

Emerging Energy Solutions



ViaSat®

ViaSat
6155 El Camino Real
Carlsbad, CA 92009
Trane CGAM Chiller Performance Analysis
Oct 2016

Tests done by:
Sean McCaffery, Emerging Energy Solutions
Report published by:
Klas Berglof, ClimaCheck Sweden AB

Executive Summary

On March 16, 2016, Emerging Energy Solutions tested one of two air cooled Trane CGAM chillers located on building 2 at ViaSat's corporate campus in Carlsbad, CA. with a ClimaCheck *onsite* system. The timeframe of the evaluation period was from 10:15am to 11:50am with an ambient temperature of 80°F.

The test indicated that circuit B had a problem with high condensing pressure which caused an excess consumption in energy of 35% for this circuit. Additionally, it was noted that there was a possibility of refrigerant leaking backwards into through stand still compressors. The conclusion was that there was a problem with the condenser that was supported not by one input of data but three inputs – pressure, temperature and power.

On July 26, 2016 EMCOR had conducted their PM on this machine and reported there was not a problem with charge or a problem with refrigerant migrating back to the stand still compressors. This was a concern to us as it suggested our collected data was incorrect. To avoid any arguments or disagreements, it was agreed to go back to Viasat and retest the chiller in question.

On October 6, 2016, Emerging Energy Solutions reconnected to the same chiller. The timeframe of the evaluation period from 12:50pm to 1:50pm with an ambient temperature of 75 F. The lead chiller technician from EMCOR was present to assist in the test. Once the test had begun it was clear that the previous symptoms were no longer present. After the first 30 minutes, each circuit ran independently for approximately 30 minutes. Circuit B was operating much better and identical to Circuit A. After running each circuit independently, the system ran at normal operation. Again, circuit B was running almost identical to Circuit A. The problem was clearly rectified and no longer an issue.

It should be noted that it is now known that EMCOR had a service call on June 2, 2016. Per the paperwork the technician had found a contactor and fuses to the condenser were blown. It is not noted in the paperwork which circuit that was affected but our assumption is Circuit B since this was our problem circuit. In this case the impact of the reduced airflow over the condenser has created the same symptoms as an over charge with high condensing and high sub cool.

Assuming that this system works 24/7 at loads near the measured 45Kw (more than 50% utilization of capacity) and assuming equal distribution of load between circuits A and B, the difference in annual operating cost as measured in March until condenser fan was fixed in June, the result is approximately \$ 1,500 and the compressors would have worked near their limit with increased wear as a result.

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1 Background

The air-cooled Trane CGAM chiller consists of two circuits with two scroll compressors on each circuit without heat recovery, oil cooler or economizer. All four compressors are identical.

The two circuits are hereafter referred to as Circuit A and Circuit B while the compressors are referred to as compressor A1, A2 (on circuit A) – B1 and B2 (on circuit B). This corresponds with the circuits labelled in the chiller as Circuit 1 (A) and Circuit 2 (B).

