TECHNICAL REPORT

# HERMETIC pumps for the refrigeration industry

Dr. G. Feldle

LEDERLE Hermetic

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**SUMMARY**

In choosing pumps for the forced re-circulation of refrigerants in large-scale refrigeration systems, the data on the specific systems and pumps and the design criteria is of great importance. The issue of minimum suction head can be addressed by taking into account the irregular conditions in the system, as well as the thermodynamic effects on the suction performance of the pump. Due to leakage and the virtual lack of maintenance required, hermetically sealed centrifugal pumps are generally the preferred choice these days. They feature a compact design, easy installation, high operational safety and extremely low noise levels, in addition to low life-cycle costs.

## 1. INTRODUCTION

Today, the trend for industrial refrigeration system design is as a system with forced circulation of the refrigerant on the low-pressure side. In comparison to other system types, the use of pumps offers a range of advantages, which are described below:

- Problem-free distribution and control of the refrigeration output or refrigerant with multiple consumers and evaporators, even in a remote installation.
- Due to the low temperature differences in direct vaporisation, the electrical output required is minimised.
- The piping system is simplified and the corresponding sizes and dimensions are reduced.
- Optimised heat transfer to the vaporisers.
- Concentration of the most important system elements into one compartment.
- Simple defrosting and degreasing.



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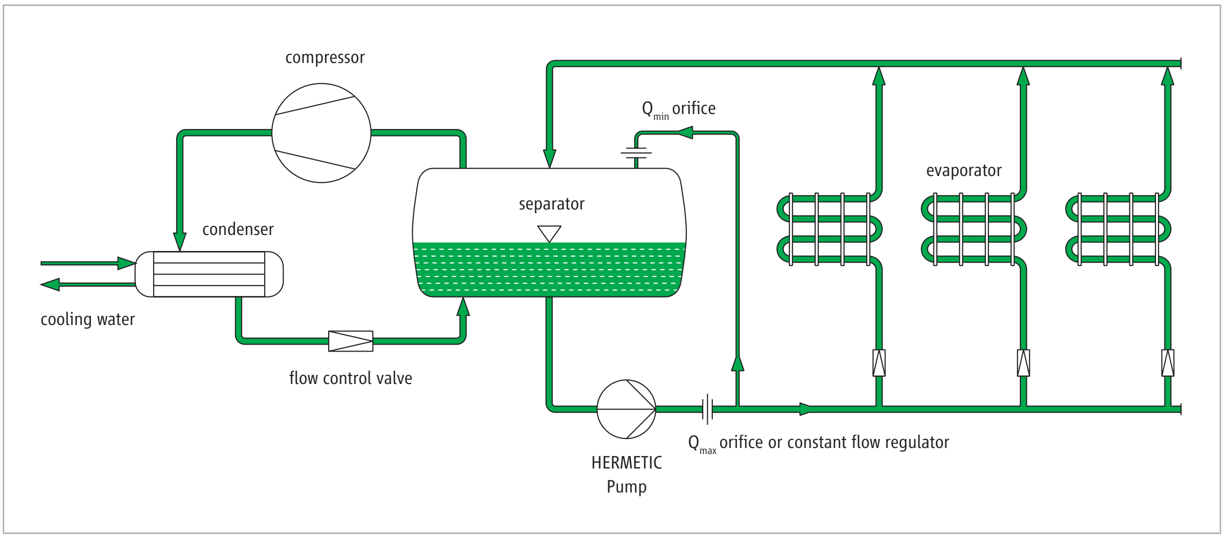


Figure 1: Simplified diagram of a large refrigeration plant

The simplified diagram of an industrial refrigeration system with forced circulation is given in figure 1. A largescale refrigeration system consists of a primary and a secondary circuit. The principle of the forced circulation process means that a higher volume of refrigerant is circulated than is vaporised in the vaporiser under heat absorption. The ratio between both mass flow rates is known as the circulation factor Z. The vapour produced and the excess refrigerant is conveyed via the return line in the secondary circuit back to the separator. The liquid refrigerant which is produced in the central separator can be conveyed to the consumers (vaporisers) using one or more pumps. The compressor, condenser and regulating organ are positioned in what is known as the primary circuit.

The layout and dimensioning of the pumps depends on the refrigeration output, the circulation factor, the vaporisation temperature, the design of the vaporiser and the geometric layout of the system.



