Guides to Good Practice
in Corrosion Control

Pumps
and Valves

NPL
National Physical Laboratory

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Pumps and Valves

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This is an update of a DTI publication first issued in 1982. The new version has been prepared by Dr. R. Francis of Weir Materials and Foundries under contract from NPL for the Department of Trade and Industry.

1.0 Introduction

This guide describes potential corrosion problems in pumps and valves, and outlines measures that can be taken to minimise these problems. It is not intended that this guide be used to select the most appropriate pump or valve type for a specific application, but it does give indications of the applications for the major types being considered. The guide also indicates the different kinds of corrosion which may be encountered and the means of avoidance which can be considered, both for new equipment and items which have failed in service.

There is a large number of pump and valve types, as well as a wide range of fluids to be handled, so that advice on design and materials selection in this guide is given in general terms.

2.0 General considerations

Pumps and valves are designed or chosen primarily for their mechanical performance i.e. containment of pressure, fluid sealing and, in the case of pumps, pumping capacity. For reasons of economy manufacturers offer their products in a limited range of materials. Each of these materials is suitable for a range of common fluids, and has the advantage of being available with relatively short delivery times. However, for corrosive and/or erosive fluids the user may require special designs (e.g. of seals) and/or special materials, which increase cost and delivery times. The balance of cost versus the likelihood of failure due to corrosion must be taken into account along with the criticality of the component, i.e. what are the consequences of a failure. For example, a firewater pump is a high criticality item and materials should be chosen so that there is no safety risk.

When requesting non-standard items it is important to realise that most of the wetted components in a valve or pump are cast and hence an alloy with good foundry characteristics must be selected. A compatible wrought alloy must be selected for items such as shafts and stems. Even when an alloy is available as a casting, it may not have all the properties that are required. For example, phosphor bronze (BS 1400; CT1) is sometimes used for pump impellers, but rarely for pump or valve bodies because of the difficulty in producing pressure tight castings in this alloy.

If an alloy change from a standard material involves the production of wholly new patterns, the additional costs will be great, and it may be cost effective to consider an alternative alloy with similar properties which only requires minor pattern modifications.

When selecting a pump or valve the user must provide the supplier with details of the composition of the fluid to be handled (including trace chemicals), the pH, the temperature, the solids content and the flow rate. Other factors which are also required for cost effective materials selection are the desired life and the criticality of the component i.e. the consequences of an unplanned shutdown.

Tables 1 and 2 list the common types of pumps and valves and some of their advantages and disadvantages in relation to corrosion and allied problems. Nowadays most valve types can be made fire safe and are available in a range of common materials. Stem glands will require maintenance on all types of valves.

3.0 Types of corrosion

3.1 General corrosion

This involves more or less uniform metal dissolution over all the wetted surfaces. Although this is less serious than localised corrosion, a number of problems may occur. One is the reduction of tolerances on items such as wear rings in pumps, which will result in a loss of pumping efficiency. Also, the continued release of metal into the fluid may cause unacceptable levels of contamination.

There are many tables and charts giving data on general corrosion rates of numerous alloys in a wide range of fluids. However, care is needed in applying these as much data have been generated under quiescent or slow flow conditions, and high velocities can greatly increase dissolution rates with some materials.

