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Copper and Silver Water Treatment

Corrosion Report

Are metal ions of copper and/or silver corrosive to pipework?

A Study Report

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Introduction

From time to time clients and potential clients ask whether copper is corrosive to pipework, which we always reply no, it isn't, based on our 25-year experience with over 200 Orca copper and silver ionisation (CSI) systems installed in the UK, Europe and the Irish Republic.

However, to satisfy our customers further, we teamed up with one of the UK's most reputable universities, University College London (UCL), to address this question scientifically.
This report is based on results from the study carried out in 2017-18 by MSc students from UCL.

The effectiveness of disinfection using copper and silver ionisation (CSI) has been studied in many previous researches (Lin et al. 1998, Liu et al. 1998, Pedro-Botet et al. 2007). The recommended concentration of copper and silver ions for controlling Legionella bacteria is 0.20-0.80 mg/L and 0.02-0.06 mg/L respectively (Lin, Stout and Yu 2011).

CSI was also showed to be successful in inactivating E. coli at pH ≤6 for 2.5 hours; after which the water quality was shown to be of a satisfactory standard for drinking (Parr, 2016). In addition, Armstrong, Sobsey & Casanova (2017) showed that copper ions at the concentration of 0.3mg/L could disinfect MS2 within 6 hours. Pedro-Botet et al. (2007) showed a 68.7% reduction in fungi, i.e. 11 of 16 treated water systems, compared with none in the control group.

Most studies thus far have focused on CSI effectiveness for the control of bacteria, fungi and viruses. However, not many studies have looked into corrosion or pitting by CSI.

Materials and Methods

Set up

The main set up consisted of 22 mm ND copper alloy pipe with coherent compression fittings (T connector, Elbow, etc). The physical set up (3D model) can be seen in Figure 1. The black arrow points out the flow direction within the system. Detailed coupon placement locations are shown (1 = elbow; 2 = flat). The section within the yellow frame (3) is the rubber tube (4.3 m in length) for water-cooling, which was immersed in the water tank to reduce the rising temperature caused by the operation of the pump (4).

Testing of coupons

The coupons were placed in different locations to observe the effect of bend in the design set up of normal pipe work. The coupons were cleaned with dilute acid before and after operation. The following equation was applied to determine corrosion rate (equation 1) with the obtained measurement (Krisher, 2005).

$$\textit{Corrosion Rate (CR)} = \frac{\textit{Weight loss+K}}{\textit{Alloy density+Exposed area+Exposure time}}$$

Where, weight loss is in g; alloy density (p_A) is in g/cm^3; exposed area (A) is in in^2/cm^2, according to the desired CR value unit; and exposure time (T) is in hr.

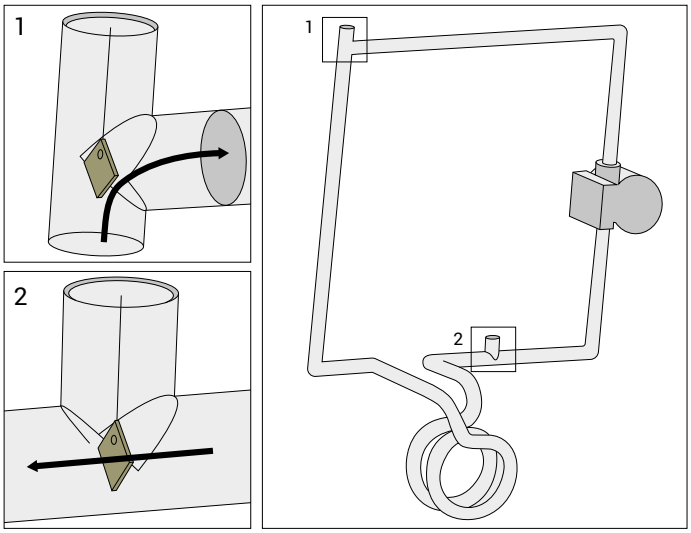


Figure 1: The physical set up of the experiment. 1=elbow; 2=flat; 3=rubber tube and 4=pump.

