

Diaphragm pumps

in the oil and gas industry



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1. Fields of application for diaphragm pumps

In the oil and gas industry, you come across diaphragm pumps within a wide performance range from exploration over processing up to transportation to the consumer.

1.1. Chemical injection

A great variety of applications is included in the term “Chemical Injection”.

In all production steps, the operators have to add a variety of different additives in order to prevent undesirable conditions in processes, pipelines, heat exchangers and other components. With partially complex mixtures of organic and inorganic components, very specific effects are attained. The substances injected protect against corrosion, prevent mineral scaling, paraffin and asphaltene precipitation, improve the oil/water separation, support the coagulation of solid particles and have numerous other tasks depending on the oil- and gas composition.

Apart from their use for precise supply and injection of such chemicals, the application range of diaphragm pumps in the oil and gas industry has considerably expanded for the last years with regard to the fluids as well as the flow rates. Additionally, they deliver e.g. extremely difficult hydrocarbon-condensates and -slurries loaded with a high portion of toxic components, they inhibit the formation of hydrates by injection of alcohols, they are used for pumping glycols for gas drying, and they safely and very economically boost large volumes of sour gas and CO₂ to the injection pressures required for the transportation and storage in geological formations.

1.2. Requirements for diaphragm pumps

Widely differing requirements are placed on the pumps mainly depending on the physical and chemical properties of the fluids, the specific application and, to some extent, on the strongly varying process conditions. Precise monitoring prevents the necessity for excess metering and hence reduces consumption, costs and potential risks to the environment. Uncritical fluids are often conveyed by reciprocating plunger pumps, however, many of the chemicals used in the oil and gas industry are difficult to handle, not just because they are corrosive, have high vapour pressures or extremely low lubricating properties, but due to the fact that a great number of them are unhealthy and partly even extremely toxic or environmentally harmful.

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The only convincing solution to safely prevent the release of such critical chemicals into the atmosphere is hermetically tight handling. For leak-free pumping of fluids all dynamic seals (mechanical seals, packings etc.) must be avoided. This, among others, has led to canned motors and magnetic drives for centrifugal pumps and to diaphragms for reciprocating positive displacement pumps.

Due to this fact, leak-free diaphragm pumps have found a wide application range in the oil and gas industry, too. This technology is suitable even for the most difficult and critical fluids, which must be injected at high pressures during production, processing and transportation.

Apart from leak tightness, diaphragm pumps provide all advantages of reciprocating plunger pumps, which are appreciated by operators:

- pressure firm characteristics (flow is dependent on pressure to a small extent only)
- linear flow rate adjustment via stroke length and stroke frequency
- high accuracy and reproducibility
- high volumetric and mechanical efficiency

1.3. Applications and fluids

Diaphragm pumps have proven their operational safety and reliability in innumerable applications for the conveyance of fluids with most different physical and chemical properties.