Table 1. Guide to pump types

TYPE	DESIGN	PROBLEMS	ADVANTAGES
Centrifugal	Horizontal	Not usually self-priming and can lose prime if air/vapour is present. Poor performance on viscous liquids.	Available in wide range of materials. Continuous-flow, free from large pressure pulsation.
	Vertical: in line	As above plus: Special motor; bottom bearing (if fitted) becomes contaminated. Smaller mounting area (footprint).	
	Vertical: submerged	As above plus: Bottom bearing exposed to liquids. Liquid drain down whilst stationary leads to air/liquid interface within the pump, and also probably on the pump or pipework external surface.	
	Canned: a glandless pump. Electrical windings separated from fluid by a thin can of corrosion resistant alloy.	No use for liquids containing solids because of close tolerances between stator and rotor; carbon bearings easily destroyed.	Has no seals and isolates liquids from motor.
Rotary		Rotary pumps are usually not suitable for handling liquids containing solids.	
	Gear: two meshing gears within closed casing. Lobe: two meshing lobes. Vane: offset fined impeller.	Available in most metallic materials. Small amounts of corrosion or wear reduce efficiency. Generally mild steel or carbon.	Suitable for all fluids including viscous fluids. Positive displacement type pumps suitable for metering.
	Screw: helical screw in elastomeric stator.	Limited materials available for stator.	
Reciprocating	Diaphragm: the diaphragm is forced into reciprocating motion by mechanical or hydraulic linkage.	Limited materials available for diaphragms and check valves. Pulsed flow, which can be smoothed by the addition of dampers. Vulnerability of check-valve materials to process fluids. Poor with solids, but designs exist that allow slurries to be pumped	Suitable for various speed/ stroke. Can handle viscous liquids. Capable of high heads. Fluids isolated from pumping mechanism.

Table 2 Guide to valve types

TYPE	FUNCTION	DESIGN	ADVANTAGES	DISADVANTAGES
Gate (wedge)	On/off throttling possible.	A straight-through valve incorporating a rising-wedge gate.	Widely used on water duties but can be used for control of process fluids. Cheap in large sizes and generally made of cast iron.	When used for throttling may suffer erosion and where solids are carried at high velocities, seat and wedge may be hardfaced, (e.g. with Stellite 6 or tungsten carbide). The groove in the base is liable to blockages. Can be "overshut" causing seizure.
Gate (parallel)	On/off throttling possible.	More sophisticated version of wedge.	Used mainly for steam duties at high pressure.	As above.
Plug	On/off.	A straight-through valve incorporating a rotating plug. Lubricated plug for critical service under pressure. Non-lubricated plug (sleeved plug). PTFE sleeve for frictionless operation.	Can be fully PTFE-lined and hence have very good chemical resistance.	Lubricant can cause contamination of products and limit the temperature of operation. Not widely used because of level of maintenance required. Pressure/temperature conditions limited by lining material. Liable to seizure in service.
Globe	Throttling (needs suitable materials).	Widely used for regulating flow consisting of a rising plug from the seat.	Wide range of sizes and pressure/ temperatures.	Not available as a lined valve.
Ball	On/off.	Straight-through flow.	Widely used for corrosive conditions and range of pressure/ temperature. Can be made fire-safe.	Poor for throttling. Not suitable for fluids containing solids which damage seats.
Needle	Throttling.	Fine regulation of flow.	Suitable for high pressures.	Available only in smaller sizes.
Butterfly	On/off. Can be used for throttling if suitably designed.	Very simple design consisting of a flat disc rotating into a seat.	Available in a wide range of materials including many linings and coatings. Suitable for large flows of gases, liquids and slurries. Relatively cheap, particularly in larger sizes. Slim Design.	
Diaphragm	Throttling can be used for on/ off duties.	Glandless type of valve incorporating a flexible diaphragm and available either as a weir type or as full bore.	Widely used for corrosive fluids, but good where leakage must be avoided.	Limited on pressure and temperature by diaphragm materials. Not recommended for mains insulation.
Check	Prevention of backflow.	Automatically prevents backflow.	Wide pressure/temperature range.	Not reliable on critical duties.
Safety	Safety and protection.	"Pop-open" valve for gases and vapours (steam).	Reseats.	Only for gases: prevents excess pressure.
Relief	Safety and protection.	Proportional life valve for liquids.	Reseats.	Only for liquids: prevents excess pressure.
Bursting disc	Safety and protection.	Protection of plant systems where very rapid pressure rises may occur.	Instantaneous unrestricted relief. Wide range of materials available.	Not-reclosing and expendable. Subject to corrosion and creep if hot, causing premature failure.

3.2 Localised corrosion

There are two main forms of localised corrosion: pitting and crevice corrosion.