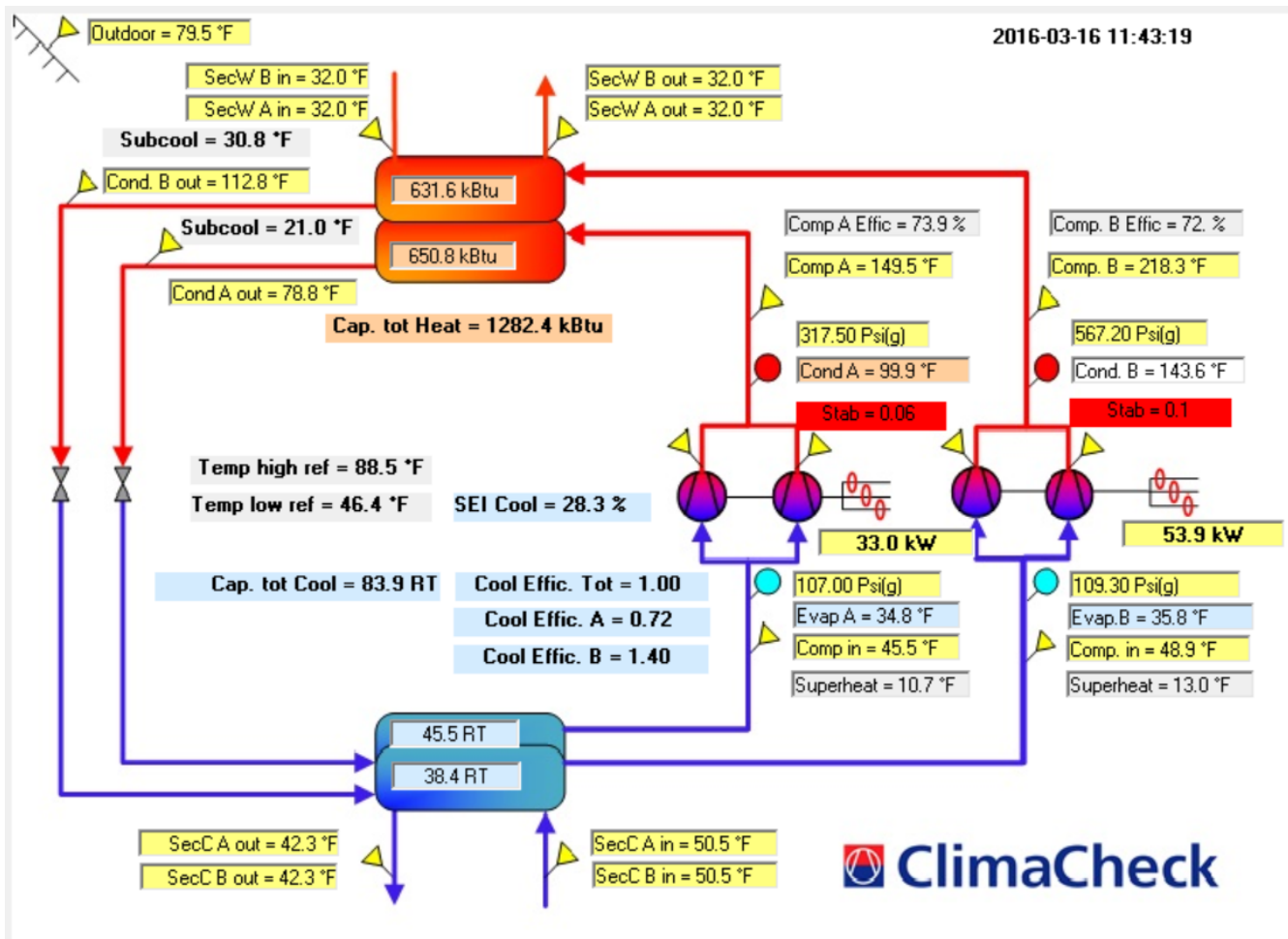


Figure 1 Chiller flowchart

Chiller Specifications:

Chiller Brand: Trane – CGAM series Air Cooled Chiller

Model Number: CGAM 080F 2H02 AXB2 AXA1 A1AX XA1C 1A2X XX88 XAXA 3A1D XXXL XX

Serial Number: U13A34087

Chiller Capacity: 80 tons

Refrigerant: R410A

2 System Performance Graph – Before Maintenance – March 2016

System is operating stable with some slow fluctuations on discharge. At the beginning of the measurement, compressors A1, B1, and B2 are running. At 10:53, compressor A2 starts to run. At 11:15 compressor B2 is turned off and is later turned back on at 11:36. The following is identified:

- Energy consumption of **circuit A is 33 kW**, while the consumption of **circuit B is 53.9 kW** (The equivalent of having 3 comps on Circuit A).
- Discharge on **Circuit B is 220 F – Circuit A is 150 F**. 70 F difference between the two circuits at full load.
- Condensing on **Circuit B 143 F – Circuit A 99 F – 34 F DT**

