Smart Thinking

Topic

Regular Maintenance and Aftercare – What's the cost?

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Regular Maintenance and Aftercare – What's the cost?

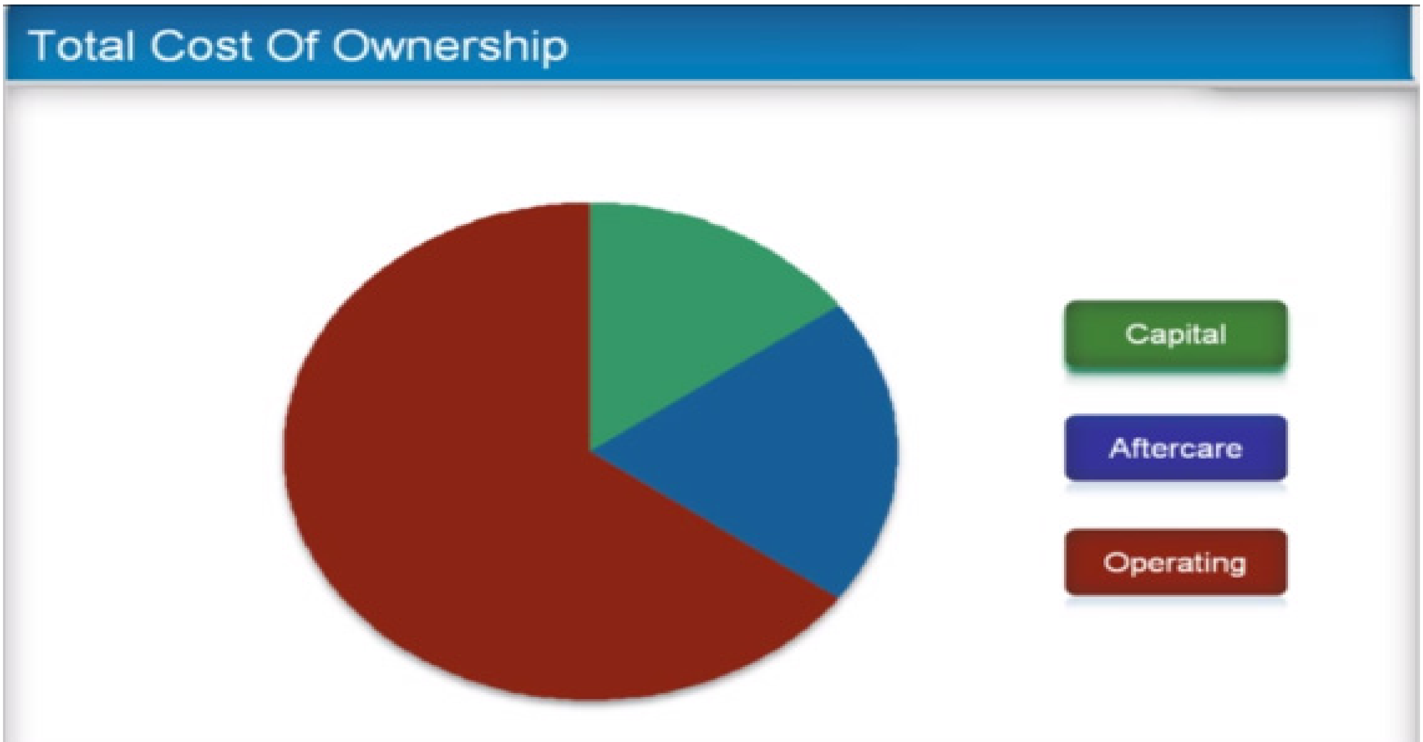
Maintenance, Aftercare, Vibration and Condition Site Monitoring of Industrial Refrigeration Systems

Refrigeration is vital to the survival, safety and continued operation of businesses. But, more often than not, refrigeration is neglected and relegated to the bottom of the list of priorities, until things start to fail.

