Optimum Case Study and Report

Prepared For

BAE Systems

Designation

Commentary Report

Equipment Performance & Energy Review

CHILLER OIL ENHANCEMENT

Ref: Rev A:
Report Date: May 2011

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Equipment Location	**BAE Systems** **Chester House** **Government House Road** ***Farnborough*** ***GU14 6XL***
For the Attention of:	**Alan Irving**
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Report Description	**Equipment Performance & Energy Review for Oil Enhancment**
Checked By:	**JC / LM**
Revision	**A**

BAE System, Chester House - York Chiller Circuit 2

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Test period April - May 2011.

General

BAE System, Chester House Farnborough is served by a single York YCWA5120 Air-Cooled liquid chiller, incorporating two refrigerant circuits each with a single York 'J-Type' reciprocating compressor.
The chiller was manufactured circa 1991 and underwent a refrigerant retrofit from R22 to R417a to overcome the phase-out of ozone depleting substances. All main components are original except the condenser coils which were replaced at some point in the past.

The chiller unit is overdue a replacement and it was considered prudent to aid the mechanical operation through the summer until a replacement unit is installed.

FrigiTech lubrication enhancement was added to chiller circuit 2 only so as to provide a like for like comparison of the circuits.

Energy and temperature loggers were installed to record key data both before and after the addition of FrigiTech.
The Energy logger was connected via current transformers and voltage sensors to the chillers 3 phase incomer.
Temperatures were recorded on the chilled water flow, return and ambient via calibrated 'K-type' thermocouples.
The Climacheck performance analyser was also used to record the refrigeration system performances.

During the first weeks data logging circuit 1 was found to have failed on high pressure, thought to be a controls failure the common chilled water flow sensor also went out of calibration as temperatures nearing 0oC were recorded. A replacement sensor was fitted and tested for correct calibration, circuit 1 was left out of operation.

For comparison purposes a stable 90 minute operating log was taken and used for graphing of the before and after enhancement addition.
No adjustments were made to the system operation except the addition of the FrigiTech

Monitoring Equipment Used

Energy Meter – EL Components SPC Pro
Temperature Logger – Testo 174
Climacheck – Performance Analyser Pro
Water Flow Meter – Comdronic AC6

Chiller Operating Reports

Original York Chiller Design Data

York Chiller Model YCWA 5120 – R22

Ambient	25oC		30oC		35oC	
LWT	Capacity	Input kW	Capacity	Input kW	Capacity	Input kW
6	515	126	490	132	464	139
8	546	129	519	136	491	143
10	576	133	548	140	485	145

Status Before Enhancement Addition

Prior to the addition of the FrigiTech to a chiller circuit the performance was measured as follows

Average of data recorded on 28-04-20101 between 13:24 & 14:51

Compressor Input Power	= 60.3kW
Cooling Capacity	= 115kW
EER Cooling	= 1.91
CHW Flow	= 11.34 degC
CHW Return	= 13.24 degC
Ambient	= 17.43 degC

Status After Enhancement Addition

After to the addition of the FrigiTech to a chiller circuit the performance was measured as follows

Average of data recorded on 09-05-2011 between 13:24 & 14:51

Compressor Input Power	= 55.07 kW
Cooling Capacity	= 216.5 kW
EER Cooling	= 3.92
CHW Flow	= 12.19 degC
CHW Return	= 8.62 degC
Ambient	= 18.2 degC

Average Percentage Differences After Enhancement Addition

Compressor Input Power	= 9.49% decrease
Cooling Capacity	= 46.6% increase
EER Cooling	= 105.3% increase
CHW Flow	= 23.9% decrease
CHW Return	= 7.9% decrease
Ambient	= 3.2% increase

Data Table

Error!