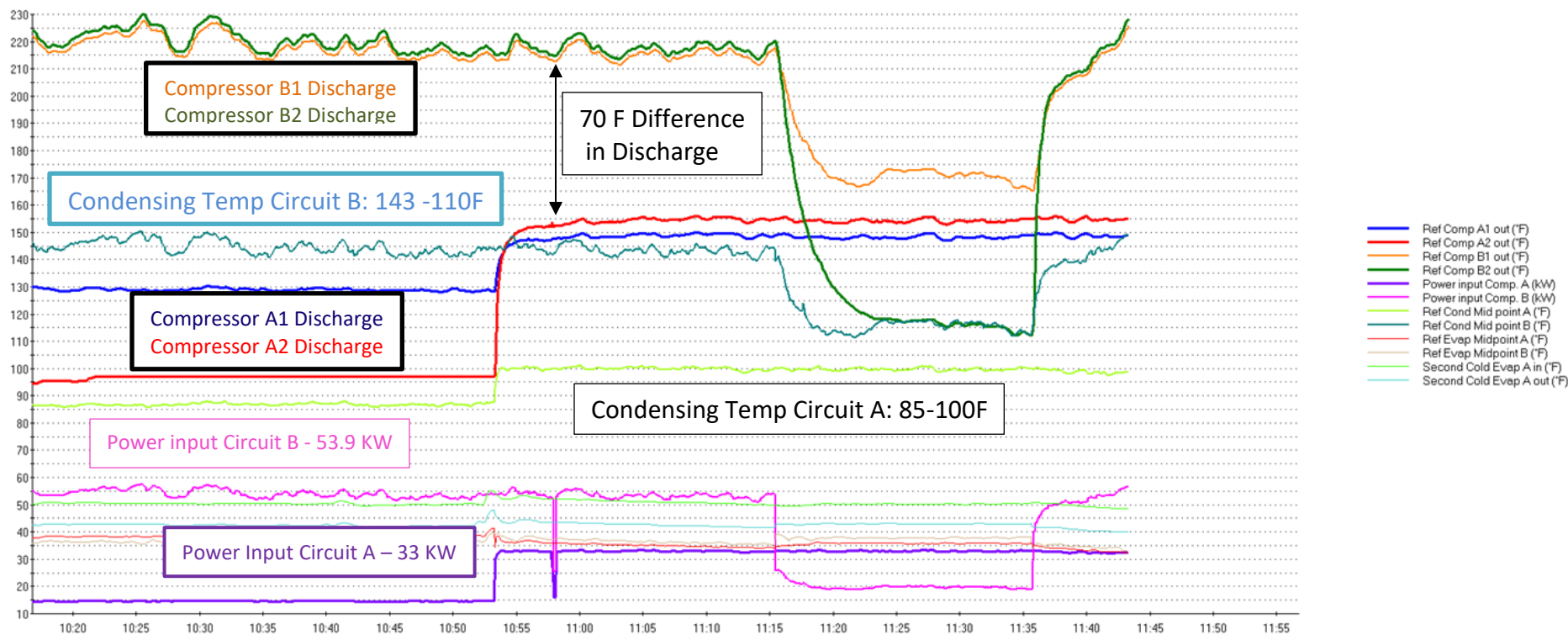


Figure 2 Operation of Circuits A and B March 2016

2.1 System Performance Graph – After Maintenance – October 2016

In graph from October 6th we can see that Circuit B runs almost identical to circuit A.

- Energy consumption is the same **33Kw** on both circuits.
- Discharge on both circuits never goes above **157 F**
- Condensing never goes above **102 F** on either circuit.

