ICE ENERGY HEAT PUMPS LTD.

RESEARCH & DEVELOPMENT

Report Title:

E6 Coefficient of Performance with the installation of a Tadpole (AquaStan)

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E6 Coefficient of Performance with the installation of a Tadpole (AquaStan)

This report details the procedure conducted to obtain the coefficient of performance of an E6 with the installation of a product design by AquaStan Heating limited called 'Tadpole'.
The 'Tadpole' claims to be a deaerator which would therefore improve the COP, reducing air in a system, hence increasing heat transfer rates.
Using monitoring equipment to record sensor readings on the E6 heat pump, 150 litres of hot water was run off at 10 litres / Min and start and stop temperature were noted.
This experiment was conducted three times, one without the 'Tadpole' and two with the 'Tadpole'.
A correction factor is applied to both experiments using the 'Tadpole' to make a fair comparison to the experiment without 'Tadpole' due to temperature differences.
The improvement of the E6 COP with the 'Tadpole' installed is 8%, however an additional experiment with the 'Tadpole' could support this result.

Contents

1.0 Objective

To determine the COP of an E6 with the installation of a product called 'Tadpole' designed by Aquastan Heating Ltd, by running off 150 litres of domestic hot water and recording the performance of the E6. Comparing data recoded without the use of a 'Tadpole' on the same E6, differences can be measured thus concluding results.
A second run with the installation of the 'Tadpole' was also conducted to support the result.

2.0 Process

The 'Tadpole' is installed on the return side of the hot water therefore inlet to the condenser. Pump 2 which is installed on the hot water side is set to speed 2.
Using the Eltek data logging equipment an interval of 10 seconds was set to record all the relevant temperatures on the E6 heat pump. The Eltek logger also recoded kWh from an electric power meter source set on 3 Phase and a water heat meter 'Amtron E' which recorded kWh. All data recorded was imported from the data logger into Excel.
Reviewing the results obtained in the Excel spread sheet it was noted that COP could only be measured at every 1 kWh pulse from the water heat meter 'Amtron E' due to the default factory setting. Therefore COP calculated in all test conditions was limited to a maximum of 5 intervals which are plotted in Figure 7, page 9, 'Tadpole experiments COP's. All experiments started and stopped at approximately the same hot water (GT3) temperature as each other.

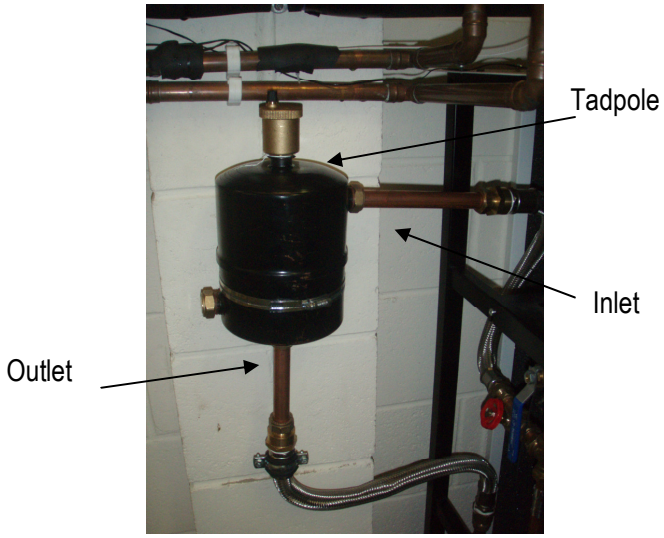
GT3 Start Temp = 51^0C
GT3 Stop Temp=55^0C

The first experiment conducted was without the 'Tadpole' using a bypass method, running off 150 litres of hot water and recording the kWh produced and consumed, therefore the E6 COP is calculated.

The second experiment is with the 'Tadpole' bypass closed, again running off 150 litres of hot water recording the kWh produced and consumed.

The third is a repeat of the second experiment to support the conclusion.

