Health Check Report [redacted]
December 2015

Continuous Monitoring of the LTHW Heating system.

Prepared for:
[redacted]

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1. SYSTEM DETAILS

Site	[redacted]
Client	[redacted]
System Type	LTHW, closed
Volume	4000 litres approx.
Installation date	TBC
Commencement of monitoring	10/09/2015
Number of floors	2
Boiler room	Upper Floor, Internal
Materials	Copper pipework, brass fittings, carbon steel in boilers
Inhibitor	Polyhib CH

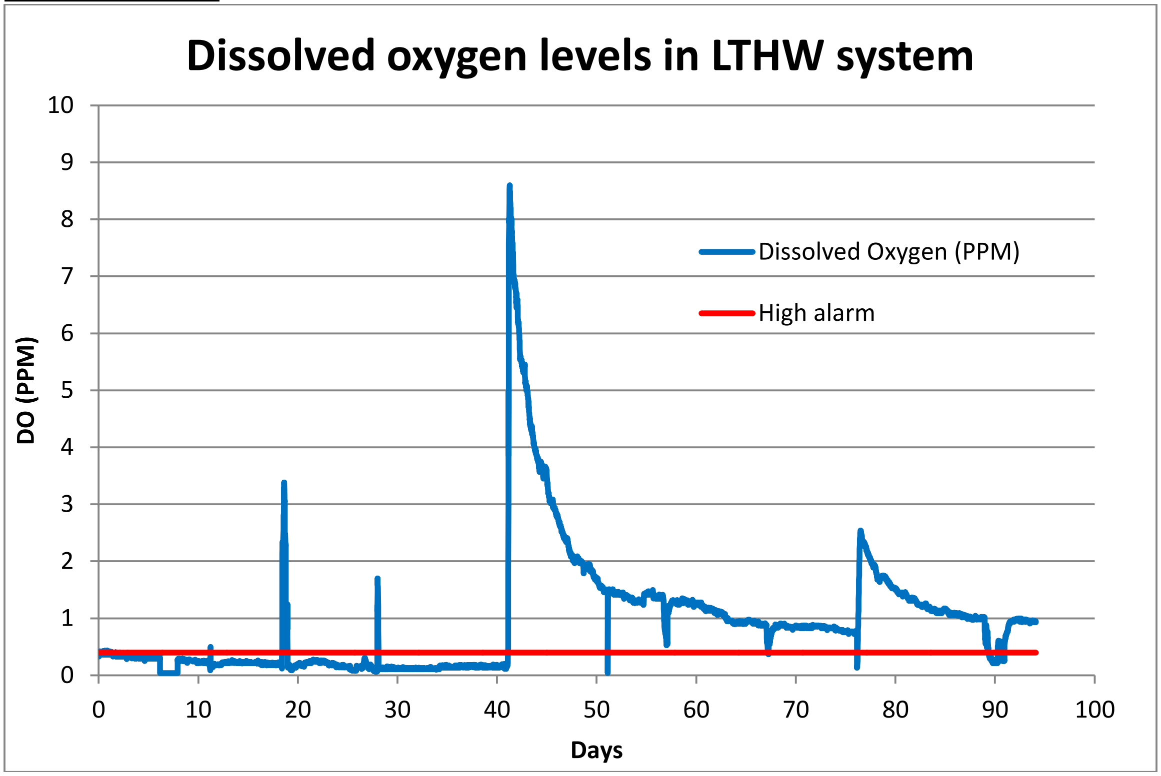
2. MANAGEMENT SUMMARY

The LTHW system is suffering from corrosion of steel and brass components, as evidenced from the crevice corrosion sensor and water analysis. Dissolved oxygen levels are significantly higher than that recommended for a closed system and analysis has shown that this is mainly due to the intake of fresh aerated water. There have been several incidents of large quantities of make-up water being drawn into the system during the monitoring period. Relative pressure has remained above 1 bar for virtually the whole of the monitoring period and therefore gaseous air intake (which can arise through AAVs when pressures become negative) can be ruled out as a cause of oxygenation.

There is some evidence of biofilm (to be confirmed) and the presence of ammonia and reduced nitrite levels in the system water point to the presence of Nitrite Reducing Bacteria (NRB). The latest water analysis figures (taken on 19/11/2015) indicates that the inhibitor is only around 74% of the recommended level. It is understood however that since this date the inhibitor level has been topped-up and biocide added.