	Before FrigiTech (B) 28/04/2011							8c Set-point	After FrigiTech (A) 09/05/2011						
Time	(B) CHW In C	(B) CHW Out C	(B) Ambient C	(B) Delta T K	(B) Cool kW	(B) Power kW	(B) EER		(A) CHW In C	(A) CHW Out C	(A) Ambient C	(A) Delta T K	(A) Cool kW	(A) Power (kW)	(A) EER
13:24:05	17.7	16.0	19.2	1.7	103.3	65.1	1.6		12.9	8.6	17.9	4.3	261.2	57.4	4.6
13:25:35	17.7	15.6	18.3	2.1	127.6	65.5	1.9		12.9	8.6	17.8	4.3	261.2	57.3	4.6
13:27:05	17.7	15.4	17.7	2.3	139.7	65.3	2.1		12.7	8.5	17.7	4.2	255.1	57.1	4.5
13:28:35	17.6	15.1	17.4	2.5	151.9	64.8	2.3		12.7	8.5	17.8	4.2	255.1	57.7	4.4
13:30:05	17.3	14.8	17.1	2.5	151.9	64.5	2.4		12.8	8.5	17.9	4.3	261.2	57.4	4.6
13:31:35	16.9	14.5	17.1	2.4	145.8	64.4	2.3		12.8	8.4	18.0	4.4	267.3	57.1	4.7
13:33:05	16.6	14.1	17.1	2.5	151.9	63.4	2.4		12.7	8.4	17.9	4.3	261.2	57.0	4.6
13:34:35	16.2	13.9	17.1	2.3	139.7	64.0	2.2		12.6	8.4	18.0	4.2	255.1	57.1	4.5
13:36:05	16.0	13.7	16.9	2.3	139.7	63.5	2.2		12.8	8.3	17.9	4.5	273.3	57.0	4.8
13:37:35	15.7	13.5	16.9	2.2	133.6	62.5	2.1		12.6	8.3	17.9	4.3	261.2	57.0	4.6
13:39:05	15.4	13.2	16.9	2.2	133.6	62.8	2.1		12.4	8.2	17.9	4.2	255.1	57.2	4.5
13:40:35	15.2	13.1	16.8	2.1	127.6	62.3	2.0		11.9	8.2	18.1	3.7	224.7	56.9	3.9
13:42:05	14.9	12.9	16.9	2.0	121.5	62.4	1.9		11.8	8.3	18.0	3.5	212.6	56.9	3.7
13:43:35	14.8	12.7	16.9	2.1	127.6	62.3	2.0		11.5	8.3	17.8	3.2	194.4	56.5	3.4
13:45:05	14.5	12.5	17.0	2.0	121.5	61.9	2.0		11.8	8.2	17.9	3.6	218.7	56.6	3.9
13:46:35	14.4	12.4	17.0	2.0	121.5	62.4	1.9		12.0	8.2	18.1	3.8	230.8	56.9	4.1
13:48:05	14.2	12.3	17.2	1.9	115.4	61.9	1.9		12.4	8.3	18.1	4.1	249.0	54.9	4.5
13:49:35	13.9	12.1	17.3	1.8	109.3	61.9	1.8		12.3	8.5	17.9	3.8	230.8	49.7	4.6
13:51:05	13.9	12.0	17.1	1.9	115.4	60.8	1.9		12.3	8.5	17.8	3.8	230.8	49.9	4.6
13:52:35	13.8	11.8	16.9	2.0	121.5	60.4	2.0		12.3	8.5	18.2	3.8	230.8	50.9	4.5
13:54:05	13.7	11.7	16.7	2.0	121.5	60.8	2.0		12.0	8.6	18.1	3.4	206.5	50.6	4.1
13:55:35	13.5	11.6	17.0	1.9	115.4	60.4	1.9		11.5	8.6	17.8	2.9	176.1	50.2	3.5
13:57:05	13.3	11.4	17.0	1.9	115.4	61.2	1.9		12.1	8.7	17.9	3.4	206.5	50.5	4.1
13:58:35	13.3	11.3	16.9	2.0	121.5	59.5	2.0		11.8	8.8	17.8	3.0	182.2	50.4	3.6
14:00:05	13.1	11.2	17.0	1.9	115.4	60.5	1.9		11.8	8.8	17.7	3.0	182.2	50.2	3.6
14:01:35	13.0	11.1	16.9	1.9	115.4	58.8	2.0		11.7	8.8	17.9	2.9	176.1	50.5	3.5

