Substantial cost implications can arise for oil and gas operators and contractors if material for pump ancillary equipment is not fully specified

The need for full specification

When an organisation in the petroleum, petrochemical or gas industry specifies a centrifugal pump, it will generally rely on the standard known as API 610, and for some of the ancillary equipment, API 682. API is an acronym for the American Petroleum Institute, a body that develops technical standards for oil and gas industries. Given the demanding nature of oil and gas applications, such as oil processing and refining facilities and gas processing plants, API 610 and API 682 are necessarily strict and were developed to ensure the following:

- **Safety** – this is of prime importance in the oil and gas industry, as a cracked pump casing, failed bearing or leaking mechanical seal can lead to catastrophic consequences.
- **Reliability** – after safety considerations, production is the main concern, as downtime can cost millions of dollars per day.
- **Maintainability** – planned pump overhaul is essential, but the pump must be back in service as quickly as possible to ensure production downtime is kept to a minimum.

With these demands, pumps manufactured according to API standards cost considerably more than those manufactured to lesser hydraulic standards. However, the oil and gas industry is now extremely competitive, and operators and contractors must ensure that pumps both meet their demands and are procured at the best cost.

Although API 610 for centrifugal pumps and the associated API 682 for mechanical seals and seal support systems are strict, there are numerous areas where different interpretations of information by manufacturers, particularly where customers have not fully specified what they require, can lead to significant differences in the final cost of a pump system to perform a specified duty.

One such area is the materials for ancillary equipment, such as the mechanical seal, seal support system and instrumentation. These materials are not fully specified within the API standards. This article will consider the design decisions that could be made and the potential cost implications of such decisions when customers leave the material specification open to interpretation by pump manufacturers.

Process wetted and non-process wetted equipment

A pump skid comprises of three distinct zones:

- Equipment that is in direct contact with what is usually a corrosive or toxic process fluid, which is known as 'process wetted' equipment.
- Equipment that is not in contact with the process fluid, which is known as 'non-process wetted' equipment. This equipment may be in contact with barrier fluid (such as water, water/glycol mix or light mineral oil) or is simply other ancillary components not in contact with any fluids.
- A mechanical seal that prevents the leakage to atmosphere of the process fluid and is in contact with both the process fluid on one side and the pressurised barrier fluid, i.e. the non-process fluid, on the other.

Figure 1 illustrates a typical arrangement with centrifugal pump,

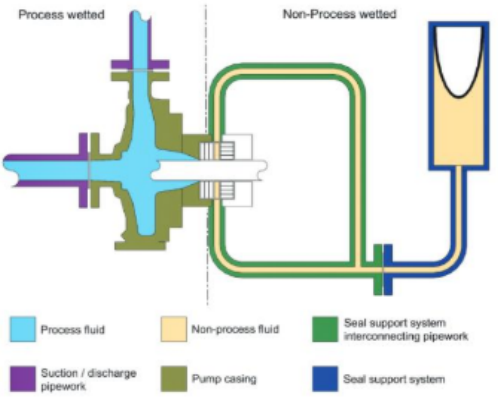

Figure 1: Equipment on a typical pump skid

mechanical seal, seal support system and interconnecting pipework.

The process wetted equipment (left) comprises the pump casing, impeller, as well as the pipework and valves carrying the process fluid.

The non-process wetted equipment (right) comprises the seal support system and interconnecting pipework between the mechanical seal and seal support system, along with any components not directly in contact with the process fluid, such as fasteners and instrumentation.

The mechanical seal on the pump shaft is in contact with both the process fluid on one side and the pressurised barrier fluid, i.e. non-process fluid, on the other. It is usually considered as process wetted equipment since the material specification for process wetted equipment will be higher than that for non-process wetted.

Material selection

We will now consider the standards used to define the materials for the following equipment, as well as the consequences of not specifying those materials fully:

- Pump – the pump standard, usually API 610.
- Seal support system – the seal manufacturer's proposal and standard, usually API 682.
- Mechanical seal – the seal manufacturer's proposal and standard, usually API 682.
- Process fluid pipework – the customer's piping class standard.
- Seal support system pipework – the seal manufacturer's proposal.
- Non-process wetted ancillary components – the pump and seal manufacturer's proposal.

Pump

The standard for centrifugal pumps used in the oil and gas industry is API 610 and this, along with the knowledge of the process fluid, enables the selection of material for the process wetted components in the pump, including the casing and impeller, from API 610 Table H (see Table 1). Depending on the corrosiveness of the process fluid, this material may range from low-cost carbon steel to expensive, exotic alloys such as duplex stainless steel or Hastelloy.

Part	Material class	S-8	C-6	A-8	D-1	D-2
Pressure casing	Yes	Carbon steel	12 % CR	316 AUS	Duplex	Super Duplex
Impeller	Yes	316 AUS	12 % CR	316 AUS	Duplex	Super Duplex
Shaft	Yes	316 AUS	12 % CR	316 AUS	Duplex	Super Duplex

Table 1: Extract from API 610 Table H showing various materials for process wetted components

Mechanical seal

The mechanical seal contains the process fluid, which is usually corrosive or toxic, within the pump preventing leakage at the pump shaft. The standard for mechanical seals used in the oil and gas industry is API 682, which contains no specific material specification table. However, it does specify that the material for the gland plate of the mechanical seal in contact with the process fluid must be of equal or higher specification to that used in the pump casing. In practice, due to the smaller components used in the seal, the material is often a higher specification than the pump casing to minimise seal wear and prevent the need for premature replacement.