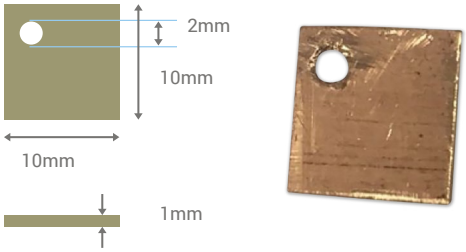
Table 1: Corrosion rate unit with associated parameter units (Krisher, 2005)

Corrosion Rate Unit (CR)	Area Unit	K-Factor
mils/year (mpy)	in2	5.34 x 105
mils/year (mpy)	cm2	3.45 x 106
millimeters / year (mmy)	cm2	8.76 x 104

The specification of the physical property of the coupons are as follow:

1. Side length, width, thickness and the size of hollow were assumed to be the same for all coupons at an error allowance of 5%.
2. For determining the density of the coupons, randomly picking 3 coupons, weighing them and measuring the volume with a 10 ml graduated cylinder. Due to the small size of the coupons, 3 coupons were placed in the cylinder and the total volume difference was measured.

The fixing of the coupons was simply designed with a hanging hook instead of coupon arm (screw fixing) as shown in diagram and picture.



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Operation

The experiment was divided into two phases due to the chronic property of corrosion effect. The first phase was the operation with ordinary tap water; the second phase was the operation with ionized water (copper and silver ions at 0.2mg/L and 0.02mg/L) which will be called 'Orca water'). Both types of water came from the same tap, but the Orca water was then ionised by going through the Orca CSI system. Each working month (phase) contains two batches (producing two pairs of coupons).

Results and Discussion

As can be seen in Figure 2, both type of water gave a corrosion rate of 10 years' service life much lower than the global standard allowance. Moreover, tap water containing copper and silver ions gave slightly negative corrosion rate.

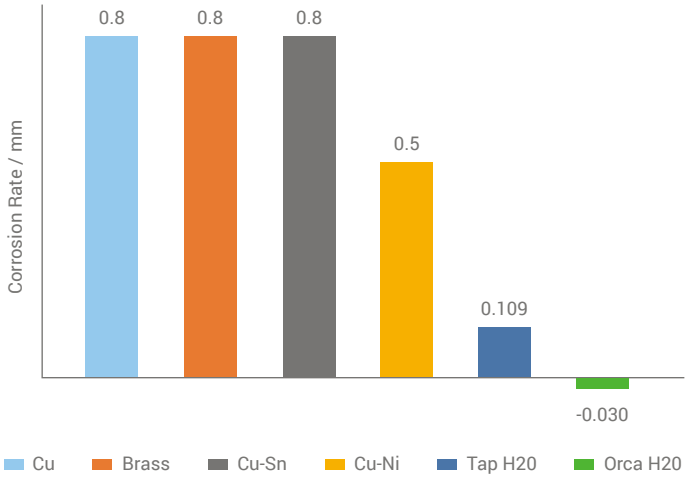

Figure 2: Overall corrosion rate comparison

As can be seen in Table 2, only the first batch elbow section gave positive corrosion rate (Orca water test) within the obtained four sets of data. Therefore, the data for elbow section in the first batch was rejected as being considered to be an error. The cooling section (water bath) can make certain reduction in water speed due to low temperature and surface roughness of the rubber tube. The coupon may give less material loss due to the insufficient mechanical driving force (flow speed) while having a relatively short-term operation period.

The obtained corrosion rate was negative for the Orca water phase operation, which indicates the ions could have possibly been deposited onto the surface of the coupon. The deposition can be in either simple matter form, or the ions reacted with other substances in the water and formed compounds. Scanning electron microscope (SEM) can help to investigate this assumption. The coupons' weight difference only varies within the range of 3rd to 4th d.p. (mostly 4th) which indicates therefore that the error caused by the weighing balance could still be a factor.

Table 2: Tap water and Orca water phase operation results

Tap water test					
Date	**Position**	**Duration (hr.)**	**Average Temperature**	**Corrosion Rate (millimeter)**	**DO mg/L %**
1.15 - 1.26	Elbow	204	20.4 °C	0.073	7.95 (92);
	Flat			0.118	
1.29 - 2.9	Elbow		20.4 °C	0.091	0.98 (10)
	Flat			0.155	

Orca water test					
Date	**Position**	**Duration (hr.)**	**Average Temperature**	**Corrosion Rate (millimeter)**	**DO mg/L %**
2.12 - 2.23	Elbow	204	20.4 °C	0.018	9.40 (97);
	Flat			-0.082	
2.26 - 3.9	Elbow		20.4 °C	-0.018	1.10 (9)
	Flat			-0.036	

Note: date is month/day

The tested copper coupons indicated that the water from the Orca CSI system gave negative corrosion rate (Fig. 3) when compared with ordinary tap water, which showed a corrosion rate of approximately 10% of the regular allowance.