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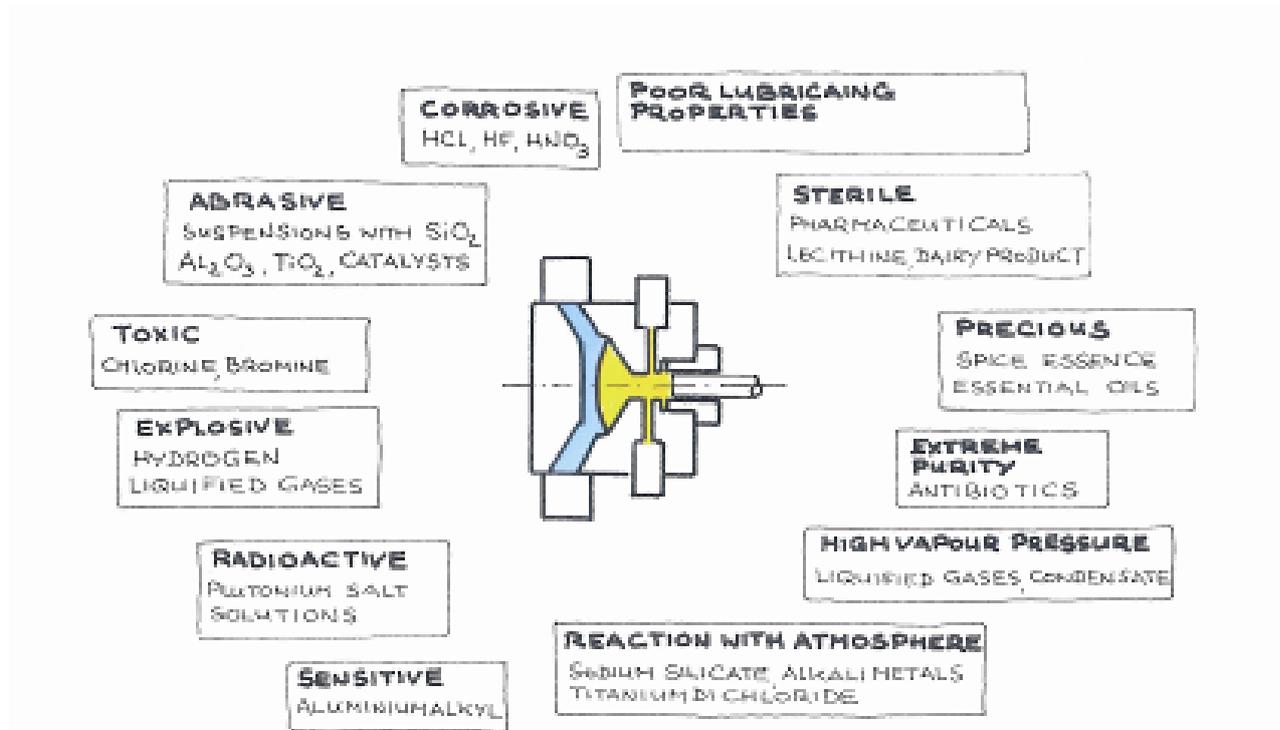


Fig. 1 Fluids for which diaphragm pumps are used

Therefore they are found also in the main process steps of the:

- Chemical Industry
- Process Technology
- Nuclear Technology
- Pharmaceutical Industry, Gene- and Biotechnology
- Food Industry

Diaphragm pumps are mainly used for low to medium flows at medium to high pressures. They are predominantly known for applications with small flows. In the last 20 years however, process diaphragm pumps with hydraulic powers of up to nearly 1000 kW have been developed. The typical application limits of plastics diaphragms are pressures of up to 400 bar at temperatures of -50° C to 150° C.

Special designs are used in processes up to 800 bar. Pumps with metal diaphragms can reach pressures up to 1200 bar at temperatures up to 250° C.