Selected Data Stability ViaSat 2016-10-06 14:01:05

Data Setup

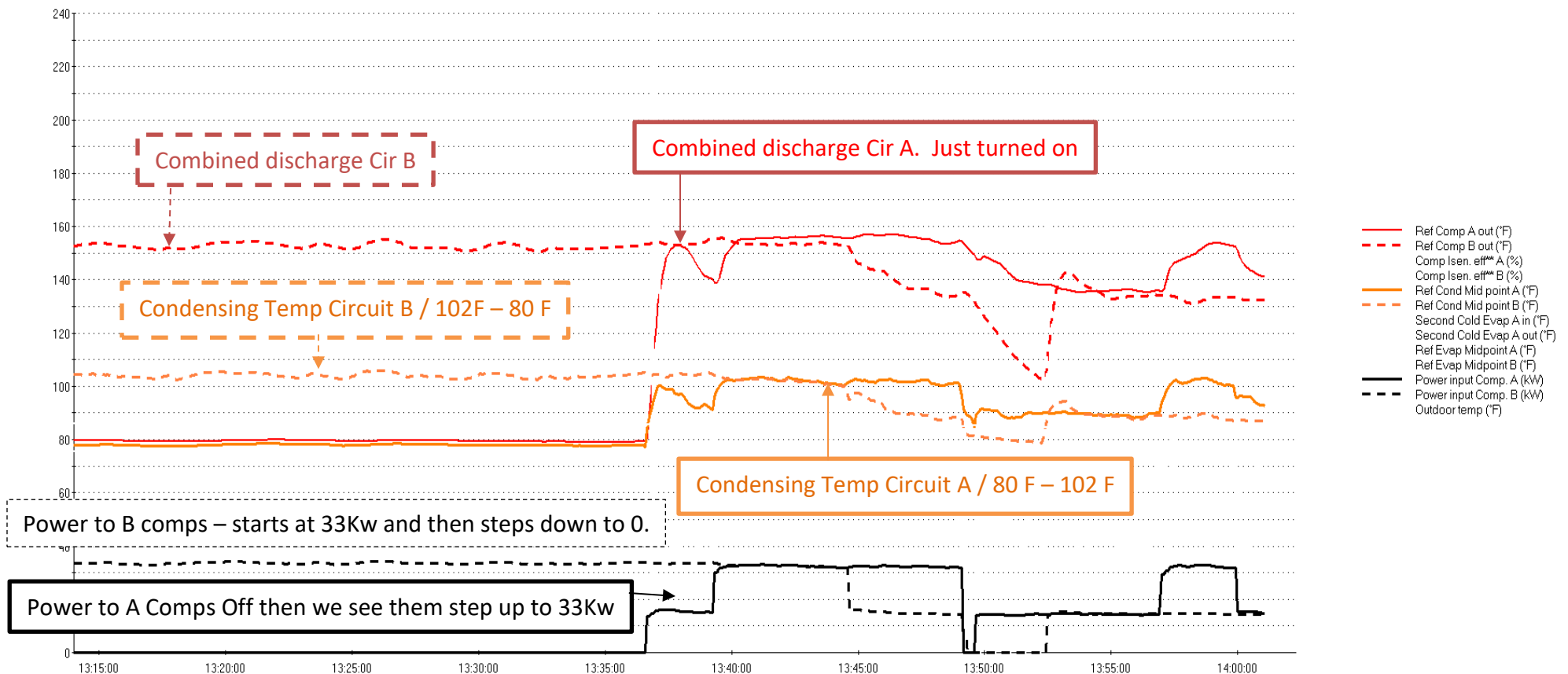


Figure 3 Operation of Circuit A and B October 2016

2.2 System Performance Report Page – Operation in March

In the following figure 4, we are outlining the detailed data collected between 10:55am to 11:15 March 16, 2016 and how each component mentioned earlier is affected. There is no room for measuring errors as all measured values marked in individual boxes below are showing the poor condenser performance which include:

1. Energy consumption of **Circuit A is 33 kW**, while the consumption of **Circuit B is 53.9 kW** at identical conditions.
2. The COP of Circuit A is 4.9 (0.7 kW/RT) whereas COP is only 2.5 (1.4 kW/RT) for Circuit B.
3. Condensing pressure in **circuit A is 317 psi(g)** and **B is 567 psi(g)** which corresponds to condensing temperature (labelled as “Ref Cond Midpoint A and B) increased from **99.9F to 146F – a 44.6F DT**.
4. Discharge temperature measured with three different sensors at **Circuit A is near 150F** and **Circuit B is near 218F** - also a result of the higher-pressure ratio and the higher condensing pressure.
5. Liquid temperature at expansion valve inlet for **Circuit A is 79F** and for **Circuit B 113F**. The difference is **34F** whereas the difference in condensing temperature between circuits is **44.6F** (noted in bullet 3 - 99.9F to 146F).
6. **Circuit A has a sub cool of 21 F** and **Circuit B of 31F**. The latter is a high level of sub cool corresponding to liquid build up blocking a significant part of condenser surface.