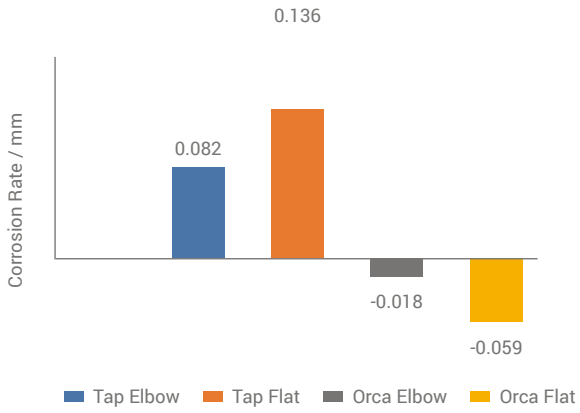

Figure 3: Corrosion rate variation at two locations (elbow or flat pipe surface).

Although the coupons used in the study showed negative material loss compared to those in the tap water control, further studies should be conducted to evaluate whether any pitting might have occurred.

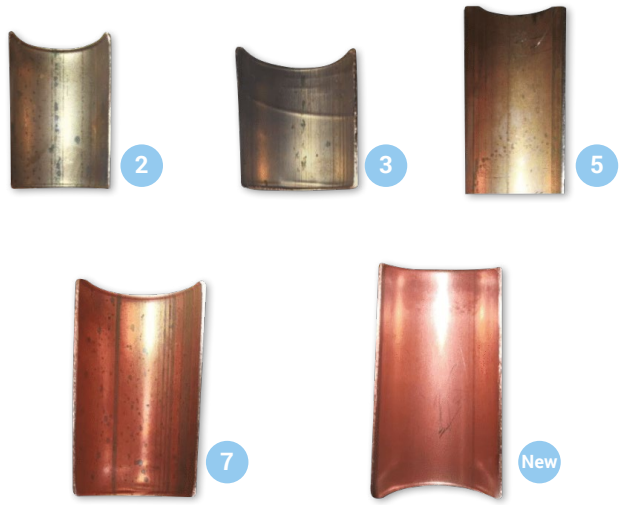

Figure 4: Photographs of sections of pipes' inner wall surface for detailed observation.

As can be seen in Figure 4, sections marked as 2, 3, 5 and 7 show higher rate of occurrence of speckle-like traces which are suspected to be caused by pitting corrosion effect. SEM can be used for the surface composition test to confirm if it is indeed caused by pitting. It can also be noted that the speckle-like traces were more likely to arise in locations with lower water speed (locations 2 and 7).

The speckle-like traces may be the outcome of pitting corrosion since it visually conforms to the characteristic of pitting corrosion. Furthermore, since the corrosion process is a chemical reaction, higher water speed would lower the speed of the reactions, which in this case, the lower water speed section did indeed give more traces than higher water speed sections.

The dissolved oxygen both in tap water test and Orca water test showed a dramatic decrease (See Table 2) which could potentially have been consumed by the corrosion process where oxygen was required as an oxidant in the series of chemical reactions.

Conclusions

The Orca water showed a negative corrosion rate, which indicates the ions could have possibly been deposited onto the surface of the coupons. The deposition can be in either simple matter form, or the ions could have reacted with other substances in the water and formed compounds. Scanning electron microscope (SEM) would help to investigate this assumption further.

References

Armstrong A., Sobsey M., Casanova L. (2017). Disinfection of bacteriophage MS2 by copper in water. Applied Microbiology and Biotechnology 101(18):6891-6897.

Krisher A. (2005). Coupon testing. [online] Alspi.com. Available at: http://www.alspi.com/cpntst.htm [Accessed 17 Dec. 2017].
Lin Y.S., Stout J.E., Yu V.L., Vidic R.D. (1998). Disinfection of water distribution systems for Legionella. Semin. Respir. Infect. 13(2):147-159.

Lin Y., Stout J., YU V. (2011). Controlling Legionella in hospital drinking water: an evidence-based review of disinfection methods. Infection Control and Hospital Epidemiology 32(2):166-173.

Liu Z., Stout J.E., Boldin M., Rugh J., Diven W.E., Yu V.L. (1998). Intermittent use of copper-silver ionization for Legionella control in water distribution systems: a potential option in buildings housing individuals at low risk of infection. Clinical Infectious Diseases 26:138-40.

Parr J. (2016). Utilizing silver and copper ions for bacterial disinfection and subsequent removal of ions to supply safe drinking water.

Pedro-Botet M.L., Sanchez I., Sabria M., Sopena N., Mateu L., Garcia-Nunez M., Rey-Joly C. (2007). Impact of copper and silver ionization on fungal colonization of the water supply in health care centers: implications for immunocompromised patients. Clinical Infectious Diseases 45(1):84-86.