There is only a minimum requirement for the non-process wetted side of the mechanical seal of 316 stainless steel. Beyond this, it is based on Appendix B in API 682. As such, without any specific material specification in API 682, it is down to either the customer to specify the non-process wetted material for the mechanical seal or leave the selection to the seal manufacturer, who will either specify the non-process wetted side to be manufactured from the same material as the process wetted side, or may simply specify the minimum requirement of stainless steel for non-process wetted components.

When selecting the material for the non-process wetted side of the mechanical seal, consideration should also be given to a seal or support system failure. If a primary seal fails, then the secondary seal would continue to retain the process fluid for a period of time. The system would normally have safeguards to stop pumping before any major damage occurs. Any process fluid that crosses into the seal support system during a failure would just need to be drained and the system flushed before being brought back into operation. In certain installations, should the seal support system fail, then the primary seal will reverse pressurise to seal the process fluid until the system reaches equilibrium. Again, the system will have safeguards to stop pumping before any major damage occurs.

Given the mechanical seal design and the safeguards against the process fluid crossing the primary mechanical seal, the material chosen for the non-process wetted side of the seal could be lower than that used for the process wetted side. However, without a customer material specification, should higher specification materials be selected on the non-process wetted side

than are necessary, the cost of the seal would be considerably higher than required.

Seal support system

The standard for seal support systems used in the oil and gas industry is API 682. However, unlike API 610, there is no material specification table in API 682, other than a minimum requirement of 316 stainless steel, and so it's down to the seal supplier to propose a material, or the customer to provide the material specification. The seal support system barrier fluid is usually water, a water/glycol mix or a light mineral oil, and as such there is minimal corrosive action and a low risk of contamination should leakage of the barrier fluid occur.

Without a customer material specification for the seal support system, the default position for the supplier would be to select materials based on the barrier fluid, and so this would usually be stainless steel. However, in some cases the customer mistakenly specifies that the seal support system should use the same material as the pump; if the pumped fluid is particularly corrosive or toxic, this would require a high material specification, such as duplex stainless steel or even Hastelloy. This would be a more expensive material than necessary for the seal support system, which could be manufactured from stainless steel and/or alloyed carbon steel, as it will never be in contact with the process fluid during normal operation, as the barrier fluid would always be at a higher pressure than the process fluid.

Process fluid pipework

Some specifications will contain a customer or project-specific piping class. This will detail the material for the process pipework considering the process fluid, pressures and maintenance routines of the customer. The process pipework could be manufactured from the same material as the pump casing, but it could also be manufactured from a lower quality material, as pipework is often considered a maintenance and expendable item by the customer in comparison to the pump itself. The piping class may be relevant when looking at the seal support system pipework, as below.

Interconnecting pipework

During normal operation, the material for the interconnecting pipework between the seal support system and the mechanical seal does not carry, or come into contact with, the process fluid, just the barrier fluid. As such, it does not need to be manufactured from the same material as the process pipework (which may be specified by the piping class, as above, for the process fluid pipework). The pipework for the seal support system will, by default, be chosen by the supplier based on the barrier fluid, and so would usually be stainless steel. However, if the customer mistakenly refers to the process piping class, which has a higher specification than stainless steel, then the same material as the process pipework may be used. This could lead to the seal support system pipework being over specified (for example, using super duplex stainless steel or even Hastelloy) and therefore it will be more expensive than is required. Conversely, by following the process fluid piping class, the seal support system pipework could also be under specified, as the process fluid pipework may be manufactured from carbon steel. This is not suitable for the seal support system pipework, which should be a minimum of stainless steel to prevent any corrosion inside the pipework entering and damaging the mechanical seal faces.

Instrumentation and other ancillary components

The materials for instrumentation on process wetted equipment should be specified where relevant in the hook-up diagram or instrumentation specifications. It is important that the material for process wetted instrumentation is specified fully, otherwise the materials used for the process wetted instrumentation would have to be the same as used for the pump, which may well be of a higher and more expensive specification than required, potentially leading to extended procurement lead times.

Figure 2: Amarinth skid package with API 610 OH1 pumps and seal support system

The materials for the non-process wetted ancillary components (such as the gauges and valves in the seal support system) only see the barrier fluid or non-process fluid. These should be fully specified by the customer and should not simply follow other material specifications, otherwise unnecessarily expensive materials may be selected for such components.

Cost implications

If the customer does not specify the materials for the non-process wetted ancillary equipment and components as above, suppliers are either forced to use more expensive materials than necessary following other specifications, or to make material decisions on the customer's behalf, which may not be in the customer's best interest.

The financial impact of the customer not specifying non-process wetted materials may be high if the pump supplier does not take any further action, as the following examples show:

- The cost of a Plan 53B seal support system for a sour service pump could be 60% higher if more expensive materials are used than necessary.
- The cost of other ancillary components for a sour service pump could be 30% higher than those more readily available and suitable for the needs.

Additionally, customers should consider the extended lead time needed to procure non-standard components and instrumentation manufactured in exotic materials.

Amarinth's approach

If materials are not specified fully for ancillary systems and components, then to deliver the most cost-effective design, Amarinth will always seek clarification at one of three stages:

1. Front-end engineering design
2. Bid/quote
3. Post order

However, the earlier that full material clarification can be achieved, the easier it will be for a manufacturer to meet the required lead time and ensure that the most cost-effective system is proposed. This also reduces the risk of confusion, queries and contract discussions at the time of delivery. ▮

For more information:
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