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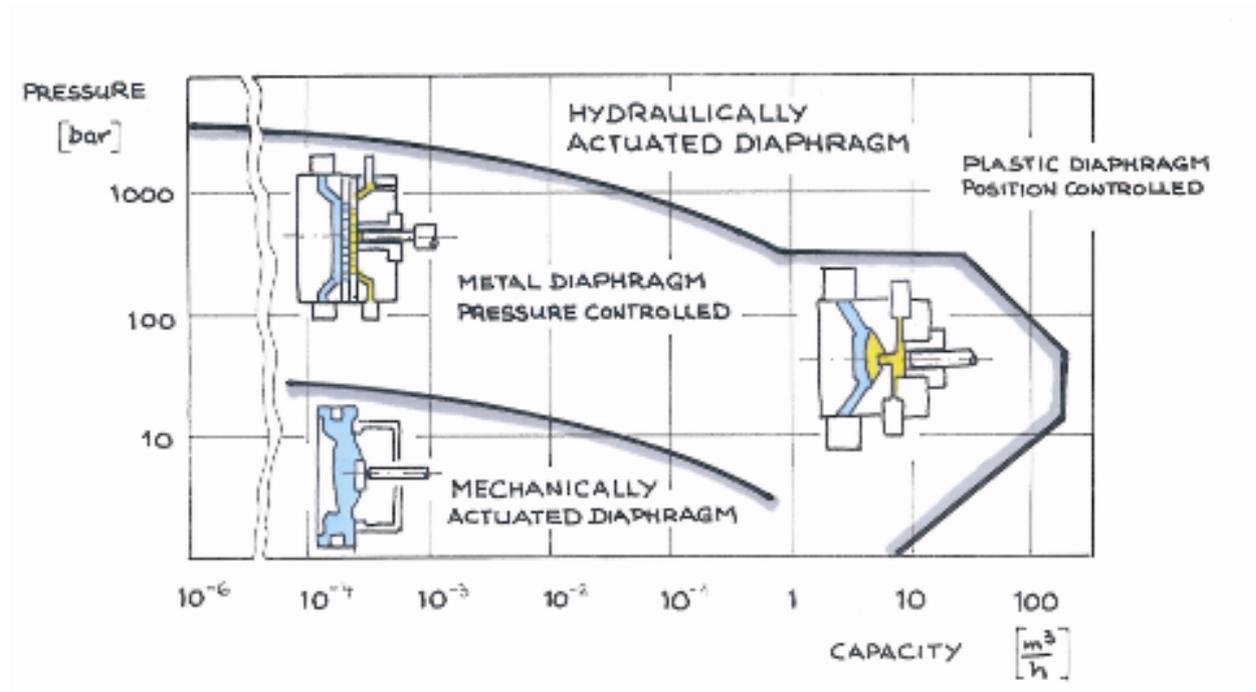


Fig. 2 Pressure and flow range of diaphragm pumps

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2. Chemical injection in the oil and gas industry

Chemical injection processes are all injection processes for which special chemicals are used, which facilitate and improve oil and gas production, processing and transportation. Nowadays, the oil and gas industry cannot work economically without the use of large amounts of such chemicals. Usually chemical injection is understood as precise injection of additives against high pressure.

2.1. Injection of active substances

In order to achieve specific effects during production and processing, diaphragm pumps are used for the injection of the following active substances.

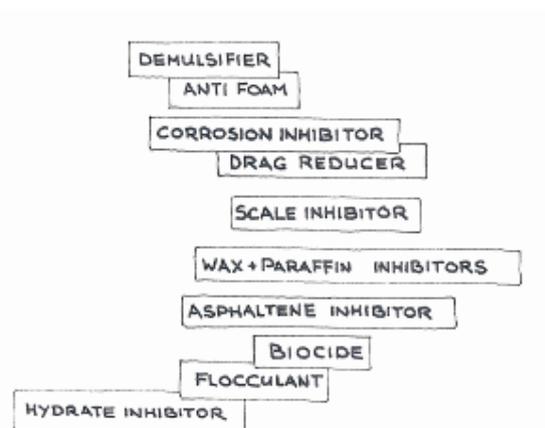


Fig. 3 Chemicals for the oil and gas industry

Newly developed deep-sea oil and gas fields as well as fields in remote locations with extreme climatic conditions demand more and more of these application-specific chemicals. The extreme effort required by production plants in water depths of 3000–4000 metres as well as the increased vulnerability to failures and the raised potential for damages necessitate a rigorous quality process for the chemicals applied and for the injection equipment used. Figure 4 shows the example of a floating production platform (FPSO-Floating Production, Storage and Offloading) for a simplified illustration of some points in the production process where additives are injected for chemical treatment.