Things going wrong, however, should not be your only concern. If your business uses industrial refrigeration, you should be thinking about the need for investing in a quality maintenance regime for your plant as, most likely, you will be spending most of your electricity bill on this – 50% is an average electrical spend for cooling in industrial applications. And if you are in the cold storage and distribution sector, the following figure will make you think twice. Recently, the Carbon Trust revealed that refrigeration accounts for 90% of the energy costs in this sector, so the potential for savings is considerable when carrying out appropriate maintenance that ensures the cooling system is performing to design specification.

It's important to keep on top of regular maintenance to guarantee safety, low operating costs, reliability, efficiency, and plant longevity.

To put things into perspective, let's have a look at the total life cycle costs of an industrial refrigeration system. Typically, 60% of a system's total life cycle costs are accounted for by its operation, while maintenance accounts for 20%. The graph below also shows the marginal value of low capital investments when it comes to selecting a refrigeration solution.



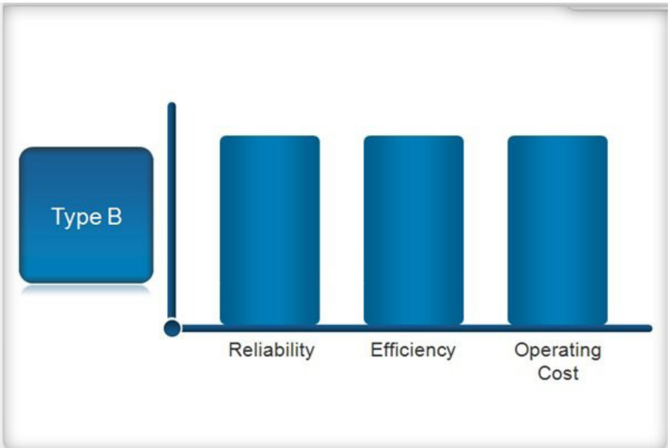
Often referred to as aftercare, there are various ways to maintain your system. A traditional maintenance regime involves a programme of planned site checks by engineering specialists, where a series of performance health checks are carried out and immediate adjustments are made to correct any issues. This means high maintenance costs due to the number of site visits and also a greater margin for error. Corrections are not based on data tracked, analysed and recorded over a period of time, with both external (readily visible) and internal (within the system) indicators available for evaluation.

Star however recommends "Condition Based Maintenance." With this type of preventative maintenance, you are ensuring the reliability and optimal efficiency of the refrigeration plant, and therefore reducing your operating costs; these reductions could be as much as 20%.

This type of proactive maintenance involves the use of remote monitoring, data collection 24/7, analysis of data and generation of task list.

How is "condition based maintenance" different from traditional aftercare?

- Performance checking (health system check)
- Vibration monitoring – fixed installation or a portable handheld device
- Oil analysis – periodic or on line
- Refrigerant Quality Check (ARQ)



Condition Based Maintenance ensures optimal reliability and efficiency of the refrigeration plant

Performance Checking

How to carry out a System Health Check

One of the most important procedures of maintenance – the system health check – is often overlooked or not performed often enough. So, what is a system health check and what is the point of one?

A careful system health check looks at the efficiency of a refrigeration system and compares how it's performing today to how it was originally designed to perform when first installed. Also, it is useful to see what the effects of maintenance or non-maintenance are on a refrigeration system.