3.2.1 Pitting

This is very localised and pits are often extremely narrow but deep. Penetration rates can be several mm/y in severe cases. Pitting occurs when the protective film on the material breaks down at a small point. Repassivation does not occur and more metal dissolution takes place. The environment in the pit is of low pH and generally very high in chlorides leading to rapid dissolution rates at the base of the pit. Total metal loss is small but penetration can occur in a short time.

3.2.2 Crevice corrosion

This occurs where a tight crevice occurs between two components e.g. a threaded joint or a flanged coupling. The environment in the crevice quickly becomes deaerated and metal dissolution inside the crevice increases. There are two forms of crevice corrosion; one involves a differential aeration cell between the crevice and the bulk metal, whilst the other involves a metal ion concentration cell. The former affects metals such as stainless steels and aluminium alloys, while the latter affects copper alloys. With a differential aeration cell the corrosion occurs inside the crevice, while the corrosion occurs just outside the crevice with a metal ion concentration cell.

Once initiated this type of attack is similar to pitting and very high propagation rates can occur under certain conditions.

3.3 Galvanic corrosion

This occurs when two or more dissimilar metals are in electrical contact and are immersed in a conducting, corrosion liquid. Corrosion is more likely the further apart the metals are in the electrochemical series (i.e. the greater the difference between their open circuit electrochemical potentials in the fluid in question).

Normally corrosion occurs with potential differences of 200 mV or more, but rapid corrosion can occur in couples with only 50 to 100 mV difference, if other conditions are unfavourable. A classic example is preferential corrosion of weld beads, and it is imperative that the weld material should have an equivalent or more electropositive potential than that of the parent metal in the specified fluid.

Galvanic corrosion is strongly influenced by the relative areas of the two metals, and dissimilar metals are often connected successfully when the more electronegative material has a large area compared to the electropositive material. A good example is the use of 316 stainless steel impellers in sea water pumps with austenitic cast iron bodies.

The severity of attack is also governed by the temperature and the cathodic efficiency of the electropositive metal in the couple. The latter factor governs the critical area ratio required to avoid problems.

It is important when selecting materials for valves and pumps to look at all the components in the system to avoid costly failures due to galvanic corrosion. This should include not only the valve or pump, but also the piping, to which it is connected.

3.4 Flow effects

3.4.1 Erosion

This occurs in fluids with high solids contents where material is mechanically abraded away. Erosion is a function of the solids content, the cube of the velocity and the angle of impact. Resistance to erosion increases as the strength and hardness of the material increases. Alloys which work harden in service have been used successfully to resist erosion. In severe cases ceramic coatings/inserts are necessary. Figure 1 shows severe erosion of a cast iron impeller.

Figure 1. Erosion of grey cast iron impeller after two months handling coal dust

3.4.2 Erosion corrosion

This process is also known as impingement attack. It occurs when turbulent fluids or entrained solids damage the protective film. The metal then corrodes and the film reforms. Successive repetitions of this process lead to rapid corrosion. The corrosion usually occurs locally and takes the form of smooth, waterswept pits, often undercut. Typical sites of attack are at the tips of impeller vanes, after sharp bends and after partly throttled valves, i.e. areas of high turbulence.

3.4.3 Cavitation

This occurs when a sudden decrease in pressure leads to the formation of vapour cavities. These migrate along the pressure gradient and collapse at regions of higher pressure. The mechanical forces at the surface lead to local loss of metal, which can be severe. Cavitation occurs in pumps run under non-optimum conditions or after control valves producing substantial pressure drops. Attention to detail in design usually avoids this problem except under abnormal operating conditions.

3.5 Environmental cracking

3.5.1 Stress corrosion cracking (SCC)

This is a very localised form of attack which requires a tensile stress (either external or internal) and a corrosive liquid. Different alloys tend to be susceptible to cracking in specific chemicals and also at specific temperatures. Some common examples are carbon steels in hot alkaline solutions, austenitic stainless steels in hot chloride solutions and copper alloys in ammonia or nitrite containing solutions. Because of uncertainty in actual operating stresses (including residual stresses from manufacture and fabrication) it is difficult to ensure that operating conditions are below the threshold stress for that alloy system. Alloys, even in one class, vary in their susceptibility to stress corrosion cracking and it is usually possible to select a resistant material. Figure 2 shows stress corrosion cracking of an austentic cast iron.

