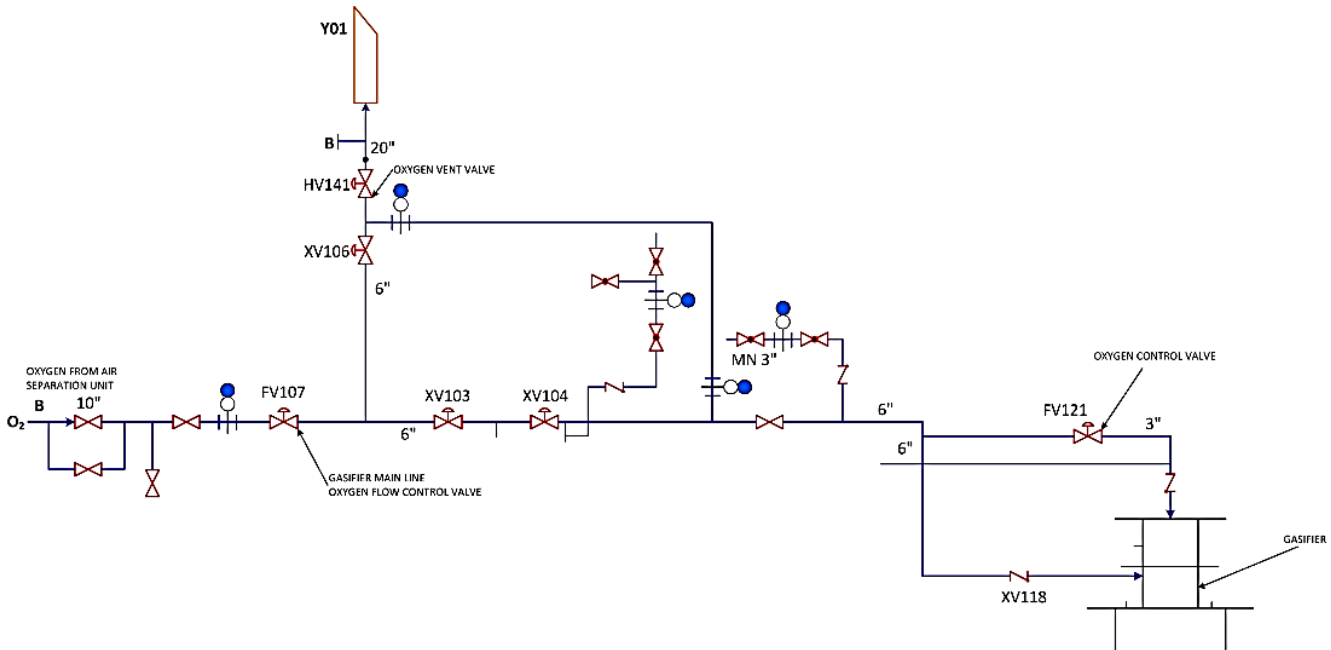
Oxygen on-off valves are widely applied in the GE Texaco and Shell coal gasification process (SCGP).

They are used to quickly cut off or open in the oxygen pipeline or purge line. As the medium is oxygen, which itself has a combustible characteristic, when the valve leaks, it can easily lead to burning, or even explosion. Requirements for oxygen ball valve sealing performance, switching time, material selection and service life and other performance are very strict.

Nitrogen shut-off valves are used in coal gasification devices, and are controlled by a gasification furnace safety interlock system. A gasification furnace oxygen pipeline will be automatically cut off by a nitrogen shut-off valve when shut down or in the event of a breakdown, then use high-pressure nitrogen to purge and protect the oxygen pipeline.

Coal slurry switch valves are used to quickly cut off or open coal gasification coal slurry pipes.

Figure 14: Valve application in gasification process (coal slurry)



With reference to Figure 15: a high-pressure black water flash angle valve is used to reduce the black water pressure in the wash tank and quench chamber, and initially separate the gaseous components, solid particles and water, in order to achieve further purification and recovery of the water. The valve application conditions are characterized by: large pressure differential, high flash ratio, large fixed particles, the valve erosion and abrasion is very high. The main product is the Survivor series angle valve.

A synthesis gas venting control valve is used to adjust the pressure of the synthesis gas scrubber. It is fully closed during normal operation, and only when commissioning, it sets the pressure of the washing tower to normal operating pressure. The main application of the valve is characterized by large pressure differential, large flow, noisy, while the media contains fixed particles. The main product is Mark One/Mark 100 large-diameter control valve.

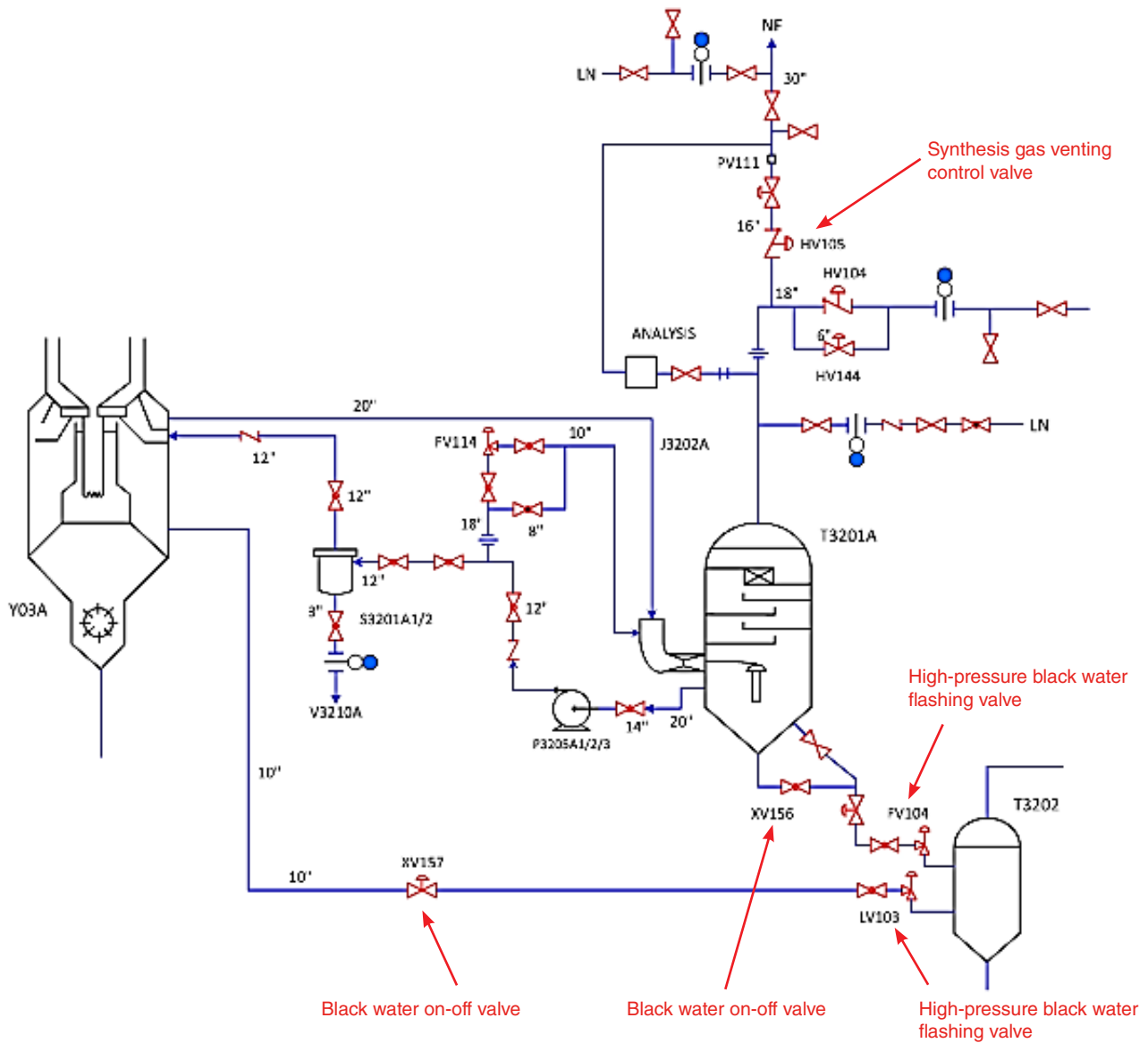
A gray water pump return valve is mainly used to ensure the normal operation of the gray water pump during the startup stage. The main features of the conditions are large pressure differential, serious