3. KEY PERFORMANCE INDICATORS AND TRENDS

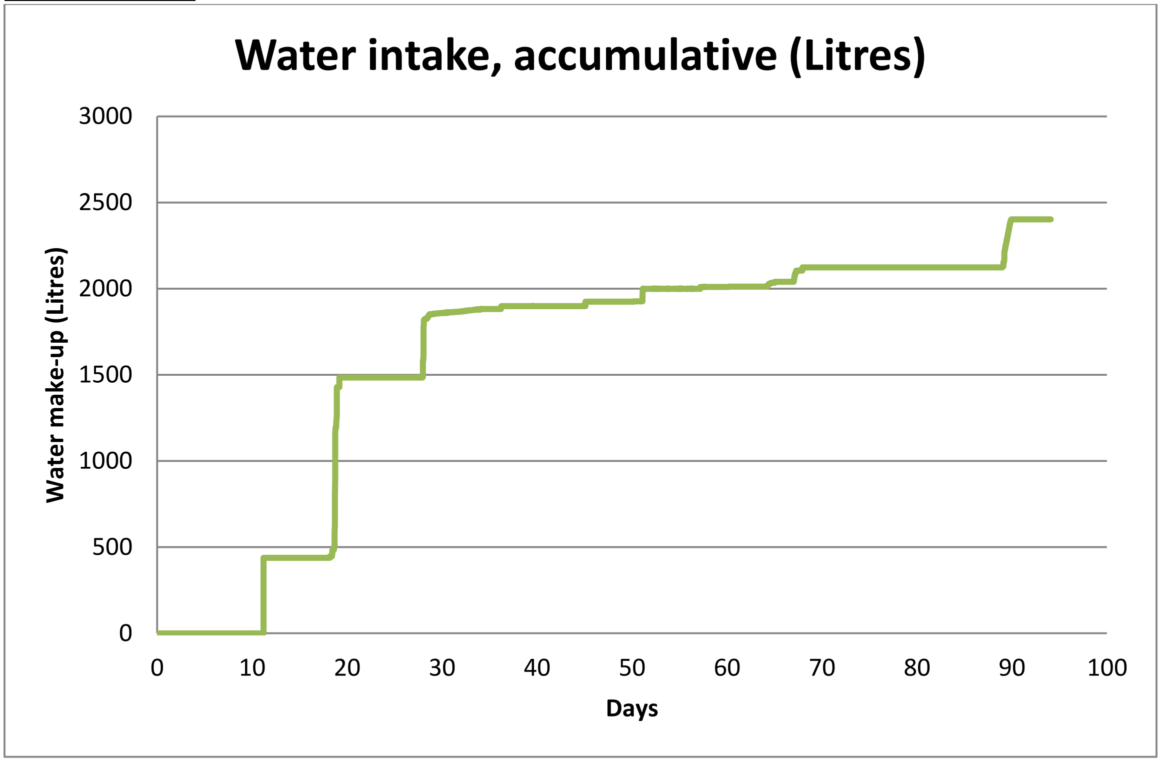
Dissolved Oxygen



Issues of concern: Dissolved oxygen levels have been higher than ideal for much of the monitoring period and increased dramatically on days 11, 18 and 28 when large quantities of fresh water were detected entering via the make-up line into the pressurisation unit See water make-up chart. However on day 41 (21/10/15) the system water reached to saturation levels (of dissolved oxygen) during which no significant amount of make-up water entered the system. It is understood that event coincided with partial drainage of the system during repair operation. Since that time, the dissolved oxygen gradually decreased (probably a result of oxidation / reduction reactions) but then increased again on day 76 (25/11/2015). At the last reading 13/12/2015 dissolved oxygen was still well above recommended levels at nearly 1 ppm.

In order to help understand what can be causing dissolved oxygen to be increasing at certain times further consideration has been given to the two main possible causes; namely, introduction of air or the addition of fresh, oxygenated make-up water. For a system of 4000 litres the amount of air needed to increase the dissolved oxygen by 1ppm has been calculated at 14 litres. Conversely (since incoming water only contributes around 10 ppm DO at 20C) the amount of fresh water needed to increase the dissolved oxygen by 1ppm has been calculated at 400 litres. The increase in dissolved oxygen is therefore felt to come from both sources (contribution from make-up water alone cannot explain the increases). It is summised that high flow rates of water entering the pressurisation unit cause gaseous air to also be drawn-in during the filling of the 4 litre tank.