14:03:05	13.0	11.0	17.0	2.0	121.5	59.5	2.0		11.4	9.0	17.9	2.4	145.8	51.0	2.9
14:04:35	12.8	10.9	17.0	1.9	115.4	59.3	1.9		11.5	9.0	17.8	2.5	151.9	50.9	3.0
14:06:05	12.7	10.9	17.0	1.8	109.3	59.7	1.8		12.2	9.2	17.9	3.0	182.2	51.5	3.5
14:07:35	12.6	10.7	17.2	1.9	115.4	59.1	2.0		12.7	9.3	18.0	3.4	206.5	51.6	4.0
14:09:05	12.4	10.6	17.3	1.8	109.3	59.2	1.8		13.0	9.3	18.0	3.7	224.7	58.8	3.8
14:10:35	12.4	10.6	17.3	1.8	109.3	59.0	1.9		13.1	9.3	18.1	3.8	230.8	59.2	3.9
14:12:05	12.3	10.6	17.2	1.7	103.3	58.8	1.8		13.0	9.4	18.1	3.6	218.7	59.1	3.7
14:13:35	12.2	10.4	17.1	1.8	109.3	59.0	1.9		13.0	9.3	18.2	3.7	224.7	59.9	3.8
14:15:05	12.1	10.4	17.3	1.7	103.3	59.6	1.7		13.0	9.0	18.4	4.0	243.0	57.8	4.2
14:16:35	12.0	10.3	17.4	1.7	103.3	59.2	1.7		12.6	9.0	18.4	3.6	218.7	57.6	3.8
14:18:05	11.9	10.2	17.5	1.7	103.3	58.0	1.8		12.5	8.9	18.2	3.6	218.7	57.5	3.8
14:19:35	11.9	10.2	17.6	1.7	103.3	58.1	1.8		12.7	9.0	18.4	3.7	224.7	57.7	3.9
14:21:05	11.8	10.1	17.5	1.7	103.3	59.1	1.7		13.0	9.0	18.4	4.0	243.0	57.6	4.2
14:22:35	11.8	10.0	17.6	1.8	109.3	58.5	1.9		13.0	8.9	18.6	4.1	249.0	57.6	4.3
14:24:05	11.7	10.0	17.7	1.7	103.3	58.6	1.8		12.9	8.8	18.6	4.1	249.0	57.3	4.3
14:25:35	11.7	9.9	17.8	1.8	109.3	58.4	1.9		12.7	8.8	18.3	3.9	236.9	57.2	4.1
14:27:05	11.6	9.9	17.9	1.7	103.3	59.4	1.7		12.2	8.6	18.3	3.6	218.7	57.3	3.8
14:28:35	11.6	9.8	17.8	1.8	109.3	58.8	1.9		12.4	8.6	18.2	3.8	230.8	57.3	4.0