cavitation, while the media contains a large number of solid particles. The main products are Multi-Z or DiamondBack adjustment angle valves.

Each gasifier sets up three lock hopper valves; there are two lock hopper valves on the entrance side of the locked hopper. The first lock hopper valve is controlled by the program and switches every 30 minutes, and the second lock slag valve is normally open for standby. Low liquid level of shock chamber in the gasifier will cause gasification furnace security system interlocking action, and the No.1 lock valve will also be interlocked to prevent the gasifier gas flow into the lock system. The lock bucket discharge port also has one lock hopper valve, commonly known as the lower lock hopper valve. The lock hopper valves participate in the slagging control of the gasifier. It is directly abraded by the high-temperature and high-pressure ash, and the switch is frequently required to achieve the bi-direction seal in the high-pressure differential.

A black/gray water switch valve is used to cut off or open the gasification and slag water treatment pipeline.

Figure 15: Valve application in gasification process (coal slurry)



Seals

The key seals used in coal gasification are below.

UHTW/DHTW:

- Custom engineered for specific applications in high-energy pumps such as boiler feed process barrel pumps
- Available anti-electrical corrosion features for ultra-high purity boiler feed water
- Extra heavy-duty face geometry and drive features suitable for high torque, high pressure and high speed
- Dual-seal arrangement available for robust applications where leakage and emissions control are critical
- Applications include: hydrocarbons, CO₂, boiler circulation, pipelines, etc.

BXRH/BXHH:

- Standard anti-coke device helps keep atmospheric side clean
- Distortion-free face design maintains face flatness throughout operating range
- Extended travel bellows core allows for extreme linear shaft growth, typical in high-temperature pumping

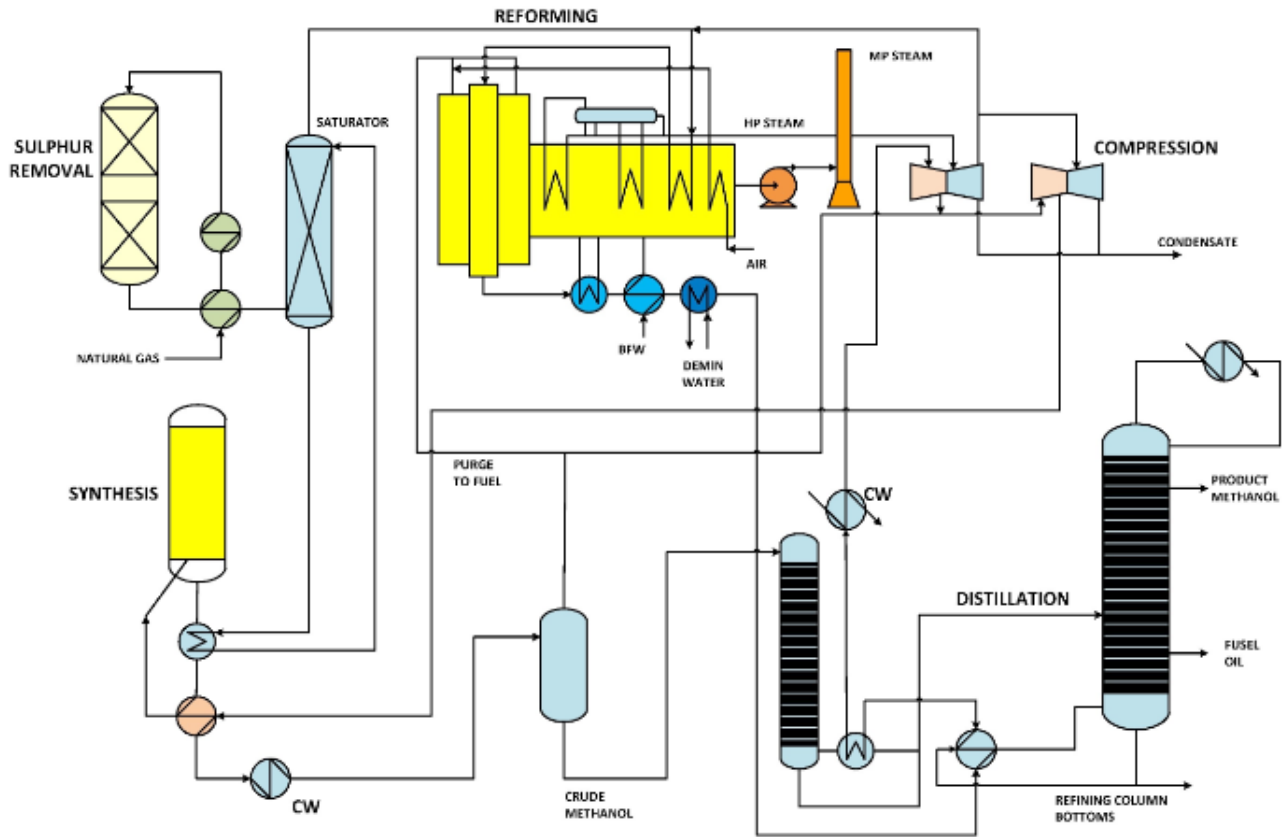
The detailed data are shown in the next section.