Water make-up



Issues of concern: The chart of water intake (make-up) shows that fresh aerated water is continuing to be drawn into the system. Significant water losses were detected (by pulses from the water meter) on the following days

Day	Date	Approx volume intake	Over time period
11	21/09/2015	435	1 hour
18	29/09/2015	750	3 hours
28	08/10/2015	500	4 hours
89	08/12/2015	275	24 hours

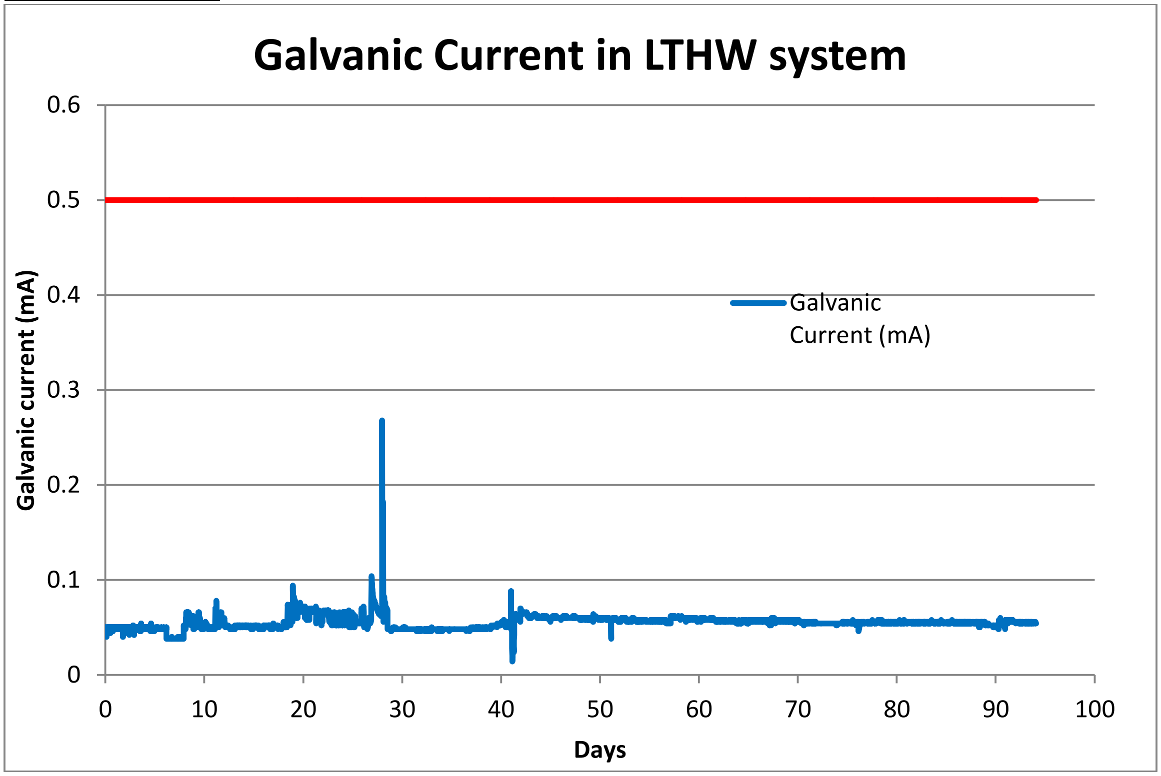
It is noticeable that the events of day 11, 18 and 28 coincided with sudden increases in dissolved oxygen. However, the slow fresh water intake between days 89 and 90 coincided with a drop in dissolved oxygen.

Confirmation of the large intake of fresh water has come from the dial on the water meter (2108 litres between 18/09/15 and 09/12/15)

Day	Date	dial reading	Delta	Cumulative
0	10/09/2015	meter not fitted		
8	18/09/2015	8680	0	x
39	19/10/2015	10364	1684	1684 + x
70	19/11/2015	10513	149	1833 + x
91	10/12/2015	10788	275	2108 + x

