



CORROSION IN ALUMINIUM MULTI-METAL SYSTEMS

Aluminium, the most abundant material on Earth's crust, is increasingly popular in the heating system industry, in both the production of radiators and the design of boiler heat exchangers.

For instance, given the growing interest in the principle of thermal exchange by condensation, manufacturers are developing boilers that not only are more efficient, but can also run in critical conditions.

ADVANTAGES OF ALUMINIUM

Aluminium is a pure, soft metal, which is ductile and corrosion resistant. If it binds to some other elements, such as magnesium, zinc and silica, then it produces a range of materials that keep the same lightness and durability of pure aluminium, with additional advantages. In short:

- Lightness: specific weight of about 2.7
- High thermal conductivity
- No magnetic properties
- High resistance
- Machinability
- Resistance to corrosion
- Low thermal inertia

CORROSION OF ALUMINIUM

We can confirm that in quite a lot of cases corrosion is the process that adversely affects the useful life of a heating system. It is a natural and irreversible process, which happens whenever a metal comes in contact with water.

The corrosion behaviour of aluminium and its alloys depends on metallurgical conditions, its impurities, the elements that constitute the alloy, and the nature of the salts dissolved in water.

The aluminium alloy has the ability to form a protective oxide film closely sticking to the surface, which gives the metal a high resistance to corrosive attacks. The passivating film results from the metal reaction with oxygen, which is present in the air or in the water.

It is interesting to note that, in neutral saline solution (e.g. sodium chloride) and comparable conditions, aluminium has a rate of corrosion lower than copper, a semi-noble metal.

The film that forms on the aluminium surface is generally stable at a pH ranging between 4.5 and 8.7; however, beyond this range it becomes active and unstable, and tends to dissolve with the development of hydrogen.

Every now and then, we hear concerns because in a few areas of our country the pH of network water tends to increase (i.e. to get more alkaline), and this can have a potentially negative impact on aluminium elements. However, even though aluminium can dissolve easily in alkaline solutions (with an high pH), resistance to corrosion with a pH higher than 8.5 depends on the type of alkalis present; in the end, aluminium is certainly stable in a lot of types of alkaline water. In any case, in these conditions, it is possible to treat the water used in the heating system, as outlined in the relevant appendix.

CORROSION OF HEATING SYSTEM COMPONENTS

As aforementioned, corrosion is a natural process that affects all metals, except precious ones such as gold, platinum, etc.

Not being able to use such metals to produce radiators, piping and heat generators, the most common metals used in heating systems are those listed below, together with their most frequent applications:

Steel:	Boilers, radiators, pipes and joints
Cast iron:	Boilers, radiators, joints
Copper:	Boilers, pipes, joints and terminal units
Aluminium:	Radiators and boilers
Brass:	Valves and fittings, joints, collectors
Bronze:	Valves and fittings, joints, collectors

With water and/or oxygen present, all metals are subject to oxidation, which is the chemical reaction of the metal with the oxygen dissolved or resulting from water dissociation. If oxidation shows to be a continuous process and the superficial oxide layer is not able to protect metal surfaces, then true corrosion is activated, whose negative effects can challenge the normal system operation up to its complete breakdown.

Boiler corrosion (water side), besides obviously becoming destructive when it passes, is accompanied by the formation of deposits or sludge that restrict heat exchange and cause a reduction in thermal performance. This is often accompanied by difficulties in water circulation, also causing heat imbalances among the various exchanger areas and inducing tension and stress that can lead to the boiler body breaking.

Pipe corrosion involves consequences similar to those described for the heat generator: difficulties in water circulation cause a decreased flow to heating units, while the damage resulting in the perforation of pipes is even more important if they, as usually happens, are buried or laid under the floor. Visible consequences of this situation could be damp, decreasing boiler pressure or partially cold radiators.

Corrosion of heating units finally results in water spills, with the relevant immediate and unpleasant effects.

There are other factors that testify the progress or occurrence of a corrosive process. Such phenomena are much less evident, but should be duly taken into consideration:

- Formation of cold areas in the lower areas of radiators, due to the narrowing of the water flow caused by sludge.
- Formation of cold areas in the upper areas of radiators, because of the gas accumulation developed during the metal oxidation process.
- Circulation noises, caused by inadequately bleeding the gas bubbles present.
- Reduction in heat exchange, prevented by improper water circulation inside the heating unit.

The oxide formed during corrosion, even of a single system component, should not be underestimated since it can damage or prevent the correct operation of other parts; just think of particle deposits of metal oxides on valve seats, pumps or other system components.

Water, however, is the sole responsible for the starting of corrosion: filling water has undergone rapid worsening in the last few years following a reduction in water tables or the progressive increase in the

presence of pollution in surface water. The diffusion of plastics to build heating system parts was widely justified by their compatibility with especially aggressive water or scaling elements. Despite this, the problem of corrosion should be analysed beforehand.

WATER TREATMENT IN MULTI-METAL SYSTEMS

Any heating system can be regarded as composed of five components:

1. Boiler
2. Radiators
3. Pipes
4. Pumps, valves and fittings
5. **Water**

The latter is decidedly the most neglected, although we find it hard to understand the reasons for this, especially after seeing the impact it can have on the other four components. What should be greatly considered by those who are interested in the well-being of the system is the aspect of prevention, which affects the return on investment.

RINSING AND PICKLING OF NEW SYSTEMS

The installer who wishes to avoid unpleasant problems in the future should rinse the system before starting it and clean the new heating system well to remove contaminants such as grease, oil, metal shavings and residues from it. If you don't complete full pickling, then the system will be exposed to the risk of corrosion and dirt, therefore shortening its useful life.

Obviously, it is always advisable to use pickling products with a neutral pH, at least for the safety of operators who handle them. However, if the system contains aluminium parts, then the use of near-neutral products (pH of about 7) becomes mandatory.

WATER TREATMENT WITH CORROSION INHIBITORS

Once best prepared, the new system should be permanently protected with an adequate water treatment. Today, in our country and in several parts of the world, aluminium radiators are increasingly used. This material has a maximum resistance to corrosion with a pH equal to 6.5; if the pH of water remains close to this value, then corrosion of aluminium radiators will be reduced to the minimum. This concept should also be the basis of an effective water treatment program.

In general, it should be said that it is not advisable to use aluminium with water softened using ionic exchange resins. As a matter of fact, this pre-treated water has a corrosive behaviour and causes an increase in the pH up to critical levels for corrosion.

As regards preventive treatment with corrosion inhibitors, in the light of all the aforementioned considerations, these should be formulated to keep the pH near neutral. There were cases in which the application of corrosion inhibitors with high alkalinity – which work well and without problems with carbon steel – turned out to be disastrous on aluminium components.

SYSTEM DESCALING

Similar issues should also be taken into account when removing scale from old systems, which because of a certain number of symptoms (boiler noise, reduced heat exchange, etc.), appear subject to lime scale. The traditional approach, which consists of adding acid, followed by the application of caustic soda solution to neutralise acidity, would lead to the rapid deterioration of aluminium components.

Today, technology has evolved quickly, and the current availability on the market of non-acidic lime scale removers based on polymers allows these problems to be successfully and safely overcome.

CONCLUSIONS

There are many good reasons to use aluminium in the residential heating industry. The advantages of this material can be easily appreciated by anyone by simply adopting the due precautions when choosing the chemical treatment to be applied to the circuit water so as to permanently protect the system. In this respect, it is worth recalling that in Italy these issues are dealt with in the UNI-CTI 8065 and 8884 standards, which set out water treatment procedures in all multi-metal heating systems.

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