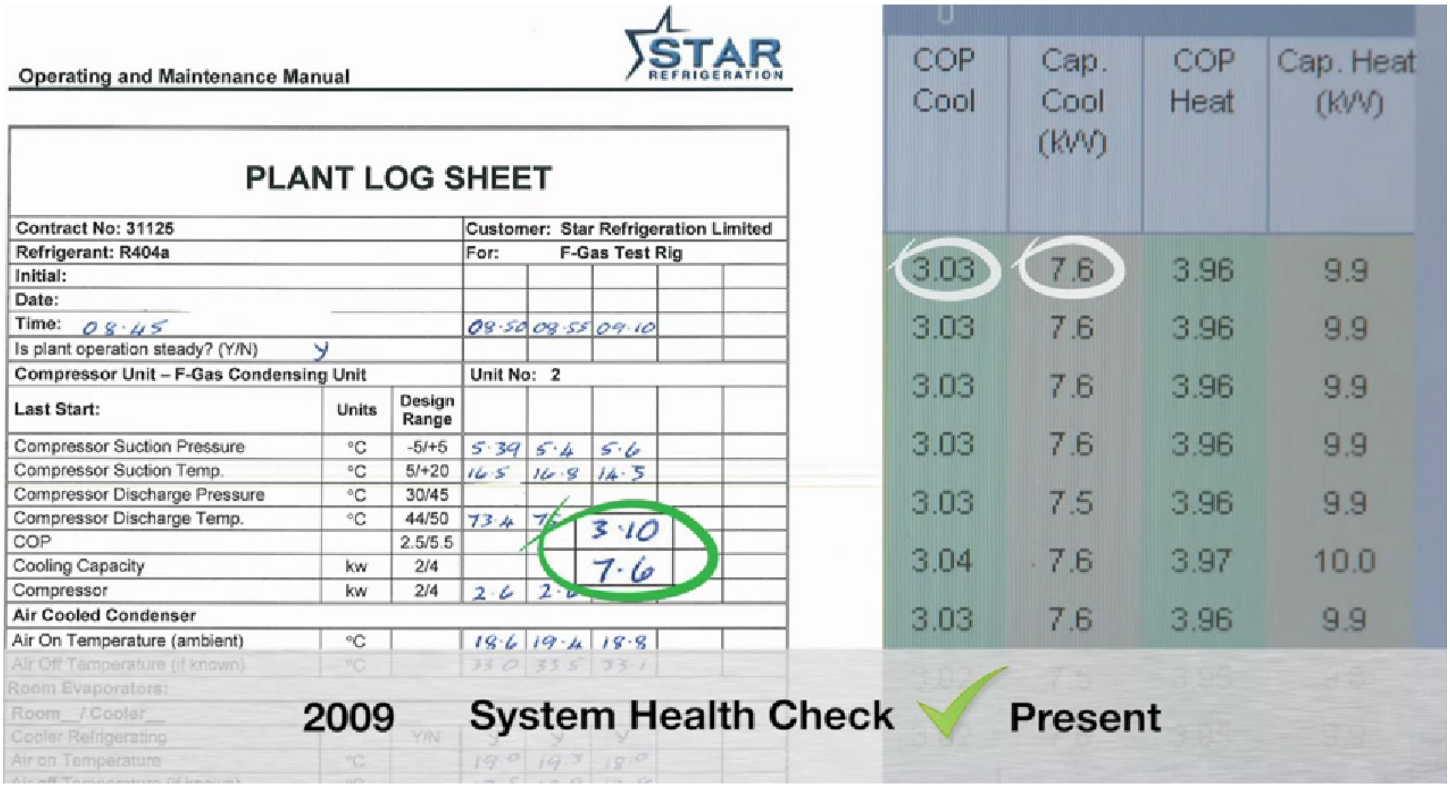
Read on for Star's Step by Step Guide to completing a quick system health check.

First of all, you need to ensure your own health and safety and you need to have a certain amount of equipment to carry out the check – hand tools, goggles, gloves, safety shoes and overalls. You also need to check you've got the original design information, connections and the original log, so you can compare that to how the system is operating now.

The first step is to attach all the pressure and temperature transducers to the unit – then just switch the unit on. All you need to do now is start the datalogs and record some of the data. As an example, we usually log data about every five seconds.

After two or three minutes, it is time for a quick comparison. Here you can see the cooling capacity – what the actual plan is doing at the moment – but also what you are looking at in this instance is the Coefficient of Performance (COP) of the cooling system.