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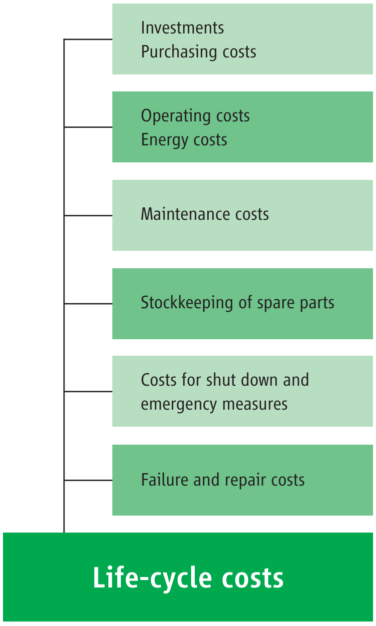


Figure 2: Life-cycle costs of centrifugal pump

## 2. SELECTING THE PUMP TYPE

Pumps in industrial refrigeration systems must be able to convey refrigerants not only when boiling but also ensuring maximum operational safety and the absolute minimum of maintenance. In addition, recently the issue of minimum overall costs (life-cycle costs) has become important. This is why today centrifugal pumps are by far the most preferred option for use. Self-priming pumps are now rarely used due to their particular sensitivity to contamination and the consequential wear involved.

Centrifugal pumps with stuffing box packing or mechanical seal, as used in earlier years, now only fulfil requirements for environmental friendliness and the modern concept of “life-cycle cost” in large-scale refrigeration systems only to a very limited extent.

If no pumping media may be permitted to escape, as is the case in large-scale refrigeration systems, double-stage mechanical seals are used which have a sealing fluid in the spaces. This lubricates and cools the sliding surfaces on the joint rings.

With environmentally harmful media, the use of this type of pump has reached its economic limits, however, as only with the corresponding level of safety precautions in the form of locking and monitoring systems is it possible to prevent the medium escaping into the atmosphere.

In comparison to seal-less centrifugal pumps, the lifecycle costs of pumps with shaft seals are considerably higher. The life-cycle costs consist of the purchasing costs, operating costs (energy costs), repair and maintenance costs, and the costs of shut down times. [Figure 2]



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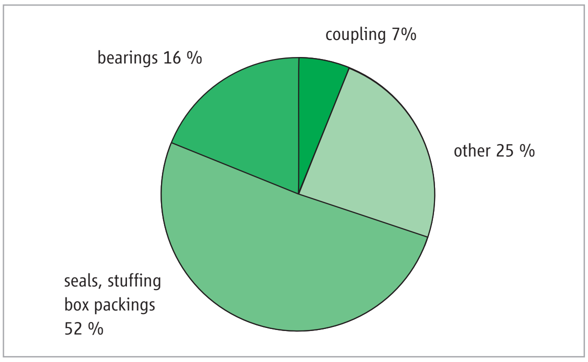


Figure 3: Failure causes with conventional centrifugal pumps

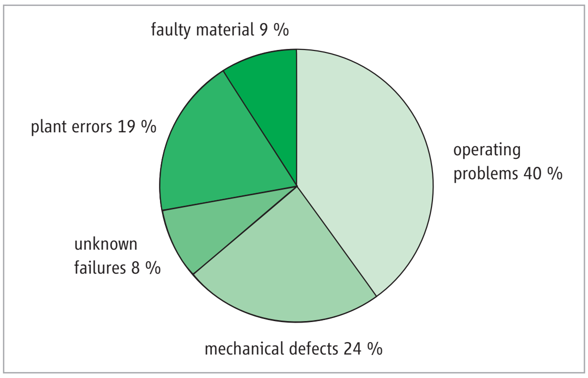


Figure 4: Failure classification regarding seals with conventional centrifugal pumps

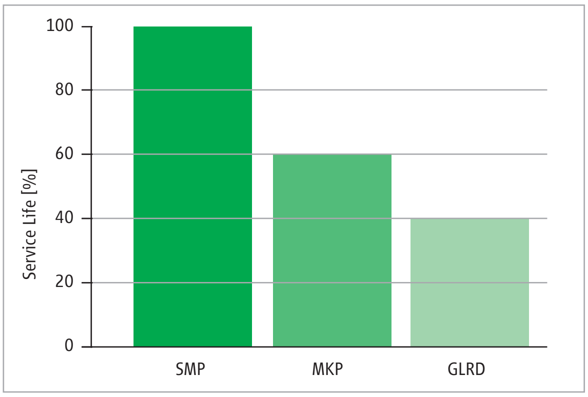


Figure 5: Service lifes of varius types of centrifugal pumps
SMP canned motor pump
MKP magnetically coupled pump
GLRD mechanical seal pump

Figure 3 shows that with conventional centrifugal pumps the seals at 52 % play a dominant role in the cause of failure. Damage caused by roller bearings and couplings is considerably lower. Looking in detail at these seal-related causes in conventional pumps, it is obvious that operating problems such as system and operational faults on the other hand take the lion's share with 40 %. [Figure 4]

## 3. HERMETICALLY SEALED CENTRIFUGAL PUMPS

Of the two hermetically-sealed drive systems
- electromagnetic using a canned motor
- permanent magnetic using a magnet drive

it is primarily canned motor pumps which have secured themselves a considerable market share in refrigeration technology. This has to do with the fact that canned motor pumps themselves are more compact, easier to install, more cost-effective and, in particular, more reliable and resistant to failure in operation.