Flowserve Products and Capabilities in Conversion of Syngas Into Methanol

Overview

A methanol synthesis system mainly includes synthesis gas purification, methanol synthesis, methanol distillation, etc.

Figure 16: Methanol synthesis system



Products

Pumps

The key pumps used in a methanol synthesis system where Flowserve pumps can serve include the following services:

• H ₂ S concentrated tower discharging pump	HDX	2 sets
• CO ₂ absorption tower feed pump	DMX	2 sets
• Semi-methanol pump	DMX	2 sets
• Methanol regenerating tower feed pump	HPX	2 sets
• Methanol/water separating tower feed pump	HPX	2 sets
• Methanol regenerating tower reflux pump	HPX	2 sets
• Underground methanol pump	ESP2	2 sets
• Tail gas washing tower bottom pump	HPX	2 sets
• Vacuum pump	LPHX/LPH/Type SIHI ^{dry}	

Syngas purification is the most important stage in the process. There are two technical process: Linde and Lurgi processes.

Germany's Linde process will be cited as an example for introduction.

Germany's Linde process-supporting pumps are: H₂S concentrated tower discharging pump, H₂S concentration tower feed pump, methanol regenerating tower feed pump, methanol pump, semi-methanol pump, methanol/water separating tower feed pump, methanol regenerating column reflux pump, underground sewage methanol pump, and tail gas washing tower bottom pump.

- H₂S concentrated tower discharging pump: -70°C, the medium is methanol, high pressure of inlet pressure, low temperature, medium toxicity. Choose the low-temperature, single-stage centrifugal pump (FLS: HDX).
- CO₂ absorption tower feed pump: -60°C, the medium is methanol, high flow rate, low temperature, medium toxicity, corrosion resistant. Choose the low-temperature centrifugal pump (FLS: DMX).
- Methanol regenerating tower feed pump: -60°C, the medium is methanol, high flow rate, low temperature, toxicity of medium, corrosion resistant. Choose the low-temperature, single-stage centrifugal pump (FLS: HPX).

- Semi-methanol pump: high flow rate, high head, high outlet pressure, severe seal, high power. Choose a multi-stage pump with high power motor. (FLS: DMX)
- Methanol/water separating tower feed pump: the medium is methanol, toxicity of medium. Choose a corrosion-resistant, single-stage centrifugal pump (FLS: HPX).
- Methanol regenerating tower reflux pump: high temperature, the medium is methanol, high flow rate, low temperature, toxicity of medium. Choose a corrosion-resistant, high-temperature, single-stage centrifugal pump (FLS: HPX).
- Underground methanol pump: -60 to -50°C, the medium is methanol. Choose a corrosion-resistant, low-temperature, single-stage vertical sump centrifugal pump (FLS: ESP2).
- Tail gas washing tower bottom pump: Choose a corrosion-resistant, single-stage centrifugal pump (FLS: HPX).

The above pumps are requested for API standard. The material of cryogenic pump is requested by 316SS or 304SS austenitic stainless steel.

Valves

There is no critical service application for valve products and customer has no specific requirement. So Tier 2 and 3 products are very common in this process. A common range of Flowserve control and ON/OFF valves is below:

Rectisol Device in Syngas Purification

- Control valve Valtek Mark One
- On/off ball valve Argus/FK76

Methanol Synthesis and Refrigerating Station Device

- Control valve Valtek Mark One
- Compressor cut-off valve Argus/FK76
- Pneumatic on/off valve Argus/FK76

Methanol Distillation Device

- Control valve Valtek Mark One
- Pneumatic on/off valve Argus/FK76

The detailed technical data is shown in the next section.

Seals

The recommended pump seal is a double-tandem welded metal bellows cartridge mechanical seal with suitable flush piping plan. Detailed data is shown in the next section.

Type QB

- Extremely robust to reverse pressurization service conditions; reverse pressure handling capabilities far exceed conventional balanced seals.
- Welded keys drive rotating seal face, providing robustness to high torque scenarios.

Type BRCS

Welded metal bellows seals are exceptionally robust and designed to seal high-temperature hydrocarbons, heat transfer fluids and severe services in hydrocarbon processing plants.

- Alloy 718 heat-treated bellows and end adapters provide the highest resistance to stress corrosion cracking.
- Applications include cryogenic, corrosive, hydrocarbons and heat transfer fluids.
- Canned face design eliminates shrink fit distortions.

Flowserve Products and Capabilities in MTO

Overview

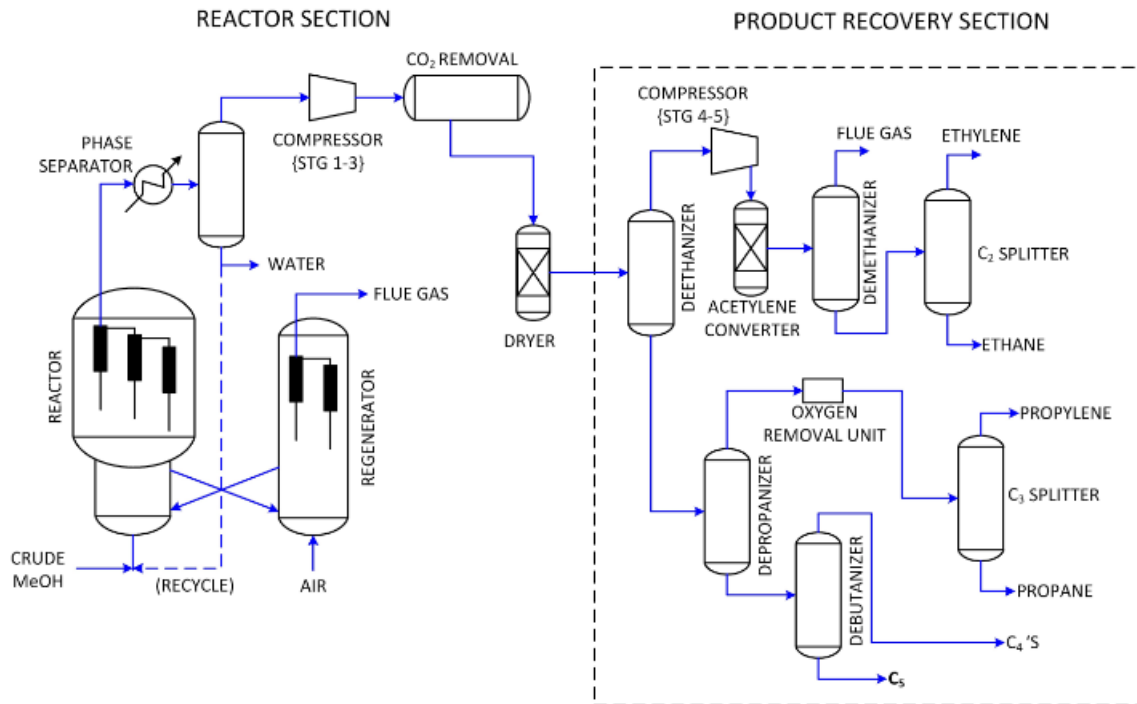
The overall process of MTO mainly includes reaction regeneration, quench fractionation, gas compression, flue gas energy utilization and recovery, reaction heat, regeneration heat, etc. UOP was the first company to design and implement the MTO process. After that, other companies adopted this technology and further developed their own process. Thus far globally, three main companies have licensed methanol-to-olefin technologies; all three are currently being used in commercial operation:

1. MTO by UOP
2. D-MTO by Dalian Institute of Chemical Physics
3. S-MTO by Sinopec

Normally, an MTO process is comprised of two parts: reactor section and product recovery section.

In the reactor section, methanol is converted into olefins by a fluidized bed reactor, then the products go to the product recovery section for light olefin recovering. The primary products are ethylene and propylene, and the by-products are butane, C₅ composition and fuel gas.

Figure 17: UOP-MTO process



Products

Pumps

There are more than 100 pumps used in the MTO process. Depending on different operating conditions, some pump services include large flow and high head, cryogenic, high-temperature or high-pressure applications. Considering the stability and security of the operation, ¼ of the pumps are identified as Tier 1 products that Flowserve can serve. The following pumps are often provided by Flowserve for MTO processes:

Part 1:

• Quench tower bottom pump	HDX	2 sets
• Catalyst/cocatalyst regenerator wastewater pump	HPX	2 sets
• Quench oil pump	HDX	1 set
• Dryer tower bottom pump	Mark 3	2 sets
• Separator top transport pump	HDX	2 sets

Part 2:

• C ₂ green oil tank bottom pump	HPXM	2 sets
• C ₂ green oil extraction pump	HPX	2 sets
• C ₃ separator reflux pump	HDX	2 sets
• C ₂ separator reflux pump	ERP	2 sets
• Wash tower bottom pump	HDX	2 sets
• Deethanizer reflux pump	HPX	2 sets
• HP depropanizer reflux pump	HPX	2 sets
• Demethanizer reflux pump	HPX	2 sets
• Ethylene fractionator tower reflux pump	HPX	2 sets
• Ethylene rectification tower side line extraction pump	HPX	2 sets
• Propylene distillation tower bottom pump	HDX	2 sets
• Propylene fractionator reflux pump	HDX	2 sets
• Propylene fractionator bottom fluid transporting pump	HDX	2 sets
• Ethylene transfer pump	WUC	2 sets
• Propylene transfer pump	WUC	2 sets
• Disqualified ethylene deliver pump	HPX	1 set
• Recycle ethane pump	WUC	2 sets
• Demethanizer intercooler pump	HPX	2 sets

Most of the reactions in the separation unit require low-temperature and high-pressure conditions. Those pumps are also required to comply with API standards.

Valves

There is no critical service application for valve products and customers have no specific requirements. So Tier 2 and 3 products are very common in MTO processes. A common range of Flowserve control and ON/OFF valves is below:

- Control valve Valtek Mark One/FlowTop
- On/off valve Argus/FK76

Detailed technical data is shown in the next section.

Seals

Depending on the type of pumps used in the MTO process, QB Series and ISC2-682 are the recommended products for the various applications. Detailed data is shown in the next section.

QB:

- Welded keys drive rotating seal face, providing robustness to high torque scenarios.

ISC2-682:

- Designs are built on ISC2 seal basic components, sharing the benefits of thermal management technology, volute groove design and Alloy C-276 bellows.
- Built for general duty refinery and chemical plant services

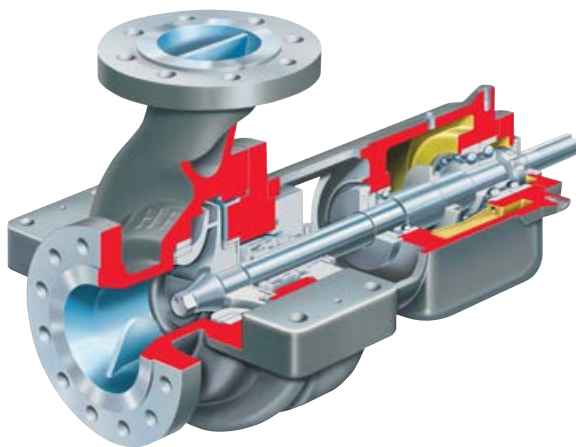
Flowserve Products for CTO/MTO Processes

Pumps

The Flowserve HPX pump meets or exceeds the rigorous requirements of ISO 13709/API 610 (OH2) latest edition. Engineered and built for reliable, safe performance, it also provides optimal emissions containment. Further, the HPX represents the most comprehensive range of hydraulic coverage available to the industry, thereby permitting precise selection for best operating efficiency.

Operating Parameters

- Flows to 2000 m³/h (8800 gpm)
- Heads to 350 m (1100 ft)
- Pressures to 80 bar (1160 psi)
- Temperatures from -160 to 450°C (-250 to 842°F)



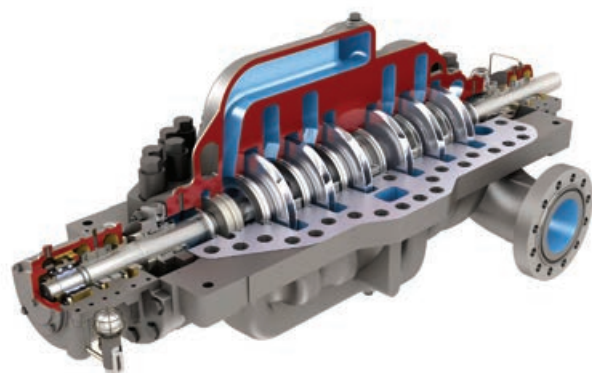
HPX

Fully compliant with ISO 13709/API 610, latest edition, the Flowserve DMX is a horizontal, multistage, axially split, near centerline mounted pump. With more than 10 000 units supplied, the DMX is the first choice of users for applications involving high-flow, high-pressure movement of water, hydrocarbons, CO₂ and other process liquids.

Available in numerous sizes, hydraulics and material combinations, DMX pumps are particularly well suited for use in process charge, pipeline and injection services where uncompromising reliability over wide flow ranges is of utmost importance.