2.3 System Performance Report Page – Operation in October

In the following figure 5, we are showing you the same parameters as above to show you a straight comparison as to how the chiller is now operating versus how it was running during our first test.

- Circuit B behaves nearly identical to Circuit A on all measured values and performance.

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10	1034																					60	75	0.5	0.00				
11																						60	75	0.5	0.00				
14	2016-11-02																					60	75	0.5	0.00				
		Secondary Cold Media					Low Pres. Ref					High Pres. Refrigerant					Compressor												

Circuit A												3	5	6	4				1	2								
	Time	Outdoor temp (°F)	Outdoor rel. Hum (%)	System Second Cold return (°F)	System Second Cold supply (°F)	Second Cold Evap A in (°F)	Second Cold Evap A out (°F)	diff Second Cold Evap A (°F)	Ref Low press. A (PSI(g))	Ref Evap Midpoint A (°F)	Ref Comp A in (°F)	Super heat A (°F)	Ref High press. A (PSI(g))	Ref Cond Mid point A (°F)	Ref Exp. Valve A in (°F)	Sub cool total A (°F)	Ref Comp A out (°F)	Ref Comp A1 out (°F)	Ref Comp A2 out (°F)	Comp Isen. eff** A (%)	Comp Isen. eff** A1 (%)	Comp Isen. eff** A2 (%)	Power input Comp. A (kW)	COP Cool A	EER Cool A (Btu/Wh)	Cap. Cool A (kbtu/h)	Cap. Cool A (RT)	Effic. Cool A (kW/RT)
	11:10:04	79.5	48.3	50.5	42.3	50.5	42.3	8.3	107.0	34.8	45.5	10.7	317.5	99.9	78.8	21.0	149.5	149.0	154.8	73.9	74.6	67.3	33.0	4.9	16.6	547.1	45.6	0.72
	11:09:59	79.5	48.2	50.7	42.3	50.7	42.3	8.5	107.0	34.8	45.5	10.7	317.6	99.9	78.8	21.0	149.5	149.2	154.8	73.9	74.4	67.3	33.0	4.9	16.5	544.5	45.4	0.73
	11:09:54	79.5	48.2	50.7	42.3	50.7	42.3	8.5	107.3	34.9	45.7	10.7	317.4	99.9	78.6	21.1	149.5	149.2	154.9	73.8	74.3	67.0	32.9	4.9	16.6	545.1	45.4	0.72
	11:09:49	79.5	48.2	50.7	42.3	50.7	42.3	8.5	107.3	34.9	45.7	10.7	317.0	99.8	78.6	21.0	149.7	149.2	154.9	73.3	74.1	66.8	32.9	4.8	16.6	544.9	45.4	0.72

Circuit B												3	5	6	4				1	2				
	Ref Low press. B (PSI(g))	Ref Evap Midpoint B (°F)	Ref Comp B in (°F)	Super heat B (°F)	Ref High press. B (PSI(g))	Ref Cond Mid point B (°F)	Ref Exp. Valve B in (°F)	Sub cool total B (°F)	Ref Comp B out (°F)	Ref Comp B1 out (°F)	Ref Comp B2 out (°F)	Comp Isen. eff** B (%)	Comp Isen. eff** B1 (%)	Comp Isen. eff** B2 (%)	Power input Comp. B (kW)	COP Cool B	EER Cool B (Btu/Wh)	Cap. Cool B (kbtu/h)	Cap. Cool B (RT)	Effic. Cool B (kW/RT)				
	109.3	35.8	48.9	13.0	567.2	143.6	112.8	30.8	218.3	217.8	219.9	71.9	72.4	70.5	53.9	2.5	8.5	460.5	38.4	1.4				
	109.3	35.8	48.9	13.0	571.7	144.3	113.0	31.2	218.3	217.6	219.9	72.8	73.5	71.3	53.9	2.5	8.6	463.3	38.6	1.4				
	109.4	35.9	48.9	12.9	573.1	144.5	113.0	31.4	218.3	217.6	219.7	72.9	73.6	71.6	53.9	2.5	8.6	464.0	38.7	1.4				
	109.4	35.9	48.9	12.9	573.0	144.5	113.2	31.2	218.3	217.4	219.7	72.9	73.8	71.6	53.9	2.5	8.6	463.3	38.6	1.4				

