ST PANCRAS CASE STUDY

Contents

Executive Summary

A new type of Side Stream Filtration and Automatic Dosing Unit (X-POT+AD) has been designed by VEXO International which incorporates dosing VEXO's X-PO10 neutral pH inhibitor to improve the efficiency of commercial heating and cooling systems.

The claims for the X-POT+AD include:

- Maintains system efficiency for new systems.
- Restores system efficiency as close to original design efficiency for older systems.
- Prevents scale precipitation or build-up throughout the system.
- Dissolves proportionate amount of existing scale back into solution – for existing systems.
- Inhibits corrosion which forms hydrogen gas and detritus / debris throughout the system.
- Filters out magnetic and non-magnetic material down to a filtration rate of 5 micron to comply with BSRIA Guidelines BG50/2013 and BG29/2012.
- Inbuilt temperature compensated conductivity sensor to allow for high accuracy dosing of X-PO10 inhibitor which maintains the system water at a neutral pH state.

To examine these claims a prototype X-POT+AD has been installed in the boiler room at St Pancras Hospital in London and measurements, samples and photographs have been taken of the heating system and components. By running a four month trial of the unit including dosing of inhibitor into this system, this report and the various measurement methods are described and the results analysed for a 4 month period.

The following conclusions were reached regarding the VEXO X-POT+AD Side Stream Filtration and Automatic Dosing Unit which dosed X-PO10 pH neutral inhibitor.

- The thermal efficiency of the primary system plate heat exchanger has increased due to the scale deposition being dissolved back into solution.
- The thermal conductance of the heat emitters e.g. radiators, has increased as the whole radiator area is now more effective in transmitting heat due to scale and sludge being dissolved and removed from the system.
- The corrosion rate of the system has slowed significantly resulting in less build up of hydrogen gas and therefore cold spots on radiators have been removed.
- The life of system components will be extended due to the removal of detritus from the system.
- The system water is being maintained at a neutral pH, especially with any aluminium within the system will not be under the threat of corrosion.
- The laboratory analysis confirms the system water now complies fully with BSRIA BG29/2012 for water cleanliness for a 'New Build' system.
- The removal of particulates larger than 5 microns from the system water has been confirmed by the laboratory analysis which confirms the system water now complies fully with BSRIA BG29/2012.
- The advantages to the NHS Trust will be lower fuel bills, the extended lifespan of system components and reduced maintenance costs.
- The advantage to society will be reduced green house gas emissions from this system ongoing.
- Following the trial and collating the results and analysis, this system as a whole will be operating at a conservatively 10-20% higher efficiency than previous.

Background

To limit the production of greenhouse gases (GHG), resulting from the combustion of fossil fuels and the impact of global warming, it is essential to use energy as efficiently as possible. Some 30% of energy is used to heat or supply hot water to commercial properties in the UK so even a small increase in efficiency of the production and distribution of heat will significantly reduce GHG emissions.

The Carbon Trust has identified a number of limiting factors which result in the loss of system efficiency in commercial heating systems namely, that of scale build up on the inside of heat exchangers etc [1] and the prevention of corrosion and sludge build-up to the inside of the system components, pipework, radiators etc [2]. Vexo International has developed a Side Stream Filtration and Automatic Dosing Unit (X-POT+AD) which through independent laboratory tests have shown will take this scale back into solution [3], breakdown existing sludge build-up [4], limit any further corrosion for taking place by the dosing of an independently approved (BuildCert) pH Neutral inhibitor at the correct dosage levels [5] to raise the efficiency levels of older systems and / or maintain the levels of system efficiency of new systems.

The purpose of this installation and study was to identify and understand the effects of the X-POT+AD Side Stream Filtration & Auto Dosing Unit to the water quality within an existing circulating heating system. The objective was to confirm the X-POT+AD could mitigate the factors above which the Carbon Trust identify as being detrimental to the efficiency of heating systems and therefore return an old in-efficient system back to as close to its original design efficiency as possible.

The trial installation of the prototype was to ensure the X-POT+AD performed to within its design parameters and was capable of improving a non BSRIA compliant water quality system and converting it to a standard which meets BSRIA BG50 / 2013 & BSRIA BG29 /12 Guidelines.

This included testing the accuracy of the X-POT+AD's "Auto Dosing" function when monitoring inhibitor levels and adding additional Inhibitor, as and when the intelligent 'Conductivity Sensor' identified changes to the water chemistry, thus identifying when and how much inhibitor to dose. The dosage is based on the software and pre-set algorithms through temperature compensation.

Both BSRIA BG50/2013 & BSRIA BG29/2012 documents are used within the Industry by MEP Design Consultants, MEP Contractors, and FM & Water Treatment Specialist as a standard to work too. They are used as the benchmark for maintaining water quality in Commercial Heating & Cooling Systems, so systems continue to operate within design, use as little fuel as possible and ensure longevity of the client's investment.

Many heating systems when not correctly maintained using water treatment chemicals can lead to lower operating efficiency, plant failure, breakdowns, leaks, cold/warm spots and poor flow, all as highlighted by the Carbon Trust and the Energy Savings Trust.

The trial would also demonstrate beyond doubt that the X-POT+AD Side Stream Filtration & Auto Dosing Unit is capable of maintaining newly commissioned systems to their design parameters.

Donor Site & System Overview

To fully demonstrate the performance of the X-POT+AD Unit, it was important to find a suitable Donor Site, the criteria was therefore:

1. No current water treatment regime in place and had no inhibitor added previously.
2. A system which is suffering from the symptoms of poor water quality (Radiator cold spots and poor flow, etc...).
3. A system which is known to be suffering from corrosion.

The site and system which became available was the NHS Trust –St Pancras Hospital, London. The system was an aged LTHW Heating system.

System Type	Heating (LTHW)
Year of Construction	1940
Repairs/Construction	1950s/60s/70s/80s/90s/00s & 2013
Closed/F&E	F&E (Feed & Expansion) - Hard Water (2.6m^3 @20m Head)
System Materials	Cast Iron/Milk Steel/Copper/Brass/Possibly Aluminium
System Volume	65,500 Litres

System Type	Heating (LTHW)
No. 2 Boiler	Riley Steam Boiler (Installed 1962)
No. 3 Boiler	Riley Steam Boiler (Installed 1962)
No. 4 Boiler	Riley Steam Boiler (Installed 1969)
Boiler Rating (Each)	10.5 million BTUs (set at 70psi)
Primary Heat Exchanges	2 No Steam Fed Vertical Calorifiers
Circulating Pumps	2 No Pullen Belt Driven
Shunt Pumps	Various within Tunnels
Terminal Units	Various Radiators

London sites also suffer from the effects of Hard Water (as does 70% of the UK), so this project displays a more representative study.

