

## DESIGN AND LAY-OUT FOR CORROSION PREVENTION (continued)

### Welding aspects relating to design

It is very important to take weldability into account when equipment is being designed. As stated earlier, welded joints are often preferable to bolted or riveted joints - assuming high welding quality. If crevice corrosion is a risk, then a crevice-free full-penetration weld must be used. Figure 4 illustrates how correct welding design can minimise corrosion risks.

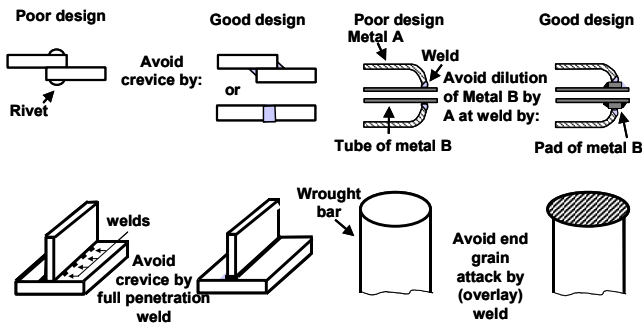


Figure 4: Weld design aimed at reducing the risk of corrosion

Crevices are present between the pipes and the pipe plates in the normal pipe/plate welded joints on heat exchangers. The risk of either crevice corrosion or stress corrosion is high in these crevice areas, particularly when the corrosive components in the crevices can build up due to the evaporation of water. Crevices in pipe/plate joints can be avoided by using the internal bore welding technique. Of course this type of construction is quite expensive, but in critical situations, designs such as this it should be considered.

### Design aspects in relation to drainage of vessels

It is essential that vessels be constructed so that they can be fully drained when the installation is taken out of service. Figure 5 illustrates design faults resulting in incomplete drainage; design solutions are also illustrated. Residues left behind (even small quantities) can result in corrosion damage. The increasing concentration of the contaminants

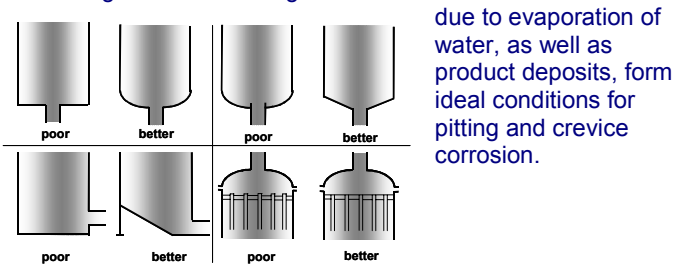


Figure 5

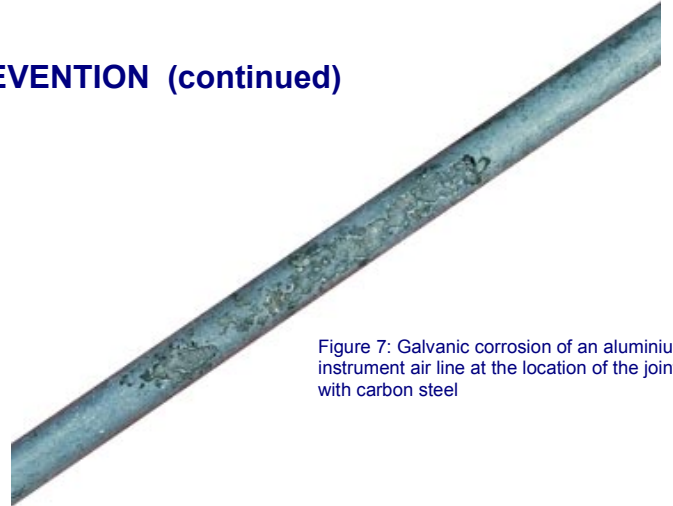


Figure 7: Galvanic corrosion of an aluminium instrument air line at the location of the joint with carbon steel

### Galvanic corrosion in relation to design

The risks of galvanic corrosion occurring should be reviewed at the design stage. If a combination of different metals cannot be avoided, the following measures can be taken:

- Use materials that are close to each other in the galvanic series.
- Avoid unfavourable surface effects - the corrosion of a small anodic area will be greatly accelerated if it is connected to a large cathodic area.
- Isolate where possible: break the circuit between the two metals as shown in figure 6.
- If a coating is used, ensure that it is adequately maintained; a coating applied to anodic material can result in very serious local attack at coating defects.
- Bring a third material into metallic contact with both materials. This third material must be anodic to (less noble than) the other two metals.

The above illustrates that in some cases galvanic corrosion can be used as a corrosion protection technique (cathodic protection). An example is the use of galvanised steel for atmospheric corrosion protection. It should also be stated that the risk of galvanic corrosion should not be exaggerated.

Galvanic corrosion can only take place if an electrolyte (moisture) is present - galvanic corrosion is not possible in a gaseous atmosphere or dry air. Many combinations of materials that lie far apart in the galvanic series will not or will scarcely be liable to corrosion. For example aluminium connected to stainless steel and exposed in a moist atmosphere will not result in significant galvanic corrosion. Aluminium connected to carbon steel will however result in serious galvanic corrosion of the aluminium.

