

TECHNICAL REPORT

Canned motor pumps in compliance with API 685 – A contribution to environmental protection

Dr. G. Feldle



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INTRODUCTION

Environmental awareness, which has increased in the past few years, has resulted in chemical and petrochemical plants being judged more severely in regard to health and safety regulations. Canned motor pumps, which have no shaft sealing and are completely leakage-free, are a significant contribution to maintain such regulations. The API 685 (American Petroleum Institute) is the specification that standardises the application of seal-less pumps in refineries and the petrochemical industry.

ENVIRONMENTAL LEGISLATION

By the EC-Directive 96/61/EC dated 24. September 1996 about the integrated avoidance and reduction of environmental pollution (the so-called IVU-Directive), and the Federal Immission Protection Law of September 2002, and also the TA-Luft (July 2002), emissions from plants and components, such as e.g. fittings and pumps, have been severely restricted. The target of the IVU-Directive is the integrated prevention and reduction of environmental pollution (Integrated Pollution Prevention and Control) as a result of the IPPC activities.

The function of this integrated reflection is to achieve a higher degree of protection for the environment (protection of air, water and ground), but not to protect air at the expense of water. IVU plants must trace this target by the employment of the "best available technologies". Emission limits must be geared to these techniques. As a result the IVU-Directive 96/61/EC is the instrument of the European Union for the harmonisation of licensing procedures and conditions of approval. It comprehends the fundamental rules for integrated approvals. These approvals are based on the concept of "best available technologies" (BVT).



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Approximately 30 sectors are specified in annex IV of the Directive for consideration and judgement as the best available technologies (i.e. organic base chemicals and refineries). The compilation of the best available technologies can be found in the so-called BVT leaflets. Seal-less pumps are named as best available technologies for the prevention and reduction of subtle emissions.

THE NATIONAL IMPLEMENTATION OF EU-DIRECTIVE 96/61/EC

The national implementation of the IVU or IPPC Directives in Germany is reflected in the Act of protection from harmful environmental effects by air pollution, noises, vibrations and similar processes, and the Federal Immission Protection Law (BimSchG) of 26 September 2002. The purpose of this Act is to prevent humans, animals and plants, the ground, water and the atmosphere, as well as cultural and material assets, from detrimental environmental effects. Particularly for plants which are subject to approval, such as refineries and petrochemical complexes, this law also serves to integrate the prevention and reduction of harmful effects on the environment through emissions in the air, water and ground by taking waste management into account, in order to achieve a high protection level for the environment as a whole, and protection and precaution from risk and other considerable disadvantages which may be caused.



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TA - LUFT

The new TA-Luft results from the first general administrative regulation to the Federal Immission Protection Law, and derives from the Technical Instruction for protection of the air of July 2002. Insofar as BVT leaflets or advanced leaflet drafts of the European Commission were available at the issuance of the TA-Luft, which have been compiled within the scope of the exchange of information of the IVU Directives, the information contained therein are already considered in the emission controlling requirements of the new TA-Luft. The criteria are essentially the contents of the Federal Immission Protection Law to prevent or reduce emissions during the production of liquid and organic materials. This concerns easily enhanced, carcinogenic organic media (such as ethylene oxide, carbonyl chloride, vinyl chloride, benzene, butadiene, acrylonitrile, etc.) that are regulated in the MAB tables (maximum workplace concentration). The employment of tight pumps, such as canned motor pumps and magnetic drive pumps, as well as conventional pumps with de-pressurised or pressurised mechanical seals, are fixed as necessary measures (TA-Luft, section 5.2.6.1):

- Hermetic pumps with canned motor drive. Complete density by double seal (can and motor casing), no locking medium is required.
- Magnetic drive pumps, only single seal (containment shell), secondary mechanical seal (GLRD) needs to be monitored. The regeneration of seal gas is absolutely imperative.
- Multiple mechanical seal (GLRD) with locking medium; the regeneration of confining liquid is absolutely imperative.
- Multiple mechanical seal (GLRD) with dry running seal; the regeneration of confining liquid is absolutely imperative.

The target is zero-leakage on the dynamic shaft seals. However, no special requirements are made for static seals. Under specific conditions a back fitting may become necessary before October 2007.



