Problems Detected in Daikin Rebel RTU Feb 2014

The low compressor efficiency registered during earlier test can based on the result reported below be quantified and much better understood.
The fixed compressor has a isentropic efficiency of around 40% instead of expected around 70% the total COP is due to this decreased from approximately 8.1 to measured 5.2 at the only test where operation of the fixed was measured after additional sensors were added. At this condition Variable compressor was running at low speed at higher load the variable compressor with better performance will decrease the impact somewhat. It is recommended that this compressor should be replaced before a total failure result higher repair costs.
The design of oil return also cause clearly measurable losses but due to that these gradually disappear with only the limited amount of measured operation the impact of this cannot be quantified with accuracy but it is clearly limited and much smaller impact than the poor compressor.

1 ClimaCheck Method – evaluation of low performance

To understand why certain operation modes resulted in an unexpected low performance was documented on the Daikin Rebel unit additional sensors where mounted.

At some operating modes the compressor efficiency is reduced around 70% to around 45%. Originally the system was monitored with the sensors shown in picture below. This does not allow for identification of what is taking place within the "compressor unit" consisting of one fixed and one variable speed compressor. The compressor unit also contain one oil separator per compressor that has an oil return that is going from discharge of the variable speed to the return of the fixed and vice versa.

1.1 Daikin Rebel – original sensor location

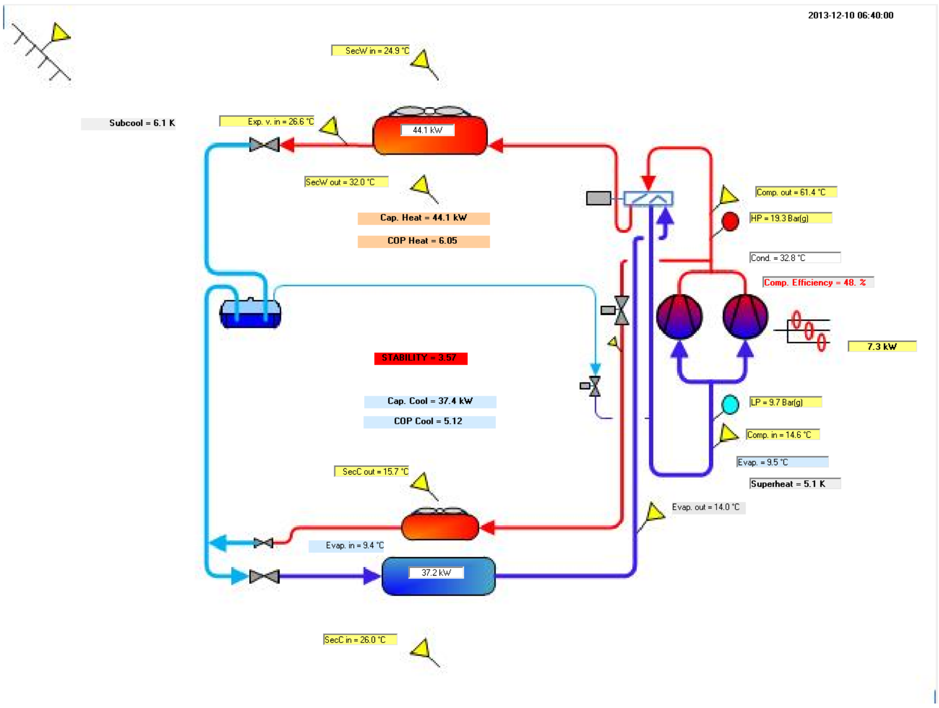

Figure 1, Flow chart with original sensor placement

There is a very limited amount of data with the fixed compressor in operation but I believe important conclusions can be drawn as the result are clear and in agreement with and explain earlier reported data with poor performance i.e. 2013-12-10 06:34 (see below).

It should be noted that only one sequence of 10 minutes operation of the fixed compressor is identified so the analyses are based on this sequence and compares this with sequences with variable speed only. But the results are consistent with the issues noted during summer period.