This is also reflected in the service life in comparison to other types of pump [Figure 5], where canned motor pumps (100 %) have considerable advantages over magnetically coupled pumps (60 %) and conventional pumps (40 %).



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Figure 6: Maintenance costs of varius types of centrifugal pumps

| | |
|---|---|
| SMP | canned motor pump |
| MKP | magnetically coupled pump |
| E-GLRD | pump with single mechanical seal |
| D-GLRD | pump with double mechanical seal |

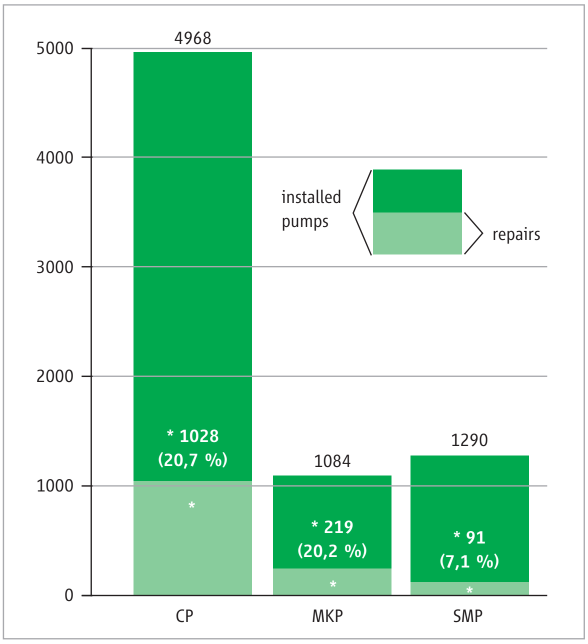


Figure 7: Number of pumps and repairs of pump Types

| | |
|---|---|
| SMP | canned motor pump |
| MKP | magnetically coupled pump |
| CP | conventional chemical pump |

The servicing costs for canned motor pumps are higher than with other types of centrifugal pumps. [Figure 6]

On the other hand, the frequency of repairs for canned motor pumps is only around 1/3 of the repair quota for mechanical seal pumps and magnetically coupled pumps. [Figure 7]

This means that the life-cycle costs for canned motor pumps are generally the lowest.



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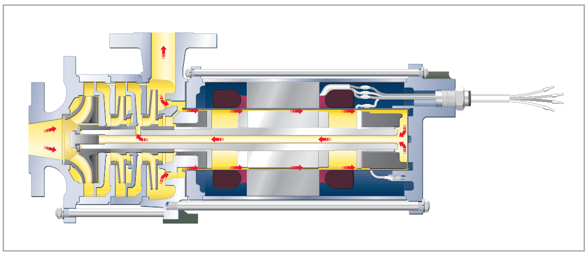

Figure 8: HERMETIC-pump type CAM

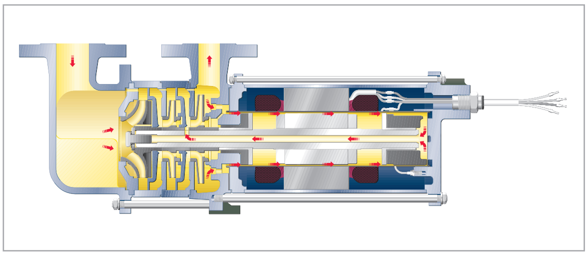

Figure 9: HERMETIC-pump type CAMR

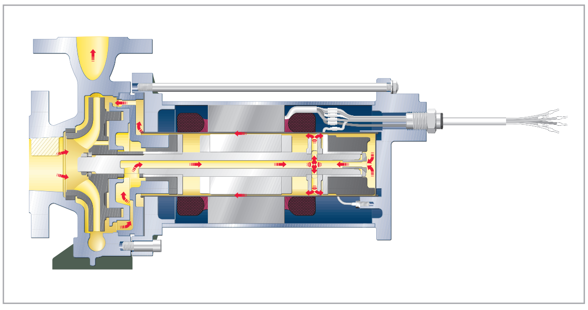

Figure 10: HERMETIC-pump type CNF

## 4. DESIGNS OF CANNED MOTOR PUMPS

With canned motor pumps the impeller is fitted on the motor shaft. The pump casing is connected directly to the motor. The stator winding in the drive is separated from the pumping medium by a thin tube, called can. [Figure 8]

During operation the rotor compartment is filled with pumping medium and together with the hydraulic section of the pump forms a compact, integral unit. The electromagnetic field generated by the stator acts through the can to the rotor surrounded by medium, so that the required driving torque can be created. Due to the pump and motor unit, canned motor pumps do not require either base plates or special foundations. In addition, this type of pump is characterised by an extremely low noise level. The motor is liquid-cooled; to this end a cooling flow runs from the pump pressure-side into the rotor compartment, and, once it has absorbed the heat lost from the motor, returned through the hollow shaft between the first and second impellers in an area of higher pressure. This prevents the motor cooling flow evaporating.

