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Testing of Commercial Tadpole Product in an oil Fired Central Heating System for the Holy Family Primary School, Tralee.

Report

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1.0 Introduction

Tadpole Energy Ltd. approached Dr. James Prendergast and Mr. Chris O' Donoghue who lecture in the Department of Engineering, School of STEM in the Institute of Technology Tralee, Co. Kerry, to independently test a Commercial Tadpole unit they had developed. A small commercial building was required. It was decided to test the unit in a primary school as energy use in such an establishment is generally predictable. The company sought expressions of interest from several primary schools in and around Tralee and finally settled on a primary school located at Balloonagh, Tralee. It was agreed in conjunction with IT Tralee that the following tests would be carried out and a report compiled on the results of the tests:

1) A 24 hour test to enable a baseline to be obtained without the unit installed and measuring the appropriate parameters. Zone 1 was chosen to run continuously over a weekend period when the school was unoccupied for this 24 hour test.
2) A similar test to 1 above but this time with the Commercial Tadpole installed.
3) A longer test over a 3 week period without the unit in the system to reflect general operating conditions of the school central heating operation and recording results from all zones in the school.
4) A comparison test to 3 above with the unit installed.

The parameter chosen as measurables for the tests 1 and 2 above was Dissolved Oxygen (DO) in parts per million (ppm), For tests 3 and 4 oil usage, on time of burners and outside temperature were recorded.

The Commercial Tadpole product (figure 1) utilised 54 mm connections and was installed by KMS Ltd. along with an oil meter and burner counters. Appropriate shut off valves were also included to enable the unit to be bypassed if necessary depending on test requirements.

Figure 1 Commercial Tadpole unit 54mm installed.

Figure 2 The Holy Family Primary School (*source: http://www.hfstralee.com/about/history*)

2.0 Test Site Description

The test site, figure 2, consisted of a 4 zone oil fired heating system retrofitted to the building during summer works in 2014. This is a state of the art heating system. The building itself was built around 1979 and first occupied in January 1980 and today the school has a staff of 20 teachers and support staff with a total of 300 students.

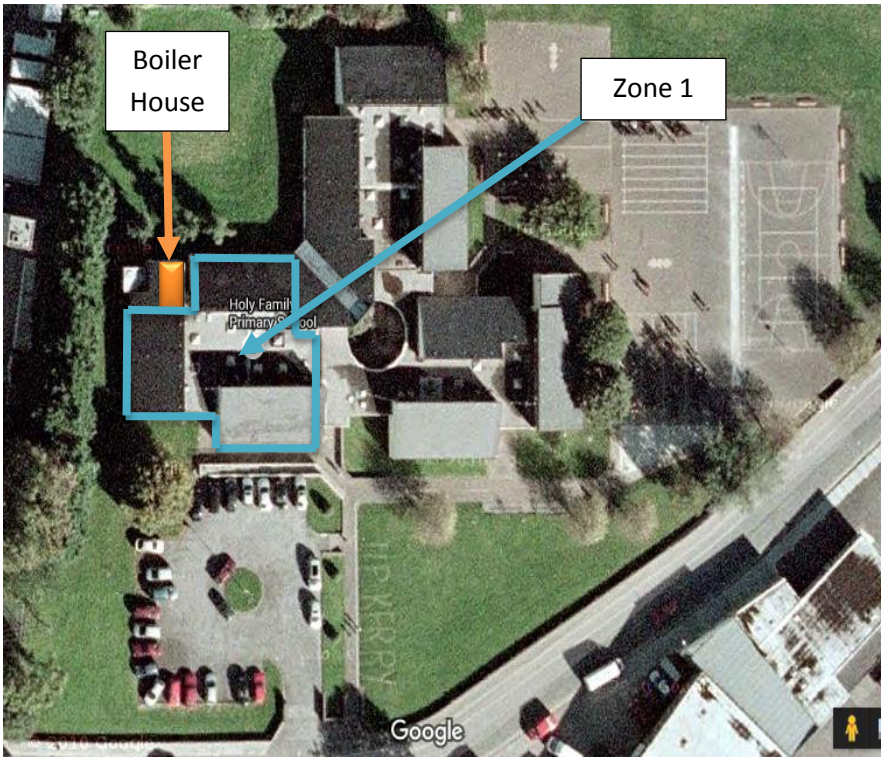

Figure 3 Arial photograph of school buildings (*source: https://www.google.ie/maps*)