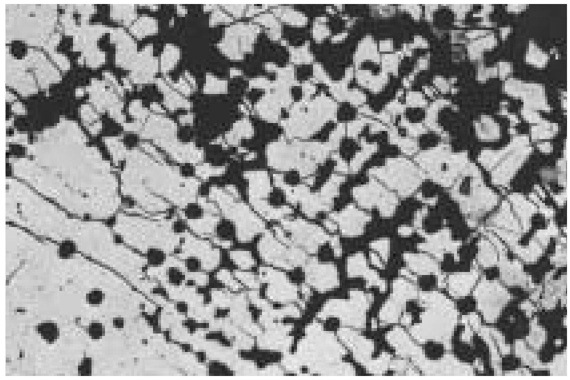

Figure 2. Stress corrosion cracking in an austenitic cast iron (x70)

3.5.2 Sulphide stress corrosion cracking (SSCC)

This is a special form of stress corrosion cracking which is of particular concern in oil and gas production and refinery environments. It requires stresses as for SCC plus the presence of hydrogen sulphide in solution. The temperature of greatest susceptibility to SSCC varies from alloy type to alloy type. In addition to H_2S partial pressure and temperature, the corrosiveness of process brines is also governed by chloride concentration and pH. The suitability of materials for sour environments is regulated mostly by NACE document MR0175, which lists alloys and their limits of use. Qualification of other alloys or use outside NACE limits requires appropriate testing such as is described in EFC publications Nos 16 and 17. [For full details see references.]

3.5.3 Hydrogen embrittlement

This occurs under stress as for SCC and when there is also a source of hydrogen ions, the most common of which is cathodic protection. Pumps and valves are rarely protected internally by cathodic protection, but are often subject to it externally when used subsea. Copper alloys and austenitic stainless steels are largely immune to hydrogen embrittlement, whilst other stainless steels, some nickel base alloys and titanium are susceptible. However, even with susceptible alloys, the threshold stress for cracking is often well above the 0.2% proof stress.

3.5.4 Corrosion fatigue

Corrosion fatigue occurs when there is a regular cyclic stress and a corrosive environment. Failure generally occurs at weak areas or those where stresses are concentrated. Hence, it can affect pump shafts and impellers but does not usually affect valves. The presence of a corrosive medium generally reduces the fatigue limit for most materials, sometimes dramatically. Figure 3 shows a typical corrosion fatigue failure of a pump shaft.

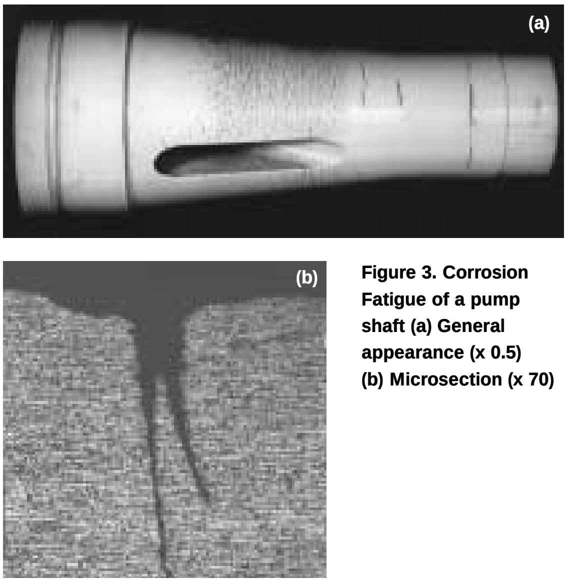

Figure 3. Corrosion Fatigue of a pump shaft (a) General appearance (x 0.5) (b) Microsection (x 70)

3.6 De-alloying

The most well known form of de-alloying is probably dezincification, which affects some brasses. In this type of attack, zinc is preferentially removed leaving a porous, spongy copper remainder with the dimensions of the original component, but obviously much weaker.