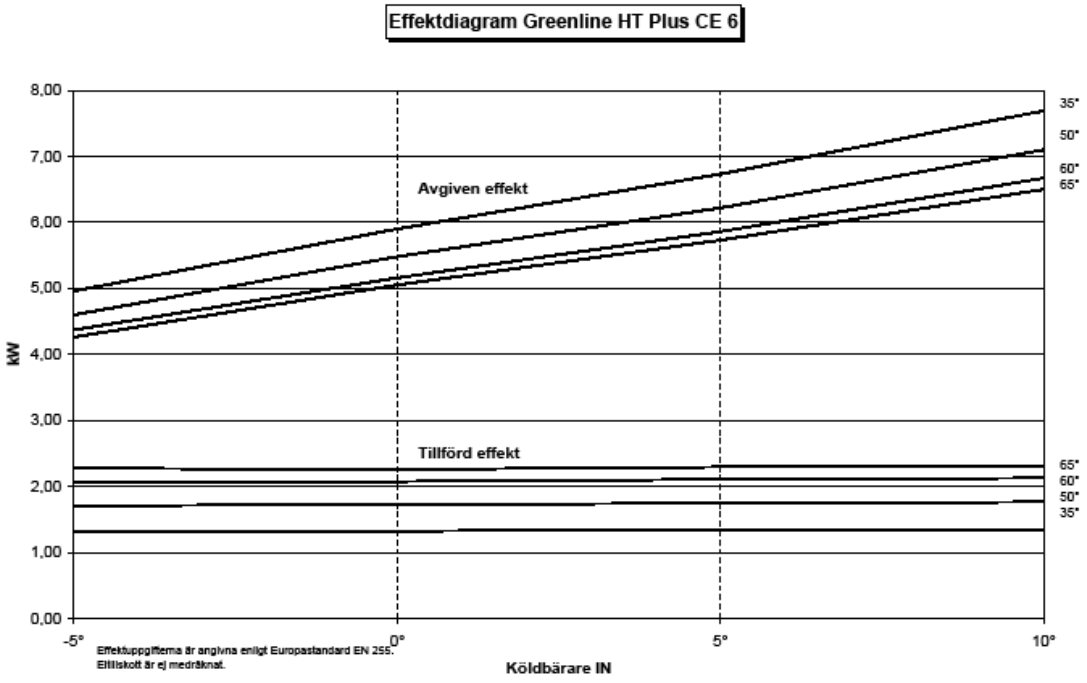
It is important to indicate that in order to support a fair test a correction factor should be introduced when calculating the COP for the 2nd and 3rd experiments. Due to difference in the temperatures of the ground loop GT10 and GT11 from the water tank compared to the 1st experiment.
Therefore the following calculations are used to incorporate the correction factor to the COP.



3.0 Results

In order to obtain a fair result a correction factor is applied at for each COP recorded. The process used to calculate a percentage for the CF (correction factor) at every COP instance is conducted with the use of an IVT Effect Diagram. The 50^0C linear line has been use for the CF as it the nearest degree to all experiments GT8 values.

Note: Please see page 12 for GT temperature references.



[1] IVT Effect Diagram HT Plus C/E 6
Figure 1

The graph has been reviewed for the linear equation y = mx + c. So it can be transposed onto an excel spreadsheet and thus correction factors can be applied. Please see Figure 2.