Figure 4 Report Page Circuit A and B March 16, 2016

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2016-10-06	13:43:45	85.6	68.4	53.6	41.9	11.7	106.5	34.6	47.8	13.2	323.7	101.2	83.7	17.5	83.7	17.5	156.2	156.0	155.1	71.7	71.9	73.1	32.0	4.5	15.3	489.9	40.8	0.78																																																																																																																																																																													
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Figure 5 Report Page Circuit A and B October 6, 2016

2.5 Expansion Valve – March 2016

In our first measurement whether one compressor was running or two the superheat on circuit B was relatively higher than the superheat on circuit A, as shown in Figure .

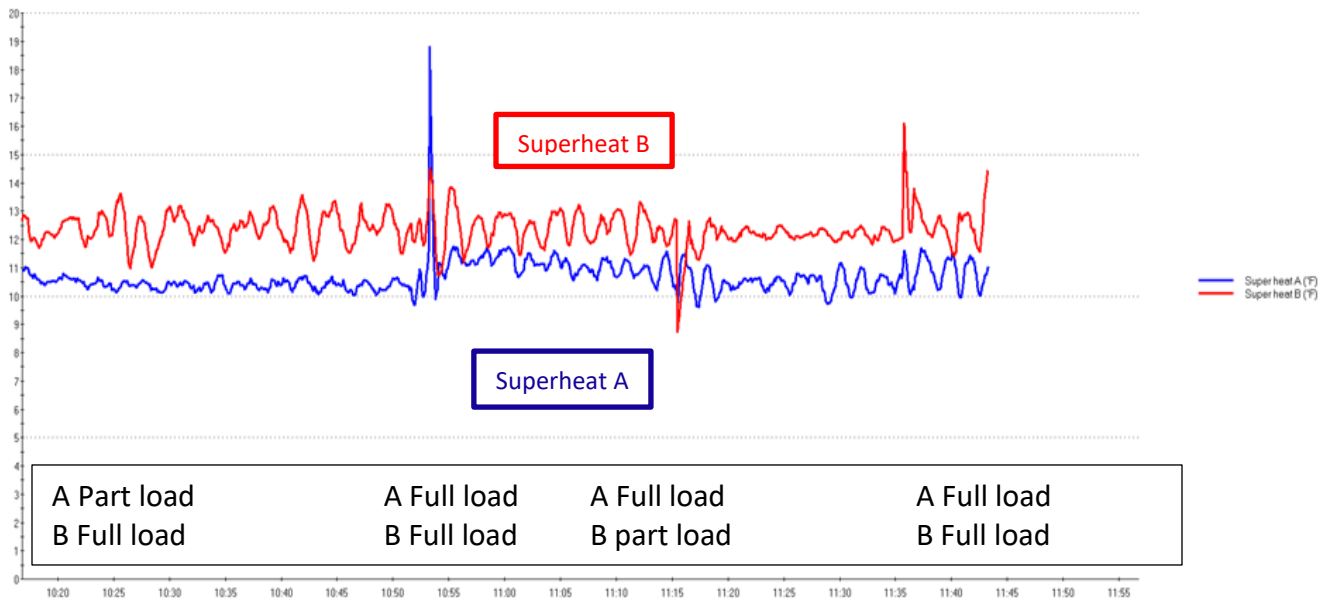


Figure 6 Superheat on Circuits A and B – Mar 2016

2.6 Expansion Valve – October 2016

After maintenance, the superheat remains similar and within expected range as seen in **Error! Reference source not found.**