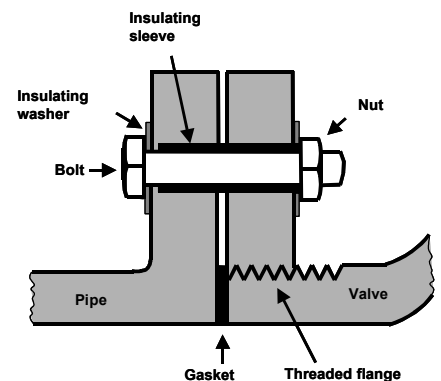


Figure 6: Correct isolation for preventing galvanic corrosion

Figure 7 (see first page) shows galvanic corrosion (from the atmosphere) of an aluminium instrument air line that was connected to a carbon steel line. During the design of the process installation it was assumed that connecting the aluminium instrument air line to the process lines was an inexpensive solution, but it had disastrous consequences for corrosion.

### Erosion corrosion (cavitation) in relation to design

The mechanism of erosion corrosion is not just related to the environment, but is also closely connected to the design. The risk of erosion corrosion increases if the design and layout lead to turbulence. Narrowing in pipework and incorrectly installed packing can result in erosion corrosion. Figure 8 illustrates how this problem can be solved using correct design and correct packing assembly.

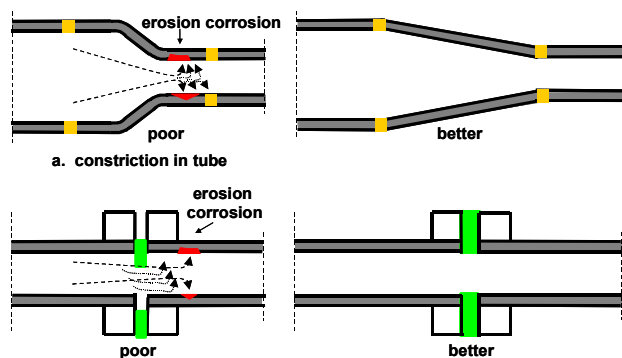


Figure 8: Prevention of erosion corrosion by avoiding local turbulence

How erosion corrosion can be avoided by using design measures can be illustrated by using a storage tank for concentrated sulphuric acid as an example. In principle concentrated sulphuric acid can be stored in carbon steel storage tanks, assuming that the protective  $\text{FeSO}_4$  layer that forms on carbon steel in concentrated sulphuric acid is not damaged. This protective layer may be damaged by:

- Turbulence or high flow rates ( $> 0.6 \text{ m/sec}$ );
- Temperatures above  $40^\circ\text{C}$  to  $50^\circ\text{C}$ ;
- Thinning of the concentrated sulphuric acid.

Erosion corrosion can be expected in the bottom plates of sulphuric acid storage tanks, under the sulphuric acid supply line. This problem can be solved by using a sacrificial plate on the bottom under the sulphuric acid supply pipe and by shortening the pipe (see figure 9). Concentrated sulphuric acid and  $\text{SO}_3$  vapours are very hygroscopic. A consequence of this is that moisture can enter the tank via the ventilation pipe on the roof of the tank and via the overflow pipe (in the wall) to the drain. The tank roof will be subject to corrosion around the ventilation pipe and also the tank wall under the overflow pipe, due to the formation of diluted sulphuric acid (reaction of  $\text{SO}_3$  with  $\text{H}_2\text{O}$ ). Allowing the ventilation pipe and the overflow pipe to penetrate the tank as illustrated in figure 9 can solve this problem.

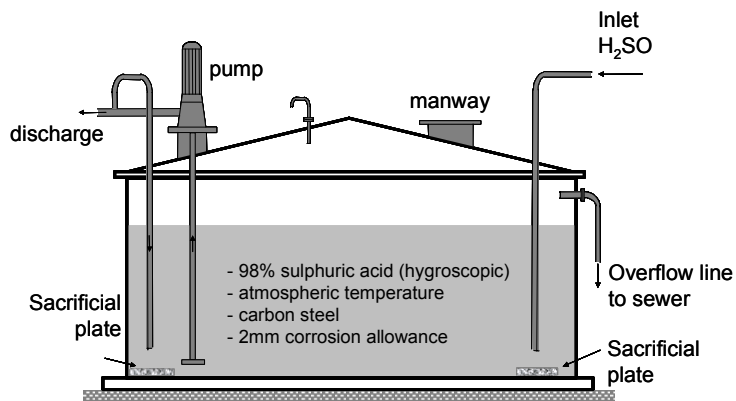


Figure 9: Storage tank for concentrated sulphuric acid designed to prevent erosion corrosion

Figure 10 illustrates an example of erosion corrosion in a T-piece of a piping system for concentrated sulphuric acid. In this T-piece turbulence and as a consequence damage to the protective  $\text{FeSO}_4$  layer can hardly be avoided.

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Figure 10: Erosion corrosion in a T-piece from a sulphuric acid line