A similar type of attack, called dealuminification, can occur with aluminium bronzes. In both cases attack only occurs in certain fluids, but usually involves chlorides.

3.7 Wear

Wear results from rubbing between rotating and fixed components. In pumps and valves this cannot be avoided and so materials with high hardness are frequently used where this is deemed to be a potential problem.

Fretting is similar to wear but occurs between close fitting components which experience slight oscillatory slip. The surfaces are often badly pitted with finely divided oxide detritus. The prevention of fretting requires consideration at the design stage, by removing the movement or by selection of a suitably resistant material.

Galling is caused by rubbing action between certain materials or combinations of materials and leads to welding and tearing of metal surfaces. The higher the load the greater the risk of galling. 300 series austenitic stainless steels are well known to be susceptible to galling e.g. bolts.

4.0 Materials of construction

Some common materials used in pump and valve construction are listed in Table 3 with an indication of their use. This is only in very general terms and more detail would be required for specific alloy selection. The nominal compositions of these common alloys are shown in Table 4.

Valve and pump bodies are usually produced as castings and so it is important that the selected material has good foundry characteristics. Some of the well known wrought alloys are difficult to cast and alternatives with better castability could be more cost effective.

Cast alloys sometimes have different corrosion properties to their wrought counterparts. Corrosion data tables do not indicate this and it is important to check this prior to final selection.

Another difference between cast and wrought alloys is their mechanical properties. Cast forms often have a lower proof stress than the wrought ones and hence this should be incorporated in the design.

Galvanic corrosion should be avoided at all costs
(see Section 3.3).

Table 3. Materials of construction for pumps and valves

PUMP OR VALVE BODY	USAGE
Cast Irons/Steel	*Water, steam, alkaline conditions, dry solvents, organic substances, strong sulphuric acid. Grey cast iron and carbon steel are unsuitable for use in sea water without protection (such as cathodic protection or coating).*
Grey cast iron Malleable iron Nodular (SG) iron Cast steel/forged steel Austenitic (Ni-resist) iron	Sea water, brackish water, waste water.
Stainless Steels	*Generally good corrosion resistance to waters, alkalis, some acids and dry solvents.*
Martensitic	Oil and gas process fluids. Unsuitable for use in sea water.
Austenitic	Type 304 unsuitable for use in sea water. Type 316 may be used in sea water but can suffer crevice corrosion unless subject to galvanic protection. Alloy 20 used for sulphuric and phosphoric acid duties.
Duplex Super Austenitic Super Duplex	More corrosion resistant than type 316 especially to chloride SCC. Excellent corrosion resistance to a wide range of fluids including sea water, produced waters, brines, caustic and mineral acids.
Copper Alloys	
Brass	Water, steam, unsuitable for use in sea water.
Bronzes	*Generally good corrosion resistance in waters including sea waters. Unsuitable for strong alkalis.*
Gunmetal Phosphor Bronze	Brackish water, sea water.
Aluminium Bronze Nickel Aluminium Bronze	NAB has good corrosion resistance in sea water. Should not be used where water is ‘sour’ i.e. contains hydrogen sulphide.
Aluminium	*Not usually used in chemical plant.*
Aluminium and Alloys	
Nickel Alloys	*Generally good resistance to a wide range of acids and alkalis.*
Alloy 400	Resistant to sea water and brine but can suffer crevice corrosion.
Alloy 625	Excellent sea water crevice corrosion resistance.
Alloy 825	Resistant to organic alkalis and salts, H_2S and some acids.
Alloy B-2	Principally used for HCl under reducing conditions (all strengths).
Alloy C-276	Good resistance to a wide range of waters and chemicals.
Titanium and Alloys	*Suitable for a wide range of acids, alkalis and sea water.*
Tantalum	Poor under reducing conditions.
Non Metallics	
Glass Reinforced Plastic (GRP)	Suitable for water, sea water.
Polyvinylchloride (PVC) Polypropylene	Used for acids and alkalis.
PVDF, FEB, PTFE	Acids, alkalis, solvents and other organic substances.
Ceramics	*Used for valve seats and pump wear ring. Resistant to a wide range of fluids. Care should be taken to ensure that materials containing binders are acceptable for the given duty.*
Sintered Solids Coatings	
Linings and Coatings	
Glass/Enamel	All conditions except pure water, hydrofuoric acid and hot alkalis.
Ebonite, natural rubber, Polypropylene	Non-oxidising acids and alkalis.
PVDF, FEP, PTFE	Most organic substances, acids and alkalis.
Note	Holes in linings and coatings can result in severe corrosion. It is vital that the surface be correctly prepared before coating and tested after coating.