As part of the health check, what you want to do is compare how the system is performing on cooling capacity, which, in the below example, is about 7.6/7.5, and its COP is 3.03. Compare this data with what it was originally running at when it was first commissioned – here is an example of one system that was commissioned in 2009:



What is the cost of non-maintenance?

After measuring the cooling capacity performance when the system is fully charged, it's time to move on to the second phase of the health check – comparing the efficiency of a fully charged system with a system that is only part charged.

The video below shows what happens if a refrigeration plant is not adequately maintained and the system operates on low charge. How does this affect the running conditions of your refrigeration plant?

Reduce about 30% of the charge, a kilo for a system with a nominal capacity of 3.1 kilos, and then check what the running conditions are. Give the unit a chance to settle down so that the temperatures are running at the right conditions. You will identify two issues; after reducing the refrigerant load, the cooling capacity will come down – but, more importantly, the COP will be reduced.

To demonstrate this, we have taken refrigerant out of a small unit at our Bellshill branch (see video below) and the result showed not only a significant decrease in cooling capacity but an 18% reduction on the COP indicator – the coefficient of performance dropped drastically from 3.03 to 2.51. Therefore, the refrigeration system has not been maintained appropriately and it is working outside its designed operating conditions. This is costing you extra in electrical running costs.

https://youtu.be/wv0CR3WnbGQ

Star Refrigeration's Andy Smith and Clive Greig run through a system health check and show the detrimental effect that non maintenance can have on system performance, especially where running costs are concerned. If a refrigeration plant is not adequately maintained, how will this affect the running conditions of your plant?

An oil sample should be taken once a month to maintain the system at its correct operating conditions

Vibration Monitoring – fixed installation or a portable handheld device

Vibration analysis, when performed by a qualified technician, can predict failure of compressor components and can even often predict when the failure will occur.

Many manufacturers make vibration equipment, each with special features. However, the basic objective is to identify noise or vibration in an operating compressor. Items that must be analysed are: imbalance of rotating parts, misalignment of couplings and bearings, bentor cracked shafts, worn speed increaser gears, worn or damaged antifriction bearings, or worn or damaged sleeve bearings on the compressor and motor, hydraulic forces, rubbing forces, and electromagnetic forces.

Vibration is caused by a force that changes direction or amount. All vibrations have specific characteristics that specific characteristics that are determined by the manner in which the forces/vibrations are generated. And despite what you might think, every compressor has a different vibration footprint. The vibration monitor measures vibration displacement in mils (0.001 in.), which is often called "spike energy." It measures vibration velocity in inches per second, and measures vibration acceleration in Gs, due to gravity. It also measures high frequency vibrations.

These measurements are plotted and compared to the compressor's original footprint. This is the vibration analysis that should be run when the compressor is started for the first time. Analysis of the variations in the reading will predict a coming failure of a specific item (such as a thrust bearing).

This, if a failure mode exists, plans can be made to repair the thrust bearing at the next plant shutdown. It is imperative to maintain a file on each compressor with a vibration analysis that is done every six months.

A realistic mechanical vibration analysis for a screw compressor requires about 30 different readings at various points on the compressor and motor. With this type of analysis, even faults – such as lack of lubrication on motor bearings – can be detected.

There are several full-time mechanical analysis systems available.