Fig 1.
The boiler room under construction in 1940.

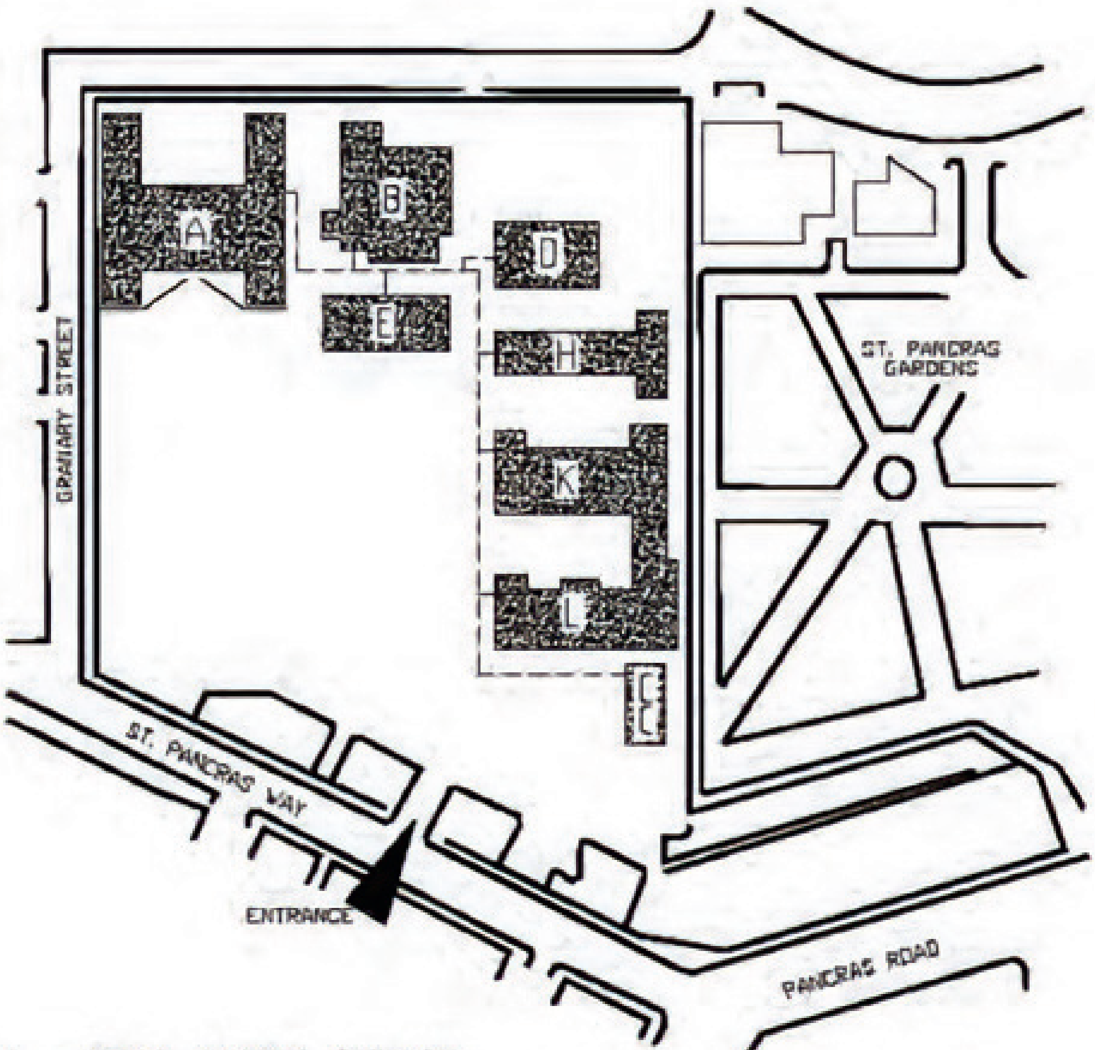
Fig 2.
Entrance to the site, some buildings date back to 1890s.

Fig 3.
No Riley steam boilers installed in 1960s.

Fig 4.
Two Pullen belt driven circulating pumps with two Steam fed vertical heat exchanges.

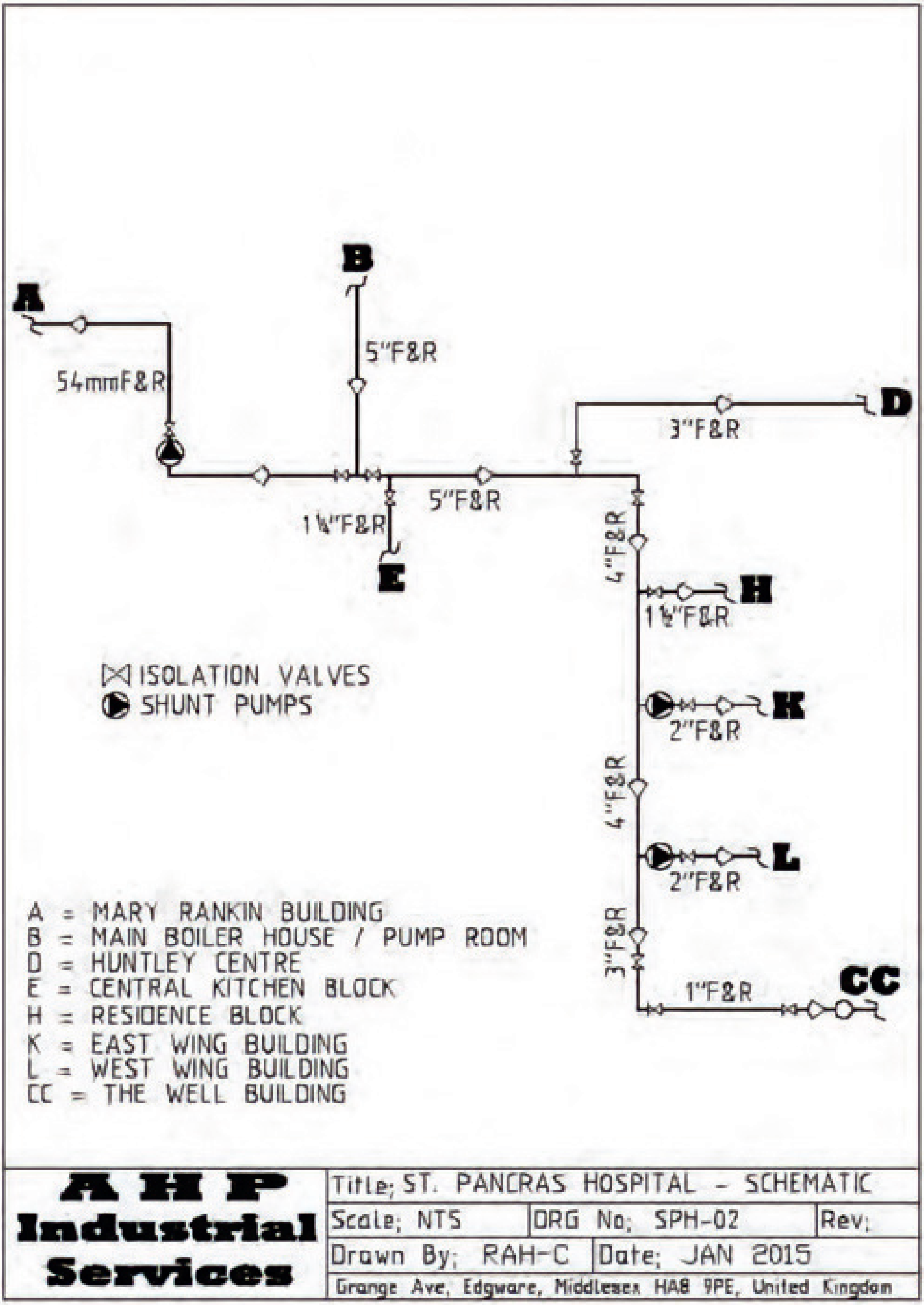
Fig 5.
LTHW pipework is routed via services tunnels to each individual building.