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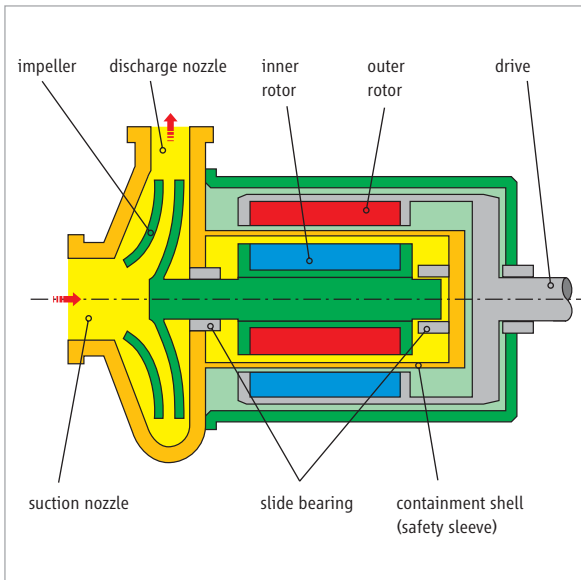


Figure 1: Schematic diagram of a magnetic drive pump

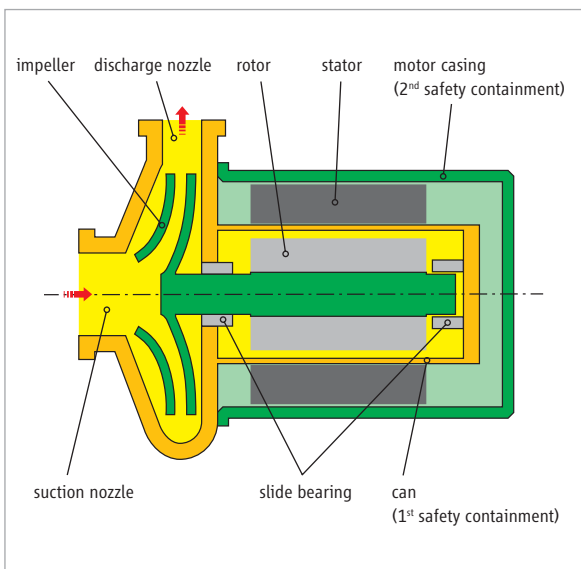


Figure 2: Schematic diagram of a canned motor pump

SEAL-LESS PUMPS

The sealing of the shaft passage at the pump housing is a critical point with conventional centrifugal pumps. Some system-related liquid can leak from the shaft seal, however, and this is not always visible. This problem can be resolved by a double mechanical seal. Higher safety is provided by hermetically sealed pumps, such as canned motor pumps and pumps with magnetic coupling, because they do not have the "shaft seal" weak point, and nothing system-related can leak out. The hermetically sealed pumps are special as a result of the kind of drive utilised, otherwise they are "regular" pumps. Pumps with magnetic coupling have, in contrast to canned motor pumps, a conventionally external motor. The rotations of the motor are non-contact transmitted by the containment shell onto the shaft in the pump. [Figure 1]

The magnetic coupling consists of inner and outer rotors that are both equipped with permanent magnets. The inner rotor is located on the impeller shaft and is driven by the outer rotor that is located on the motor shaft. The magnetic attraction between the poles drives the coupling. The sealing between the inner and outer rotor is taken by the containment shell so the impeller, slide bearing and the internal rotor are located in the medium.

The drive is normally separated from the pump (e.g. electro-motor). The force is transmitted from the outer motor through a mechanical coupling to the pump impeller. If you install the motor into the pump you may refrain from the shaft passage at the casing. As everybody knows, an electric motor consists of two main parts; the rotor and the stator, which are separated from each other in the canned motor pump by the can of the motor. [Figure 2]



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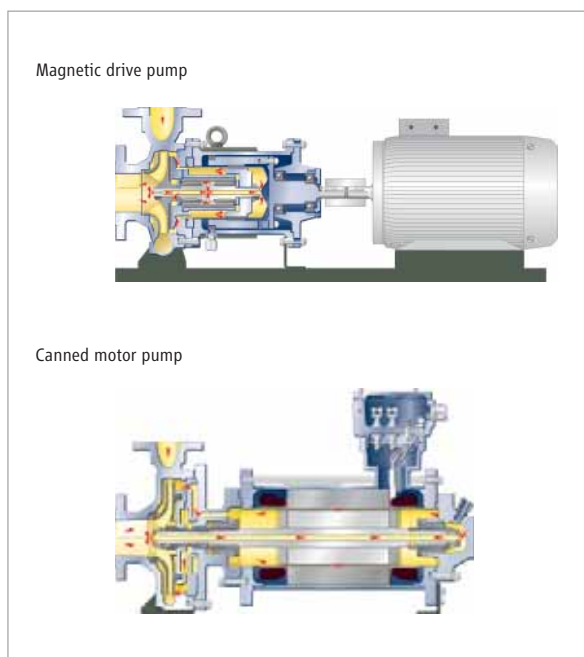