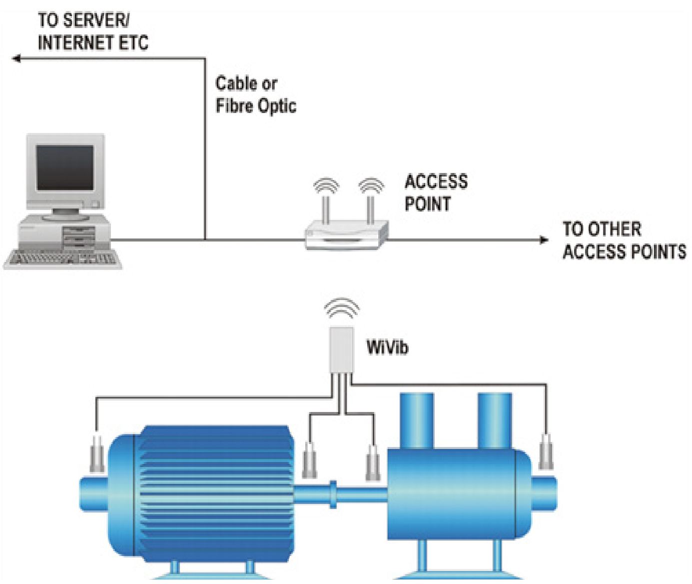


Diagram showing vibration monitoring from running motor and compressor

Why Vibration Analysis?

- It reduces maintenance costs because maintenance is scheduled only when needed.
- It reduces overtime because you can predict when the machine may fail, requiring weekend and night work. Emergency repairs are reduced dramatically.
- It reduces repair costs because major repairs are practically eliminated due to a thrust bearing failure or a gear failure that may ruin the compressor.
- It reduces unplanned system, or possibly plant, downtime.
- It increases plant safety.
- It helps control insurance costs.

System Health Check + effects of non maintenance

Oil Sample – once a month

There are a number of substances that can contaminate the oil within the refrigeration system. Commonly, these are water, iron, insolubles (general muck), refrigerant, and general debris.

Contaminated oil can and will cause premature failure of components within the refrigeration system, which in turn could result in a total loss of refrigeration!

If the oil is acidic, this will attack the compressor motor windings in semi hermetic and hermetic compressors, resulting in the failure of the compressor's drive motor. This will also apply to systems that may have hermetic liquid pumps etc.

If the oil contains water, this will have the effect of washing the oil away from the compressor/liquid pump bearings, resulting in less bearing lubrication and resultant premature failure. Water could also start corrosion within the system which will cause iron to be detected, which again will cause issues with the operating of the systems' components, premature wear of bearings, and loss of correct control of the systems' valves etc. This could result in loss of refrigeration and/or complete failure of the system due to liquid carryover to the compressor itself.

Frequent checking of the oils' condition allows the maintenance engineer to address any out of specification issues and, if necessary, replace the oil, filters, control valve internals, clean strainers, etc., which will help to maintain the system at its correct operating conditions.

Testing oil quality

You can test the quality of the oil in your refrigeration system by:

Attaching a magnet to your oil sample to check if iron has polluted it.

Measuring the amount of insolubles – this relates to materials within the oil that, as the name suggests, will not dissolve. Some oils contain detergents, which has the effect of cleaning the internal part of a system which then can be removed by replacing the oil filter and liquid line drier etc. There will also be other contaminants that will not dissolve, and can be removed by the filters. Again, frequent oil sampling and analysis will assist the maintenance engineer in his work by actioning any highlighted issues promptly, thus reducing potential operational issues.
See below example of an oil sample analysis report indicating the various elements that we are able to check and record trends for – Iron Wear, Steel Alloys, Non-Ferrous Alloys, Viscosity, Water Content,

Contamination – including 23 elements. This level of analysis then shows if there is any wear within the internal components based upon the ppm of the element recorded. This then helps to determine where and what item is starting to fail. This can then be addressed and planned in prior to catastrophic failure.