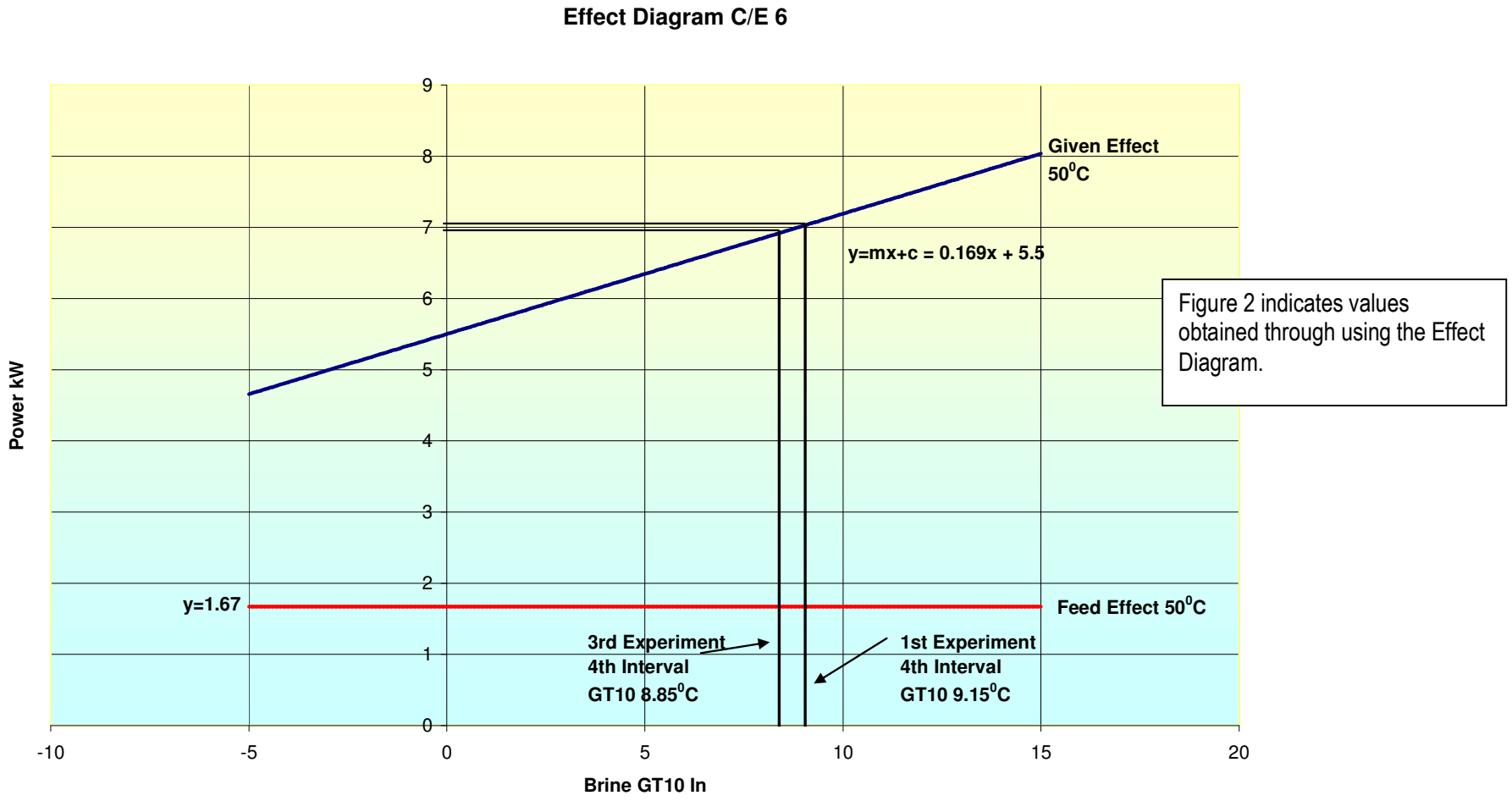


Figure 2
The details of effect are given according to European standard EN255. Electrical cartridge is not included.

4.0 Table of Results

2nd Experiment (1st Tadpole Test)				Graph Data From Effect Diagram					
	COP		GT8	GT10	Consumed kW	Omitted kW	Effect Diagram COP	CF	COP with CF
Time	With Tadpole	Without	^{0}C	^{0}C					
00:34:00	4.19		49.9	8.45	1.67	6.93	4.15	1.0520	4.407946441
00:45:00	3.74		51.6	7.7	1.67	6.80	4.07	1.0541	3.944101763
00:56:30	3.44		53.35	7.3	1.67	6.73	4.03	1.0535	3.625090563
01:08:00	3.25		55.1	6.95	1.67	6.67	4.00	1.0528	3.418067879
01:19:30	3.13		56.4	6.65	1.67	6.62	3.97	1.0520	3.287506977
1st Experiment (without Tadpole)									
00:29:10		3.42	49.95	10.7	1.67	7.31	4.38		% Improvement
00:39:40		3.21	51.4	10	1.67	7.19	4.31		
00:50:10		3.09	53.1	9.55	1.67	7.11	4.26		22%
01:01:10		2.98	54.85	9.15	1.67	7.05	4.22		19%
01:12:10		2.90	56.55	8.8	1.67	6.99	4.18		15%
									15%
									12%
								Average	17%

