11 Materials and Corrosion

1. Non-alloyed ferrous material

Even in very clean water, without acids, salts and oxygen, with a pH value 7, corrosion will occur on non-alloyed ferrous material. As soon as water comes into contact with iron, iron ions dissolve from the structure and connect with OH^- ions, building iron hydroxide ($Fe(OH)_2$). Hydrogen ions are discharged with the released valence electrons and they form molecular hydrogen. If a state of saturation is reached or exceeded during the formation of iron hydroxide in the material's surface layer, iron hydroxide forms a sediment on the iron surface, thus preventing corrosion

This process can be expected only if water is calm. If there is any flow, hydroxide enrichment is made more difficult and it may happen that no saturation occurs. A protective layer is then not created and iron keeps corroding. In practice, this was seen in the case of a boiler feeding pump after a completely desalted water was used. Rotary pumps made out of non-alloyed steel, that were using alkaline water with pH 9,5 for a long time without any damage, had considerable corrosion damage on parts subjected to high speeds after desalted water was introduced. By itself, desalted water is less corrosive than alkaline water. However, the latter is still more favourable due to the fact that even in the case of a flow, a protective layer is created. This leads to the following statement:

Pumps and pump installations made from ferrous material will have a sufficient lifetime only if water quality and operating conditions enable the creation of a protective layer.

a) Water quality:

In this connection, DIN 50930 part 2 can be quoted as follows: "With respect to the assessment of the corrosion behaviour of ferrous material depending on water quality, different experiences have been made. It is not possible to provide safe limits for the concentration of water substances.

The following reference values apply to cold water up to 30 °C with the aforementioned reservation:

Oxygen:	Since, no protective layer can be created without oxygen, the concentration must be at least 3 mg/l . Maximum limit values are not known. Water supply companies usually allow 8 - 9 mg/l.
pH-value:	For standard type EDUR pumps 6 to 10. (in case of higher values, Fe type should be used, in case of lower values GBz type.)
Carbonic acid:	In water, there must be balance between carbonic acid and lime. Carbonic acid in excess leads to corrosion. A lack of it is not good either because it leads to precipitation of calcium carbonate, preventing the creation of a thick protective layer and leading to incrustation.
Calcium ions concentration Ca^{2+} :	higher than 20 mg/l (0,5 mmol/l)
Chloride ions concentration Cl^- :	less than 180 mg/l (5 mmol/l)
Sulphate ions concentration SO_4^{2-} :	less than 290 mg/l (3 mmol/l)
Solids:	must not be present.

Note: Sending a water sample to a pump producer in order to choose a suitable material is not advisable. Water analysis results are only useful if conducted by an expert on site under the actual operating conditions. It is only then that it can be guaranteed that gas concentration is not changed.

If drinking water provided by the water company is supplied at a consistent quality, unalloyed ferrous material will last long enough. In all other cases, getting the advice of a water treatment expert is recommended.

b) Operating conditions:

Protective layers are created only in running water; in case of a longer stand still, corrosion will take place. The abrasion of material is usually not excessive; however, a pump may /stop operating /seize, jam. This is why we recommend a regular “forced” starting. Under no circumstances should a pump made from non-alloyed ferrous material be partially filled or remain empty. On the material-water-air interface, heavy corrosion will occur.

Although the corrosiveness of water at higher temperatures is a controversial topic among experts, experience does show a strong increase in the danger of corrosion. In many cases, pump damages could be avoided by just increasing the pH value. Oxygen proportion in water could play a decisive role. In the case of installations for hot water delivery that are closed and under pressure, only rarely is there corrosion damage. However, if there is a possibility of oxygen escaping under atmospheric pressure, material damage is likely.

Problems can also be expected if,the evaporated water is constantly replaced by new fresh water in a pump circuit. In such a case, there are higher concentrations of water contents. It is only a constant control of conductibility and a timely sedimentation that can guarantee a sufficient life expectancy for the pump under these conditions.

In the case of boiler feeding plants, the requirements of TRD 611 should be given due consideration.

2. Bronze

The pure copper-tin-bronze used by EDUR is regarded as one of the best materials for the water-related sector, irrespective of the water application, whether drinking water, raw water, salt (sea) water or desalted water. Corrosion problems are possible only if water has a pH value below 3, if water contains ammonia or if desalted water is delivered at the temperature higher than 70 °C.

There are no limitations on high pH values. The reason why bronze pumps are seldom used is that ferrous materials are also resistant and preferred due to the lower costs.

Mix installations of pipes and pumps made out of different materials require particular attention. A combination of iron pipes with a bronze pump is not allowed. There are no doubts in this regard for stainless steel /synthetic pipes.

3. Stainless steel

Stainless steel’s high resistance to corrosion is mainly due to the alloy proportion of chrome that oxidises in the presence of oxygen. In contrast to an iron-oxide layer, a chrome-oxide layer is a firm and impermeable protective layer. It is no precious metal; corrosion can be expected if the creation of an oxide protection layer does not take place or if it is prevented.

An example is crevice corrosion, which occurs if the water in narrow gaps does not contain enough oxygen.

Corrosion problems also arise in the presence of chloride ions, with the danger increasing with an increase in temperature. This can be prevented by applying an alloy with a high concentration of chrome and molybdenum. However, in the case of shafts it must not be forgotten that this kind of steel has a strength much lower than the normally used martensitic alloys of EDUR pumps.