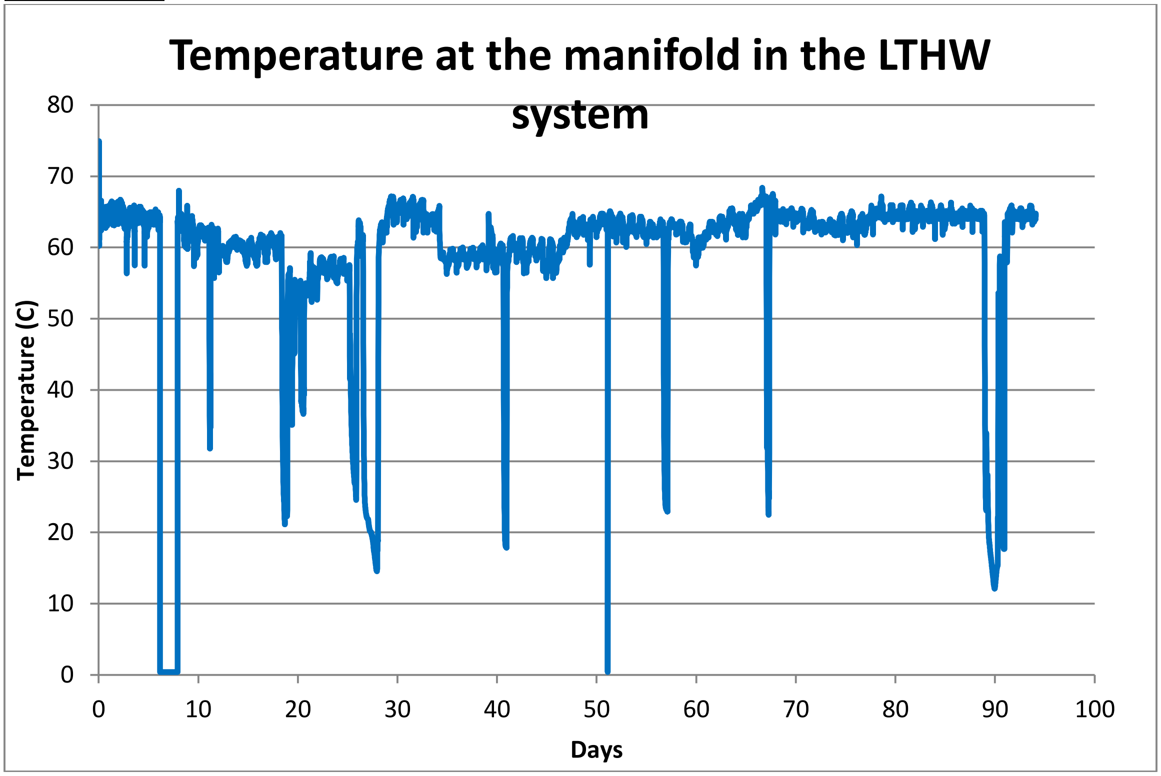
As a further check, dilution of the system water can be determined by analysis of sodium and molybdenum levels. Between 09/09/15 and 19/10/15 (a period where no water treatment chemicals were added) calculations show that the drop in concentration of these two elements are consistent with 2500 litres of water entering the system, based on a total estimated system volume of 4000 litres. This is around 800 litres higher than the indicated by the water meter dial between the dates 18/09/15 and 19/10/15. It is possible therefore that the estimate of system volume is too high (for the chemical analysis figure to agree with the dial readings, the estimate of system volume needs to be around 2700 litres).

Galvanic Currents



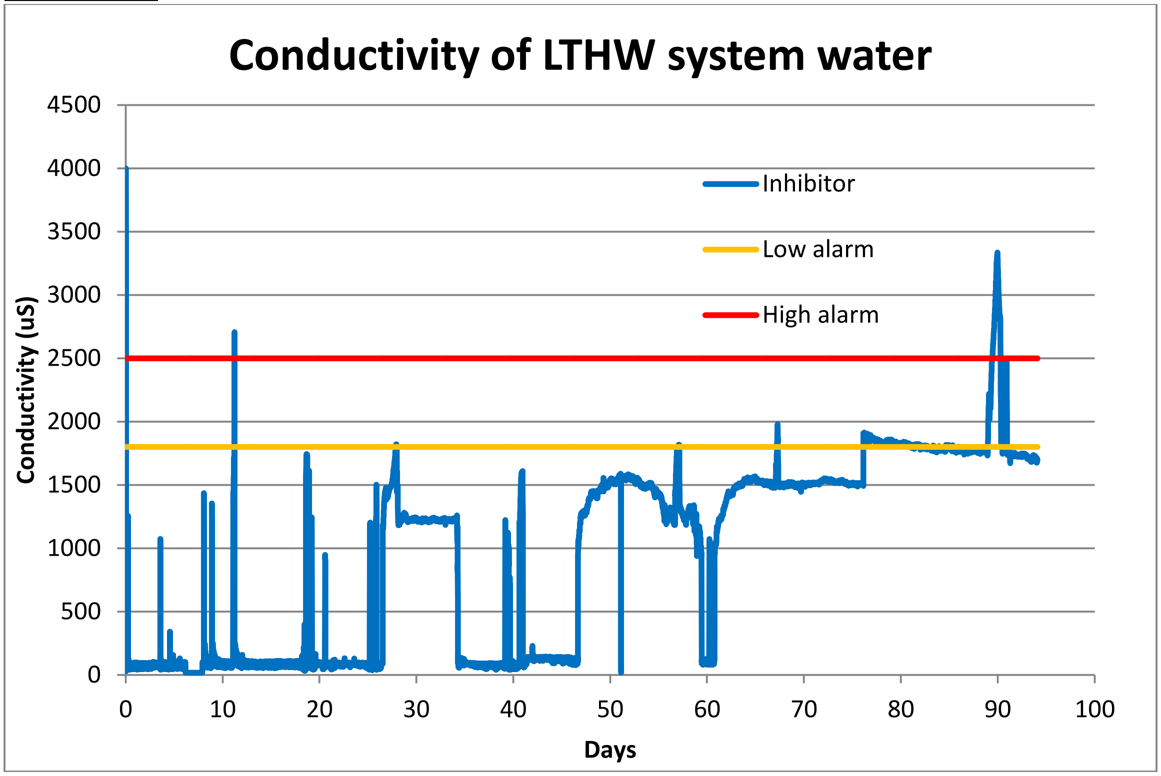
Issues of Concern: None –Galvanic currents between steel and copper have been negligible except for a sudden increase around day 28 (coinciding with an increase in DO). The fact that galvanic currents are low does indicate that the inhibitor is suppressing corrosion of steel on open surfaces (but not necessarily under debris and in crevices)