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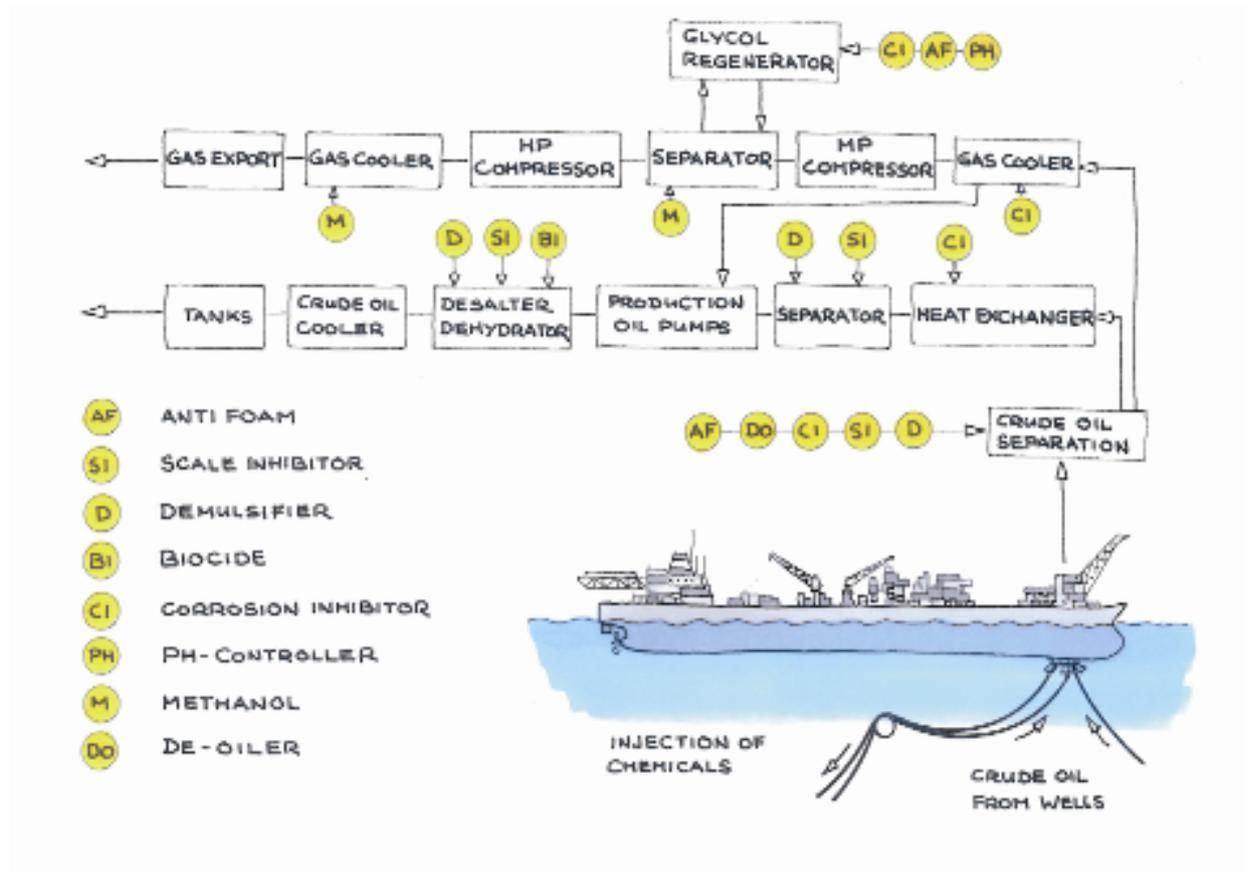


Fig. 4 Chemical injection on a floating production platform

2.2. Chemical Injection Packages

On modern production platforms often up to one hundred metering pumps are installed. Due to their importance for the processes, the operators place highest demands on the availability and the reliability of all components required for injection.

There is a great variety of such injection systems starting from the individual pump for one single injection point up to a complete package with dozens of pumps for numerous chemicals. Often these packages are equipped with multi-compartment tanks for safe storage and include all measuring and control equipment required.