Operating Parameters

- Flows to 5620 m³/h (24 750 gpm)
- Heads to 2620 m (8600 ft)
- Pressures to 275 bar (4000 psi)
- Temperatures to 204°C (400°F)
- Speeds to 6000 rpm
- Specific gravities down to 0.35

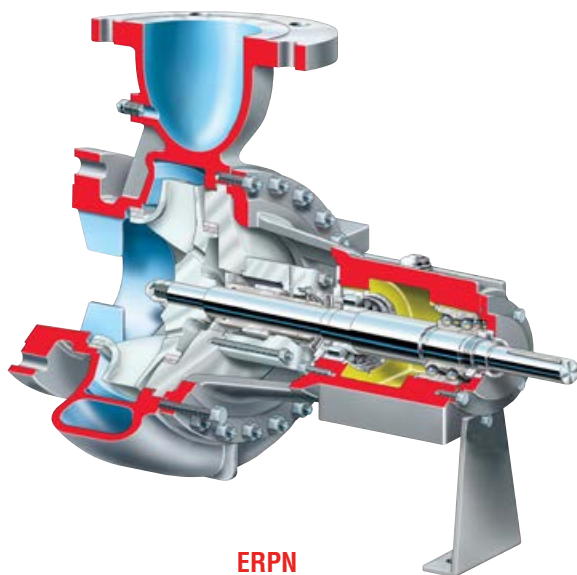


DMX

The ERPN is the pump of choice for severe chemical, petrochemical, refining and heavy-duty industrial services where deviations to API 610 are accepted. This pump provides users with the important mechanical, hydraulic, emissions control and safety components required by the latest ISO 13709/API 610 standards.

Operating Parameters

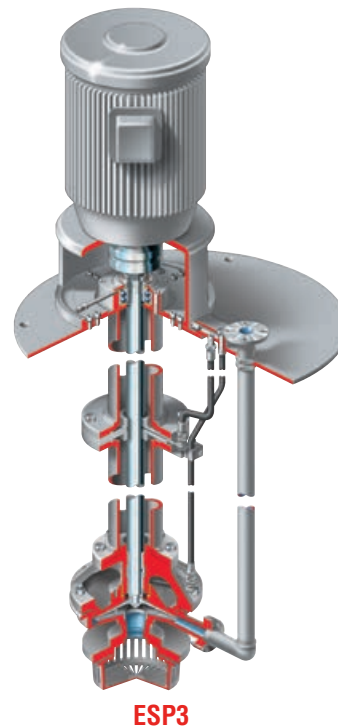
- Flows to 1100 m³/h (4800 gpm)
- Heads to 230 m (750 ft)
- Pressures to 60 bar (870 psi)
- Temperatures from -50 to 350°C (-58 to 660°F)



Boasting the same casing, reverse vane impeller and CBL cover as the industry-leading Durco Mark 3 chemical process pump, the ESP3 is ruggedly built to handle tough applications. It is the only vertical wet-pit immersion sump pump to offer parts interchangeability with standard ASME B73.1 horizontal pumps, increasing parts standardization and reducing inventory costs.

Operating Parameters

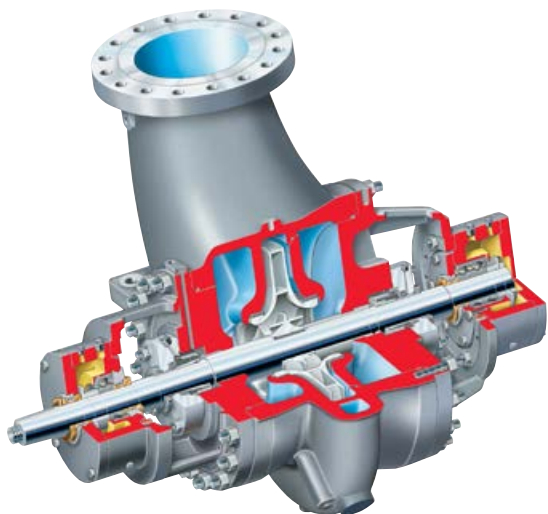
- Flows to 1300 m³/h (5700 gpm)
- Heads to 116 m (380 ft)
- Pressures to 12 bar (175 psi)
- Temperatures to 180°C (350°F)



HDX pumps complement flow and pressure requirements between overhung and multistage process pump lines for high-temperature applications. These top suction, top discharge, between bearings, centerline mounted pumps are fully compliant with ISO 13709/ API 610 (BB2).

Operating Parameters

- Flows to 4100 m³/h (18 000 gpm)
- Heads to 450 m (1500 ft)
- Pressures to 42 bar (610 psi);
100 bar (1450 psi) with HDX-H model
- Temperatures to 450°C (842°F)

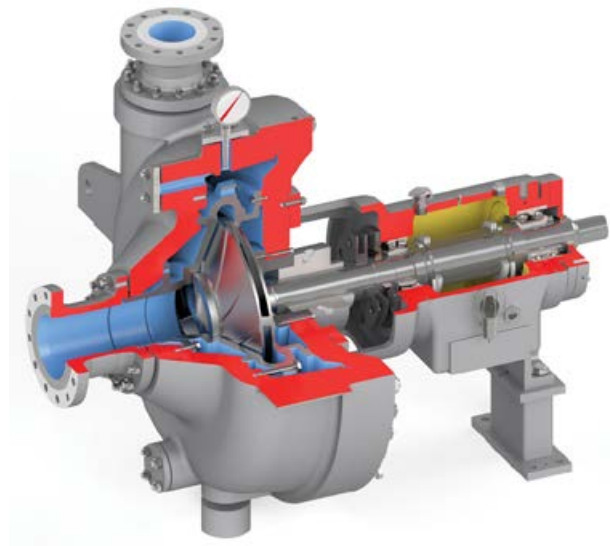


HDX

The HPX 6000 is high-temperature process slurry pump for API 610 applications. It is a double-walled pump, where the outer casing manages the pressure and the internal liners are made from erosion-resistant material that provides long life. The impeller is also made from the same erosion-resistant material and is a true slurry design with repelling vanes in place of wear rings.

Operating Parameters

- Flows to 3409 m³/h (15 000 gpm)
- Heads to 244 m (800 ft)
- Pressures to 83 bar (1200 psi)
- Temperatures to 426°C (800°F)



HPX 6000

Liquid ring vacuum pumps of the LPHX/LPH series are two-stage displacement pumps with a simple but robust construction.

Operating Parameters

- Flows to 10 700 m³/h
- Shaft sealing: stuffing box, mechanical seal
- Materials: gray cast iron, stainless steel



SIHI LPHX

SIHI^{dry} is a vertically oriented and self-draining vacuum pump with no mechanical shaft seals. It is an ideal choice for chemically related processes where there is a high possibility of liquids or solids carry-over. This award-winning solution can accommodate corrosive gases and vapors, and has superior resistance to heat-accelerated deposition.