The boiler house was located as shown in figure 3 in the western extremity of the school adjacent to the oil tank house. A layout of the boiler house/tank house can be seen in Figure 4. Zone 1 was used for testing during the 24 hour test only. This zone consisted of 22 radiators, 2 of which were permanently shut off.

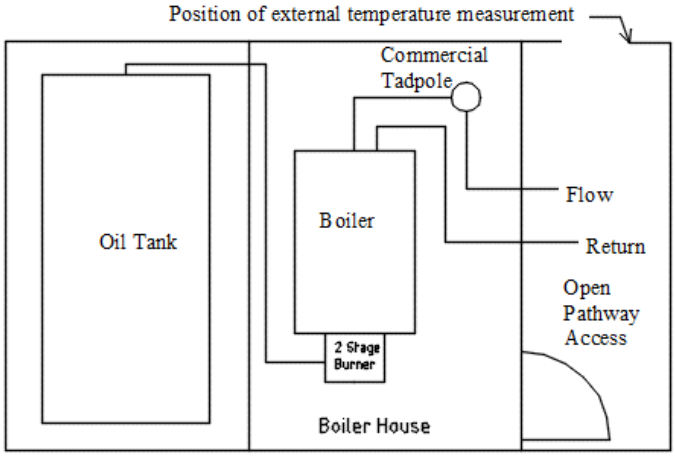

Figure 4 Layout of Boiler and Tank houses

3.0 Boiler and Burners

The boiler was a cast iron DeDietrich GT 339 Oil fired unit giving a useful output of between 280 to 330 KW. It used a 2 stage Riello RL44 burner. Both Burners were set at 70 °C and setting was not altered between test periods, figure 5 and Table 1.

Figure 5 Boiler/Burner ID plates and Burner

Table 1 Boiler and Burner specifications

Boiler Make/Model	DeDietrich GT 339
Heat Output	280 – 330 KW
Max Operating Pressure	6 bar
Max Operating Temperature	90° C
Burner Make/Model	Riello RL44

4.0 Heating System Control

The heating system was controlled using a 4 channel controller, figure 6, in the principals office. Operation of the 24hour tests consisted of switching Zone 1 to constant operation for a period of 24 hours during weekend slots. The longer operation tests (3 weeks) involved the school recording their use of the heating system in relation to on time duration on a daily basis.

Figure 6 Heating System control panel

5.0 Test Parameters

Parameters that were measured and recorded with respect to on time duration of the system for the 24 hour and 3 week tests were as follows in Table 2:

Table 2 Parameters measured and recorded for tests

24 Hour Tests	3 Week Test
Dissolved Oxygen (ppm)	Time zones are on (Hrs)
	Oil Consumed (L)
	Stage 1 Burner on time (Hrs)
	Stage 2 Burner on time (Hrs)
	Outside Temperature (Met Eireann/Accuweather)(°C)

5.1 Dissolved Oxygen

A sample of system water was drained off periodically from a drain valve installed between the return and the shunt pump circuit as seen in Figure 7. A portable Dissolved Oxygen meter was used to measure the D.O. levels in parts per million for these samples and then these results were recorded.

Figure 7 Sample drain valve.

5.2 Oil Consumption

For tests 3 & 4, outlined in the introduction, oil consumption was measured using an oil volume flow meter installed by KMS in the oil flow line to the burner as seen in Figure 8.

Figure 8 Oil Volume meter

5.3 Burner On-Time

The Riello 44 used a two stage burner operation. KMS installed electrical counters for both burners and these could be read in hours and 1/100 of an hour of operation. This panel installation can be seen in Figure 9.0.

Figure 9 Burner On-Time for both Riello burners.