Figure 3: Comparison of magnetic drive pump – canned motor pump

The conveyed liquid is in the can of the motor, i.e. it is wet. There is the rotor and the two medium-lubricated slide bearings in which the shaft is running. The rotor is connected with the impeller through the shaft. Outside of the can of the motor – and so in the dry – are the winding motor and the electric terminals. This provides a brief comparison of the seal-less centrifugal pumps [Figure 3]:

Canned motor pumps

- Double sealing cover: even in very rare cases of destruction of the can no liquid will penetrate to the outside, therefore 100% leakage-free!
- No mechanical seals: these cost-intensive wearing parts are cancelled by the seal-less method of construction, therefore optimal MTBF values (mean time between failure), reduced maintenance costs and long service life.
- No lubrication liquids and locking media necessary at all: no cost-intensive and lavish installation of lubrication and cooling systems are necessary thanks to the seal-less shaft construction and the medium-lubricated slide bearings.
- Modular construction: no shaft alignment becomes necessary due to the integrated and solid modular construction, as well as lavish constructions of base plates.
- Low noise levels: without coupling, ball bearing and motor fan the noise levels are far below the standard level.

Magnetic drive pumps

- Containment shell: leaks are possible if the containment shell becomes damaged. A secondary containment shell is not available.
- Motor and pump are separated: pump and motor need to be aligned. A base plate is necessary to carry the immense weight of the motor and to avoid the danger of misalignment.
- High noise level: ball bearing, coupling and mainly the motor fan determine the noise levels, the standard corresponds to conventional centrifugal pumps with mechanical seal.

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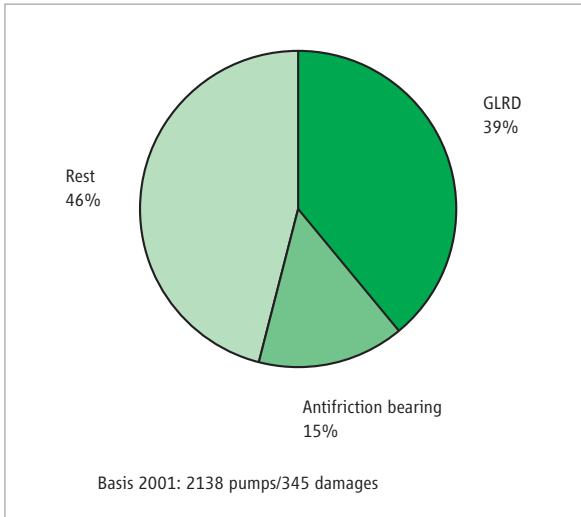


Figure 4: Distribution of damage at conventional centrifugal pumps
Source: Raffinerie Schwechat / OMV

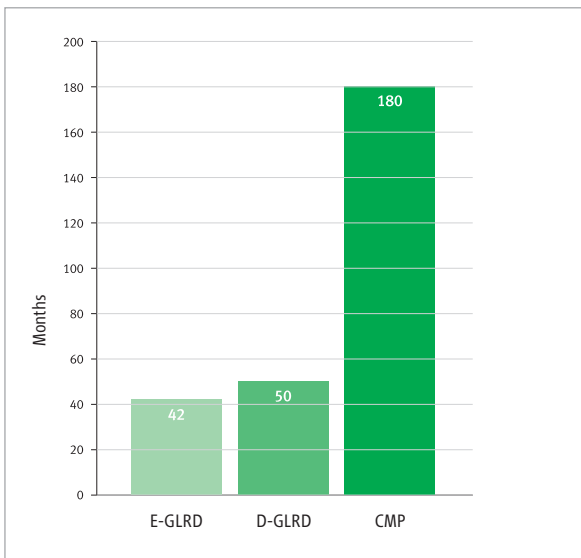


Figure 5: MTBF comparison of conventional pumps and canned motor pumps

THE API (AMERICAN PETROLEUM INSTITUTE) 685 SPECIFICATION

The first canned motor pumps with limited performance, being of a simple constructive design, were heating re-circulation pumps. This construction proved to be so good that centrifugal pumps with shaft seals to circulate the hot water in central heating systems have been superseded. As shown in an analysis by the Schwechat refinery, the percentage of damage caused by the shaft seal on conventional centrifugal pumps is 39%: 2138 pumps have been analysed over a period of 10 years. [Figure 4]