Fig 6.
Two 1/2” Brassh DOCs. These were removed from a fouled pipe during a clean-up operation and show the effects of corrosion debris. Ultra fine particles that are capable of passing through system strainers will still settle out in low flow parts of a system.



A = MARY RANKIN BUILDING
B = MAIN BOILER HOUSE / PUMP ROOM
D = HUNTLEY CENTRE
E = CENTRAL KITCHEN BLOCK
H = RESIDENCE BLOCK
K = EAST WING BUILDING
L = WEST WING BUILDING
CC = THE WELL BUILDING

A H P Industrial Services	Title; ST. PANCRAS HOSPITAL – SITE LAYOUT		
	Scale; NTS	DRG No; SPH-01	Rev;
	Drawn By, RAH-C	Date, JAN 2015	
	Grange Ave, Edgware, Middlesex HA8 9PE, United Kingdom		



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Introduction to the X-POT+AD

The X-POT+AD is a skid mounted fully automated Side Stream Filtration Unit filtering down to 0.5micron by using a twin filtration system of rare earth magnetic grates and fine filtration bag filters. The unit also includes the capability of analysing the system water along with the correct dosage rate of the inhibitor by measuring the conductivity to determine if there is sufficient inhibitor within the system. The inhibitor used in the X-POT+AD is X-PO10, it is a neutral pH BuildCert approved inhibitor and fully complies with BS7593.

Fig 8.
Skid mounted X-POT+AD Unit.

NOTE:

All other inhibitors which are automatically dosed to system water are of a high pH and the sensors are calibrated to that high pH.

The drawback to these systems is that high pH (8.5pH+) inhibitors can not be used when aluminium is installed in a system as aluminium corrodes above 8.3pH.

Aluminium has a better conductivity or heat transfer rate than steel (approx 11 times better), it is advantageous to include aluminium plate heat exchangers in a system other than steel as this will give a better heat transfer rate and reduce overall running costs which, ultimately reduces green house gas emissions.

Therefore by measuring the conductivity, a pH neutral inhibitor can be used, so offering the end user the opportunity of installing aluminium into the system. The X-POT+AD utilises a new sensor which, can be pre-programmed with the temperature compensated thermal conductivity of the system water and the pH neutral (X-PO10) inhibitor combined and is bespoke for that system.

The X-POT+AD's patented design means that Building Services Designers, Contractors, FM Managers, Property Owners etc, are able to purchase a "plug & play" fully automatic system which will look after the complete system water and is capable of maintaining a very high level of water cleanliness for Commercial Heating & Cooling Systems. It can also be used to clean up fouled dirty systems, which could contain aluminium without the threat of potential corrosion issues to plate heat exchangers etc, thereafter maintaining the restored system efficiently.

The X-POT+AD can be hard-wired or wireless linked to the building management system (BMS), to communicate to the engineering team should a fault occur, for example should a filter change be required, or chemical stock is running low or empty.

The X-POT+AD not only ensures water quality is filtered from anywhere above 100 micron down to 0.5 micron, by using polypropylene needle felt bag filters, the unit also has 13 x 8000 Gauss Rare Earth magnets, each encased within a stainless steel coating, these magnet bars are then secured within 2No 316 Stainless Steel Magnet Grates and submerged fully within the system water.

This unique magnet grate provides a longer life cycle of the filter bags, plus it can also be used as a stand alone (without bag filter) for systems which are heavily fouled with iron oxide deposits.

Features of the X-POT+AD

- 25 litre 304SS vessel polished mirror finish internally and externally.
- Factory hydrostatically tested to 25 bar – suitable for systems up to 16 bar working pressure.
- Removable lid c/w 25mm SS304 tundish fill point, IV, NRV and manual vent.
- Flamco FC Ventsuper AAV.
- 2 No 316SS magnet grates c/w 13 rare earth magnet rods each encased in a 316SS tubes.
- 1 No 316SS baffle plate.
- 1 off each 100, 50, 25, 5 & 0.5 micron bag filters.
- 316SS filter basket.
- All 304SS pipework, valves and fittings.
- Pressure gauges on both the dirty flow and clean return.
- Bespoke insulation jacket for the vessel body and removable lid.
- Control panel c/w mains isolator, audible alarm, flashing beacon and BMS alarm interfaces (Inhibitor low level, empty chemical drum and common alarm).
- Pre-wired super efficient inverter driven 240V Grundfos pump which is capable of 1 l/s (60 l/m or 86,400 litres/day) or for the larger 2 l/s (120l/m or 172,800 litres/day) X-POT+AD/2.
- Hamilton conductivity sensor pre-wired, temperature compensated & calibrated to suit site mains water (pre-installation sample required).
- Pre-wired Grundfos Auto Dosing pump c/w Perspex anti-splash shield to Control Panel.
- 25 Litre drum of BuildCert approved pH neutral premium X-PO10 Inhibitor in a chemical drum bund.
- Pack of 50 X-PO10 inhibitor test kits.
- Stabilising bracket.
- Stainless Steel legs.
- All mounted on a purpose built powder coated welded support frame ready to “plug and play”.
- Includes system water conductivity and inhibitor level test post-contract by independent specialist.
- O&M documents, on site commissioning and demonstration.