14:30:05	11.6	9.9	17.7	1.7	103.3	57.9	1.8		12.5	8.6	18.3	3.9	236.9	57.5	4.1
14:31:35	11.5	9.7	17.6	1.8	109.3	57.7	1.9		12.4	8.6	18.3	3.8	230.8	57.2	4.0
14:33:05	11.4	9.7	17.7	1.7	103.3	58.4	1.8		11.7	8.4	18.2	3.3	200.4	57.2	3.5
14:34:35	11.4	9.6	17.8	1.8	109.3	58.7	1.9		11.7	8.4	17.9	3.3	200.4	56.9	3.5
14:36:05	11.3	9.6	17.8	1.7	103.3	58.8	1.8		11.4	8.4	17.8	3.0	182.2	56.4	3.2
14:37:35	11.3	9.6	17.6	1.7	103.3	58.1	1.8		11.2	8.3	17.8	2.9	176.1	56.8	3.1
14:39:05	11.2	9.5	17.7	1.7	103.3	57.6	1.8		11.0	8.2	17.6	2.8	170.1	56.2	3.0
14:40:35	11.2	9.5	17.8	1.7	103.3	58.7	1.8		11.0	8.2	17.6	2.8	170.1	56.5	3.0
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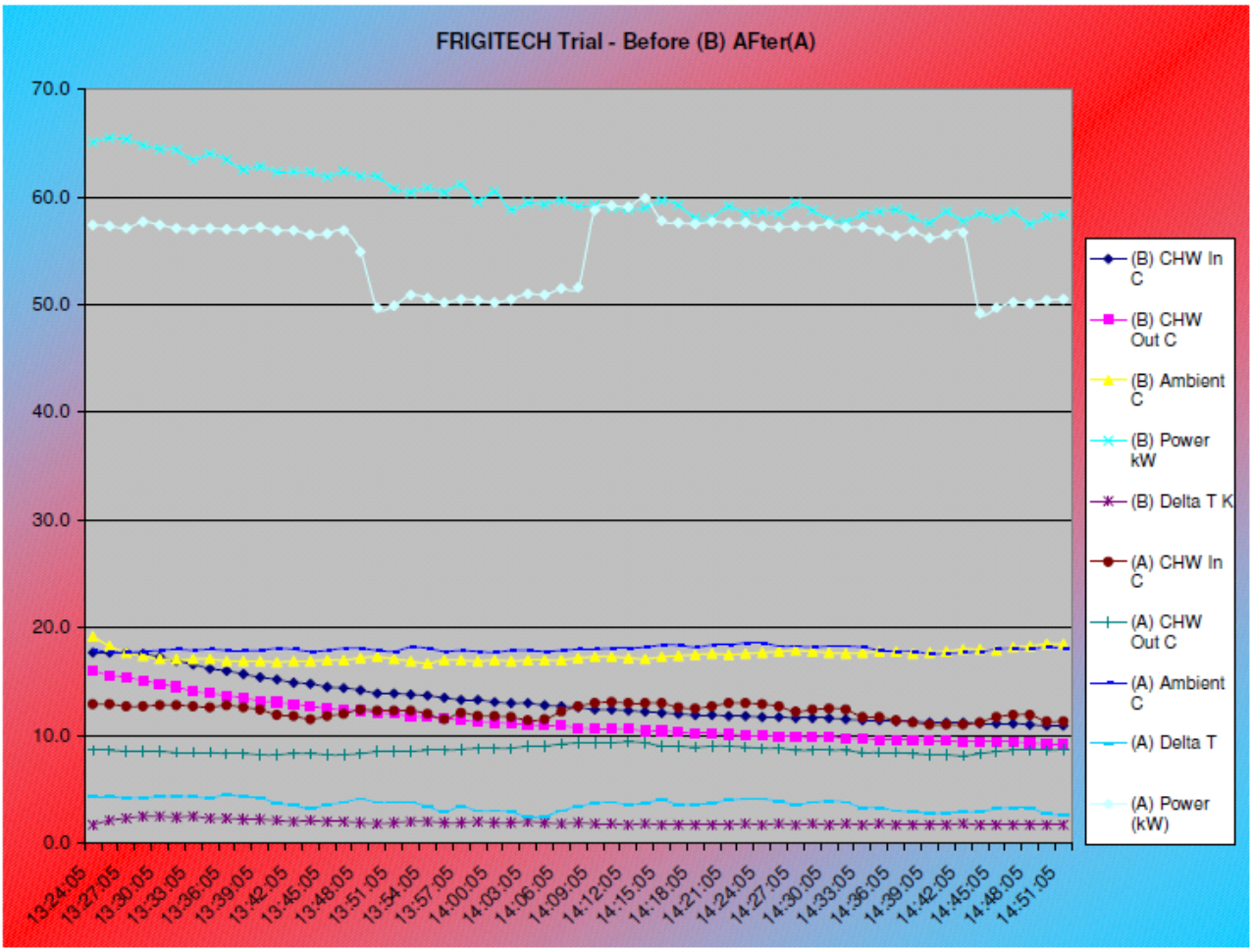
14:43:35	11.1	9.4	18.0	1.7	103.3	58.5	1.8		11.2	8.3	17.8	2.9	176.1	49.2	3.6
14:45:05	11.1	9.4	17.9	1.7	103.3	58.0	1.8		11.7	8.5	18.0	3.2	194.4	49.7	3.9
14:46:35	11.1	9.4	18.2	1.7	103.3	58.6	1.8		11.9	8.6	18.1	3.3	200.4	50.2	4.0
14:48:05	11.0	9.3	18.3	1.7	103.3	57.5	1.8		11.9	8.6	18.0	3.3	200.4	50.1	4.0
14:49:35	10.9	9.2	18.5	1.7	103.3	58.2	1.8		11.3	8.6	18.2	2.7	164.0	50.4	3.3
14:51:05	10.9	9.2	18.5	1.7	103.3	58.4	1.8		11.3	8.7	18.1	2.6	157.9	50.5	3.1
AVER-AGES	**13.2**	**11.3**	**17.4**	**1.9**	**115.5**	**60.3**	**1.9**		**12.2**	**8.6**	**18.0**	**3.6**	**216.5**	**55.1**	**3.9**
								% Diff From (B)	**-7.9**	**-23.9**	**3.2**	**46.6**	**46.6**	**9.5**	**105.4**