CENT Star Refrigeration Condition Monitoring

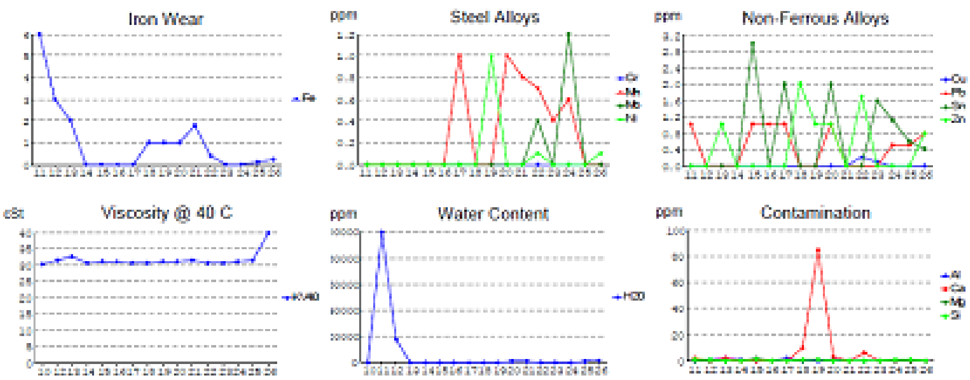
STAR REFRIGERATION

Customer	DSM NUTRITIONAL
Site	DALRY
Make	HOWDEN
Model	321
System	UNIT 1
Lubricant	CASTROL 2293
Plant Ref	565408
Cust Ref	
Lab Ref	5074960

CLIVE GREIG
STAR - DSM NUTRITIONAL
4 MURRAY PLACE
RIGHEAD INDUSTRIAL ESTATE
BELLSHILL
ML4 3LP

Samp No	Date Sampled	Date Received	Appearance	Oil Age	Hours Run
23	14/07/14	17/07/14	Clear & Bright		60498
24	03/02/15	06/02/15	Hazy		61228
25	08/04/15	10/04/15	Hazy		
26	12/06/15	17/06/15	Free Water & Debris		63640

Samp No	Insols	KV@40	PQ index	TAN	Water ppm		
23	19.48	30.7	10	0.03	14		
24	44.59	31.2	10	0.03	79		
25	626.40	31.3	11	0.03	646		
26	23.67	39.8	10	0.02	1294		



Elements in ppm				
Samp No	26	25	24	23
Aluminium (Al)	<1	<1	<1	<1
Barium (Ba)	<1	<1	<1	<1
Boron (B)	<1	<1	<1	<1
Cadmium (Cd)	<1	<1	<1	<1
Calcium (Ca)	<1	<1	<1	<1
Chromium (Cr)	<1	<1	<1	<1
Copper (Cu)	<1	<1	<1	<1
Iron (Fe)	<1	<1	<1	<1
Lead (Pb)	<1	<1	<1	<1
Lithium (Li)	<1	<1	1	<1
Magnesium (Mg)	<1	<1	<1	<1
Manganese (Mn)	<1	<1	<1	<1
Molybdenum (Mo)	<1	<1	1	<1
Nickel (Ni)	<1	<1	<1	<1
Phosphorus (P)	11	5	4	<1
Potassium (K)	<1	<1	1	<1
Silicon (Si)	<1	1	<1	<1
Silver (Ag)	<1	<1	<1	1
Sodium (Na)	4	<1	<1	<1
Tin (Sn)	<1	<1	1	2
Titanium (Ti)	<1	<1	<1	<1
Vanadium (V)	<1	<1	<1	<1
Zinc (Zn)	<1	<1	<1	<1

SIGNED: Sean George
DATE: 22/06/15

FUCHS

Cust Notes: NONE
INTERPRETATION OF ANALYSIS BASED ON CURRENT SAMPLE
Visible debris present. Water contamination. Wear appears satisfactory. Action should be taken to correct - Consider fluid clean/change and/or filter change.

SERIOUS

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CENT ▲■● Star Refrigeration Condition Monitoring