1.2 New sensors mounted

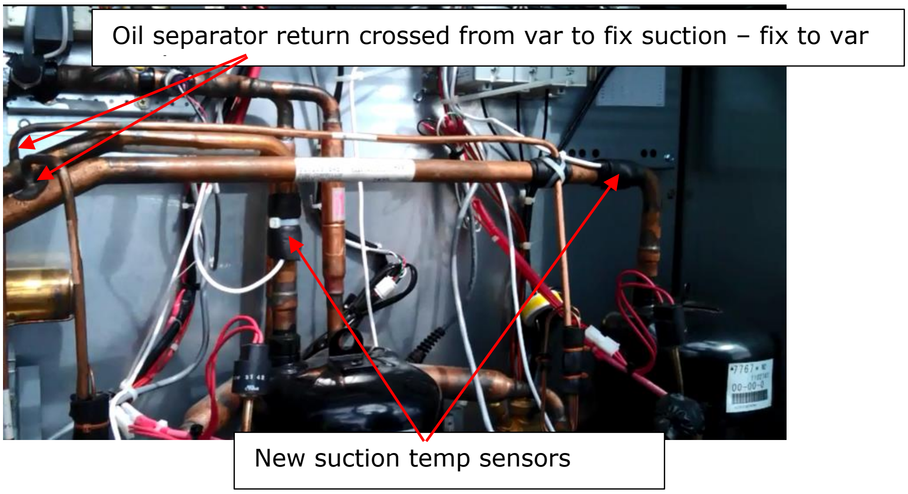

Figure 2, Added temperature on suction side

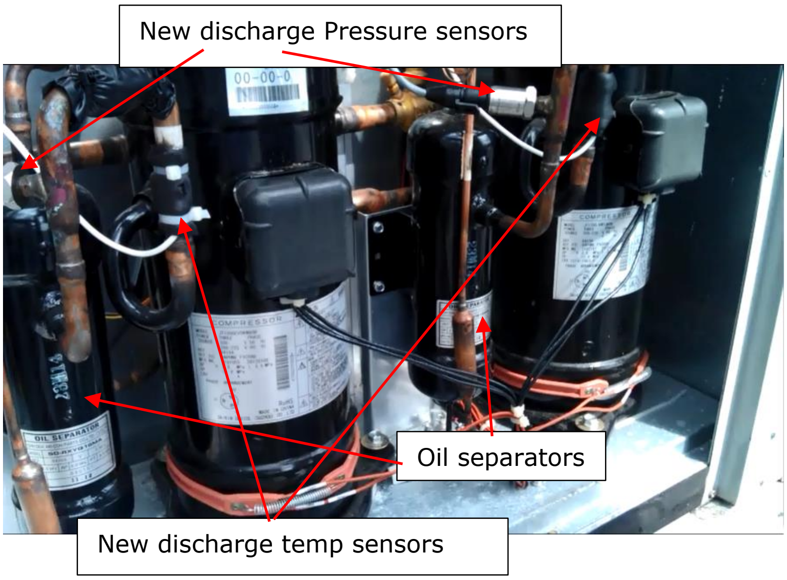

Figure 3, Added pressure and discharge temperature

ClimaCheck

1.3 Analyses of results with additional sensors

At start up in the morning Jan 22nd the variable speed compressor starts first and operate for a few minutes before the fixed compressor starts and operate for 10 minutes,

1.3.1 Evaluation of oil return line impact on suction and discharge gas

Evaluating the suction gas temperatures it is clear the suction gas temperature of the variable speed is affected by the start of the fixed e.g. there is a return through the oil separator. To get the oil back to the compressors is essential in particularly with variable speed/refrigerant flow as the low velocities in the system otherwise can risk to leave oil in evaporator. **At the same time the recirculation here documented represents a loss.** As I have understood it the oil separators are without floats and return is controlled by capillary tubes with floats would practically eliminate this loss but introduce an additional mechanical part (cost/risk).