Another statistic of a German refinery shows the comparison of the MTBF values (Mean Time Between Failure) between conventional pumps with a single (E-GLRD) or double-acting (D-GLRD) mechanical seal and canned motor pumps (CMP). This analysis is also the result of an interpretation of several years of more than 1,000 process pumps with mechanical seal and approximately 100 canned motor pumps. [Figure 5]

Even in the thirties canned motor pumps prevailed in the chemical and processing industries. As a result of the environmental protection legislation mentioned above they are now also on the advance in petrochemical systems and refineries. This is a decisive contribution by the relatively new API 685, 1st edition – Seal-less Centrifugal Pumps for the Petroleum, Heavy Duty Chemical and Gas Industry Services. It fills the gap of a missing specification for seal-less pumps, analogue to the API 610 for conventional centrifugal pumps. The API market has been waiting for such a standardised technology for a long time to successfully implement the advantages of seal-less pump technology, such as hermetic density, operational safety and reliability in its applications.



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The individual working capacities or business segments for the recovery of oil and gas into chemical products are shown in figure 6. The transitions, and therefore the employment of API pumps and pumps according to the chemical standards ANSI or DIN ISO, flow at certain intersections. The API 685 is obligatory and applies everywhere where certain performance characteristics in refineries, and the petrochemical and gas industries exceed assessed limiting values. Apart from that, even the plant operator or end consumer may demand the employment of API 685 pumps. The constructive version of seal-less centrifugal pumps is specified in API 685. Besides the basic construction, including accessories, it also comprises specific demands on canned motor pumps. The demands particularly concern the constructive set-up including sealing and drive.