Why have Water Treatment, the Simple Facts

Manufacturers are improving and enhancing materials, plant and equipment being installed into Heating and Cooling systems to improve energy efficiencies. These items are becoming more and more complex with smaller orifices, smaller surface areas to conduct heat transfer and lower flow rates. These finer slower flow water-ways easily get blocked with settled corrosion debris and detritus, once a water treatment regime is not put in place for that system and then the system water is no longer within the parameters set out in the BSRIA guidelines.

“Effective maintenance is essential in getting the best performance from your LTHW boilers. Without it, boiler efficiency can drop significantly and equipment life expectancy is reduced. Effective maintenance can also highlight potential problems quickly and enable remedial action to be taken before there is a major impact on performance.” Carbon Trust document – CVT008

The Carbon Trust, Energy Savings Trust, British Standards and DECC all confirm that heating systems lose efficiency by the following if water treatment is not utilised within a system:

1. “A 1mm layer of limescale will cause a 7% increase in energy input to the boiler to meet the same heat demand.” **– Carbon Trust.**
2. “An estimate of between 5 – 10% loss of efficiency due to the build up of excess air / hydrogen Gas within the radiators.” **– Carbon Trust.**
3. “A new system can be up to 6% less efficient within a matter of weeks if it has not been treated correctly.” **– Energy Savings Trust.**
4. Estimate of up to 20% loss of efficiency of the heating system due to build up of sludge within the system radiators / plant causing cold spots and loss of flow rate and ultimately leading to failure of major system components. **– DECC.**

It is plain to see from the above, it is critically important a system is maintained from the start and monitored regularly to make sure the correct levels of water treatment chemicals are circulated around the system. Otherwise the system will lose efficiency of as much as 30% and components will fail leading to higher overall running and maintenance costs.

The Purpose of Water Treatment within Closed Heating & Cooling Systems:

1. Control Corrosion
2. Prevent Scale from forming
3. Prevent Bacterial colonisation
4. Maintain the system in a clean condition
5. Assist in maintaining system efficiency
6. Prolong system life

Methodology of the Trial

The routine at St Pancras Hospital for running the heating system was to circulate heated water during the Autumn, Winter and Spring months only, when heating was needed.

By running the system only during the heating season gave concerns when the heat and pumps were not running. The system acts during the down time as a stagnant circuit with microbiological infection occurring (Microbiological Induced Corrosion) from the feed tank, along with general corrosion taking place throughout the system.

As the system has no previous history of water treatment additives being added, it was also felt that once the system pumps are run for the first time, much iron oxide and scale detritus could be mobilised into the system flow.

VEXO proposed and executed the following methodology:

1. Sample Mains Water Supply for microbiological analysis (prior to trial) – refer to Microbiology Certificate of Analysis – Job No: 14-42705.
2. Sample LTHW system water for chemical analysis (prior to trial) – refer to Chemistry Certificate of Analysis – Job No: 14-42705.
3. (Day 1) Install the X-POT+AD Side stream Filtration & Auto Dosing Unit connected to the main return pipes within the boiler room, then operate the unit (Auto Dosing off) in parallel with running the LTHW system pumps.
4. It was decided at the initial start of the trial not to add any inhibitor to this very old system as this would be the first time the main system pumps had been run for a number of months. Therefore the auto dosing facility was turned off, the X-POT+AD circulating pump was activated and only the 2No magnet grates containing the 13 rare earth magnets were added to collect any magnetic particles.
5. Operate the system pumps (heat off) for 26 days with magnet filtration only, to capture ferrous metals and gently clean the system.
6. (Day 26) Main hospital heating system turned on due to falling external temperatures. Heat on and main system circulation pumps running with magnet filtration only in the X-POT+AD.
7. (Day 30) Record temperature distribution on radiators in the Mary Rankin Building.
8. (Day 56) Post 30 days of circulation and with heat on; slowly add X-PO10 inhibitor (25 Litres) via the X-POT+AD units' intelligent sensor and Auto Dosing function, clean magnet grates and install a 100 micron bag filter.
9. (Day 57) Turn the Automatic Dosing function on. As this system is very old, we wanted to slowly introduce inhibitor into the system gently and not "shock" the system.
10. (Day 58 and ongoing) The site maintenance team continue to monitor and clean the magnet grates, change out the filter bags slowly reducing the micron rating until the 5 micron filter is installed.
11. (Day 70 and ongoing) Inhibitor levels are increased slowly via the Auto Dosing Pump. Visual water quality checked via the 1" visual flow indicator on the clean return. Filters changed as and when required, lowering micron size, until water quality is within BSRIA BG50-2013 Guidelines with sufficient X-PO10 Inhibitor protection added.
12. (Day 107) Record temperature distribution on radiators in the Mary Rankin Building.
13. Sample supply water for microbiological analysis (Post trial) – refer to Microbiology Certificate of Analysis – Job No: 15-64263.
14. Sample LTHW system water for chemical analysis (Prior to trial) – refer to Chemistry Certificate of Analysis – Job No: 15-64263.
15. Gather all relevant information and collate the case study.

Installation of the X-POT+AD and Cleaning Filters

Fig 9.
The X-POT+AD Prototype was installed in the main Boiler House/Pump Room and commissioned on site on the 10th September 2014.

It was connected with 1" steel Pipework to the main system return.

As can be seen, the water treatment chemicals are visible and ready to be injected into the system via the Grundfos Auto Dosing Pump.

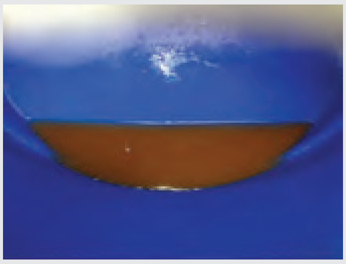

Fig 10.
Initial water taken from the return within the boiler room, with system pumps running, note the dark colour of the water caught within a blue bucket.

Prior to the trial the water quality was found to be dirty in appearance (Fig 10), with high levels of suspended solids and heavy solids found – refer to lab analysis Job No: 14-42705.

This debris was analysed by the laboratory the results concluded much of the debris composition was made up from Iron, with some scale and copper.

Fig 11.
Magnet Grate after 5 days (Ho Heat)

Fig 12.
Magnet Grate after 5 days (Ho Heat)

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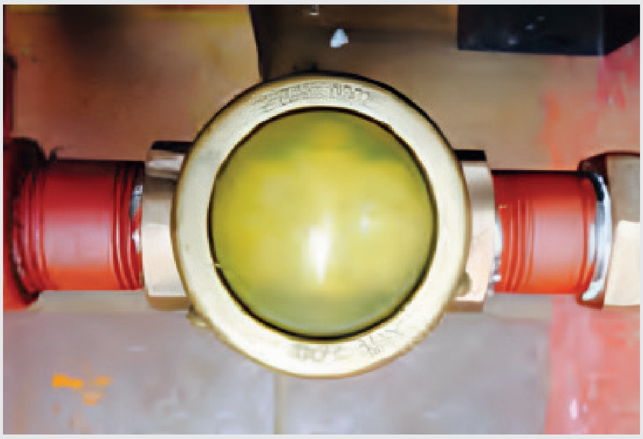

Fig 13.
Slight flow indicator showing dirty/murky water after 5 days (No Heat).

