POSITION PAPER COPPER CORROSION

- SOFTENED WATER IS NOT MORE CORROSIVE THAN WATER BEFORE SOFTENING! –

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June 6th, 2007

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Corrosion is an invisibly creeping enemy that manages to penetrate even the smallest spots of a water distribution system. Corrosion eats away water pipes, often slowly, but surely.
Unfortunately this destructive process only comes to light when the damage is done: small holes in the water pipe. This can become an expensive item of loss...

Corrosion occurs when water flows through a pipe; the dissolved oxygen in the water causes the metal ions of the pipe to dissolve; in other words, the pipe corrodes. Evidently there are many factors that can accelerate and/or aggravate corrosion. Often the hardness of the water, or better, the absence of hardness is considered to be an aggravating factor. Everybody who is regularly confronted with the issue of corrosion in practice, knows very well that this assumption is not valid for water softened by means of ion exchange. In this Position Paper Aqua Belgica wants to clarify why this assumption is not correct.

1. Where does this assumption come from?

For many decades certain terms are incorrectly mixed up. Because of this, softened water has often been blamed, wrongfully. Here's a list of the most important misconceptions.

- *aggressive* versus *corrosive*
  Softened water generally has an aggressive character. Water that has a tendency to dissolve calcium deposit, is called *aggressive*. Water that has a tendency to dissolve metal (f.e. copper) with which it comes in contact, is called *corrosive*. Water can very well be aggressive, without being corrosive, and vice versa!
  OUR FIRST POSITION: AGRESSIVE ≠ CORROSIVE!

- *naturally soft* water versus *softened* water
  Softened water is often mistakenly put on par with naturally soft water. Softened water and naturally soft water have a low hardness in common; on many other parameters they differ strongly. A number of these parameters (pH, TDS, oxygen content, free dissolved CO_2 content,...) do have an influence on the corrosive character of the water.
  Softened water on the other hand, is obtained by removing all calcium and magnesium ions present in the supplied water, by means of ion exchange, and exchanging these by sodium ions. The water retains its balance and the ion

exchange process doesn't change anything to f.e. the acidity or dissolved oxygen content of the water!
OUR SECOND POSITION: NATURALLY SOFT ≠ SOFTENED!

- *scale* versus *passivation*
  Hard water will result in a layer of scale in the pipe. Mistakenly this layer is considered to be a good protection against corrosion. A metal that comes into contact with a corrosive environment will generate a natural protective layer, depending on the circumstances. This protective layer does contribute positively to slow down or ideally even stop the corrosion. This is called the passivation.
  OUR THIRD POSITION: SCALE ≠ PASSIVATION!

2. Theoretical background

Corrosion in a water distribution system is an electrochemical interaction between the metal and the water, whereby the metal is attacked and consequently looses its specific characteristics. The driving force behind this corrosion is oxygen. As long as new oxygen enters into the system, the corrosion is maintained. In a closed system (central heating) the corrosion will spontaneously stop when all oxygen is consumed and no new oxygen is supplied. In an open system (drinking water installation) in which fresh oxygen containing water enters continuously, the corrosion is maintained.

Passivation works as a *corrosion retarder*. This protective layer is formed by the complex compound of metal oxides and bicarbonates at the surface of the pipe. The absence or presence of calcium, magnesium and sodium ions has no influence on the formation of such passivation!

A number of factors have a *corrosion accelerating* effect, such as:
- accumulation of oxygen (corrosion through differential aeration),
- anaerobic bacteria in biofilm (microbiological corrosion),
- mixing of different metals in the water distribution system our vagabond currents (galvanic corrosion), …

The presence of hardness leads to scale deposit and stimulates among other things corrosion through differential aeration as well as microbiological corrosion.

3. Practical experience

Ion exchange is a process that is applied since more than one century, in multiple sectors; one of them being water softening; so this is not a new and/or unknown process; no, water softening by means of ion exchange is since a long time accepted as the most efficient and reliable process to reduce the hardness of water.

Since water softening by means of ion exchange originated, many millions of water softeners have been installed worldwide; most of them totally soften the water, in other words, no more residual hardness present. Everyone knows that *in practice* no systematic problems of increased corrosion occur.

4. Studies

A number of international studies [1-10] have been published that clearly indicate that there is no increase of corrosion after softening of the water. Often even the contrary is established.

Also in Belgium, Aqua Belgica had two similar *studies* [11-12] conducted. From the measurements done in a laboratory setting, as well as in four existing residential water distribution systems, it was clear that no difference could be found in corrosion speed versus copper, not even when the mains water was softened to 0°f!

5. Norms

The European norm EN 12502 - part 2 for "Protection of metallic materials against corrosion – copper and copper alloys" does not impose a value for hardness. No requirements have to be met concerning water softening.
This norm has been adopted integrally by the NBN (= Belgian Bureau for Normalisation) in NBN EN 12502.
The Technical Prescription of the WTCB/CSTC (Scientific and Technical Centre for the Construction) "recommendation for use of copper tubes for distribution of sanitary hot and cold" is conform this norm and does no longer recommend a residual hardness.

6. The Aqua Belgica position

1. Aggressiveness of water is not the same as corrosivity of water;
2. The assumptions that relate to naturally soft water cannot be applied to softened water;
3. The natural passivation, that protects the metal against corrosion, is not influenced by the absence or presence of calcium, magnesium and sodium ions;
4. Softened water as such does not have a higher ability to dissolve metals than hard water, versus copper.

In short: softened water, obtained by water softening by means of ion exchange, is not more corrosive than the water before softening, with respect to an internal drinking water system, composed of copper.

References:

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5. "Étude Électrochimique du Couplage Galvanique Cuivre/Brasures", by H. Idrissi, S. Audisio, J.-P. Millet and A. Irhzo
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9. "How to reduce copper concentration in sewage sludge and drinking water", by B. Herbst
10. "Ion exchange softening: effects on metal concentrations", by Thomas J. Sorg, Michael R. Schock and Darren A. Lytle
11. "Determination of the difference in corrosivity between hard and softened water versus copper and galvanized steel", by Metalogic
12. "In situ corrosion investigation on the effect of hard and softened water to domestic copper and galvanized steel drinking water systems", by Metalogic (Cis Verdonckt and Carlo Nijs)