Midland Corrosion Services Ltd.

Report Number: 0967-2a

Influence of In-Line Anti-Scaling Device on Limescale Deposition in a rapid scaling test

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Date: 1st May 2024

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1. INTRODUCTION

Midland Corrosion Services have been commissioned by KSDD to carry out rapid laboratory scaling tests to measure the efficacy of their in-line anti-scaling devices. To this aim, a specially constructed test rig, which had already been proven by MCS to measure the efficacy of similar devices, was used. Of the 6 devices sent for evaluation, a 15mm in-line scale reducer, labelled 'Sample 1', was first selected for testing. The amount of scaling produced in a heated copper coil after passing Evian Water through this device was compared to that produced in a blank control test (i.e. Evian Water with no device) and the results were detailed in report 0967. Following this report, MCS were commissioned to carry out duplicate tests with a second device, labelled 'Sample 2'.

KSDD advised that Sample 1 was a magnetic device and Sample 2 was an electrolytic device.

2. TEST METHOD

The test rig is shown schematically in Fig. 1. This consisted of a header tank containing up to 25 litres of test water connected via a flow controller to a copper heater exchanger coil. The Vogklin Qflow flow controller is capable of accurately controlling the flow between 0.5 and 2.5litres/hour. For this test, a flow rate of 1.0 litres/per hour or 24 litres over a 24 hour period was set. The heat exchanger coil contained 10 x 150mm loops of 10mm copper pipe. Limescale accumulated in the copper heat exchanger coil in the heater bath before being collected in the discharge tank. A platinum resistance thermometer (PRT) or thermocouple (TC) was also fitted to the discharge side of the coil to monitor the outlet temperature of the water.

Before the test began, the header tank was filled with 25L of pure Evian water and the heater bath filled with silicone oil set to 85°C. A sample of the Evian water, S1 was retained for analysis.

At the start of the test, the water was fed through the system at a rate of 1L per hour by adjusting the flow meter. After a few hours' operation, a check on the flow rate was made by weighing the amount of water discharged and adjusting the flow meter, if required. After 24 hours, the heating bath was turned off and a small sample of water, S2 was taken from the discharge tank for analysis. The rest of the 24 litres of water was then fed back into the header tank, the heating bath turned back on and water was fed back under gravity through the rig. After a further 24 hours, the heating bath was turned off and a further sample of water, S3 taken from the discharge tank for analysis.

To determine the amount of limescale accumulated within the heat exchanger coil, 4M hydrochloric acid was passed through the coil to dissolve and extract the calcium carbonate over 10 minutes. This solution was then topped up to 1L with demineralised water and a sample, S4 was taken for analysis. Analysis for calcium and magnesium was carried out by ICP to obtain total hardness values in mg/L as $CaCO_3$.

The amount of limescale deposited in the coil was given by the total hardness of the sample S4, i.e. if the analysis gives y mg/L of $CaCO_3$ then the amount of limescale deposited in the coil is y mg. This value should be similar to the reduction in total hardness

of the Evian water over the 48hr period, i.e. from analysis of sample S1 and S3. Duplicate tests were carried out for both the control and for the devices. Figure 2a displays the device & flow meter setup and 2b shows the Calmag Sample 2 in-line scale reducing device under test.