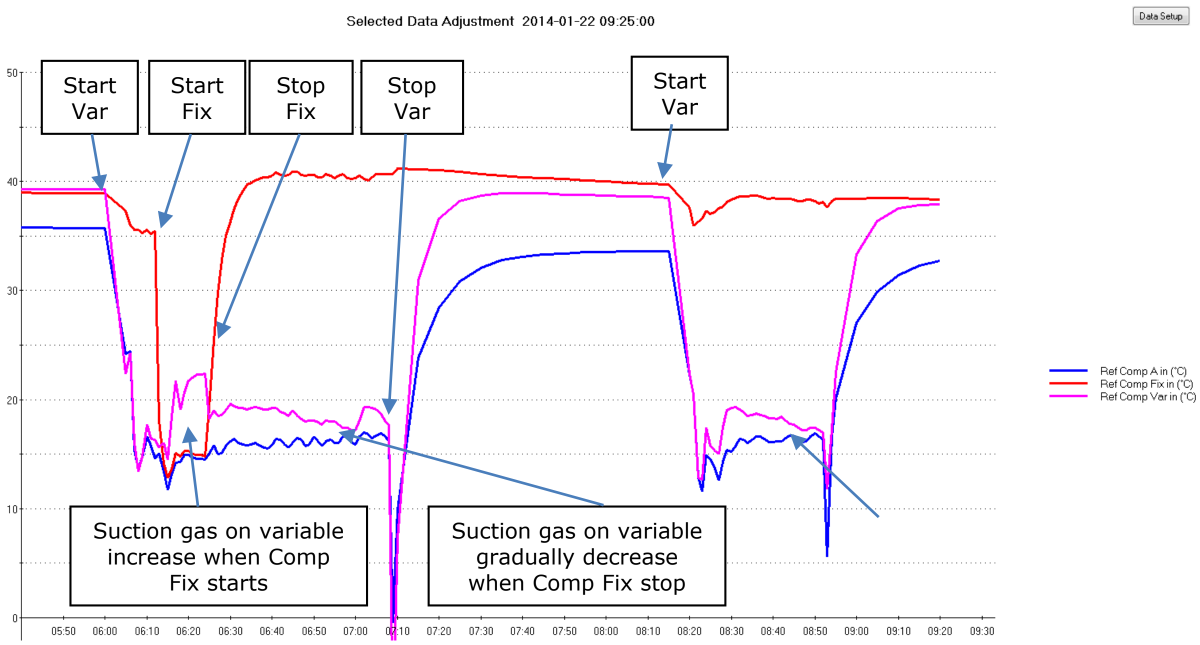

Figure 4, Oil return impact on suction

This impact decrease when pressure in fixed compressor discharge side equalize e.g. the return is only taking place in the oil return from the variable compressor itself but it remains during a longer time than what would be expected. But with the limited amount of data there is not sufficient information to analyse this fully and it is not judged of importance for the above conclusions.

But it is clear that as the suction gas temperature increase the discharge is expected to increase but instead it is decreasing which can be explained with that it is oil with dissolved refrigerant returning to the suction gas line of the compressor. The compressor is cooled by evaporation of refrigerant from returned oil.

It should also be taken into account that warm oil that is returned will be transported along the tube wall and thus risk to impact the sensor un-proportionally. But these are factors not affecting the general conclusions but rather explaining the sequence.