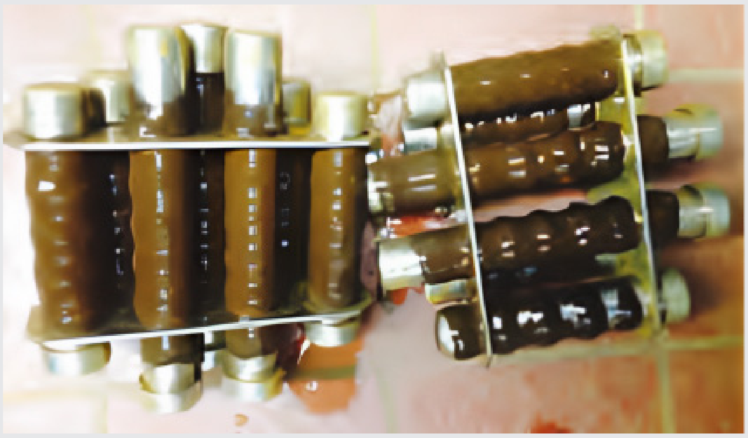

Fig 14.
Magnet Grates after 12 days (No Heat).

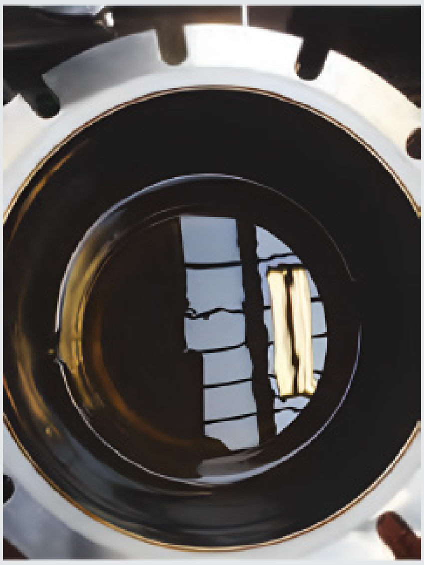

Fig 15.
View within the X-POT+AD after 12 days (No Heat) showing murky water.

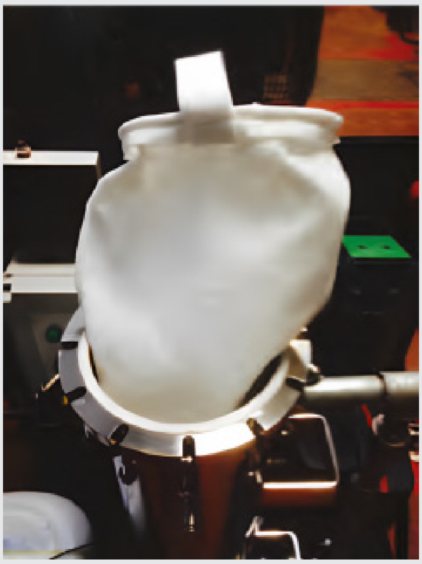

Fig 16.
First 100 Micron Filter added on day 30 (Heat on for 4 days).

Fig 17.
First filter removed after 5 days (Day 34) with new filter ready to be added.

Fig 18.
Both Magnet Grates removed for cleaning (Day 34).

Day 90 (Heat on for 72 Days)

Fig 19.
Dirty Magnet Grate.

Fig 20.
Magnet Grates after 72 days (Heat On).

Fig 21.
The water in the Sight Flow Indicator appears clear.

Fig 22.
Sampled water from the heating is also clear with a very slight haze.

The photographs of the system water above show a significant visual change to the water quality. Much of the nonsoluble Iron and Scale Deposits have now been removed.

Day 125 (Heat on for 99 Days)

Fig 23.
6 Magnet Grate

Fig 24.
7 Magnet Grate

Fig 25.
Dirty 5 Micron Filter

Fig 26.
Start/Finish Samples

Temperature Distribution in Radiators

The temperature distribution across three radiators was measured on day 30 of the trial and just after the system heating was turned on and before any inhibitor was introduced into the system. The inhibitor was then added (day 56) and the temperature distribution was then re-measured on day 107 of the trial using an infra-red laser beam thermometer (Table 1).

Inhibitor Presence	Top Right (0°C)	Bottom Right (0°C)	ΔT (0°C)	Top Left (0°C)	Bottom Left (0°C)	ΔT (0°C)	Radiator Location
Pre	43	34	9	41	33	8	Corridor 1
Post	62	61	1	48	47	1	
Pre	37	30	7	36	30	6	Corridor 2
Post	58	54	4	46	45	1	
Pre	42	35	7	39	33	6	Gents Toilets
Post	59	57	2	45	43	2	

Table 1: Temperature distribution in radiators pre and post adding inhibitor

It can be observed that:

- The differential temperature distribution from top to bottom of each radiator is very much reduced post inhibitor being added to the system.
- The temperature drop from the right to left is much higher, this confirms the flow for each of the radiators is entering from the right and exiting the radiator on the left.

This indicates the radiators have a more uniform distribution post pre-inhibitor. The thermal image of the Corridor 1 radiator Fig 27 below, before the inhibitor was added shows how the flow of the system water affects the temperature of the radiator surface. The system water flow has been slowed due to debris, detritus and sludge build up within the pipework and radiators.

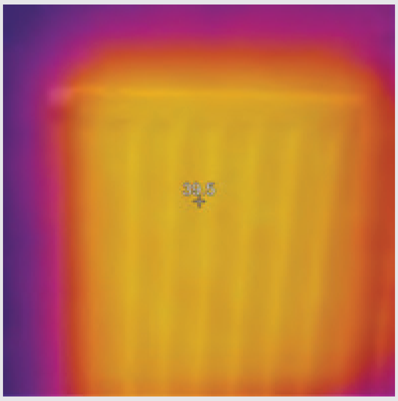

Fig 27.
Thermal image of Corridor 1 radiator - Pre Inhibitor

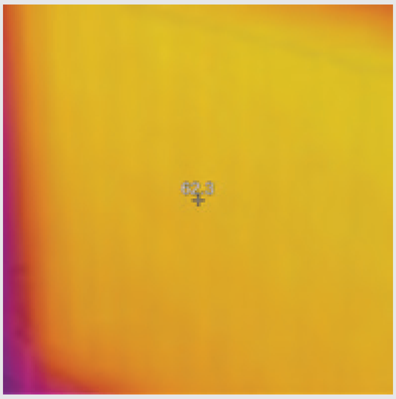

Fig 28.
Thermal image of Corridor 1 radiator - Post Inhibitor

The result of adding inhibitor is the temperature distribution of all radiators is much more uniform as well as the temperature rise across the surface areas as well. This will result in the radiators being more effective at radiating heat and keeping the room warm.