6.0 Results

The results from the 24 Hr. and 3 week tests are outlined in the following sections

6.1 Dissolved Oxygen

The dissolved oxygen was measured on the return to the boiler at a point where the shunt from the flow joined the return as seen in Figure 7.0.

The graphs in Figure 10 and 11 represent the results with and without the Tadpole installed. Without the Tadpole installed there was a large variation in the D.O. as seen below and the system never reached a consistently low level until well into the test, around 600 minutes. The lowest value achieved was 0.5 PPM at 110 minutes into the test but it was not able to maintain this value. The dissolved oxygen PPM initially started at 2.7 and the average value achieved during the test was 1.46. The large variation seen around the 1.5 PPM value would have been seen abnormal but may be consistent with the large amount of cavitation seen on the primary pump on the flow. This was a clear and audible vibration from the pump which was not expected and was not measurable at the time. This would indicate that there was air in the system which caused the vibration/cavitation to occur. When the system was switched over to Tadpole operation, no such vibration or cavitation was experienced.

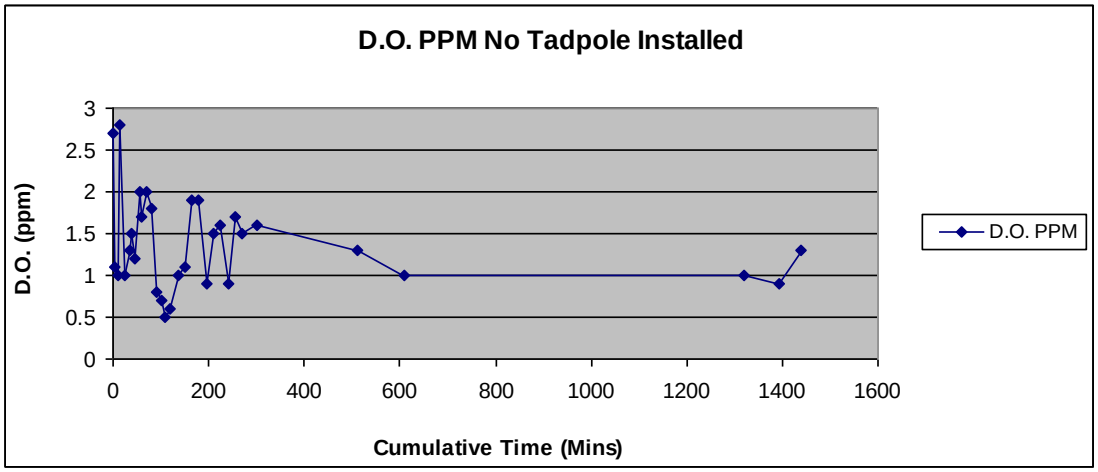

Figure 10 Dissolved Oxygen Levels Test 1 Tadpole Bypassed

When the Tadpole was switched into the system the initial D.O. value was 3.8 ppm which was higher than the 2.7 seen on the test without the Tadpole installed. The reduction in the D.O. was faster and more consistent with the Tadpole installed. There was no cavitation found in the primary pump and none of the wide variation previously seen was present here. The D.O. went from 3.8 to 0.7 ppm in 25 minutes and maintained an average value of just under 0.5 ppm for the remainder of the test. This is in stark contrast to the behaviour of the system without the Tadpole installed. This lower average value was achieved despite initially starting from a higher value (3.8 versus 2.7). The average D.O. in both cases was calculated from start up to end of test and included all values recorded. The D.O. was tested at all the points shown on the curves in figures 10 and 11. The results found here are consistent with tests on the domestic Tadpole performed in June 2010. In this instance the system with the Tadpole installed achieved lower D.O. levels (0.2 ppm) than without the unit installed (1.2 ppm) in a shorter time frame over a 24 Hr test period.