These injection systems are custom made meeting the specific project requirements and the individual specifications, complying with regulations and standards for floating production plants and of other off- and onshore installations.

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Fig. 5 Diaphragm metering pumps with multi-compartment tanks

The chemicals mentioned up to now are usually injected at low flows, which can be handled with small up to medium-sized metering pumps. Other applications however, demand the injection of considerably higher flows partly against very high pressures.

2.3. Inhibition of hydrate formation

During oil and gas production as well as during transportation, the formation of hydrates presents a permanent danger. Hydrates consist of hydrocarbon-, hydrogen sulphide-, or carbonic acid molecules from the gaseous or condensate phase, which are captured in a cage of water molecules. Certain temperature and pressure conditions make the water molecules to crystallise around the “guest molecules”.

Under given conditions, all methane hydrates especially, can form very fast and can cause blockage of oil or gas lines, which can result in hazardous incidents. In any case,

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they lead to disturbances and considerable production losses. With the development of increasingly deep oil and gas fields with higher water content, the risk of operational failures due to formation of hydrate has grown significantly.

Therefore the oil and gas industry puts enormous effort in the prevention of hydrate deposits during all process steps.

The usual additives to control hydrate formation are alcohols such as methanol, ethanol, ethylene glycol and tri-ethylene glycol. These “thermo-dynamic” inhibitors shift the hydrate formation curve to lower temperatures and higher pressures.

As partly considerably high volumes of these alcohols have to be injected, complementary additives have been developed for the last years, which allow significantly lower flows (LDHI Low Dosage Hydrate Inhibitor). According to their active principle, one differentiates between kinetic hydrate inhibitors (KHI), which reduce the hydrate formation rate and agglomerate inhibitors (AA – anti-agglomerant), which prevent accumulation of hydrate crystals. Hydrate inhibition might require the delivery of several thousand litres per hour against pressures of up to 1200 bar. The power of the pumps installed then can be several hundred kilowatts.