Temperature



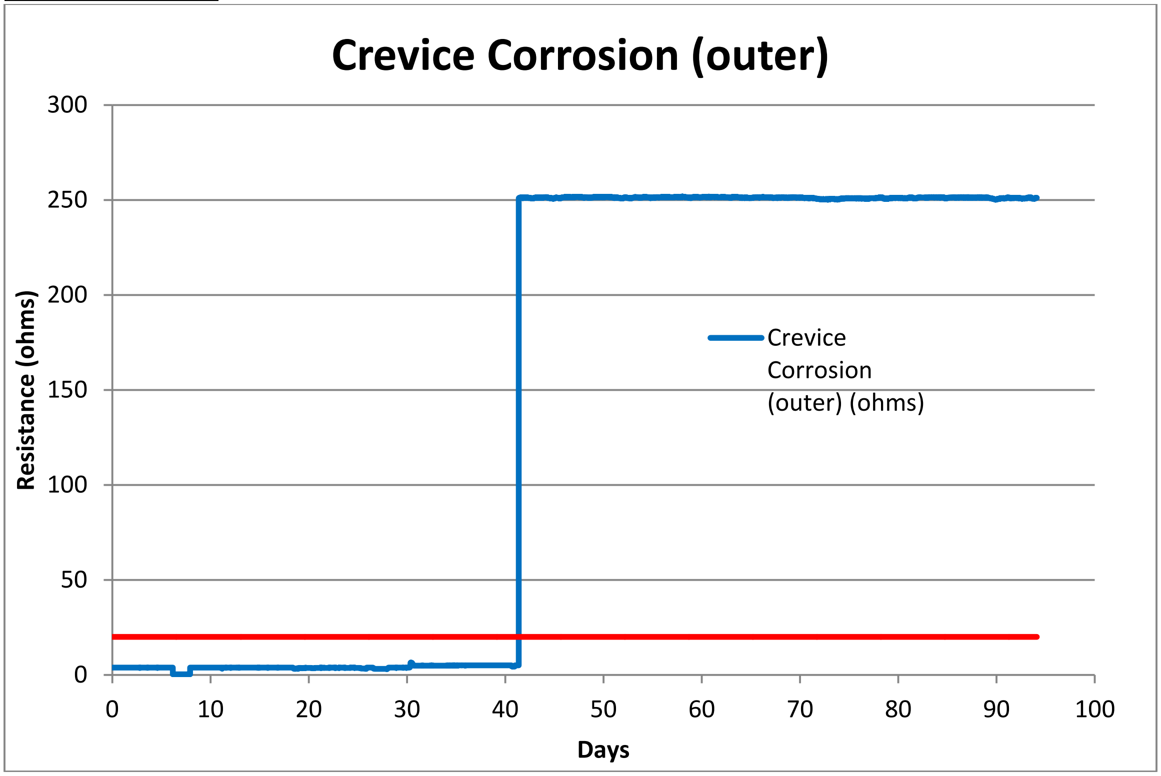
Issues of concern: None. The chart shows the temperature measured in the manifold which is slightly lower than that in the main system due to heat loss. Fluctuations have occurred however, probably as a consequence of maintenance activities (draining and refilling?) and changes in demand.

