

**Causes of corrosion problems in domestic installations**  
**Korrosionsursachen in Hausinstallationen**

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## **Zusammenfassung**

Beim Auftreten von Korrosionserscheinungen an Rohrleitungen in Hausinstallationen und an Hauszuleitungen werden Materialfehler und das Einwirken von aggressiven Medien (Wasser; Erdboden) als Hauptursachen vermutet. Anhand von Beispielen wird gezeigt, dass andere Faktoren, wie die Betriebsbedingungen, Verarbeitungsmängel und die Einwirkung von Gleichströmen weitaus häufigere Ursachen der Korrosionsprobleme sind.

## **Summary**

At the occurrence of corrosion phenomena in domestic installations poor material quality and the impact of aggressive media (water...) are often assumed as main causes. On the basis of examples it is shown that other factors, as the operating conditions, bad workmanship and the effect of direct currents are far more frequent causes of the corrosion problems.

## **Résumé**

En l'apparition de phénomènes de corrosion dans les installations domestiques une mauvaise qualité du matériau et l'influence des milieux agressifs (eau, sol) sont souvent supposés comme causes principales des dégâts. Au moyen des exemples il est montré que d'autres facteurs, comme les conditions d'exploitation, des défauts de mise en œuvre et l'effet des courants continus sont des causes des problèmes de corrosion beaucoup plus fréquentes.

## Introduction

Especially in big building complexes a lot of piping made of different materials is present for a variety of applications (water and waste water, gas, heating, air condition ...). Mostly the pipes are in contact with different media on the inner and outer side, what can lead to different corrosion phenomena [1]. In particular at the appearance of perforations, poor material quality and the corrosiveness of the transported medium (e.g. drinking water) are supposed to be the cause for the damages. However, more detailed investigations show that in most of the cases other factors are the source of the damages (Tab. 1).

Tab. 1: Causes and corrosion damages [2]

Types of damages	Possible causes
Perforation / leakage Failure of system components Impact on quality of transported media	Material quality Corrosiveness of transported media Design Workmanship Leakage tests Commissioning Operation conditions Interaction of electric currents

## Materials

In the past errors in tube fabrication quite often led to corrosion problems. But nowadays the use of quality assured pipes is common what reduced the number of damages caused by material faults to a very low level.

As an exception stainless steel components, produced in old steel works in Asia and the Far East should be mentioned. There the number of damages rose significantly during the last five years, mostly due to sensitizing of materials with high carbon contents.

## Drinking water installations

The successful application of metallic materials for drinking water applications is based on the formation of protective layers on the surfaces in contact with water. In such conditions a more or less uniform corrosion with moderate to low corrosion rates will take place. This leads rarely to perforations or leakage but may cause limit exceeds for heavy metals given by the European drinking water directive [3] at the tap.

Perforations are promoted by conditions which hinder the formation of compact, well adhering protective layers and which favour local corrosion processes. The formation of protective layers depends on different factors, where the water composition has an important role. The problem is that many substances have different actions on different materials and in many cases the ratio between different substances present in the water is more important than their absolute values. Beside the water composition above all the operating conditions (flow velocity, stagnation periods) are of big importance. The European standards [4] give useful information on the probability of the formation of protective layers for different materials. However a prediction of layer formation remains always uncertain.

The stability of once formed protective layers may be strongly impaired by changes in the water composition. A degradation of the protective layer can take place as well as

modifications in their structure. Some examples and possible resulting problems are listed in Tab. 2.

Tab. 2: Impact of water composition changes on the corrosion behavior

<b>Change in water quality</b>	<b>Possible consequence</b>
Scaling, foreign particles pH Mixing of different waters Softening Inhibitors Disinfection	Formation of aeration cells Increased corrosion rates Degradation of protective layers Lowering of pH, ev. increased Cl concentration Formation of galvanic cells Increase of redox-potential, oxidation of PE

### **Design and construction**

A lot of corrosion problems are caused by mixing different materials. If there is a direct metallic connection between materials with different corrosion potentials (e.g. galvanized and stainless steel) galvanic cells are formed where the corrosion rate of the metal with the more negative corrosion potential (in this case the galvanized steel) increases [5]. Although unfavorable from the point of view of corrosion such installations are still usual in domestic installations and lead to damages. Galvanic corrosion may also lead to an increase of heavy metal concentration in drinking water.