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2.4. Methanol injection

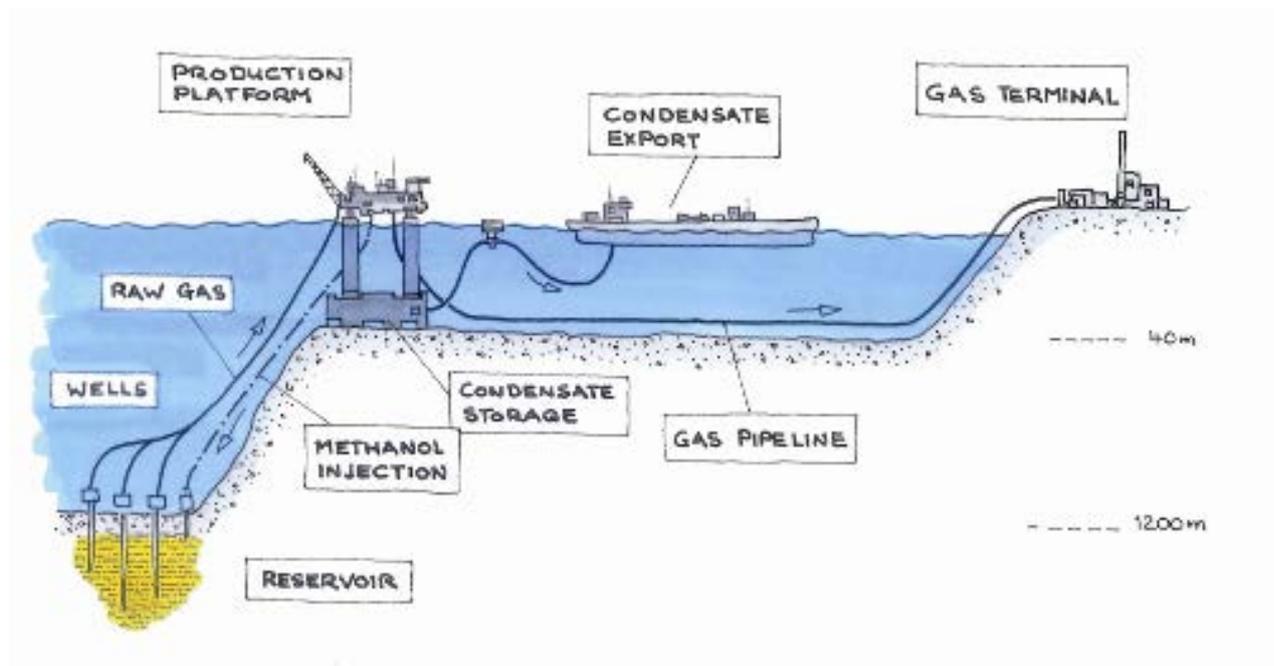


Fig. 6 Deep-sea gas production

Figure 6 shows an example of continuous inhibition with alcohol. With the diaphragm pumps installed on the platform, methanol is injected into the lines to the wellheads with a pressure of 650 bar. After processing of the crude gas onsite, the gas is transported via subsea lines to the gas terminal onshore. The condensate separated from the raw gas is transported from the platform by ship for further processing.

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2.5. Transportation of condensates



Fig. 7 Module for methanol injection

Natural gas processing includes separation of various hydrocarbons and other components from crude gas. Hydrocarbons with boiling points similar to benzene are called natural gas liquid (NGL) and are a valuable by-product of natural gas processing. After separation the gas liquid is divided into its main components which, partly, are extremely hazardous to health: These are H_2S , thiols (mercaptans), alkenes, cyclohexanes and other naphthenes as well as aromatics, such as benzene, toluene and xylene. In order to safely prevent leakages, more and more diaphragm pumps are used for transportation of these condensates.

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2.6. Removal of hydrocarbon slurries