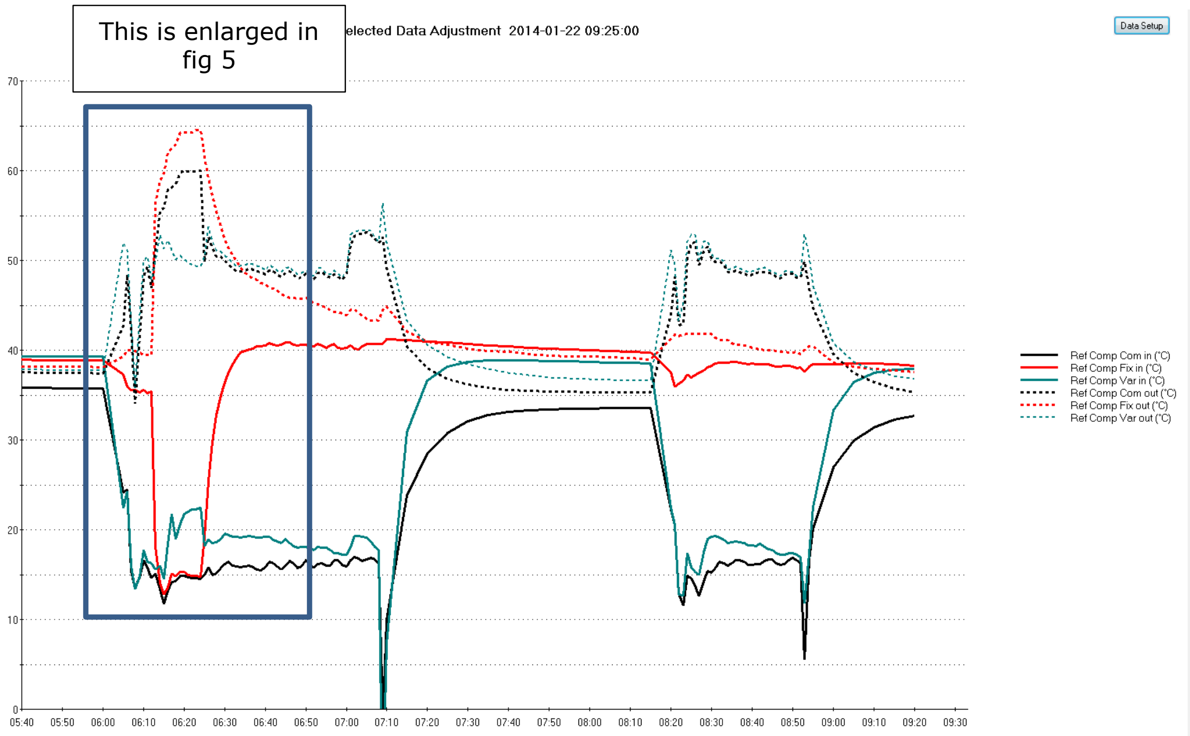

Figure 5, Evaluation of discharge temperature

There is a clear impact of the oil return but **the fixed speed compressor show significantly higher discharge temperature e.g. lower compressor efficiency** during the 10 minute operation caught after adding sensors. This is in the same problem as identified during earlier measurements.

1.3.2 Evaluation of compressor efficiency

As documented over the earlier measurement period the compressor efficiency is unexpectedly low. When variable speed run by itself compressor efficiencies is at the expected level of 65-75%. When fixed compressor is operating it indicated compressor efficiencies of near 40% which indicate a compressor with severely reduced performance and thus affected EER/COP reducing it from over 8 to 5.

There is also a clearly measurable loss from the oil return but this is much lower than the compressor issue. For some time after start of compressors there is an impact of what seems to be dissolved refrigerant in oil return. To evaluate the performance this impact has been neglected.