Operating Parameters

- Flows to 1000 m³/h
- Suction pressure: >0.001 mbar abs
- Materials: nodular iron/steel

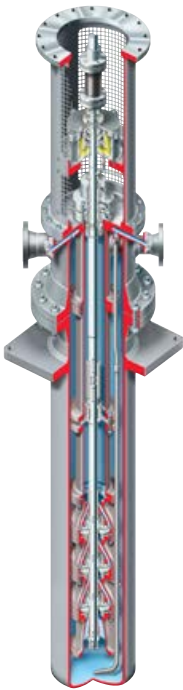


SIHI^{dry}

Compliant with ISO 13709/API 610 (VS6), the Flowserve WUC vertical turbine is a radial flow or axial flow type, multistage, heavy-duty double casing pump. It is designed for continuous un-spared duty at a variety of high-pressure services, operating at temperature extremes and handling difficult liquids.

Operating Parameters

- Flows to 500 m³/h (2200 gpm)
- Heads to 2000 m (6560 ft)
- Temperatures from -200 to 200°C (-328 to 400°F)
- Pressures to 200 bar (2900 psi)

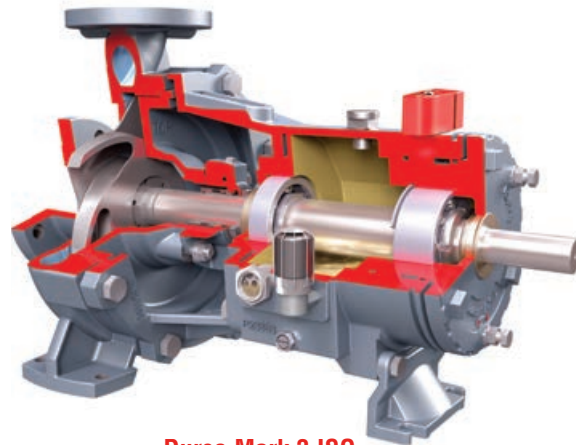


WUC

The Durco Mark 3 ISO chemical process pump provides unmatched performance and reliability, conforms to ISO 2858 and ISO 5199 design criteria, and incorporates advanced design features. The ruggedly designed pump offers significant operational- and maintenance-enhancing benefits that help users minimize the total cost of pump ownership.

Operating Parameters

- Flows to 1400 m³/h (6160 gpm)
- Heads to 220 m (720 ft)
- Pressures to 25 bar (365 psi)
- Temperatures from -80 to 400°C (-110 to 752°F)
- Discharge sizes from 20 mm to 200 mm (0.75 in to 8 in)



Durco Mark 3 ISO

Valves and Actuators

Designed to meet API-6D, ANSI B16.34 and BS 5351 requirements, the Argus FK76M delivers durability and low operating torques with a clear separation of sealing and bearing functions. It is fire-safe to BS 6755 and API 607.

Specifications

- Size Range: DN 65 to 900 mm (DIN); NPS 2½ in to 36 in (ASME)
- Pressure Class Range: PN 16 to 160 (DIN); Class 150 to 900 (ASME)
- Seating Material: Metal or Soft Seated



Argus FK76

The unique Survivor control valve design solves the harshest erosion, corrosion and flashing application problems. With a variety of ceramic trims available, no other valve will last longer — even in applications with demanding flashing and erosive particulates. The Survivor is designed to direct flashing energy away from critical equipment. Unique packing configurations solve difficult sealing problems associated with solids entraining the process fluids.

Specifications

- Valve Type: Linear Globe
- Size: DN 25 to 350; 1 in to 14 in
- Pressure: PN 40 to 160; Class 300 to 2500
- Material: Carbon Steel; Stainless Steel; Special Alloys
- Temperature: -10 to 400°C (14 to 752°F)



Survivor

The Valtek Mark One globe control valve offers superior performance in liquid and gaseous services, while also permitting easy, fast and inexpensive maintenance. The spring-cylinder actuated valve provides stiffness and maintains high positioning accuracy, repeatability, controlled high speed and faithful response.

Specifications

- Valve Type: Linear Globe
- Size: DN 15 to 915; 0.5 in to 36 in
- Pressure: PN 10 to 400; Class 150 to 2500
- Material: Carbon Steel; Stainless Steel; Special Alloys
- Temperature: -196 to 815°C (-320 to 1500°F)



Valtek Mark One

The Valtek Mark 100 is a control valve designed to meet the needs of large applications. The Flowserve Mark 100 globe control valve offers the highest flow capacity, as well as fast, easy maintenance in both gas and liquid control. The Mark 100 also has long stroke lengths, providing finer control and resulting in superior process control in smaller valve sizes.

Specifications

- Valve Type: Linear Globe
- Size: DN 150 to 750; 6 in to 30 in
- Pressure: PN 10 to 63; Class 150 to 600
- Material: Carbon Steel; Stainless Steel; Special Alloys
- Temperature: -196 to 815°C (-320 to 1500°F)



Valtek Mark 100

Trim Options of the Mark and Flow Families

CavControl valve trim lowers cavitation damage by controlling the location and concentration of cavitation vapor bubble implosions in an area away from metal parts. CavControl trim utilizes small, diametrically opposed flow holes through the walls of a special seat retainer.

Specifications

- Size Range: 1 in to 24 in
- Pressure Class Range: 150 to 4500
- Seating Material: Metal
- Directs cavitation bubbles away from metal surfaces and into opposing streams
- Impinging jets create a column of cavitation in the center of the retainer to remove the collapsing bubbles
- Increases product service life

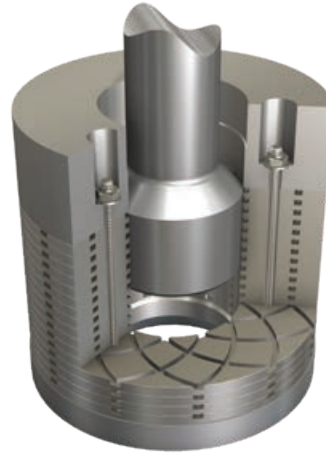


CavControl

DiamondBack trim prevents cavitation from forming and minimizes hydrodynamic noise, even in the most challenging liquid applications. Staged pressure drops eliminate cavitation by maintaining pressure above the vapor pressure, never allowing cavitation to form. DiamondBack combines new advances in pressure drop management with previously proven technologies to create the most effective device capable of eliminating cavitation in the most demanding services.