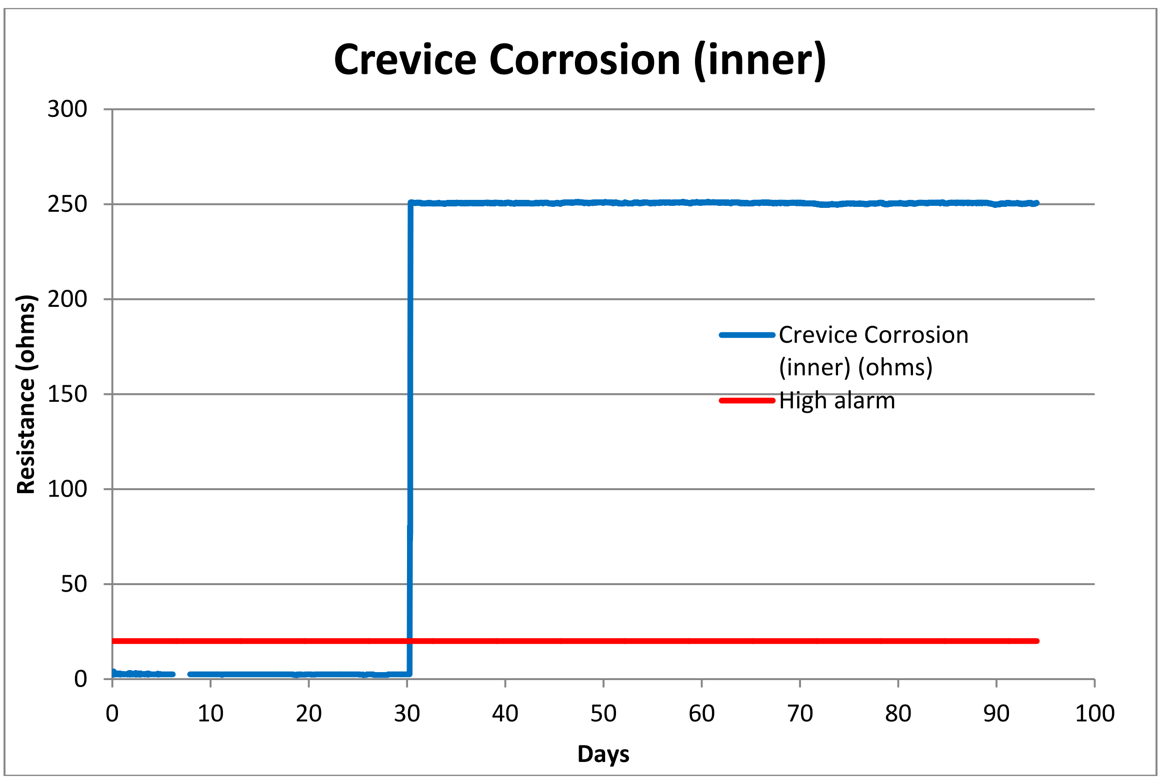
Conductivity



Issues of concern: The purpose of measuring the conductivity is to check on the concentration of inhibitor in the system. Unfortunately, early in the monitoring period the readings fluctuated wildly due to trapped air bubbles in the system. Latest results however suggest that the inhibitor level is below the recommended amount and this is consistent with the chemical analysis of the system water (see later in the report).

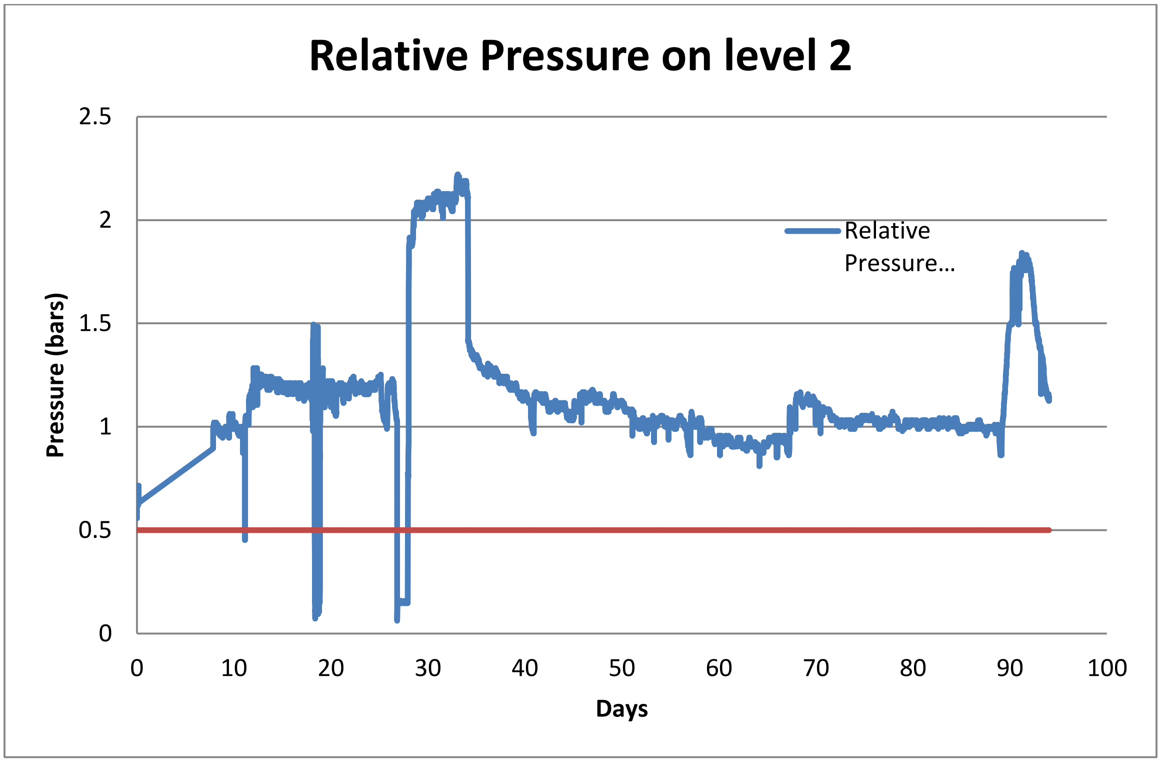
Crevice Corrosion





Issues of concern: Both of the thin (0.25mm diameter) steel wires in the crevice corrosion sensor have gone open circuit during the first 2 months of monitoring indicating that crevice corrosion of steel components has occurred.