Table 4. Typical chemical compositions of some common cast materials for pumps and valves

FERROUS AND NICKEL BASE ALLOYS WEIGHT PER CENT										
Material	**Grade**	**C**	**Si**	**Mn**	**P**	**S**	**Cr**	**Ni**	**Mo**	**Others**
Ni Resist Cast Iron	Flake graphite	<3.0	<2.8	<1.5	<0.2	-	2	15	-	Cu 6.5
Ni Resist Cast Iron	Spheroidal graphite	<3.0	<2.2	<1.5	<0.05	-	2	20	-	Mg <0.06
Martensitic St Steel	13Cr 4Ni	<0.10	<1.0	<1.0	<0.04	<0.03	12.5	4	<0.06	
Martensitic St Steel	17Cr 4Ni PH	<0.70	<1.0	<0.7	<0.04	<0.03	16.5	4	-	Cu 3
Austenitic St Steel (304)	18Cr 8Ni	<0.06	<1.5	<2.0	<0.04	<0.04	18	10	-	
Austenitic St Steel (316)	18Cr 8Ni 2.5Mo	<0.06	<1.5	<2.0	<0.04	<0.04	18	10	2.2	
Austenitic St Steel 20Cr	Alloy 20	<0.07	<1.5	<1.5	<0.04	<0.04	20	28	2.5	Cu 3
Super Austenitic St Steel	20 Cr 6Mo	<0.03	<1.0	<1.2	<0.04	<0.01	20	18	6	N 0.2 Cu 0.7
Duplex St Steel	22Cr	<0.03	<1.0	<1.5	<0.03	<0.02	22	6	3	N 0.15
Duplex St Steel	25Cr	<0.03	<1.0	<1.5	<0.03	<0.025	25	7	2.5	N 0.2
Super Duplex St Steel	25Cr	<0.03	<1.0	<1.0	<0.03	<0.025	25	8	3.5	N 0.25 Cu 0.7 W 0.7
Nickel Copper Alloy	Alloy 400	<0.3	<0.5	<2.0	-	-	-	65		Cu REM Fe<2.5
NiCrMoNb Alloy	Alloy 625	<0.15	<0.50	<0.50	<0.15	<0.15	21	REM	9	Al 0.2 Nb 3.5 Ti 0.2 Fe 3
NiCrMoFe Alloy	Alloy 825	<0.05	<0.15	<1.0	-	-	21.5	42	3	Fe 28 Cu 2 Ti 1
Nickel Molybdenum Alloy	Alloy B-2	<0.02	<0.10	<1.0	-	-	<1.0	REM	28	Co<2.5 Fe<2.0
NiMoCrFeW Alloy	Alloy C-276	<0.02	<0.05	<1.0	-	-	15.5	REM	16	Co<2.5 Fe 5 W 3.5
NON-FERROUS ALLOYS WEIGHT PER CENT										
Material	**Grade**	**Cu**	**Sn**	**Zn**	**Pb**	**P**	**Ni**			**Others**
Leaded Gunmetal	85Cu 5Sn 5PB 5Zn	REM	5	5	5	-	-			
Leaded Gunmetal	87Cu 7Sn 3Pb 3Zn	REM	7	2	3	-	-			
Phosphor Bronze	Cu 10Sn P	REM	10	-	<0.15	0.75	-			
Aluminium Bronze	Cu 10Al 3 Fe	REM	-	-	<0.03	-	<1.0			Al 9.5 Fe 2.5
Nickel Aluminium Bronze	Cu 10Al 5 Fe 5Ni	REM	-	-	<0.03	-	5			Al 9.5 Fe 5