All of the radiators on this system have shown the same positive outcome from the introduction of the X-POT+AD and X-PO10 inhibitor. The hospital maintenance team have now turned down the thermostats controlling the radiators.

Chemistry
Certificate of Analysis

Job No : 14-42705

Issue : 1

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Client Details:

Vexo International (UK) Ltd
Coppergate House
16 Brune Street
London
E1 7NJ

Site: St Pancras Hospital

Sample No: 692476 **Order Number:** X-POT PLUS TRAIL

Sampled By: Darren Wilkinson **Date Sampled:** 10/09/2014 **Time Sample Taken:** Not Declared

Date Received: 10/09/2014 **Sample Deviations:** b

Sample Point: Site District Heating - Initial

Test Name	Result	Units	Method No
pH	7.9	pH Unit	CHEM038
Electrical Conductivity @ 20℃	590	µS/cm	CHEM038
Total Dissolved Solids @ 105℃	480 #	mg/l	CHEM006
Suspended Solids @ 105℃	71 #	mg/l	CHEM007
Heavy Solids	Absent #		CHEM007
Dissolved Oxygen	10 #	mg/l	CHEM041
Nitrite as NaNO2	< 9.9	mg/l	CHEM028
Alkalinity, Total as CaCO3	233	mg/l	CHEM038
Alkalinity, Bicarbonate as CaCO3	233	mg/l	CHEM038
Alkalinity, Carbonate as CaCO3	< 10	mg/l	CHEM038
Alkalinity, Hydroxide as CaCO3	< 10	mg/l	CHEM038
Chloride	46	mg/l	CHEM028
Sulphate	43	mg/l	CHEM028
Iron, Total	22	mg/l	CHEM017
Iron, Dissolved	< 0.050	mg/l	CHEM017
Copper, Total	3.8	mg/l	CHEM017
Copper, Dissolved	0.11	mg/l	CHEM017
Zinc, Total	0.88	mg/l	CHEM017
Aluminium, Total	< 0.010 #	mg/l	CHEM017
Molybdate as MoO4	< 5.0	mg/l	CHEM022

Please Note: # - Test is not included in the UKAS accredited schedule for the Laboratory $ - Test carried out by an approved subcontractor

Samples labelled with sample deviation codes a-f on this Certificate of Analysis deviated from standard procedures and as a consequence, the reliability of the results may have been affected. Please see explanations below:

a / b - No sampling date / time provided
c - Sample provided in wrong container / Insufficient sample
d - Sample submitted outside permitted test holding times
e / f - Analysis was not carried out within permitted test holding times

Approved By: Janice Calvert MSc FRSC C.Chem Managing Director

Date of issue : 06/10/2014

UKAS TESTING 2279

Page: 3 of 4

Fig 29.
Chemical Analysis - Pre inhibitor sheet 1 of 2.

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Job No : 14-42705

Issue : 1

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Client Details:

Vexo International (UK) Ltd
Coppergate House
16 Brune Street
London
E1 7NJ

Site: St Pancras Hospital

Sample No: 692477 **Order Number:** X-POT PLUS TRAIL

Sampled By: Darren Wilkinson **Date Sampled:** 10/09/2014 **Time Sample Taken:** Not Declared

Date Received: 10/09/2014 **Sample Deviations:** b

Sample Point: Corrosion Debris

Test Name	Result	Units	Method No
Calcium, Total	< 0.50 #	% w/w	CHEM033
Appearance	Brown particles / flakes ,displaying some magnetic properties #		CHEM033
Odour on acidification	None detected #		CHEM033
Dried / Crushed Appearance	Brown powder #		CHEM033
Acid Insoluble Material	0.3 #	% w/w	CHEM033
Loss on Ignition @ 525℃	11.8 #	% w/w	CHEM033
Calcium, as $CaCO_3$	0.5 #	% w/w	CHEM033
Iron, as Fe_2O_3 / Fe_3O_4	85.1 #	% w/w	CHEM033
Copper, as $CuCO_3$, $Cu(OH)_2$	0.4 #	% w/w	CHEM033
Zinc, as $ZnCO_3$	< 0.1 #	% w/w	CHEM033

Please Note: # - Test is not included in the UKAS accredited schedule for the Laboratory $ - Test carried out by an approved subcontractor

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Date of issue : 06/10/2014

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Fig 30.
Chemical Analysis - Pre inhibitor sheet 2 of 2.

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Certificate of Analysis

Job No : 15-64263

Issue : 1

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Client Details:

Vexo International (UK) Ltd
Coppergate House
16 Brune Street
London
E1 7NJ

Site: St Pancras LTHW

Sample No: 778987 **Order Number:** ST PANCRAS TRAIL

Sampled By: D Wilkinson **Date Sampled:** 13/01/2015 **Time Sample Taken:** 11:00

Date Received: 13/01/2015 **Sample Deviations:** N/A

Sample Point: DHN LTHW Return Boiler Room

Test Name	Result	Units	Method No
pH	7.9	pH Unit	CHEM038
Electrical Conductivity @ 20℃	1200	µS/cm	CHEM038
Total Dissolved Solids @ 105℃	2270 #	mg/l	CHEM006
Suspended Solids @ 105℃	< 5.0 #	mg/l	CHEM007
Heavy Solids	Absent #		CHEM007
Dissolved Oxygen	11 #	mg/l	CHEM041
Nitrite as NaNO2	< 9.9	mg/l	CHEM028
Alkalinity, Total as CaCO3	880	mg/l	CHEM013
Alkalinity, Bicarbonate as CaCO3	880 #	mg/l	CHEM013
Alkalinity, Carbonate as CaCO3	< 10 #	mg/l	CHEM013
Alkalinity, Hydroxide as CaCO3	< 10 #	mg/l	CHEM013
Chloride	50	mg/l	CHEM028
Sulphate	< 5	mg/l	CHEM028
Iron, Total	2.5	mg/l	CHEM017
Iron, Dissolved	1.7	mg/l	CHEM017
Copper, Total	0.28	mg/l	CHEM017
Copper, Dissolved	0.034	mg/l	CHEM017
Zinc, Total	0.030	mg/l	CHEM017
Aluminium, Total	< 0.010 #	mg/l	CHEM017
Molybdate as MoO4	110	mg/l	CHEM022
Client Supplied Temperature	58.0 #	℃	Supplied