STAR REFRIGERATION

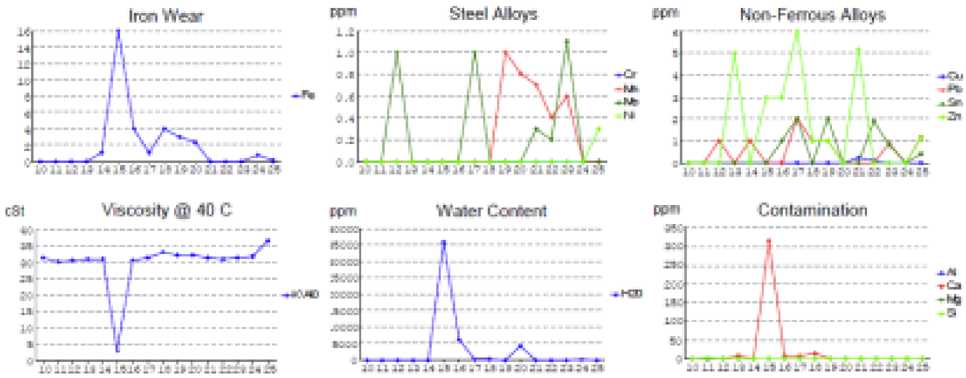
Customer	DSM NUTRITIONAL
Site	DALRY
Make	HOWDEN
Model	321
System	UNIT 2
Lubricant	CASTROL 2293
Plant Ref	565408
Cust Ref	
Lab Ref	5074961

CLIVE GREIG
STAR - DSM NUTRITIONAL
4 MURRAY PLACE
RIGHEAD INDUSTRIAL ESTATE
BELLSHILL
ML4 3LP

Samp No	Date Sampled	Date Received	Appearance	Oil Age	Hours Run
22	14/07/14	17/07/14	Clear & Bright		51104
23	03/02/15	06/02/15	Clear & Bright		54942
24	08/04/15	10/04/15	Debris Present		
25	11/06/15	17/06/15	Clear & Bright		55346

Samp No	Insols	KV@40	PQ index	TAN	Water ppm		
22	16.17	31.1	10	0.03	7		
23	72.85	31.5	10	0.03	29		
24	655.72	31.8	10	0.03	123		
25	81.13	36.8	10	0.02	42		

Elements in ppm				
Samp No	25	24	23	22
Aluminium (Al)	<1	<1	<1	<1
Barium (Ba)	<1	<1	<1	<1
Boron (B)	<1	<1	<1	<1
Cadmium (Cd)	<1	<1	<1	<1
Calcium (Ca)	<1	<1	<1	<1
Chromium (Cr)	<1	<1	<1	<1
Copper (Cu)	<1	<1	<1	<1
Iron (Fe)	<1	<1	<1	<1
Lead (Pb)	1	<1	<1	<1
Lithium (Li)	<1	<1	1	<1
Magnesium (Mg)	<1	<1	<1	<1
Manganese (Mn)	<1	<1	<1	<1
Molybdenum (Mo)	<1	<1	1	<1
Nickel (Ni)	<1	<1	<1	<1
Phosphorus (P)	6	<1	10	<1
Potassium (K)	<1	<1	2	<1
Silicon (Si)	<1	1	2	<1
Silver (Ag)	<1	<1	<1	1
Sodium (Na)	4	<1	<1	<1
Tin (Sn)	<1	<1	<1	2
Titanium (Ti)	<1	<1	<1	<1
Vanadium (V)	<1	<1	<1	<1
Zinc (Zn)	1	<1	<1	<1



SIGNED: Stephen Davidson
DATE: 19/06/15

FUCHS

Cust Notes: NONE
INTERPRETATION OF ANALYSIS BASED ON CURRENT SAMPLE
Condition satisfactory.

NORMAL

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Refrigerant Quality Check (ARQ)

Refrigerant quality checks are especially important, as any water in an ammonia system, for example, can lead to severe loss of cooling capacity and rising energy costs. Water contamination of 1% or below is not something to worry about, as long as it is monitored. But for every 1% of water, your running costs go up by 1%. If left unattended, this will also lead to oils breaking down quickly and component failure, which will cause your operating costs to increase even further.

Checking the quality of the refrigerant within the refrigeration system –

This procedure requires that a sample of liquid ammonia is taken and collected within a calibrated flask. The ammonia is then allowed to evaporate off with the water being left. This is then measured against the total sample taken, and the resultant figure is converted to % of water contamination. At Star, this procedure is carried out by one of Star's commissioning engineers.

For further information, contact jward@star-ref.co.uk

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