Comparison Graph

13/05/2011 **BAE Systems - YorkChiller FrigiTech Trial Graph** Optimum Group Services



Conclusions

Based upon the data above it can be seen that the addition of the oil system enhancement has improved the chiller circuits performance by approximately 46% in cooling capacity and a decrease of approximately 9.5% in consumed power when averaged across the data range

Cooling capacity has increased from 115kW to 216kW for a system input power of 60kW and 55kW respectively and **E**nergy **E**fficiency **R**atio (**EER** = kW Cool / Total kW power Input) has improved by 105% largely due to the significant increase in cooling duty.

Chilled water temperature differential (delta T) has increased from an average of 1.9degC to 3.6degC across 50% of the chiller operation at a recorded chilled water flow rate of 14.5lt/s.
The design flow rate calculated at 515kW with a 6k delta T with a flow temperature of 6oC would be 20.49lt/s which shows the chilled water flow rate is approximately 30% lower than design.

The original chiller design would be based upon a delta T of 6degC at design conditions.

It would therefore appear that the system enhancement has increased the cooling duty by way of vastly improved heat transfer within the evaporator.
Subsequently it could be assumed that the enhancement has improved both heat exchange capabilities of both the chilled water evaporator and the condenser heat rejection by way of clearing any oil fouling caused by build up on the heat exchanger internal surfaces which form over time.

Ambient temperatures have a significant impact on cooling duty, lower ambient conditions allow greater heat rejection capability.
The before enhancement ambient temperature was lower by 1 degC than the after enhancement recorded data, therefore the like for like ambient conditions would provide a greater improvement to cooling performance.

It is also seen that the compressor input power reduces as the machine off loads to maintain the 8oC set-point, this was not seen before the FrigiTech addition, this equates to a saving of 300kW of power input over the logging period.

To summarise, the FrigiTech system has shown that significant improvements to both cooling duty and consumed power are evident for this machine. The age of the chiller will have a large bearing on the results as oil fouling increases over time, especially when using mineral based oils.
It is therefore recommended that FrigiTech be used in all cooling systems not only as a performance improvement but also to aid resilience through improved mechanical lubricity and prevent compressor wear and possible mechanical failures, the compressor windings will also run cooler due to the decreased load and lengthen life expectancy.

For further information please contact Optimum Group Services