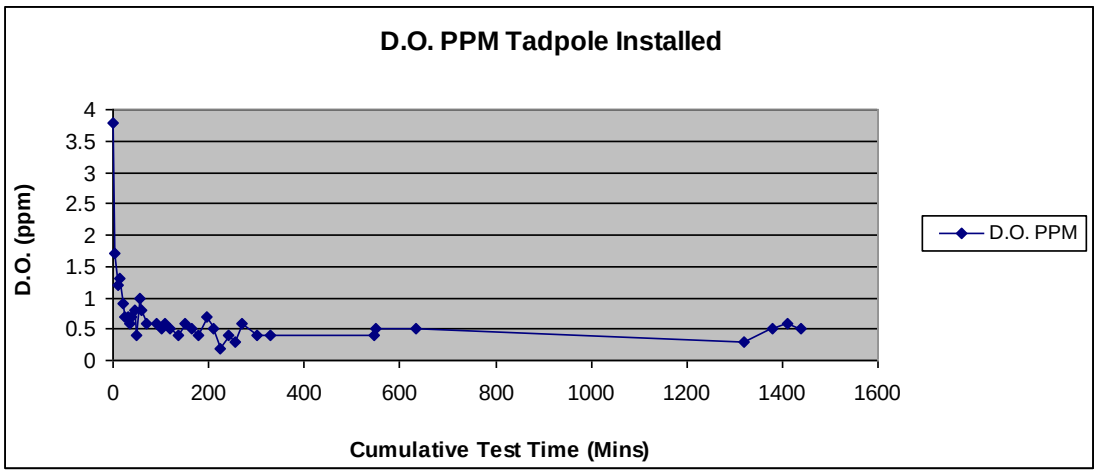

Figure 11 Dissolved Oxygen Levels Test 2 with Tadpole

6.2 “3 Week” Tests

The second phase of tests consisted of testing the Tadpole unit for a longer period in and out of the system. Testing period durations of three weeks in and out were decided upon. The school secretary kept a record of the daily on time of the four zones in the Holy Family School. The oil meter indicating the oil consumed in Litres as well as, stage 1 and stage 2 hour timers for burners 1 and 2 were recorded on a weekly basis. Weather data was sourced from **www.accuweather.com** for the weeks in question. The daily averages were computed using excel and from these averages, weekly averages and consequently averages for the three week periods were calculated. A graph of the temperature for the time frame in question is shown in figure 12 and table 7 shows the dates of the weeks used for this analysis.

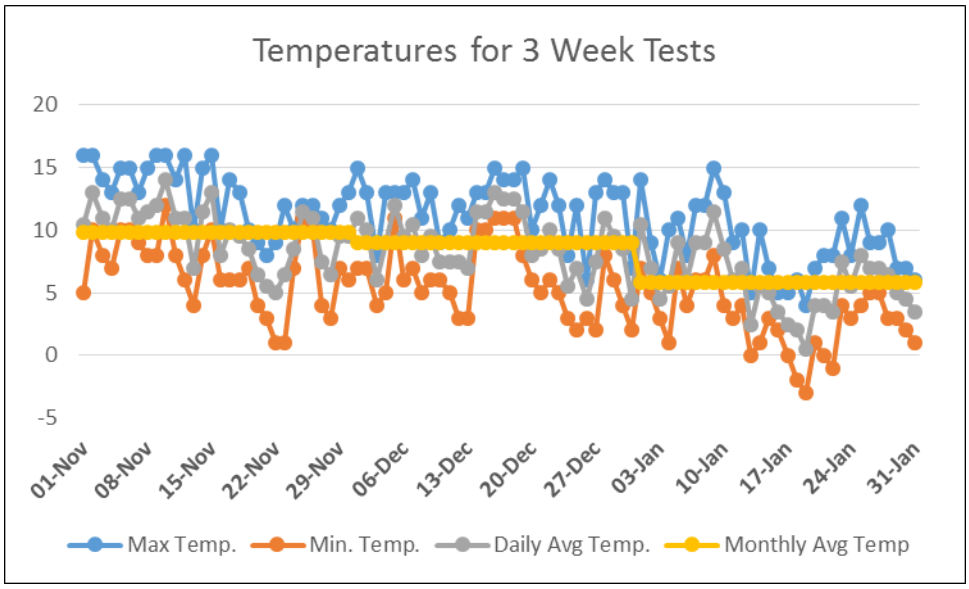

Figure 12: Maximum, Minimum Daily and Monthly Average temperature

Table 7: Weeks and dates of recorded data for analysis

Week No.	Tadpole Installed	Dates
1	Yes	23/11/15 to 29/11/15
2	Yes	30/11/15 to 6/12/15
3	Yes	18/1/16 to 24/1/16
4	No	7/12/15 to 13/12/15
5	No	14/12/15 to 20/12/15
6	No	12/1/16 to 17/1/16