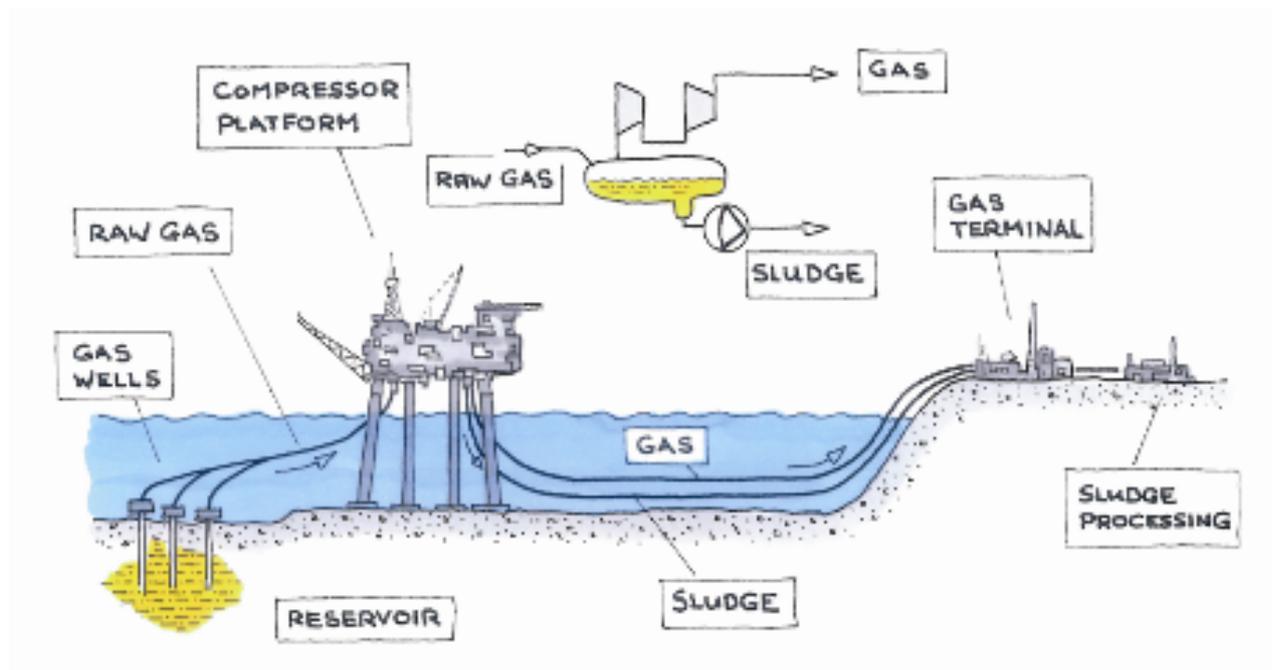


Fig. 8 Compressor platform

A special challenge for pumps is the removal of hydrocarbon slurries from gas platforms. In most cases crude gas flows (Fig. 8) from different fields and of different compositions are gathered on one platform. Hence, the slurry is kind of an undefined sludge of hydrocarbons with a wide density range as well as seawater and sands in varying compositions and must be kept away from the compressors by all means.

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Fig. 9 Diaphragm pumps for conveying of hydrocarbon sludge

Due to the continuously varying composition and the changing pressures, the pumps used for this application must be very flexible. As the gas production of the platform must be stopped after a short period of time if problems with these pumps occur, great importance is attached to the availability and reliability of these pumps.

Another frequent application for diaphragm pumps in gas terminals or for natural gas storage facilities is the absorption of humidity from gas flows. As liquid drying agents, glycol solutions – usually MEG, DEG or TEG – are used. The pump pressures are normally in the range of 150 – 250 bar, the flows start at some litres up to 25 m³/h.

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2.7. Reduction of H₂S and CO₂

A growing challenge is the reduction of H₂S and CO₂ emissions from sour oil and gas wells. Safe handling and storage of the highly toxic H₂S and sour gas has been focussed by the oil and gas industry for a long time. During the last years therefore processes have been developed for re-injection of sour gas and CO₂ in deep geologic formations. As the increased emission of CO₂ is considered to be the main reason for global warming, there are many projects pursued worldwide, which deal with economic sequestration of CO₂ from industrial processes and its safe injection and long-term storage. The injection pressures mainly depend on the geo-mechanics of the storage area and can reach 500 bar.

Enormous compression powers are required for this. The related energy costs can be significantly reduced by the integration of pumps into the compression process.

As H₂S is extremely toxic and the CO₂ sequestered includes numerous critical substances, which are harmful to health, the leak-free handling by diaphragm pumps provides a convincing solution.

In Figure 10 examples for the compression and re-injection of CO₂ and sour gas already carried out are shown in phase diagrams.