5.0 Protection of external surfaces

External surfaces, including flanges, handwheels, supports, etc., must be protected against the ambient atmosphere. This may be anything from a heated indoors dry atmosphere, through normal industrial or marine, to highly corrosive atmospheres associated with some industries or even submerged in a corrosive fluid such as sea water.

External surfaces of pumps and valves are often as vulnerable as structural steelwork and should therefore be protected by an appropriate scheme. The Code of Practice BS 5493 is a good guide, but as it was issued in 1977 (albeit with amendments in 1984 and 1993) there are now good quality products on the market which have been introduced more recently and which are well worth consideration.

Surface preparation is a most important part of a painting system, and if a long life is desired for any location outdoors or in a damp, wet, indoor atmosphere, grit blast preparation should be mandatory.

Paint products are formulated for specific applications; primers to key on to prepared surfaces, undercoats to give build and body and a finish coat for appearance and to repel water. A full proper paint system for best protection should usually include all three.

Whenever possible, the external shape should be designed to avoid surfaces and pockets where dust and water can collect. Where this is not possible then it may be necessary to consider increasing the thickness of the paint system to prevent failure in local areas.

For items such as pipes or columns and other simple, easy access shapes then a fusion bonded product is a good form of coating to use e.g. fusion bond epoxy.

6.0 Corrosion factors in design

When choosing the pump size, its size and the pressure required to move the fluid, consideration must also be given to the chemical and physical nature of the fluid. For example, if the pump is designed to move fluids that are carrying solids, then the operating velocity range is important. If the velocity is too low, settling may occur, leading to crevice corrosion. If the velocity is too high erosion may occur leading to high localised metal loss. In addition the rates of diffusion controlled reactions increase with velocity. Consideration needs to be given to materials, coatings and pump designs which minimise erosive metal loss. The same principles also apply to valves operating in the same environments.

The distribution of pressure and flow within the components should be such that erosion and cavitation do not occur. Gaskets should not protrude into the flow, where they can cause separation and turbulence.

Small items in pumps and valves also need close attention. For example, threaded drain plugs in contact with the fluid must be galvanically compatible with the body, if not of the same material, and must also be resistant to crevice corrosion. One factor which strongly affects corrosion and is not always properly appreciated is temperature. Process temperatures tend to be quoted at pump and valve inlets. However, the temperature at each location in the device should be considered, particularly in pumps which can have regions which are local sources of heat. For example, in centrifugal pumps pitting and/or crevice corrosion may occur at mechanical seal faces or on shafts under seal sleeves, due to local temperature increases, while the rest of the pump is free of corrosion.

7.0 Corrosion factors in use

Even after the user has selected a pump or valve suitable for their purpose that avoids the corrosion problems outlined above, there are actions that can be taken to avoid problems arising in service.

A common source of corrosion in service is the entry, during shut down, of air and/or moisture into a normally sealed system. This can result in corrosion conditions being produced in areas which retain small volumes of the process fluid. This can be avoided either by ensuring that all such areas have suitable drains or by flushing with an innocuous fluid such as tap water. For carbon and low alloy steels this would also need the addition of a suitable corrosion inhibitor.

Changes in the composition of the working fluid can cause corrosion of components which, until then, have performed satisfactorily. These changes can often be very small, e.g. the presence of a small quantity of ferric or cupric ions can turn a reducing fluid to an oxidising one. Other fluid changes which commonly occur can lead to sudden increases in corrosion as temperature increases and pH changes. Users must anticipate such changes in the fluid as far as possible at the initial design stage, as rectification after a corrosion failure can often be very expensive, not only because a new component is required, but also because of the lost production while the item is repaired/replaced.