Fig. 1 RAPID SCALING TEST TO MEASURE EFFICACY OF ANTISCALING DEVICES

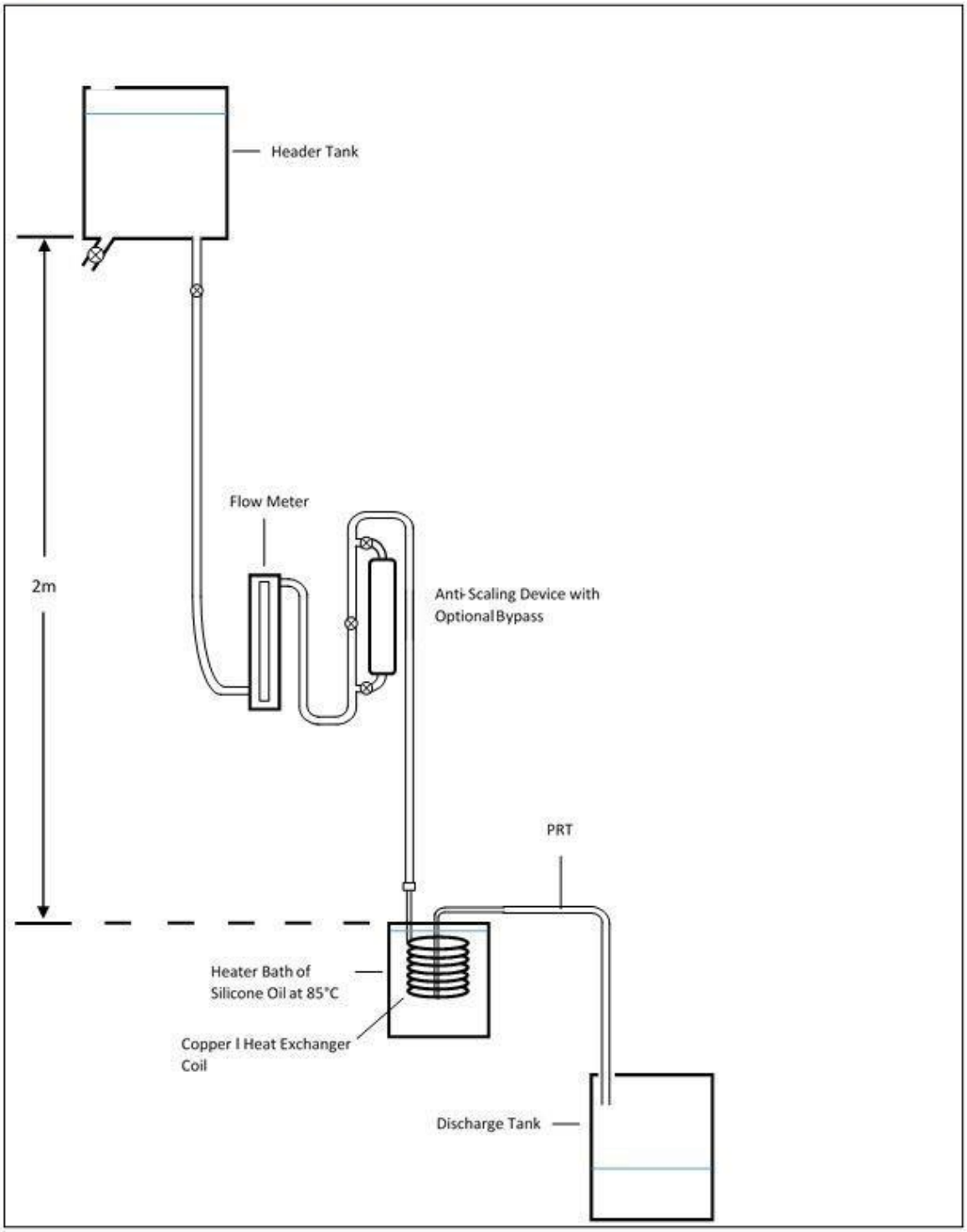

Fig. 2a Anti-scaling Device 1 with flow meter

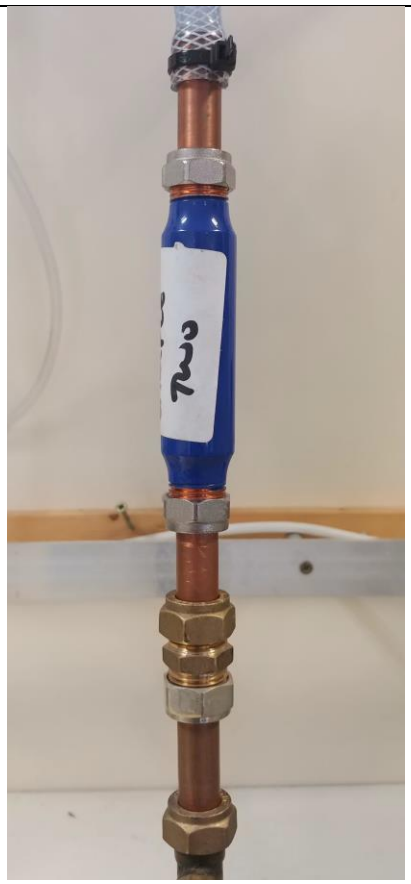

Fig. 2b Anti-scaling Device 'Sample 2' under test

3. RESULTS

The water analysis results (calcium, magnesium and derived total hardness) for S1 (Evian Feed Water); S2 (discharge water after 24 hours); S3 (discharge water after 48 hours) and S4 (dissolved scale from inside copper coil at end of test) is given in Table 1 for the 4 runs (2 x with device 1, 2x with device 2, and 2 x control). Since the tests with the device and blank control tests were carried out using different batches of Evian Bottled Water, analysis was carried out on each batch, giving 2 x S1 values.

In theory, the amount of limescale deposited in the coil should equal the reduction in total hardness of the water over 48 hours (in mg/L) x the volume of water discharged (i.e. 24 litres). This calculation is shown in Table 2.

	S1		
	Ca	Mg	TH
Evian Water (runs 1 & 2)	84.4	27.3	323
Evian Water (runs 3 - 6)	89.3	30.5	348

	S2			S3			S4			Mean Scale Deposited
	Ca	Mg	TH	Ca	Mg	TH	Ca	Mg	TH	
Run 1 (blank)	68.8	28.6	289	53.9	28.9	253	822.5	3.5	2071	**2109 mg**
Run 2 (blank)	69.5	27.3	286	51.6	26.9	239	856.5	1.3	2146	
Run 3 (Device 1)	88.7	30.6	347	77.9	29.9	317	257.7	0.5	646	**1062 mg**
Run 4 (Device 1)	77.9	30.5	320	59.6	30.1	272	588.7	1.2	1477	