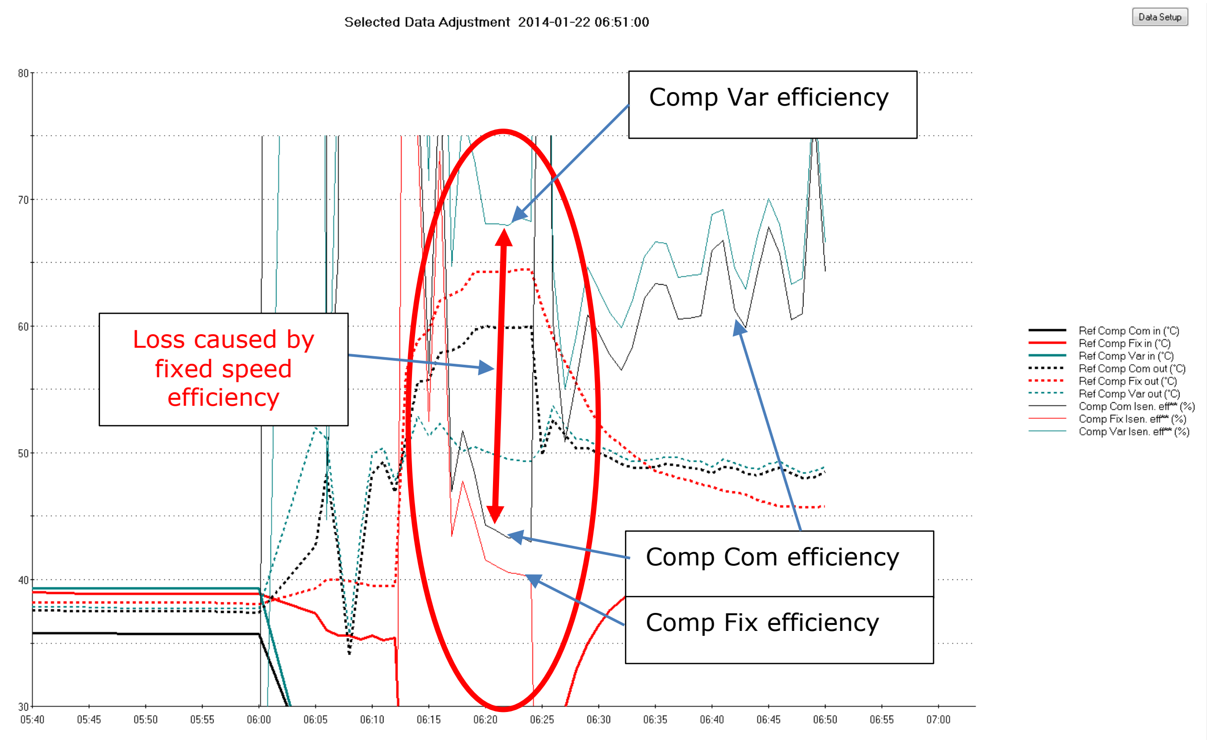

Figure 6, Fix compressor and oil return impact on compressor efficiency

In figure below it can be seen how the impact of the oil return is gradually decreasing and how it affects the isentropic efficiency if the refrigerant suction temperature including oil return is taken into account.

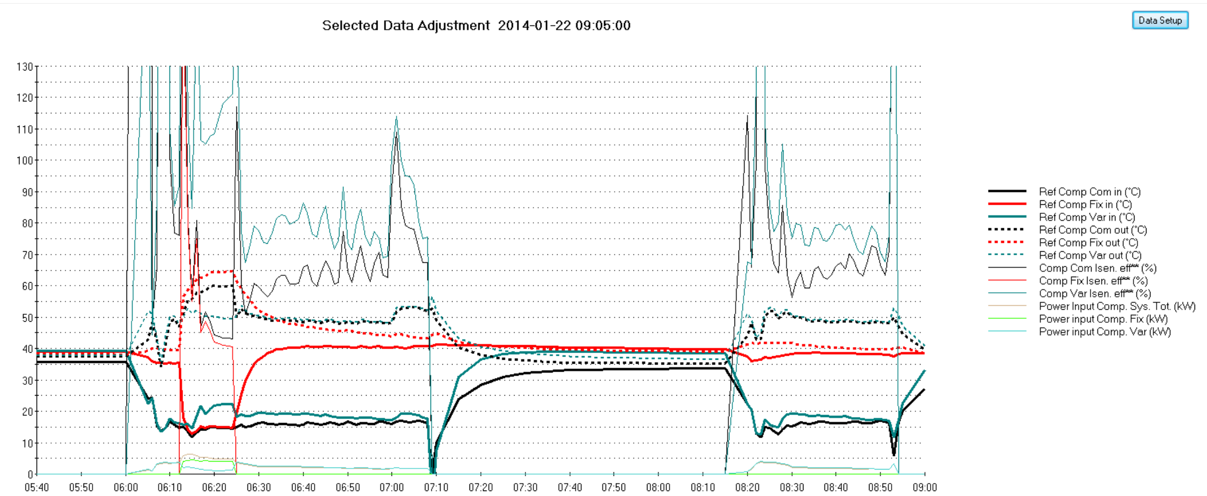

Figure 7, Compressor efficiency taking temperature increase from oil return into account

1.4 Evaluation of Pressure drops on discharge side

The discharge pressure can with the added sensors be monitored to detect if there are any issues with check valves on discharge lines as this could have explained the lower compressor efficiency as it would result in an actually higher compression than what was measured with the pressure sensor after the lines merge. The pressure drop is clearly measureable (0.5 bar) but this only explain a minor part of the low isentropic efficiency when the fixed compressor is operating.