<u>Pressure</u>



Issues of concern: There have been two occasions where the pressure has dropped to unacceptably low levels, but it is understood that this coincided with maintenance activates. During the past 60 days the relative pressure in the system has remained around or above 1 bar and therefore will not have caused the problem of oxygenation. It is also encouraging to note that when the boiler in the system was switched off causing a rapid temperature drop, the pressure remained largely unaffected confirming that the pressurisation unit is working correctly.

Biofilm risk

The biofilm sensor is currently indicating that there is a 50% risk of a biofilm forming in the system. The sensor will be removed from the system to visually check for a biofilm.

Water Analysis

Two samples of water were taken during the site visit of 9th September (mains cold water feed and LTHW system water). Full chemical analysis was then undertaken and the results can be seen in Appendix A. Further water samples were taken during a subsequent site visits (19th October and 19th November) and the results are shown in Appendix B & C.

Also during the latest visit on 19th November it was noticed that a fair amount of corrosion debris came out of the drain point adjacent to the manifold of the upper floor (see figure 1). The composition of the debris is given in Appendix D

Figure 1: Debris from system drain point on upper floor

Interpretation:

It is evident from the latest water analysis that the system is still under-dosed with inhibitor, on the understanding that this is Polyhib CH or equivalent (Polyhib NH5). Molybdenum levels are similar to that found the previous month at around 75% of the recommended level.

Although the nitrite level has increased from previous readings it is still significantly below what it should be for a system dosed with Polyhib CH. The nitrite level was found to be 91 mg/L which corresponds to 36% of the recommended dose. Since this figure conflicts with the dosing level calculated from Mo (75%) it would appear that nitrites are being consumed probably by nitrite reducing bacteria (NRB). This conclusion is further supported by the detection of ammonia in the system at 10 ppm, which is a by-product of nitrite reduction. It should be noted that Hevasure recommended in the last report that a water sample should be taken for microbial analysis to determine whether NRB is present and no confirmation has been given that this has happened.

The presence of corrosion debris is also a cause for concern, particularly since it was collected from the drain point near the top of the system (bypass between flow and return). It is more than likely that a lot more debris will be found in the lower parts of the system. The analysis of this debris confirms (Appendix D) that corrosion of steel is occurring, with a high percentage of iron oxides detected. Some zinc and copper was also detected in the debris confirming that corrosion of brass components has also been occurring.

4. CONCLUSIONS

The LTHW system at [redacted] is suffering from high levels of dissolved oxygen leading to signs of corrosion of steel and brass components

The most likely explanation for this is the intake of fresh make-up water at high flow rates.

There is a distinct possibility that the system contains some biofilm and nitrite reducing bacteria. The liberation of ammonia may eventually lead to stress corrosion cracking of brass components.

Signed...................

Date......21/12/2015

Appendix A – Chemical Analysis of water samples taken 09/09/15

Sample 1: **DCW (Mains)**

Qualitative Analysis	
Colour	Water white
Turbidity NTU's	0.46
pH	7.0
Conductivity / μS	745
Refractive Index / % Sugar	0
Debris	n/d

Quantitative Chemical Analysis	**mg/L**
Total Hardness as $CaCO_3$	318.3
M-alkalinity as $CaCO_3$	273
Boron as B	0.0
Chloride as Cl	19.6
Sulphur, Total as SO_4	33.3
Nitrite as NO_2	0.0
Nitrate as NO_3	16.5
Phosphorous, Total as P	0.8
Molybdenum as Mo	0.0
Silicon as Si	3.5
Sodium as Na	11.6
Potassium as K	1.3
Magnesium Total as Mg	6.4
Calcium Total as Ca	116.8
Iron, Total, as Fe	0.00
Copper, Total, as Cu	0.17
Zinc, Total, as Zn	0.02
Aluminium, Total as Al	0.00

Ionic balance sample 1	0.99

Sample 2: **LTHW Plant Room**

Qualitative Analysis	
Colour	Water white
Turbidity NTU's	2.22
pH	8.7
Conductivity / μS	2040
Refractive Index / % Sugar	0.2
Debris	n/d