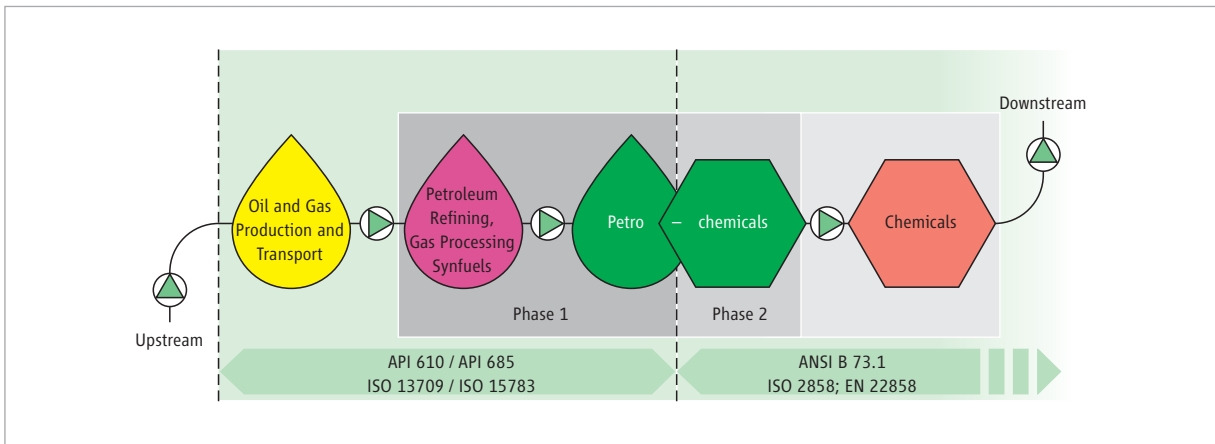


Figure 6: Definition of business segments

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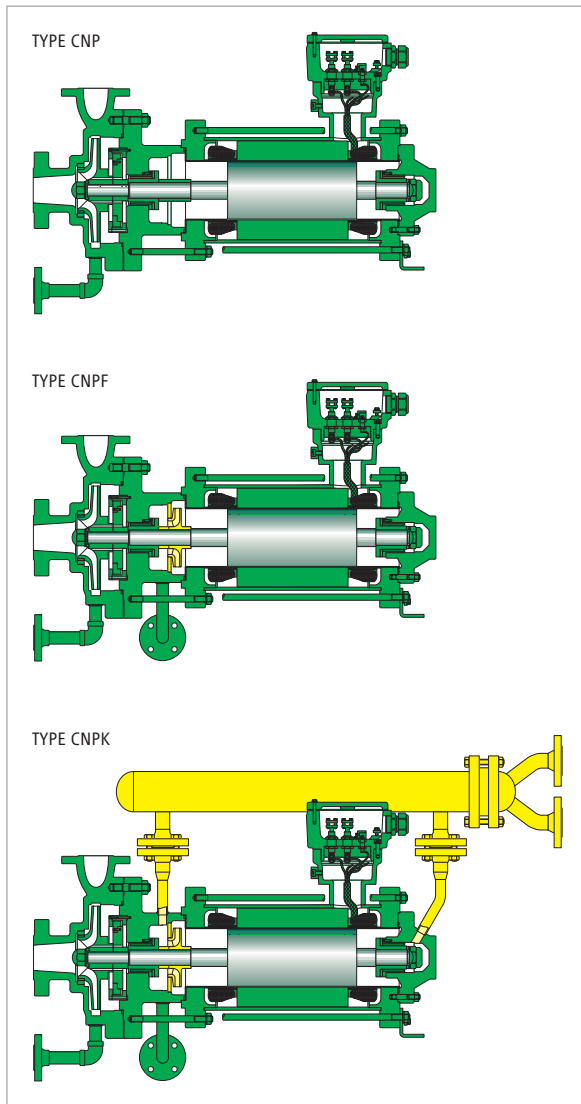


Figure 7: Modular construction principle

MODULAR CONSTRUCTION

In order to meet customer demands for lower life cycle costs on the one hand, besides the other requirements cited above, and to reduce production costs on the other hand, a modular construction has been developed for the API 685 centrifugal pumps. The objective is to obtain, with small standard assemblies, an optimum of basic performance and variations. The standard assemblies consist of hydraulics (casing, impeller), canned motor pumps, adaptors and external heat exchanger (including tubing). The following three performance variants can be prepared through physically practical combinations [Figure 7]:

- CNP Basic design
- CNPF Liquefied gas design
- CNPK High-temperature design (with external heat exchanger)

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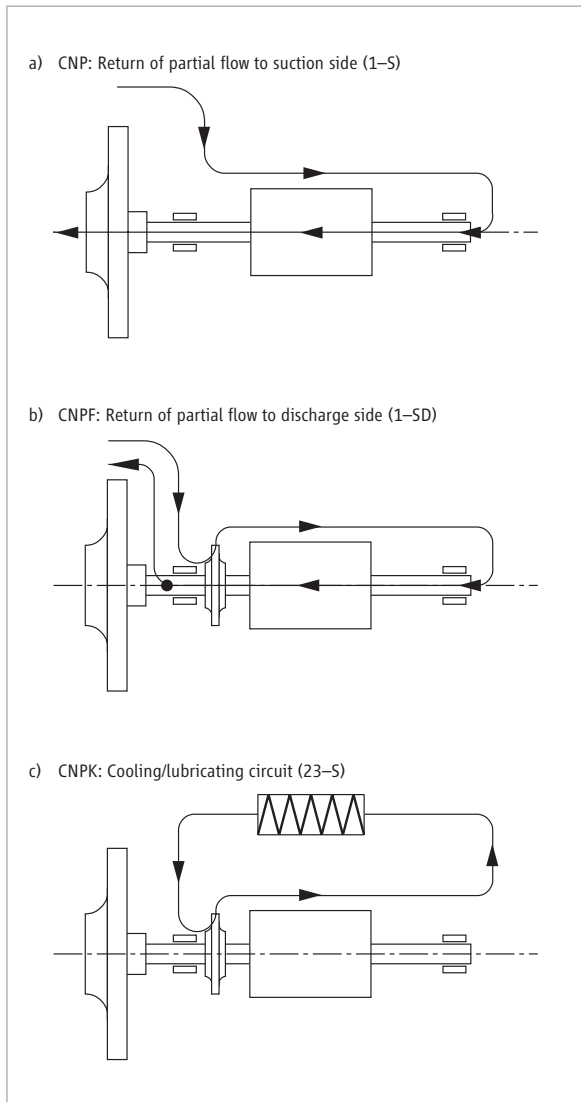


Figure 8: Tubing drafts in accordance with API 685, appendix D

These models differ mainly from the different partial stream flows of the cooling and lubricating circuit that are prescribed in appendix D of API 685. [Figure 8]

The tubing drafts 1-S (CNP), 1-SD (CNPF) and 23-S(CNPK) are for the three opposite versions.