Please Note: # - Test is not included in the UKAS accredited schedule for the Laboratory $ - Test carried out by an approved subcontractor

Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

Samples labelled with sample deviation codes a-f on this Certificate of Analysis deviated from standard procedures and as a consequence, the reliability of the results may have been affected. Please see explanations below:

a / b - No sampling date / time provided
c - Sample provided in wrong container / Insufficient sample
d - Sample submitted outside permitted test holding times
e / f - Analysis was not carried out within permitted test holding times

Approved By: N. Tabassum

Najma Tabassum Client Liaison Officer

Date of issue : 17/02/2015

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Fig 31.
Chemical Analysis - Post inhibitor

Microbiology
Certificate of Analysis

Job No : 14-42705

Issue : 1

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Client Details:

Vexo International (UK) Ltd
Coppergate House
16 Brune Street
London
E1 7NJ

Site: St Pancras Hospital

Sample No: 692474 **Order Number:** X-POT PLUS TRAIL

Sampled By: Darren Wilkinson **Date Sampled:** 10/09/2014 **Time Sample Taken:** Not Declared

Date Received: 10/09/2014 **Date of Testing:** 10/09/2014 **Sample Deviations:** b

Sample Point: Heating Supply MCW

Test Name	Result	Units	Method No
Total viable count @ 22°C/72hrs	0	CFU/ml	MIC001
Pseudomonads @ 30°C	< 100	CFU/100ml	MIC125
Nitrate / Nitrite Reducing Bacteria	Not Detected #		MIC002
Sulphate reducing bacteria @ 21 Days	Not Detected #		MIC022

Please Note: # - Test is not included in the UKAS accredited schedule for the Laboratory $ - Test carried out by an approved subcontractor

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e / f - Analysis was not carried out within permitted test holding times

Approved By: Janice Calvert MSc FRSC C.Chem Managing Director

Date of issue : 06/10/2014

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Fig 32.
Microbiological Analysis - Pre inhibitor

Client Details:

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Microbiology Certificate of Analysis

Job No : 15-64263

Issue : 1

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A: Unit 20, Greenwich Centre Business Park, 53 Norman Road, London SE10 9QF / 6 Bridgewater Square, London EC2Y 8AG

Site: St Pancras LTHW

Sample No: 778988 **Order Number:** ST PANCRAS TRAIL

Sampled By: D Wilkinson **Date Sampled:** 13/01/2015 **Time Sample Taken:** 11:00

Date Received: 13/01/2015 **Date of Testing:** 13/01/2015 **Sample Deviations:** N/A

Sample Point: DHN LTHW Return Boiler Room

Test Name	Result	Units	Method No
Total viable count @ 22℃/72hrs	0	CFU/ml	MIC001
Pseudomonads @ 30℃	< 100	CFU/100ml	MIC125
Sulphate reducing bacteria @ 21 Days	Not Detected #		MIC022
Client Supplied Temperature	58.0 #	℃	Supplied

Please Note: # - Test is not included in the UKAS accredited schedule for the Laboratory $ - Test carried out by an approved subcontractor

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Samples labelled with sample deviation codes a-f on this Certificate of Analysis deviated from standard procedures and as a consequence, the reliability of the results may have been affected. Please see explanations below:

a / b - No sampling date / time provided
c - Sample provided in wrong container / Insufficient sample
d - Sample submitted outside permitted test holding times
e / f - Analysis was not carried out within permitted test holding times

Approved By: N. Tabassum Najma Tabassum Client Liaison Officer

Date of issue : 17/02/2015

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Fig 33.
Microbiological Analysis - Post inhibitor

Conclusions

Below is a table (table 2) which demonstrates the key requirements which are set by BSRIA for water quality within Heating & Cooling Systems, this is the Industry Standard for systems expected to operate at design efficiencies and to prolong system life.

Analysis Type	BSRIA Standard	LTHW Pre-Trial	LTHW Post Trial
CHEM007 - Suspended Solids mg/l	<30	71	<5
CHEM017 - Iron (Total) mg/l	<6	22	2.5
CHEM017 - Iron (Dissolved) mg/l	<3	0.05	1.7
CHEM017 - Copper (Total) mg/l	<1	3.8	0.28
CHEM013 - Alkalinity (Total) as CaCO3	As per Specialists Advice	233	880
CHEM022 - Molybdate mg/l	As per Specialists Advice	<5	110
MIC001 - TVC @22oC cfu/ml	<100,000	700	0
MIC125 - Pseudomonad's	<10,000 cfu/100ml	<100	<100
MIC022 - Sulfate Reducing Bacteria	Absent	Absent	Absent

Table 2: Key requirements of the chemical / microbiological requirements from BSRIA and the results of the system water analysis of the hospital.

During the start of the trial it was quite evident that the water circulating throughout the system was carrying high levels of suspended solids, which included iron, scale deposits and copper.

The water quality did not meet the standards for best Industry practice; visually the water was clearly in a poor condition – see Fig 26.

The high levels of debris if left within the system not only creates the environment for erosion corrosion, it will allow these particles to settle out in low flow areas, harbour bacteria, leading to under deposit corrosion of pipework and radiators, including damage to valve seats.

Below is a summarised explanation of the system water analysis pre and post results as recorded in the table and laboratory certificates.

Alkalinity (Scale Salts)
This is the amount of scale (CaC03) salts that have been released back into solution since adding the X-PO10 Inhibitor. Initially (pre trial) the analysis from the system shows Alkalinity salts at 233 mg/l, however at the end of the trial these have been elevated to 880 mg/l. This shows previous scale minerals that had precipitated out of solution, adhering to points of heat exchange have been dissolved back into solution, with the final records showing 880mg/l.

This very action alone will improve the heat exchange process within the system, increasing efficiencies at points of heat exchange. The Carbon Trust confirm that if 1mm of scale build up on a heat exchange is present, the system will require 7% more energy in to get the same amount of heat out. Although we could not determine the thickness of any scale deposits on the heat exchangers, we can conclude by the lab results the scale deposits would have been substantial.

Iron Total (Corrosion of ferrous metals)
The Total iron is effectively made of from soluble and non soluble iron. High levels of Total iron can lead to increased actions to the corrosion cell process, as well as adding to the elevated levels of suspended particulate. Initially (pre trial) the analysis from the system shows Total iron at 22 mg/l, however at the end of the trial these have been reduced to 2.5 mg/l.