Specifications

- Size Range: 1.5 in to 16 in
- Pressure Class Range: 150 to 4500
- Seating Material: Metal
- Multiple-staged pressure drop to eliminate cavitation
- Utilizes expansion, contraction, mutual impingement, turbulent mixing and sudden turns to effectively manage and reduce fluid pressure without creating cavitation
- Easy to clean stacked disc design
- Available in a variety of materials, including some ceramics



DiamondBack

Automax RG pneumatic Scotch yoke actuators are the cost-effective choice for on/off and inching applications of quarter-turn, medium-to-large sized valves in the chemical and general process industries.

Specifications

- Torque Rating Range: up to 248 000 Nm (2.2 million in-lb)
- Pressure Rating: Operating Pressure: 2.5 to 10.3 barg (36.3 to 149.4 psig)
- True modular design
- On-off, multi-position and throttling
- Pneumatic, gas and hydraulic models
- Spring return, “fail safe” and double acting



**Automax RG Series
Heavy-Duty Actuator**

The Flowserve Limitorque MX non-intrusive electric actuator is designed for a wide range of environmental applications in the power, oil & gas, and water industries.

Specifications

- Torque Rating Range: From 20 to 1700 ft-lbs output torque; with addition of gearboxes, additional torque can be supported
- Non-intrusive electronic design
- Wide variety of configurations, including torque-only, thrust-based, linear thrust base and rising stem applications
- Weather-proof, explosion-proof and submersible applications
- 100% repeatable and redundant absolute encoder for position sensing
- Electronic torque switch
- Low-temperature capability to -60°C (-76°F) with arctic temperature and solid-state starter options for modulation to 1200 starts per hour



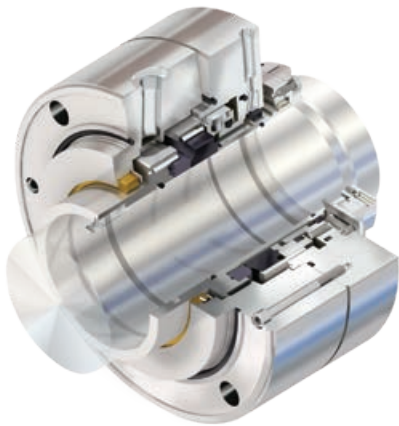
Limitorque MX

Seals

UHTW pusher-type mechanical seals are custom engineered to deliver exceptional reliability in high-energy, critical pumping applications. The UHTW is a balanced, flexible stator cartridge seal, available in single or dual seal configurations.

Operating Parameters

- Pressure up to 207 bar (3000 psi)
- Temperature from -40 to 371°C (-40 to 700°F)
- Speed up to 76 m/s (250 fps)
- Sizes 25.4 mm to 228.6 mm (1.000 in to 9.000 in)



UHTW

QB Series seals are balanced pusher seals, available in single and dual seal configurations, used for sealing environmentally restricted products and meeting the most stringent regulations. The QB Series is fully compliant with API 682 Type A requirements.

Operating Parameters

- Pressure up to 51.7 bar (750 psi)
- Temperature from -40 to 204°C (-40 to 400°F)
- Speed up to 23 m/s (75 fps)
- Sizes 12.7 mm to 139.7 mm (0.500 in to 5.500 in)

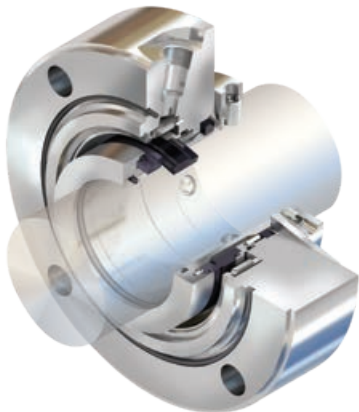


QB

ISC2 seals are the most capable and versatile general purpose family of cartridge seals available, meeting all international standards (ASME, DIN, ISO, KIS and others) and are designed to fit hundreds of pump models from global manufacturers.

Operating Parameters

- Pressure up to 20.6 bar (300 psi)
- Temperature from -40 to 204°C (-40 to 400°F)
- Speed up to 23 m/s (60 fps)
- Shaft sizes 20 mm to 200 mm (1.000 in to 8.000 in)

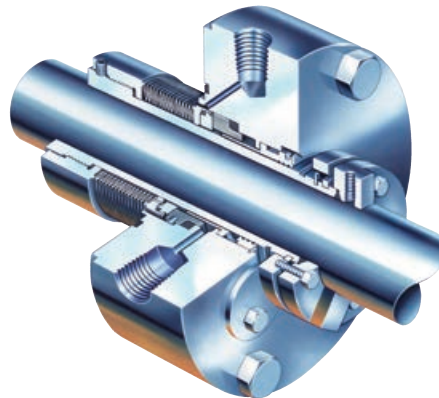


ISC2-682

BRC Series edge-welded metal bellows seals are exceptionally robust and are designed to seal high-temperature hydrocarbons, heat transfer fluids and severe services in refineries and hydrocarbon processing plants. The BRC Series is fully compliant with API 682 Type C requirements and features thick-plate Alloy 718 bellows convolutions for superior corrosion resistance.

Operating Parameters

- Pressure up to 20.7 bar (300 psi)
- Temperature from -73 to 427°C (-100 to 800°F)
- Speed up to 23 m/s (75 fps)
- Shaft sizes 28.2 mm to 150 mm (1.110 in to 5.906 in)

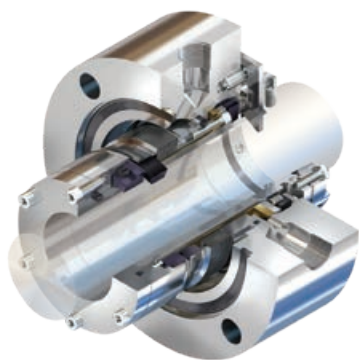


BRCs

BXRH and BXHH seals provide sealing capabilities at extreme temperatures in challenging refinery and petrochemical services. They are fully compliant with API 682 Type C requirements.

Operating Parameters

- Pressure up to 20.7 bar (300 psi)
- Temperature from -73 to 427°C (-100 to 800°F)
- Speed up to 46 m/s (150 fps)
- Shaft sizes 21.8 mm to 127 mm (0.857 in to 1.000 in)



BXRH/BXHH

Key Advantages for Flowserve in the Aftermarket

Over the last few decades, [Flowserve Quick Response Centers \(QRC\)](#) capabilities have been improved as new technologies were developed. With efficiency and reliability improvements, there is a high potential for upgrading existing installations to help owners/operations in the following areas:

- Increase plant efficiency
- Improve plant output
- Reduce emissions output

This can be achieved by overhauling existing equipment with additional reliability features, upgrade hydraulics or other capabilities through Flowserve QRCs.

These QRCs are equipped with the necessary engineering, manufacturing and servicing capabilities and equipment to serve customers in the CTO/MTO industry.