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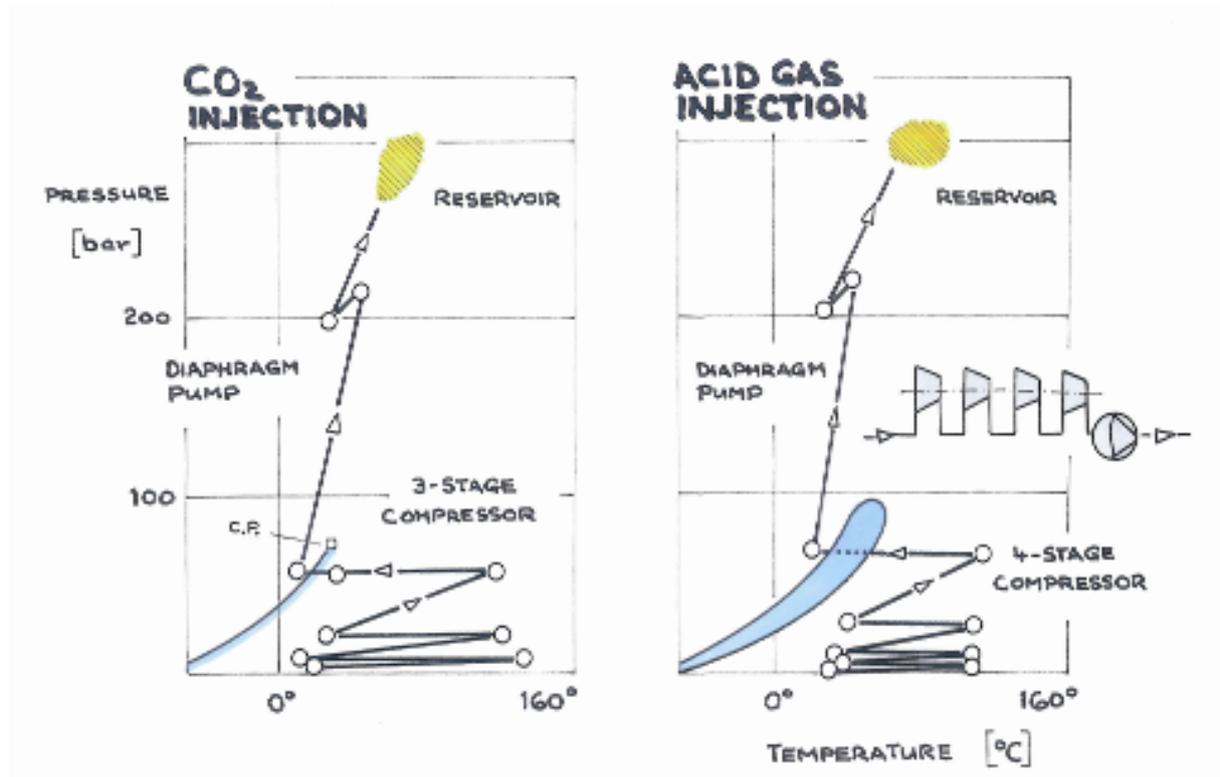


Fig. 10 Compression and injection of CO₂ and sour gas

After 3–4 compressor stages with drying and intermediate cooling, the gases are liquefied and the pressure is raised to the pipeline delivery pressure by diaphragm pumps with high efficiency in order to be pressed into geological storage areas.

The diaphragm pump shown in Figure 11 boosts highly toxic sour gas from 60 bar up the injection pressure required for re-injection, which is 250 bar.

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Fig. 11 Diaphragm pump for sour gas re-injection

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3. Summary

Diaphragm pumps have been developed up to a high grade of reliability, safety and economic efficiency. Nowadays, they are available for a performance range from a few watts up to almost 1000 kilowatts.

On one hand, they precisely and reproducibly meter a few millilitres a day and, on the other hand, they deliver dozens of cubic metres per hour against pressures of several hundreds of bar. Due to the leak-free operating method, they have found their way into the chemical industry at an early stage and today they can be found in all steps of the process technology, in which critical fluids at increased pressures are being handled. For these reasons they have been used in the oil and gas industry for years already for the injection and the transportation of highly flammable, dangerous and toxic fluids.

The most widely known application is the precise injection of various chemicals during production, processing and refining of oil and gas. To a large extent unnoticed by the public, their application range has been increased considerably to higher performances ratings in the last years.

In order to prevent continuous and failure related release of production specific fluids, vapours or gases, diaphragm pumps are more and more used for the injection of hydrate inhibitors up to 1200 bar. They deliver extremely environmentally hazardous hydrocarbon condensates and slurries, they pump glycols for gas drying and, due to their high efficiency, they reduce the compression power required for the re-injection of sour gas and carbon dioxide into geological storage sites.

Due to their wide application range in handling problematic fluids, diaphragm pumps support the worldwide effort in the oil and gas industry to minimize leakages and emissions of pollutants from high pressure processes.