Quantitative Chemical Analysis	**mg/L**
Total Hardness as $CaCO_3$	226.0
M-alkalinity as $CaCO_3$	954
Boron as B	10.1
Chloride as Cl	43.4
Sulphur, Total as SO_4	22.6
Nitrite as NO_2	0.0
Nitrate as NO_3	86.3
Phosphorous, Total as P	0.4
Molybdenum as Mo	401.7
Silicon as Si	6.1
Sodium as Na	733.0
Potassium as K	6.3
Magnesium as Total as Mg	4.0
Calcium Total as Ca	83.9
Iron, Total, as Fe	0.20
Copper, Total, as Cu	3.41
Zinc, Total, as Zn	0.53
Aluminium, Total as Al	0.00

Ionic balance sample 2	1.65

Appendix B – Chemical Analysis of water samples taken 19/10/15

Sample 1: **LTHW Plant room initial drain-off**

Qualitative Analysis	
Colour	Slight straw
Turbidity NTU's	379
pH	8.6
Conductivity / μS	1470
Refractive Index / % Sugar	0.2
Debris	Slight magnetite fines

Quantitative Chemical Analysis	**mg/L**
Total Hardness as $CaCO_3$	180.6
M-alkalinity as $CaCO_3$	661
Boron as B	4.8
Chloride as Cl	41.8
Sulphur, Total as SO_4	35.2
Nitrite as NO_2	0.0
Nitrate as NO_3	37.8
Phosphorous, Total as P	9.8
Molybdenum as Mo	155.1
Silicon as Si	3.5
Sodium as Na	276.2
Potassium as K	2.6
Magnesium Total as Mg	3.6
Calcium Total as Ca	66.4
Iron, Total, as Fe	16.56
Copper, Total, as Cu	4.79
Zinc, Total, as Zn	1.15
Aluminium, Total as Al	0.13

Ionic balance sample 1	1.00

Sample 2: **LTHW Plant room following initial drain-off**

Qualitative Analysis	
Colour	Trace straw
Turbidity NTU's	78.6
pH	8.6
Conductivity / μS	1466
Refractive Index / % Sugar	0.2
Debris	Trace magnetite fines

Quantitative Chemical Analysis	**mg/L**
Total Hardness as $CaCO_3$	171.7
M-alkalinity as $CaCO_3$	669
Boron as B	4.1
Chloride as Cl	42.1
Sulphur, Total as SO_4	36.1
Nitrite as NO_2	0.0
Nitrate as NO_3	38.9
Phosphorous, Total as P	12.7
Molybdenum as Mo	150.3
Silicon as Si	3.4
Sodium as Na	273.2
Potassium as K	2.6
Magnesium as Total as Mg	3.3
Calcium Total as Ca	63.3
Iron, Total, as Fe	3.02
Copper, Total, as Cu	0.91
Zinc, Total, as Zn	0.21
Aluminium, Total as Al	0.04

Ionic balance sample 2	0.96

Suspended solids (average of 3 samples including initial drain-off) = 630 mg/L

Appendix C – Chemical analysis of water sample taken 19/11/2015

Sample 1:	**LTHW Plant Room**
Qualitative Analysis	
Colour	Trace straw
Turbidity NTU's	2.95
pH	9.0
Conductivity / μS	1767
Refractive Index / % Sugar	0.1
Debris	n/d

Quantitative Chemical Analysis	**mg/L**
Total Hardness as $CaCO_3$	160.6
M-alkalinity as $CaCO_3$	776
Boron as B	3.4
Chloride as Cl	48.1
Sulphur, Total as SO_4	29.8
Nitrite as NO_2	90.9
Nitrate as NO_3	46.6
Phosphorous, Total as P	0.3
Molybdenum as Mo	152.8
Silicon as Si	3.2
Sodium as Na	367.8
Potassium as K	2.8
Magnesium Total as Mg	6.5
Calcium Total as Ca	53.5
Iron, Total, as Fe	0.25
Copper, Total, as Cu	1.56
Zinc, Total, as Zn	0.39
Aluminium, Total as Al	0.00

Ionic balance sample 1	1.05

Appendix D – Chemical analysis of corrosion debris taken 19/11/2015

Test	% Composition
Appearance	fine red/brown platelet material
Magnesium	0.3
Calcium	8.1
Sulphur	0.4
Boron	<0.1
Phosphorus	2.9
Molybdenum	<0.1
Aluminium	<0.1
Iron	35.5
Copper	2.2
Zinc	2.4
Silicon	0.2
Sodium	0.2

Comment

The analysis of the highly magnetic red/brown coloured platelet material has revealed that it is mainly Iron based, with evidence of some Calcium Carbonate Lime-scale (evidence of effervescing during dissolving), together with Phosphorus, Copper and Zinc.