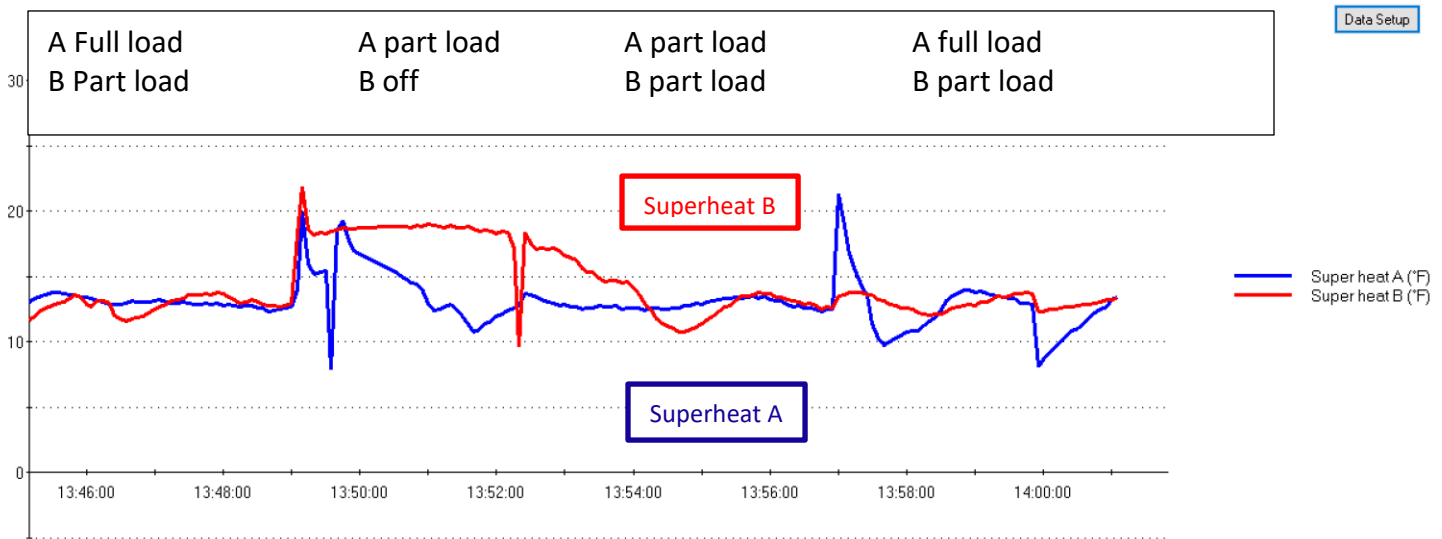


Figure 7 Superheat on Circuits A and B – Oct 2016

2.7 Sub Cool – March 2016

As figure 8 shows, the sub cool on circuit A is within range whereas the sub cool on circuit B is higher than the recommended range which is a result of high refrigerant levels in the condenser. The high refrigerant level in this case was caused by the low air flow creating a high dT between incoming air and liquid refrigerant.