Figure 3

3rd Experiment (2nd Tadpole Test)					Graph Data From Effect Diagram				
	COP		GT8	GT10	Consumed kW	Omitted kW	Effect Diagram COP	CF	COP with CF
Time	With Tadpole	Without	^{0}C	^{0}C					
00:26:30	3.94		47.95	10.85	1.67	7.33	4.39	0.9965	3.9234
00:37:00	3.56		49.5	9.85	1.67	7.16	4.29	1.0035	3.5713
00:48:00	3.33		51.3	9.3	1.67	7.07	4.23	1.0059	3.3503
00:58:30	3.22		53	8.85	1.67	7.00	4.19	1.0072	3.2448
01:10:00	3.08		54.85	8.55	1.67	6.94	4.16	1.0060	3.1035
1st Experiment (without Tadpole)									% Improvement
00:29:10		3.42	49.95	10.7	1.67	7.31	4.38		
00:39:40		3.21	51.4	10	1.67	7.19	4.31		13%
00:50:10		3.09	53.1	9.55	1.67	7.11	4.26		10%
01:01:10		2.98	54.85	9.15	1.67	7.05	4.22		8%
01:12:10		2.90	56.55	8.8	1.67	6.99	4.18		8%
									7%
								Average	9%

Figure 4

The highlighted yellow cells indicate that the GT8 temperature for the experiment is approximately the same as the Effect Diagram 50^{0}C line in Figure 1 & 2. The Average improvement calculated is 9%.

4.1 Correction factor Example

Example Correction factor (CF) from 1st experiment applied to the 4th COP interval of 3rd experiment.
Interval time 58 min and 30 seconds.

3rd experiment 4th COP interval is at 00:58:30 the following table shows kWh recoded.

Meter Name	Measuring	kWh Recorded
Amtron E	Hot water omitted	5
Carlo Gavazzi WM2-DIN	Energy consumed	1.552

Figure 5

$$\therefore COP = \frac{5}{1.552} = 3.22$$

$$with\,CF\,to\,COP = 3.22 \times 1.0072 = 3.24$$

The 4th COP interval for the 1st experiment (without Tadpole) at 01:01:10 is shown below:

Meter Name	Measuring	kWh Recorded
Amtron E	Hot water omitted	5
Carlo Gavazzi WM2-DIN	Energy consumed	1.676

Figure 6

$$\therefore COP = \frac{5}{1.676} = 2.98$$

The improvement using the 'Tadpole' is:

$$= \frac{\left(CF\,COP^{3rd} - COP^{1st}\right)}{CF\,COP^{3rd}} = \frac{(3.24 - 2.98)}{3.24} = 0.08 \therefore 8\%$$