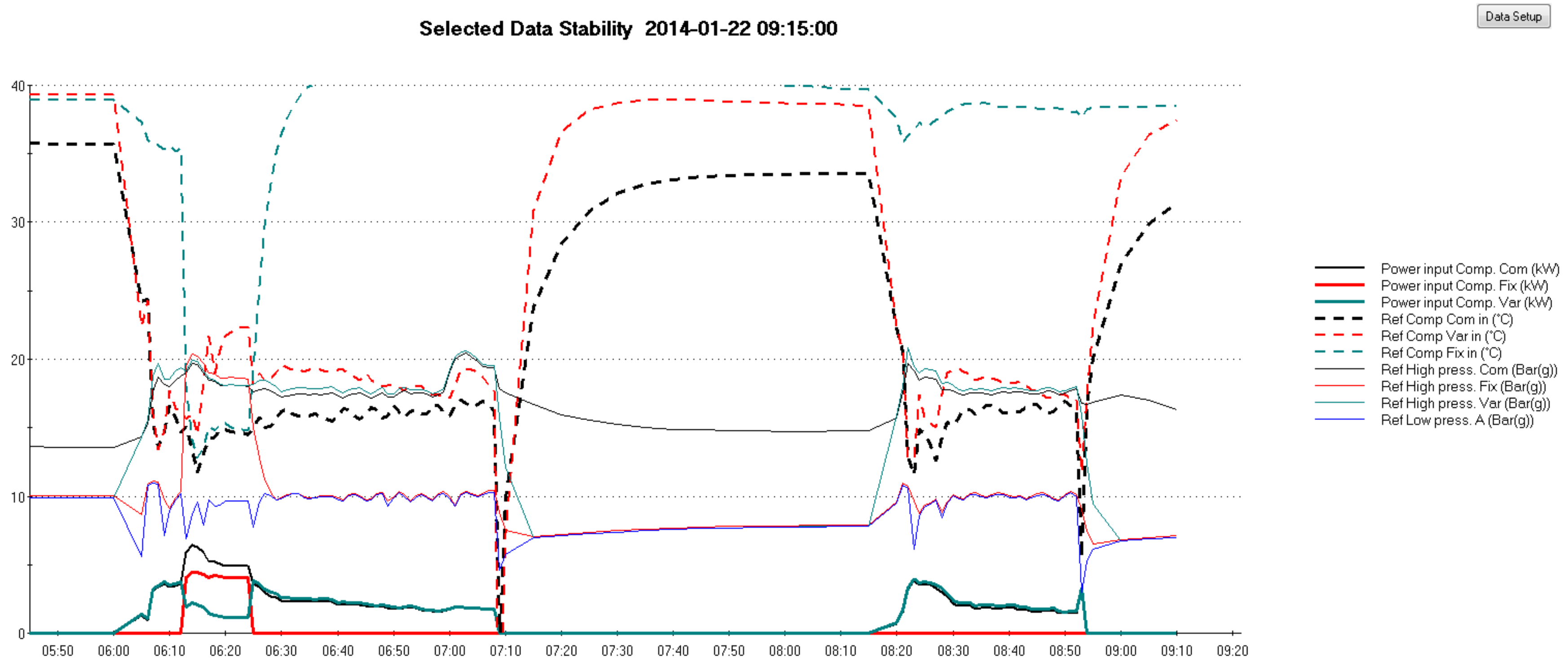

Figure 8, Pressure drop on discharge side

Rebel 2013-12-10 06:34

Performance Inspection with ClimaCheck

		R410A.MIX															Term. eff.	Elec. eff.			Max Deviation Current					Max Deviation Voltage			Stab COP		Auto Trig
																	0.93	1.00			0.10					0.05					
Min	**No of Scans**			2.0		7.4		4.0			5.0		30.8		5.7	15.0	60	0.1			7.8	8.0	8.0			131.3	131.3	131.3	3.70		5.34
Max	**32**			5.0		11.4		7.0			12.0		36.8		8.7	125.0	75	1000			9.5	9.8	9.8			145.1	145.1	145.1	7.41		9.34
								4-7							0-3		58-78														
	2013-12-17	**Evap. Sec.**			**Low Pres. Ref**				**Cond. Sec.**			**High Pressure Ref.**				**Compressor**															
Span		0.7	1.9	1.2	1.18	3.7	1.5	4.2	0.2	3.6	3.7	1.5	2.9	1.6	1.7	3.2	23.3	0.6	1.1	0.3	2.6	2.6	2.3	8.0	2.0	0.8	0.7	0.9	1.10	7.3	1.10
Average		26.2	16.0	10.2	9.78	9.8	14.8	5.0	24.9	33.1	8.2	19.7	33.6	27.0	6.5	61.3	50.5	7.0	3.2	4.4	8.5	8.7	9.1	87.3	75.8	138.3	137.6	138.7	5.24	36.9	6.17
Max		26.6	17.2	10.6	10.28	11.3	15.7	8.0	25.0	35.4	10.7	20.7	35.6	28.2	7.7	62.0	69.6	7.3	3.6	4.7	9.4	9.5	9.9	90.0	77.0	138.7	138.0	139.1	6.13	42.6	7.06
Min		25.9	15.3	9.4	9.11	7.6	14.2	3.8	24.8	31.8	6.9	19.2	32.6	26.6	6.0	58.8	46.2	6.7	2.4	4.3	6.8	6.9	7.6	82.0	75.0	137.9	137.3	138.2	5.03	35.3	5.96
Date	Time	SecC Evap A in (°C)	SecC Evap A out (°C)	SecC Evap A dT (K)	Ref Low press. A (Bar(g))	Ref Evap Midpoint A (°C)	Ref Comp A in (°C)	Super heat A (K)	SecW Cond A in (°C)	SecW Cond A out (°C)	SecW Cond A dT (K)	Ref High press. A (Bar(g))	Ref Cond Mid point A (°C)	Ref Cond. A out (°C)	Sub Cool Cond A out (K)	Ref Comp A out (°C)	Comp Isen. eff** A (%)	Power input Comp. A (kW)	Power input Comp. A1 (kW)	Power input Comp. A2 (kW)	Amps A1 L1 (A)	Amps A1 L2 (A)	Amps A1 L3 (A)	Power Factor A1 *100	Power Factor A2 *100	Volt A L1 (V)	Volt A L2 (V)	Volt A L3 (V)	COP Cool A	Cap. Cool A (kW)	COP Heat A
2013-12-10	06:40:00	25.9	15.4	10.5	9.76	9.7	14.3	4.5	24.9	31.8	6.9	19.17	32.6	26.6	6.0	60.8	47.0	7.0	3.3	4.3	8.7	8.9	9.3	88	75	138.7	137.8	138.2	5.10	35.8	6.03
2013-12-10	06:39:00	25.9	15.3	10.6	9.78	9.8	14.2	4.4	24.9	31.9	7.0	19.19	32.7	26.6	6.0	61.1	46.2	7.0	3.3	4.3	8.8	9.0	9.3	88	75	138.3	137.7	138.6	5.03	35.3	5.96
2013-12-10	06:38:00	25.9	15.3	10.6	9.69	9.5	14.2	4.7	24.9	32.0	7.1	19.27	32.8	26.6	6.2	61.1	47.9	7.3	3.5	4.4	9.1	9.2	9.8	89	75	138.1	137.8	138.6	5.09	37.1	6.02
2013-12-10	06:37:00	26.0	15.4	10.6	9.70	9.5	14.3	4.7	24.9	32.0	7.1	19.27	32.8	26.6	6.2	61.2	47.8	7.3	3.5	4.4	9.3	9.4	9.9	89	75	138.2	137.4	138.7	5.09	37.0	6.02
2013-12-10	06:36:00	26.0	15.5	10.5	9.71	9.5	14.4	4.8	24.9	32.0	7.1	19.29	32.9	26.7	6.1	61.3	47.8	7.2	3.5	4.4	9.4	9.5	9.8	90	75	138.3	137.9	138.7	5.09	36.9	6.02
2013-12-10	06:35:00	26.0	15.6	10.4	9.70	9.5	14.5	4.9	24.9	32.0	7.1	19.29	32.9	26.7	6.1	61.3	48.1	7.2	3.5	4.4	9.1	9.5	9.8	88	75	138.4	137.6	138.8	5.11	37.0	6.04
2013-12-10	06:34:00	26.0	15.7	10.3	9.68	9.5	14.6	5.1	24.9	32.0	7.1	19.25	32.8	26.6	6.1	61.4	48.1	7.3	3.6	4.4	9.2	9.5	9.9	89	75	138.3	137.5	138.8	5.12	37.4	6.05
2013-12-10	06:32:00	26.1	15.8	10.3	9.72	9.6	14.7	5.1	25.0	32.4	7.5	19.38	33.0	26.8	6.2	61.6	48.3	7.1	3.4	4.4	8.9	9.1	9.4	89	76	138.1	137.3	138.6	5.11	36.4	6.04