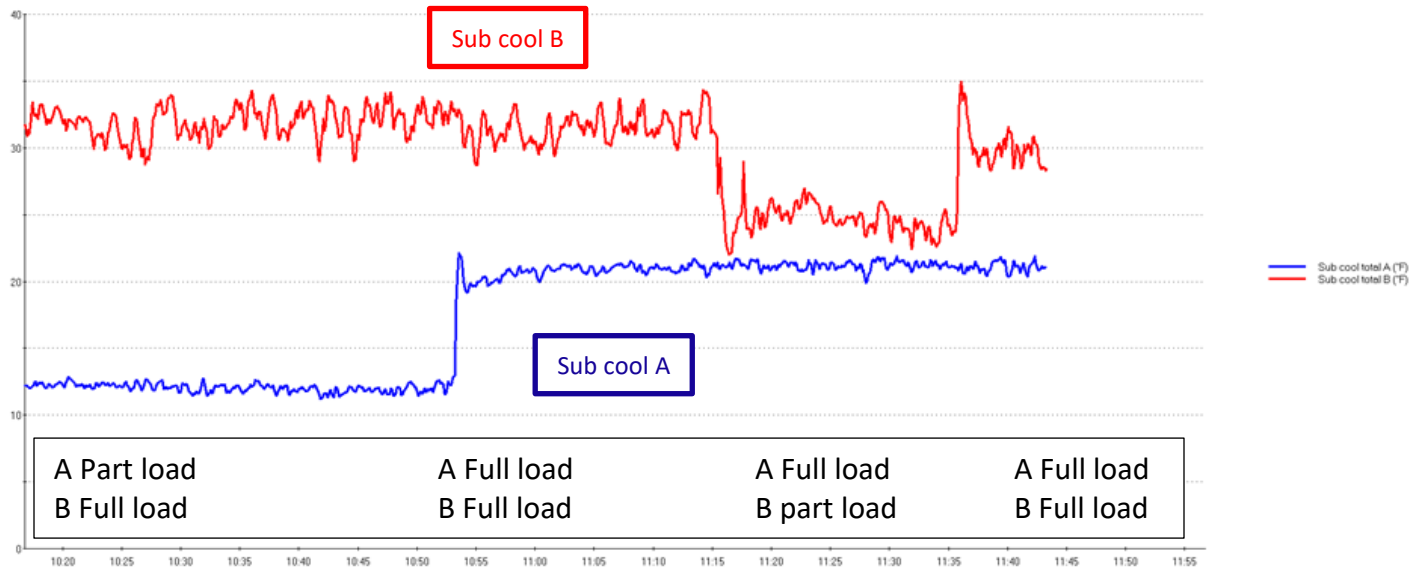


Figure 8 Sub cool on Circuit A and B – March 2016

2.8 Sub Cool – October 2016

The excess Sub-cool of circuit B which was more than 10F higher than circuit A at full load has disappeared after fan contactor/fuse was repaired. At full load circuit A has 17-19 F of Sub-cool and circuit B has 12-14 F at part load. Circuit B is now within expected range. See figure 9

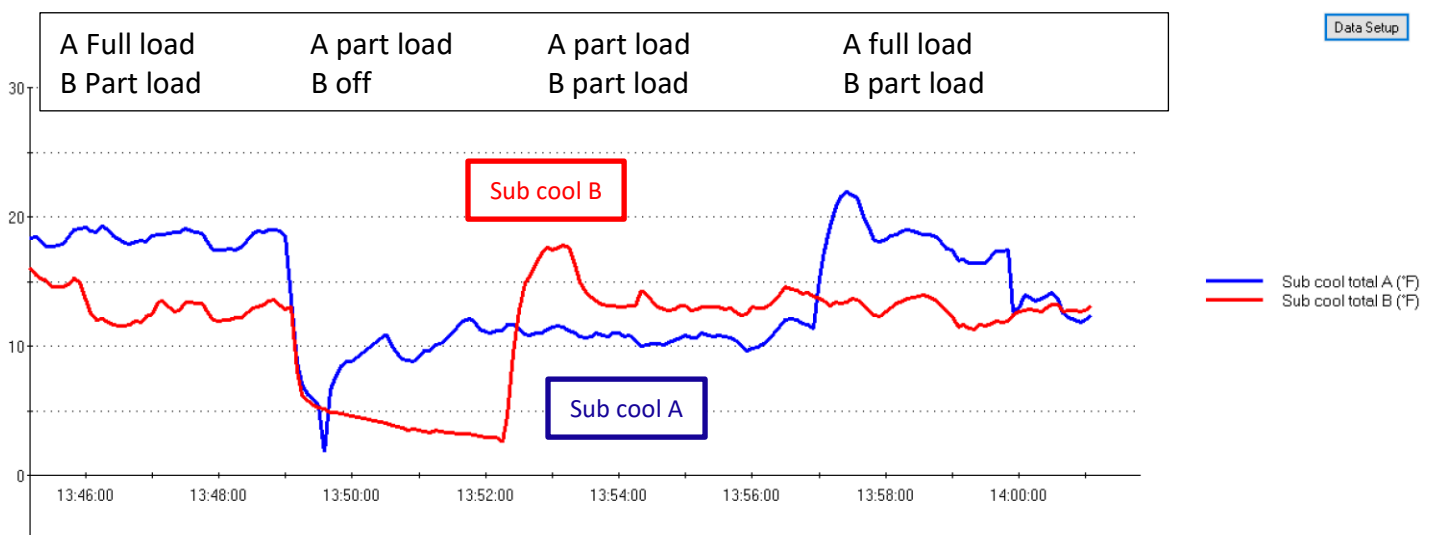


Figure 9 Sub cool on Circuit A and B – October 2016