Manner of operation of the three versions

With the basic version the partial flow is branched off through a ring filter for cooling the motor and lubricating the slide bearing at the periphery of the impeller, and after running through the motor gap is led back through the hollow shaft to the suction side of the impeller. Fluids that are close to boiling point or are even boiling already at the conveyance temperature (e.g. liquefied gases) cannot be conveyed with aggregates of this series. The partial flow of liquefied gas will also be branched off at the periphery of the impeller and, after having passed through the hollow shaft, is carried back again to the pressure side of the impeller. An auxiliary impeller serves to overcome the hydraulic losses that crop up on this flow path. By the return of the partial flow to the pressure side the connection with the heating point has sufficient gap from the boiling curve. Therefore, this series also allows the conveying of liquefied gases with an extreme steep vapour pressure curve under the same conditions.

With the high-temperature version with an external heat exchanger the conveying medium reaches the impeller through the suction nozzle and is carried through to the pressure nozzle. A heating lock prevents direct heat transition from the pump area to the motor part, which also serves as an adapter between the pump casing and different motor sizes. The motor's heat loss is removed by the secondary cooling/lubricating circuit in a separately aligned heat exchanger. This cooling/lubricating cycle simultaneously supplies the hydrodynamic slide bearings.

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This series consists of a single-stage hydraulic pump in accordance with API 610, edition 9, which is combined with the reliable canned motor pump technology in accordance with API 685, edition 1. The "centre-lined" pump arrangement with a flanged evacuation also ranks among the standard designs as the obligatory flanges in accordance with ANSI 300 lbs. RF. The modular API 685 construction covers the complete performance range of single-stage centrifugal pumps for discharge rates up to 800 m³/hour and pump lifting up to 300 metres. The canned motor pumps are available up to a capacity of 325 kW. The complete series has been certified in accordance with ATEX 100a (EC Directive 94/9/EC); the type is also available in accordance with the American explosion protection UL (Underwriters Laboratories).

The pumps are suitable for heavy-duty applications and are therefore designed in accordance with the obligatory API nominal pressure of PN 50. Both the hydraulic and the canned motor pump undergo a test pressure of 75 bars. The materials meet the requirements of API 685, appendix H. In the industries mentioned above nearly all media are conveyed. These various tasks comprise:

- fluids with lowest viscosities
- fluids with highest vapour pressures
- high and low tempered fluids between
-150 °C up to +480 °C
- high-pressure cycles with fluid materials
or supercritical gases



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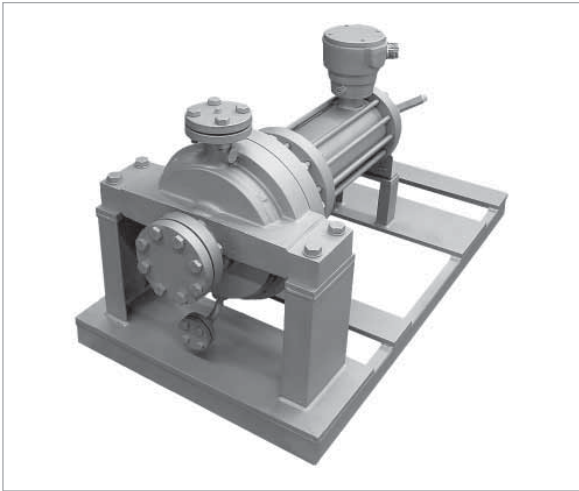


Figure 9: standard version type CNP/CNPF



Figure 10: standard version type CNPK with external heat exchanger

Besides the three standard versions there are also defined variants that can be realised out of the standard component. Figure 9 and 10 show the standard versions CNP or CNPF, and CNPK, while figure 11 shows a vertical canned motor pump CNPFV that is composed of standard components.

SUMMARY

According to the European IPPC Directive 96/61/EC and its BAT leaflets canned motor pumps are considered as the "best available technology" for the conveyance of dangerous and ecologically harmful media. They are 100% leakage-free and also significantly contribute to primary explosion protection. Due to the employment of a modular construction it is also possible to achieve flexible possibilities of modification, short delivery times and low life cycle costs.



Figure 11: vertical canned motor pump type CNPFV

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Flexibilität hermetischer Pumpen durch modulares
Baukastensystem
Industriepumpen und Kompressoren Heft 2/ 2002 Mai

S. Liegat, D. Lau

Dicht, zuverlässig und langlebig
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G. Trommer

Die richtige Balance
PROCESS 1-2/2003