This confirms the non soluble iron has been pulled from the system water by the 13 x 8000 gauss rare earth magnets resulting in the system water now complying with the BSRIA requirements and guidelines for new systems.

Dissolved iron (Corrosion of ferrous metals)
Dissolved iron (Soluble iron) cannot be removed by filtration, it can only be lowered by flushing of the system water using a potable or de-mineralised water supply. Initially (pre trial) the analysis from the system shows soluble iron at 0.05mg/l, however at the end of the trial these have been reduced to 1.7mg/l.

This confirms that X-PO10 is capable of dissolving light corrosion debris (radiator cold spots etc) from a non soluble state to a soluble state. When considering the heavy amount of corrosion and the high levels of iron removed from the magnet grates during the trial, the dissolved iron is still within BSRIA guidelines. This once again confirms how effective X-PO10 Inhibitor is at enhancing the systems performance.

Suspended Solids
Suspended Solids are fine particles that can remain in suspension for a considerable period of time (even within dead legs) and are held together as a colloid. High levels of suspended solids are a problem for circulating systems as they:

- Carry and harbour bacteria, as well as providing a nutrient food source for bacteria.
- Lead to erosion corrosion (wearing down seals and valve seats etc).
- Settle out in low flow areas as sludge in Plate Heat Exchangers, Radiators (Cold Spots), fan coils causing under deposit corrosion.
- Increase corrosion rates.
- Affect flow rates.

It is clear from Table 2 that the high levels of suspended solids (71 mg/l) that were witnessed at the start of the trial, have soon been removed via the X-POT+AD to less than 5 mg/l, even surpassing BSRIA Standards.

Total Copper
Total copper includes both dissolved and non dissolved copper. High levels of copper within a system can become a problem, as the high copper levels react with dissimilar metals, creating the environment for corrosion. It is clear from Table 2, the high level of copper (3.8 mg/l) which were witnessed at the start of the trial, have soon been removed via the X-POT+AD to less than 0.28 mg/l, surpassing BSRIA Standards.

Molybdate
Molybdate is a soft metal Inhibitor; it is one of many components within X-PO10 which provide a highly effective additive to Inhibit Scale & Corrosion.

The Molybdate within X-PO10 is included within its composition to act as a "tracer" to identify the correct level of X-PO10 is added within the system.

X-PO10 is added at 0.36%v/v and at this concentration should provide a Molybdate level at 100mg/l.

For the purpose of the trial the Conductivity Sensor and controls were set to dose at 0.4% (10% above normal dose rate) to factor for the harsh environment which the X-PO10 inhibitor had to endure.

The accuracy of the dose rate of X-PO10 and Molybdate was recorded at the end of the trial at 110 mg/l (10% over the normal level) refer to Lab results.

This confirms the accuracy of the Conductivity Sensor and Controls of the X-POT+AD, providing impeccable reliability and accuracy.

Micro –Organisms (TVC, Sulphite Reducing & Pseudomonas Bacteria)
Although no Bacteria were recorded above the recommended BSRIA guidelines, it is good practice to ensure Heating or Cooling Systems are treated with Biocides during periods where temperatures are capable of supporting bacterial proliferation.

The X-POT+AD can be supplied with super fine 0.5micron filters which are capable at removing Alkalinity (Scale) salts as well as Pseudomonad bacteria.

Water quality conclusion
The Carbon Trust, The Energy Savings Trust and BSI advise the potential for efficiency loss due to the effects of poor water quality and lack of water treatment, it is quite conclusive from the results of this trial, the X-POT+AD has converted this non-compliant BSRIA dirty system water into a clean and chemically balanced state, which now meets Industry guidelines.

The site Engineers also noted, the system was operating with fewer issues relating to poor flow, with some NHS staff commenting on a "physical" improvement to the heating within their buildings.

Therefore the system has benefited from an increase in efficiency by 10-20% (conservative estimate), furthermore, reactive maintenance costs will now be reduced, with the system lifespan prolonged further.

Camden and Islington NHS

NHS Foundation Trust

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10/03/2015

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F.A.O. Mr D Wilkinson/Mr P Hanrahan

Side stream filtration and water treatment

St Pancras Hospital's main heating system pipework was installed in the early 1940's and has subsequently been modified, extended, sections replaced and upgraded. Consequently a lot of the pipework is decaying internally due to sludge and detritus buildup. Due to the numerous drain downs of the system and the lack of treatment (if any) over a period of about 20 years there was a lot of issues with the system. As part of my remit to bring the boiler house and heating/hot water systems up to date, I have had installed a VEXO side stream filtration and automatic dosing unit.

Following extensive heating system repairs in 2013/14 where we replaced corroded and leaking sections of the distribution pipework. During these works we found filthy dark brown water and internally corroded pipes.

After careful consideration, we decided to have a Vexo Side Stream Filtration & automatic Dosing Unit (X-POT) fitted to the system. Vexo International installed their X-POT in September 2014 along with their X-PO10 neutral PH inhibitor. As our heating system uses numerous different materials including aluminium, copper, iron, etc, the inhibitor had to be PH neutral yet efficient at removing sludge and detritus. It has since been proven that your Vexo X PO10 has exceeded expectations in this regard, as the lab analysis and visual results confirmed.

Within 4 months of the installation of the X-POT the system water quality has increased significantly from its previous state. Large amounts of sludge and debris have been removed

Camden ISLINGTON

NHS

by the magnets and filter bags, with the samples now virtually crystal clear and very slight contamination of the filter bags.

Laboratory analysis of the system water from before and after samples confirm that the installation of the X-POT has returned the system water back to its original fill condition from the very poor quality water of the pre-installation of the X-POT.

Previously, the maintenance team were called to numerous complaints of poor heating temperatures on the wards and offices. We have noticed a significant drop in heating related complaints, and have actually had requests to turn down some areas which is something not experienced before.

Following the introduction of the X-POT and the accompanying PO10 inhibitor into our system we can foresee less maintenance call outs and a definite rise in efficiency, which will result in lower fuel and maintenance costs.

I would recommend any Estate managers or facilities managers to try the X-POT + PO10 inhibitor

Steve Wade ([illegible])

Acknowledgements

VEXO would like to thank the following people and organisations for their contribution and efforts during the trial of the X-POT+AD.

Mr Harry Price
AHP Industrial Services
42 Grange Hill.
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Middlesex.
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07973 509 352

AHP provided their valuable knowledge of the system and assisted in installing the X-POT+AD, along with regular cleaning of the Magnet Grates, filter change-outs, along with replacing X-PO10 25L Drums on the skid, as and when required.

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St Pancras Hospital and NHS Trust were very accommodating in agreeing to offer their system to be used as part of our trial.

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