6.3 Summary of Data Analysis – 3 week tests.

The summary spreadsheet in Table 8 shows a breakdown of data recorded and assessed during the total duration of six weeks. There is a significant difference in oil consumption in L/hr between both tests.

Over the three weeks when the Tadpole was installed the average fuel consumption was 17.87 L/hr. This was at an average outside temperature for Tralee of 6.8 ° C.

With the Tadpole taken out we see a less efficient system. The average oil consumption during the three week period was 20.41 L/hr. This was with a warmer outside average temperature of 8.2 ° C, 1.4 ° C warmer than when the system was tested with the unit installed.

Neglecting the fact that the Test with Tadpole installed was conducted at a temperature 1.4 ° C colder than the test without unit installed, we get a 12.44% saving in oil consumption. If we were to account for the external temperature factor, we would get a more favourable saving by comparing oil consumption with the unit installed versus equivalent oil consumption without the unit in the system.

Table 8: Summary of Data set for the 3 week tests.

Tadpole Status	Office Timer Hrs	Stage 1 (hrs)	Stage 2 (hrs)	Oil Used (litres)	temp Average Max	temp Min Average	Average Oil Consumption	Average Temperature
Installed (2 Wks)	37	16.8	16.3	572.3	11.5	6	**15.47**	8.75
Installed (1 Wk)	19	18.4	8.6	428.4	6.6	-1	**22.55**	2.8
Total	56	35.2	24.9	1001			**17.87**	6.8
Not Installed (2 Wks)	33	15.5	15	525.6	12.4	7.3	**15.93**	9.85
Not Installed (1 Wk)	23.5	17.7	17.4	627.6	8	2	**26.71**	5
Total	56.5	33.2	32.3	1153			**20.41**	8.2

Looking at the data in Table 8 without the unit installed we see that the average fuel consumption of 15.93 L/hr applied to the system when it was running at an external average temperature of 9.85 ° C. Similarly we saw a consumption of 26.71 L/hr at 5° C. Assuming a linear scale for this short time period this equates to a difference of 2.22 L/hr for every difference of 1 ° C.

When we factor this adjustment in we get an equivalent fuel consumption of 23.51 L/hr at 6.8 ° C without the Tadpole installed. The savings in this case are calculated at 22.76 % in favour of the Tadpole installed in the system. Again referring to domestic tests carried out in June 2010 similar efficiencies (23.71%) were achieved when degree days were taken into consideration to calculate energy savings.

7.0 Conclusion

From analysis of data in tests carried out, it can be seen that there was significant improvement in D.O. levels with the Tadpole installed. This reduction was more uniform and reached a lower level of D.O. in a shorter time frame. This can be seen in the 24 hour tests. When the 24 Hr and 3 week tests are considered together the figures achieved mirrored the results for the domestic Tadpole as mentioned above from the viewpoint of reduction in D.O. levels and the rate of reduction in these levels. These reductions contribute to reduced maintenance by reducing corrosion and cavitation. This is a critical parameter in corrosion resistance, especially in larger systems like the Holy Family School. Systems of this nature have a large variation in cycles and this leads to a larger increase in D.O. when the system is shutting down frequently. The reduction in D.O. also provides a more uniform heating fluid.

Furthermore there was considerable savings in energy consumption by having the Tadpole installed both in the domestic and commercial systems. The "3 week" tests indicated considerable savings in oil consumption. Neglecting the influence of outside temperature we see savings in oil consumption of 12.44 %. When factoring in outside temperature, savings were calculated to be 22.76 % with the Tadpole installed. These savings were 23.71 % for the domestic Tadpole and 22.76 % for the Commercial Tadpole.

References

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