In the “coal to synthesis gas” process, if the technical route is coal slurry, the operation mode is very severe for mechanical seals. Also, the breakdown rate will be higher than for a normal application. So, the parts replacement for mechanical seals is frequent.

Installation and Startup

Equipment installation and startup can be problematic if careful attention is not paid to follow the correct operational procedures. To ensure new equipment yields the specified performance and provides long and reliable service, Flowserve adheres to the industry’s most rigorous standards for installation and startup. Whether for mission critical assets or ancillary support systems, best practices are followed and all details are fastidiously managed.

- Foundation preparation and baseplate grouting
- Pipe and pump bolt-up, alignment and inspection
- Flush and lubrication system installation and testing
- Control systems and electronics function verification
- Pump and motor pre-rotation checks
- Laser alignment
- Safety inspections
- Startup and operating procedure development

Preventive and Scheduled Maintenance

Strict adherence to maintenance and repair best practices extends mean time between repair (MTBR) and helps to control operating costs over the long run. Flowserve has the expert manpower, tools and capabilities needed to keep equipment in peak condition.

- Pumps, valves and mechanical seals
- Motors and shafts
- Bearings
- Suction strainers
- Piping

Turnkey Maintenance

Flowserve recognizes that maintaining process equipment is not the primary objective of its customers, but it is necessary to achieve their goals. By augmenting customer-owned resources with its industry-leading technical experts, advanced engineering tools and top-of-the-line Quick Response Centers, Flowserve provides turnkey maintenance services that keep equipment operating optimally through its lifecycle.

COMMUNICATING OUR VALUE

Flowserve Value Proposition in CTO/MTO

Flowserve	Proposition	Customer Benefit
Ethical Business Practices	Flowserve sets the highest standards in business integrity in its dealings with suppliers and customers.	A trustworthy partner to work toward their project success
Quality	Flowserve manufactures to the most rigorous quality standards to provide reliable products.	Satisfaction in supplier choice, on-time commissioning and project startup
Engineering Excellence	The Flowserve depth of engineering experience is unparalleled in coal to olefin/methanol to olefin.	Optimized product and material selection for each application ensures reliable operation.
Experience	Flowserve has been the leader since the process was commercialized on a large scale.	Lessons learned have been built into today's products, increasing reliability, maintainability and product life.
Aftermarket Support	Dedicated after-sales support engineers	Implanted within the aftermarket group with the sole objective to resolve operational issues quickly and provide expert recommendations on upgrades and safety outlook
Local Quick Response Centers	Fully equipped Quick Response Centers are located in many regions around the globe.	Skilled team to handle upgrades and repairs. Localized to reduce downtime, full access to Flowserve component drawings, procedures and standards.
Aftermarket Solutions	Long-term maintenance	Specialist group capable of maintaining, servicing and upgrading equipment to meet operating goals throughput
Industry Partnerships	Constant discussions with all process licensors and dedicated to the communications of concerns and developments	End users and licensors have direct access to engineers to influence design needs and ensure concerns are properly communicated.

Innovative Ways Flowserve Addresses Customer Challenges

<p>Expertise and Experience</p>	<ul style="list-style-type: none"> • Flowserve has more than 20 years of experience in the coal chemical industry and has been a key supplier of pumps, valves and seals for CTO/MTO plants since the beginning of the coal chemical industry. • Flowserve has one of the largest installed bases of pumps and valves in CTO applications in China. • Specialist “Virtual Centers of Excellence” ensure that expertise acquired over multiple products and manufacturing sites is shared across the global Flowserve organization.
<p>Single-Source Provider</p>	<ul style="list-style-type: none"> • Flowserve offers a full range of pumps, valves and seals for CTO/MTO markets, simplifying the procurement process for our customers. • Global commercial operations organization ensures knowledgeable and professional reviews and responses to customer RFQs, including those with the most complicated technical requirements.
<p>Streamlined Execution</p>	<ul style="list-style-type: none"> • Each Flowserve factory has efficient and professional project management organizations to ensure on-time completion of projects to customer requirements. • Where projects involve multiple Flowserve manufacturing locations, global project managers can be provided to coordinate order fulfillment. This ensures fewer errors and delays and simplifies communications between Flowserve and the customer.
<p>Local Support Worldwide</p>	<ul style="list-style-type: none"> • A large field service organization ensures technicians are available for installation, commissioning and troubleshooting without delay. • Service and maintenance contracts for highest availability and continuous efficiency optimization can be tailored to customer needs. • A global network of Flowserve Quick Response Centers means that local service and repair are always available. • Product upgrades are continuously being introduced to improve the performance and reliability of Flowserve products in the field. • Full operation and maintenance training is available to end users.
<p>Optimized Efficiency</p>	<ul style="list-style-type: none"> • Close involvement by Flowserve within the CTO/MTO industry has provided the feedback needed to develop the range of hydraulics best suited to customer requirements, ensuring the best and most efficient selections are always available. • As one of the largest engineered pump manufacturers in the world, the Flowserve hydraulic engineering capabilities and resources are second to none. Flowserve is able to provide pumping equipment that consumes the least amount of power.

GLOSSARY

TERM	DEFINITION
bb/d	barrels per day
°C	degrees Celsius
CH ₄	methane
CO	carbon monoxide
CO ₂	carbon dioxide
COS	carbonyl sulfide
CTC	coal-to-chemicals
CTG	coal-to-gas
CTL	coal-to-liquids
CTO	coal-to-olefins
DCL	direct coal liquefaction
D-MTO	MTO technology from Dalian Institute of Chemical Physics
°F	degrees Fahrenheit
Gt	gigatons (1 billion tons)
H ₂	hydrogen
H ₂ S	hydrogen sulphide
km	kilometer
kt	thousand tons
LNG	liquefied natural gas
Mcf	1000 cubic feet
MPa	megapascal
mPa.s	millipascal-second
Mt	million tons
MTO-100	one kind of catalyst
MTBF	mean time between failure
MTBPM	mean time between preventive maintenance
NDRC	National Development and Reform Commission
OCP	olefin cracking process
PDU	process demonstration unit
PE	polyethylene
PP	polypropylene
psi	pound per square-inch
PVC	poly vinyl chloride
PX	poly xylene
RMB	Renminbi
R/P	reserves to production
SAPO-34	one kind of molecular sieve
SNG	synthetic natural gas
SO ₂	sulphur dioxide
S-MTO	MTO technology from Sinopec
TCGP	Texaco Coal Gas Process
US\$	United States dollars



North America

Latin America

Europe

Middle East

Africa

Asia-Pacific

Flowserve Corporation
5215 North O'Connor Boulevard
Suite 2300
Irving, Texas 75039
flowserve.com

Experience In Motion