The fact, that in practice the number of damages is unexpectedly low can be explained mostly by the formation of protective layers (above all on the cathodic surfaces) and the limited action of galvanic cells inside of piping with small diameter. If no protective layers are formed, heavy corrosion effects are to be expected in quite short time. In design of domestic installations adequate measures should be planned to avoid galvanic corrosion (e.g. galvanic separation, use of materials with similar corrosion potentials) or to limit its action by appropriate measures (e.g. installation of isolating pieces).

During construction and installation above all cleaning of the pipes, pressure tests and the first filling of the system are critical steps which can be the source for later corrosion problems. Some examples are listed in Tab. 3.

Tab. 3: Corrosion problems induced during installation

<b>Activity</b>	<b>Problem</b>
No/insufficient cleaning Deposits, swarfs in system	Locally disturbed protective layers Formation of aeration cells
Pressure test Water remains in the system Use of antifreezing products based on glycol	Stagnant conditions without formation of protective layers in galvanized pipes Decomposition of glycol with acid reaction products
Filling Bypassing filters	Introduction of foreign particles Formation of aeration cells

### **Dimensioning and operating conditions**

In Switzerland one of the most frequent cause for damages in water installations is the dimensioning, respectively the flow velocity. Above all on copper fittings high flow velocities may induce damages by erosion. According to the frequency and duration of water outlet the flow velocity should be limited to 2-3 m/s [4].

By far more frequent are damages caused by oversized installations which results in (too) low flow velocities and longer stagnation periods. Not only inappropriate design but also the demographic evolution (increasing living space per person) and efforts to save water (Installation of flow limiters) contribute to this problem. When the flow velocity remains below 1 m/s approximately, foreign particles, deposits and rust are not flushed out and remain in the system. This may lead to problems for nearly all materials used in domestic installations because the formation of protective layer under the deposits is hindered what favors the formation of aeration cells. In stagnation times the formation of protective layer is hindered due to lack of oxygen and carbon dioxide. Furthermore the stabilization of anodic areas in galvanic cells is favored and existing protective layers may be degraded or modified.

### **Interaction of currents**

In domestic installations only the interaction with direct current will cause corrosion problems. Alternative currents are not off importance. Also it is to distinguish between galvanic currents produced in the systems itself and stray currents from foreign sources.

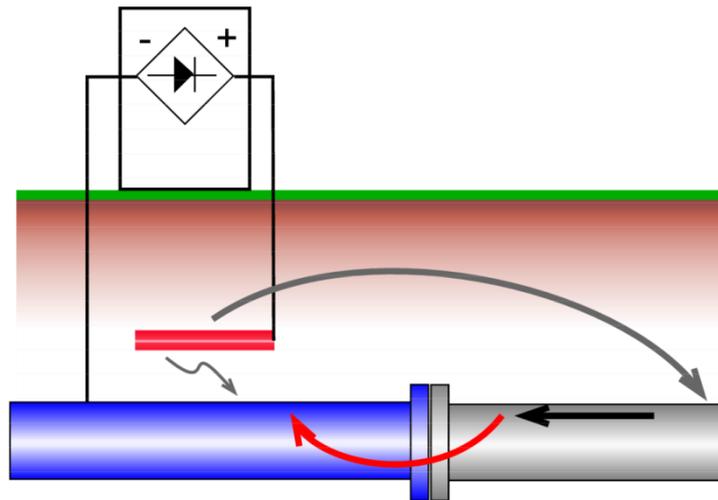
The effects induced by mixed metal systems were already discussed before. Mostly the problems arise inside pipes. A typical example, where corrosion takes place at the outer side of the pipes are ceiling penetrations in damp rooms (bath rooms, toilets ...). Heating pipes made of carbon steel are particularly in danger.

In most cases the ceiling penetrations are realized with cut outs or core holes. After the installation of the piping the voids are filled with cement mortar or insulation materials. The use of cement mortar results initially in a corrosion protection by the alkaline pore fluid. The mortars used for this purpose usually have a high porosity what leads to a rapid decrease of pH where the passive layer is no longer stable and the pipe begins to corrode. In many cases this would not be a too big problem. However, when the building/ceiling is made of reinforced concrete, an accidental or intended (e.g. equipotential bonds) contact between the pipe and the rebar is very probable, which leads to the formation of galvanic cells with the pipe as anode and the rebar as cathode. Due to the elevated concrete humidity in such locations and above all to the unfavourable area ratio between anode and cathode high corrosion rates may appear in such conditions. The use of insulation materials which can retain water for longer periods and do not provide an alkaline environment makes the situation even more critical.