2013-12-10	06:31:00	26.1	15.9	10.2	9.75	9.7	14.8	5.1	25.0	32.6	7.7	19.46	33.2	26.9	6.2	61.7	48.4	7.1	3.3	4.4	8.6	8.9	9.3	88	76	137.9	137.5	138.3	5.12	36.4	6.05
2013-12-10	06:30:00	26.2	15.9	10.3	9.77	9.7	14.8	5.0	25.0	32.8	7.9	19.52	33.3	26.9	6.4	61.7	48.6	7.0	3.2	4.4	8.7	8.8	9.2	88	76	138.1	137.5	138.4	5.12	36.0	6.05
2013-12-10	06:29:00	26.2	16.0	10.2	9.79	9.8	14.8	4.9	25.0	32.9	8.0	19.57	33.4	27.0	6.4	61.7	48.6	7.0	3.2	4.4	8.7	8.8	9.1	87	76	138.1	137.5	138.7	5.12	36.0	6.05
2013-12-10	06:28:00	26.2	16.0	10.2	9.84	10.0	14.9	4.9	25.0	33.2	8.3	19.68	33.6	27.0	6.6	61.8	48.8	7.0	3.2	4.4	8.5	8.7	9.1	87	76	138.3	137.5	138.4	5.13	36.1	6.06
2013-12-10	06:27:00	26.3	16.1	10.2	9.86	10.0	14.9	4.8	24.9	33.4	8.5	19.77	33.8	27.1	6.6	61.8	49.0	7.0	3.2	4.5	8.3	8.6	9.2	86	76	138.3	137.7	138.8	5.13	36.0	6.06
2013-12-10	06:26:00	26.3	16.2	10.1	9.87	10.1	15.0	4.9	24.9	33.7	8.8	19.88	34.0	27.2	6.8	62.0	49.4	6.9	3.0	4.5	8.1	8.4	8.9	88	76	138.4	137.6	138.9	5.14	35.6	6.07
2013-12-10	06:25:00	26.4	16.4	10.0	9.80	9.8	15.2	5.3	25.0	33.9	9.0	19.99	34.2	27.3	6.9	62.0	51.4	6.9	3.0	4.5	8.2	8.4	8.8	87	76	138.4	137.7	138.8	5.24	36.3	6.17
2013-12-10	06:24:00	26.4	16.4	10.0	9.70	9.5	15.2	5.6	25.0	34.2	9.3	20.14	34.5	27.5	7.0	61.7	54.4	7.0	3.0	4.6	8.2	8.2	8.7	86	77	138.4	137.6	138.7	5.38	37.4	6.31
2013-12-10	06:23:00	26.5	16.5	10.0	10.15	10.9	15.2	4.2	24.9	34.5	9.6	20.18	34.6	27.4	7.1	60.7	50.6	6.7	2.8	4.5	7.5	7.7	8.1	85	76	138.6	138.0	139.0	5.35	35.8	6.28
2013-12-10	06:22:00	26.5	16.6	9.9	10.28	11.3	15.2	3.8	24.8	34.8	10.0	20.48	35.1	27.7	7.4	60.9	50.4	6.8	2.8	4.5	7.5	7.7	8.1	86	76	138.5	137.7	139.1	5.31	36.1	6.24