The **CAMR** with radial suction nozzle is especially wellsuited for what are known as compact systems with small collecting vessels. The option of suction side degassing means that the pump is operational more quickly following a shut-down. The pump can be suspended in a space-saving way without 90° bend directly underneath the vessel. [Figure 9]

This has a positive effect on the NPSH pump, which saves space thanks to the suspended fixing and saves costs because no base plate is required.

The special design of the suction casing and the layout of the radial suction nozzle means that the pump does not break away at up to approx. 8 % vapour content (2-phase pumping). Naturally the pumping volume and differential head are reduced dramatically with increasing vapour content.



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In addition to versions with a multistage sectional design, single-stage refrigeration pumps with a special guide for the motor cooling flow pumps are also used with larger circulatory flows. [Figure 10]

With this type of construction the cooling flow is diverted to the periphery of the impeller and after flowing through the hollow shaft and the rotor compartment, it flows back to the pressure side of the pump. An auxiliary impeller within the rotor compartment is used to overcome the hydraulic resistance which is generated in this way. The rotor compartment is overridden by the entire pump pressure with this type, which excludes the possibility of the heated cooling flow evaporating. The motor cooling flow which is always constant regardless of the differential head, produces even cooling conditions across the entire range of characteristics.

Refrigeration pumps as shown in figures 8, 9 and 10 are characterised by the liquid-sealed design of the motor casing and the cable bushings. This protects the winding against condensation water and frost production and in the event of an accident where the can is damaged, prevents refrigerant escaping into the environment. The risks of the can freezing from outside, as occurs with permanent magnetic pumps and which can result in the sticking or blocking of the outer drive section during start-up in particular, are completely excluded with canned motor pumps. For servicing reasons, the can has a barrel-type design in all versions. In the event of damage to the motor, this permits simple access to the winding so that repairs can be carried out without welding work on the can by any motor winding unit on-site.

The hermetically-sealed design demands the use of medium-lubricated slide bearings. To protect the bearing and in particular the thin-wall can against solids and contamination, the cooling/lubricating flow is conveyed from the pressure-side of the pump via a self-cleaning ring filter. As within



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the pump, some gas yield must be expected at times, the preferred bearing materials for use are those with the relevant emergency and dry-running properties. Carbon bearings impregnated with antimony in particular have been found to be the best option here. With more powerful units, wear-proof bearing combinations based on silicon carbide against silicon carbide are now increasingly being used. Considerable service life duration can be achieved with the correct dimensioning of the bearings. Typical values range from 20000 to 65000 operating hours, depending on the operating method and gas yield.

## 5. PUMP PROTECTION USING A CONSTANT FLOW REGULATOR

The refrigerant in refrigeration systems being conveyed by pumps will always be in a boiling state. Only the installed suction head with the corresponding liquid column in the suction line in front of the pump guarantees cavitationfree operation in the pump. Therefore, the NPSH value of the system needs to be greater than the NPSH value of the pump. Depending on whether the pump is operated at smaller or larger pumping volumes, the NPSH value of the pump can reach a non-permissibly high range, which may then result in cavitation. To achieve safe operation of the pump at all times, the protection should be as follows:

- it must prevent the minimum volume being undershot using a bypass line into the gas compartment of the suction nozzle (collecting vessel) with installed $Q_{min}$ orifice and
- it should have a $Q_{max}$ orifice installed in the pressure line to protect against the maximum volume being exceeded.

The $Q_{max}$ orifice in the pressure line has by its very nature a strong throttle effect, however, which produces an undesirable conversion of energy into heat.



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A considerably greater loss with simultaneous protection against the maximum volume being exceeded is achieved by using a constant flow regulator instead of the $Q_{max}$ orifice. The constant flow regulator is a spring-loaded variable Qmax orifice which controls the volume up to a flow volume defined by the design. In the range of the minimum to maximum flow volume, the differential head of the pump is maintained at virtually the same level to prevent this undesirable energy conversion. The pump is always adjusted for the relevant operating point where the pump characteristics and the system characteristics converge.

This means that with multistage pumps, one stage can often be omitted and/or a smaller motor used.

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