Stray currents from foreign direct current installations (e.g. from direct current railways) lead to similar corrosion damages as the discussed galvanic cells. However it should be remembered that in general a current flow in a metal does not cause corrosion. This is possible only when the current passes from a metallic conductor to an ionic conductor (electrolyte). At the exit point from the metal the anodic reaction of metal dissolution takes place. In buildings the piping is normally not immersed in water and has no contact to the soil. A current exit from the metal can therefore only take place, when there is an electrolyte inside the pipe, when there are interruptions in the conductivity of the piping (e.g. isolating or high resistivity bush couplings) and when there is no parallel low resistance path for the current (e.g. equipotential

bonds). This is the reason, why damages by stray currents inside of buildings are possible but very rare.

One example where the conditions for a stray current attack have been fulfilled is shown in Fig. 1. A cathodically protected pipe was separated from the grounded domestic installations by an insulating flange only. In combination with a high protective current demand this had as a consequence, that a part of the protective current was transported through the earthing system to the cathodically protected pipe. On his way this current jumped over the insulating flange through the water. It left the pipe on the non protected side of the pipe which led to perforations after some years of operation.

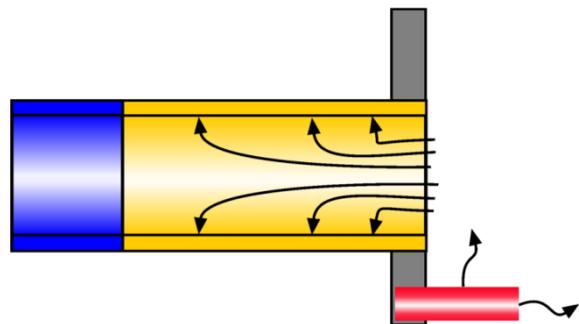


**Fig 1: Corrosion induced by cathodic protection stray current**

Another current induced effect, which recently was observed more frequently is the formation of voluminous deposits in brass fittings of cathodically protected boilers, which led to passage perturbations. The presence of these coarse grain, reddish deposits is normally limited to a length of about 2 cm. Aside only very thin brownish-red or brown surface layers are found. The chemical analyses of the deposits showed that they consist of calcium carbonate and incorporate copper particles. It is supposed that the formation of the deposits takes place according the following mechanism. In a first step the pH on the fitting surface rises due to the action of protective current. In a second step, there is the formation of calcium carbonate layers. These can be compact and isolating, thus blocking further reactions. When there is copper in the system it will be incorporated in the deposits and making them conductible. In this case, the protective current can continue its action and provides the growth of the deposit (Fig. 2).



**Fig. 2a: Fitting with voluminous deposit**



**Fig. 2b: Alkalization of fitting surface by cp**

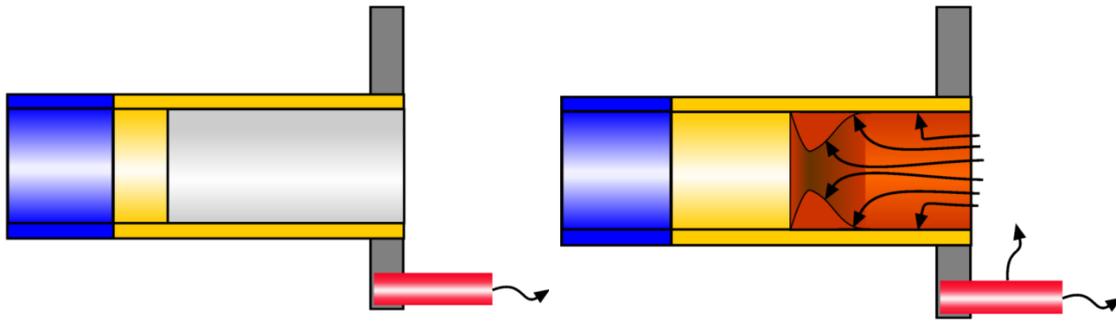


Fig. 2c: Formation of isolating surface layer

Fig. 2d: Formation of conductive surface layer

## Conclusion

Poor material quality and aggressive media are only seldom the primary cause for corrosion problems in domestic installations. Mostly the damages are due to a combination of several unfavourable factors arising from design, dimensioning, operation conditions and external influences. Before renovations and replacement of piping it is important to investigate the real causes of the problem and to check possible detrimental effects to the existing/remaining system. It is also important to pay attention to an accurate workmanship and an appropriate quality assurance during renovation.

## Literature

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