4.2

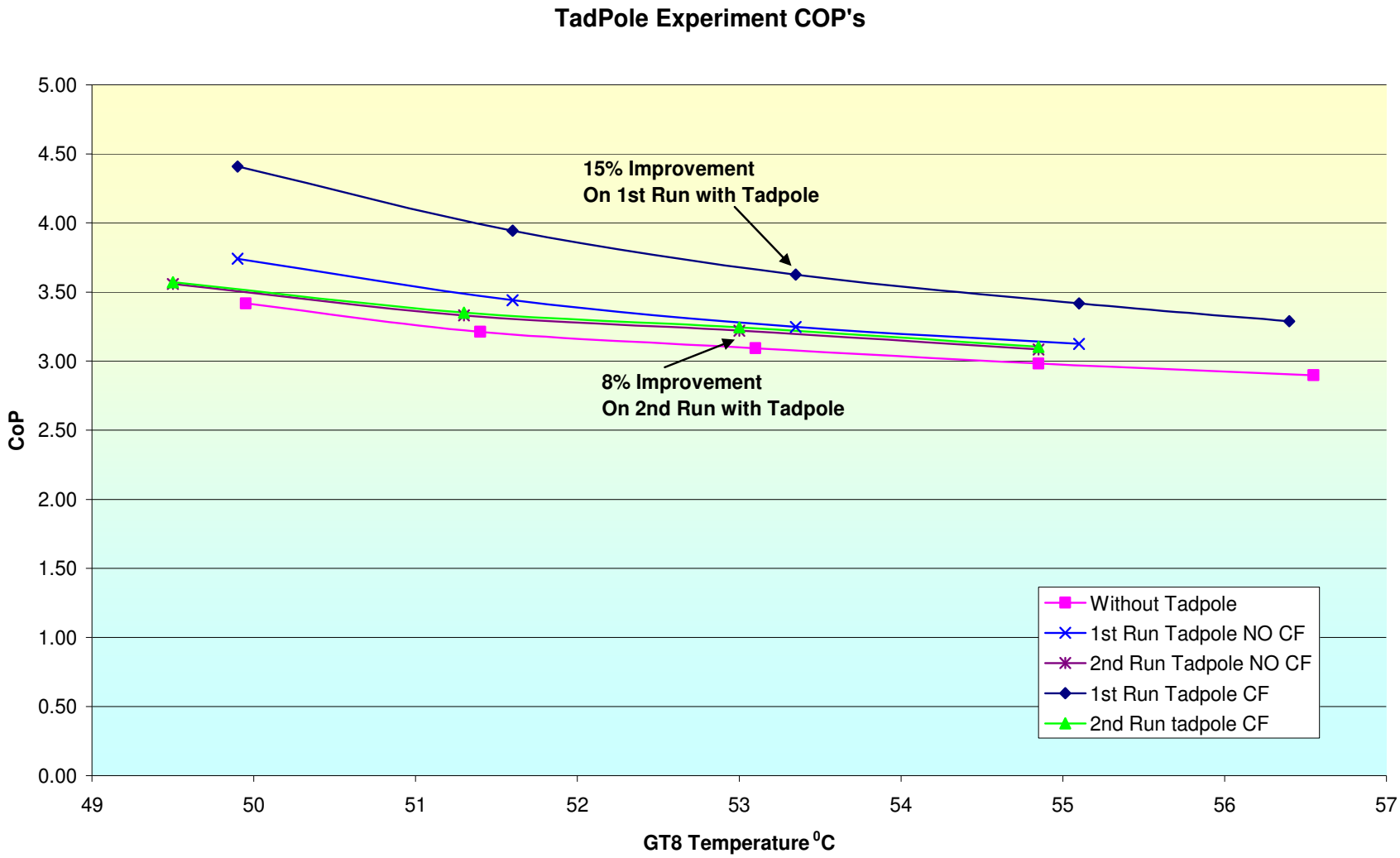


Figure 7 GT8 = Rad/ DHW Hot Flow Temperature (Please see page 12 for references)

5.0 Conclusion

Reviewing both experiments using the Tadpole and the 1st run without the Tadpole, there is a clear indication that there is an improvement using the device.
However both experiments using the Tadpole showed different results in average improvement;

- 1st Tadpole results = 15% improvement
- 2nd Tadpole result = 8% improvement

See Figure 7 for a graph representation.

The second run using the Tadpole would prove to be a more accurate result due to the similarities in temperatures on the GT sensors for both the 1st experiment without Tadpole and 3rd experiment with Tadpole. Therefore when applying the correction factor it doesn't greatly effect the COP.

A fair result based on this report would be to conclude an improvement of 8% using a Tadpole.
Additional support for the conclusion would be to run another Tadpole experiment.

6.0 Bibliography

[1] IVT Effect Diagram HT Plus C/E 6

7.0 Heat Pump Temperature Sensors

GT1	**Return**
GT2	**Outside (North facing)**
GT3	**Hot Water Tank**
GT4	**Shunt Valve**
GT5	**Room**
GT6	**Compressor**
GT8	**Heat Carrier Out (Condenser)**
GT9	**Heat Carrier In (Condenser)**
GT10	**Heat Transfer Fluid (Evaporator) Into the Heat Pump**
GT11	**Heat Transfer Fluid (Evaporator) Out of the Heat Pump**