Run 5 (Device 2)	81.0	32.8	337	66.8	32.8	302	450.1	1.0	1129	**1362 mg**
Run 6 (Device 2)	84.6	31.9	342	60.4	29.3	271	636.0	0.9	1594	

Table 1 Water Analysis Results

	TH (S1-S3)	X 24 litres	Scale deposited in Coil
Run 1	67 mg/L	1608 mg	2071 mg
Run 2	84 mg/L	2016mg	2146 mg
Run 3	31 mg/L	744 mg	646 mg
Run 4	76 mg/L	1824 mg	1477 mg
Run 5	46 mg/l	1104 mg	1062 mg
Run 6	77 mg/l	1848 mg	1362 mg

Table 2 Comparison of Theoretical amount of scale produced by difference in hardness S1-S3 and amount of scale dissolved from copper coil

4. DISCUSSION

The results shown in section 3, indicate that the mean scale deposited in the copper coil over 48 hours (i.e. derived from dissolving the scale in acid), was 1062 mg with sample 1 (magnetic device), and 1362 mg with sample 2 (electrolytic device). Compared with 2109 mg in the blank control tests, these show reductions of 49.6% and 35.4% respectively.

The amount of scaling derived from the reduction in total hardness over the 48 hours compares reasonably well with the amount of scale dissolved from the coil.

5. CONCLUSIONS

Using a rapid scaling test developed by MCS, The in-line scale-reducing device labelled 'Sample 1' (magnetic device) produced an approximate 50% reduction in limescale deposition whilst the device labelled as 'Sample 2' (electrolytic device), produced an approximate 35% reduction.

Signed

Date 1st May 2024.