Non-metallic components, such as those used for seals, diaphragms, linings, etc, may be subject to attack resulting in swelling, brittleness, softening, etc, with time. Manufacturers usually have extensive experience with a range of materials and it is important that these issues are discussed at an early stage so that any special requirements are addressed and the most suitable design and materials are selected.

Gland packings on pumps and valves are essential to satisfactory operation. A wide variety of packings are used and, as above, it is important to discuss particular applications with the manufacturer so that designs and materials compatible with the process fluid are chosen.

Note that the use of graphite containing seals/packing may give rise to galvanic corrosion in some instances.

8.0 Materials checklist

In order to select suitable materials of construction for a specific pump or valve, the following information is required:

1. **Fluid:** **nature and composition, concentration, pH, aeration, impurities, chemical additions, suspended solids, variations with time.**
2. **Temperature:** **minimum, maximum and normal; any possible thermal shocks.**
3. **Pressure:** **range, including vacuum.**
4. **Flow:** **volume with time, velocity including any local turbulence.**
5. **Operation:** **continuous, intermittent, standby.**
6. **Contamination:** **effect on fluid of any corrosion products which may be produced.**
7. **Requirements:** **reliability required, minimum life, ease and cost of maintenance.**

9.0 Sources of advice

Advice on design and choice for a given use can be obtained from the corrosion advisory centres and consultancy services listed in the Corrosion Handbook.

The same organisations can investigate failures and make recommendations for avoiding them in future. Reputable equipment manufacturers can also offer advise, based on their experiences.

10.0 Further information

General information is available from the following organisations:

National Corrosion Service
National Physical Laboratory
Teddington
Middlesex TW11 0LW
Tel: 020 8943 6142
Fax: 020 8943 7107

Institute of Corrosion
4 Leck House
Lake Street
Leighton Buzzard
Bedfordshire LU7 8TQ
Tel: 01525 851771
Fax: 01525 376690

Materials Information Service
Institute of Materials
1 Carlton House Terrace
London SW1Y 5DB
Tel: 020 7451 7350
Tel: 020 7451 7354
Fax: 020 7839 5513

Information on materials is available from the following organisations:

1. Copper and copper alloys.

CDA
Verulam Industrial Estate
224 London Road
St Albans
Herts AL1 1AQ
Tel: 01727 731200
Fax: 01727 731216

2. Nickel and nickel containing alloys.

NiDI
The Holloway
Alvechurch
Birmingham B48 7QB
Tel: 01527 584 777
Fax: 01527 585 562

3. Titanium and titanium alloys.

c/o Timet UK Ltd
Kynoch Works
Witton Road
Witton
Birmingham B6 7UR
Tel: 0121 356 1155
Fax: 0121 356 5413

11.0 References

For sources of general information on corrosion and data on the compatibilities of metal and fluids, see Guide No 1 in this series.

References on sulphide stress corrosion cracking (section 3.5.2)

MR0175 Sulphide Stress Corrosion Cracking Resistant Metallic Materials for Oilfield Equipment, (revised annually), published by NACE.

EFC 16 Guidelines on Materials Requirements for Carbon and Low Alloy Steels for H2S - Containing Environments in Oil and Gas Production, published by IOM 1995.

EFC 17 Corrosion Resistant Alloys for Oil and Gas Production: Guidance on General Requirements and Test Methods for H2S Service. Published by MPI, 1998.

For sources of advice, see The Corrosion Handbook, published by MPI, 1998.

For information on bimetallic corrosion, see British Standard Institution publication PD6484.

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The National Corrosion Service

The National Corrosion Service (NCS) is operated by NPL on behalf of the DTI to provide a gateway to corrosion expertise for UK users. By acting as a focal point for corrosion enquiries, the NCS can make the UK's entire base of experts available to solve problems or can, using in-house expertise or teams, carry out consultancy. The NCS also helps raise awareness of corrosion problems and methods of control.

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