

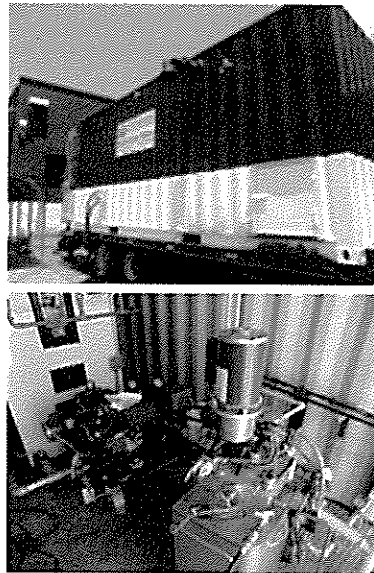
# **POWER MECHANICAL, INC.**

## **BOILER SPECIALISTS**

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# **Study of the Efficacy of a Cavitronix E2C 25 Emulsion Generating Device on a Typical Steam Boiler**

**Test Conducted at PMI Yard  
Newport News, Virginia  
July 5 & 6, 2011**



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In Cooperation with  
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July 10, 2011

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## **Purpose:**

To operate one of PMI's Mobile Boilers and measure the performance in terms of fuel savings and emissions reduction using straight #2 heating oil and a water-in-oil emulsion created by a CavitroniX Corporation emulsion generator. (Emulsion to Combustion™ - E2C® unit)

## **Background:**

Cavitronix Corporation (CVX) approached PMI with a proposal to provide their equipment for installation on PMI boilers in order to benefit PMI customers through reduced fuel consumption and a reduction in NOx and CO<sub>2</sub>. CVX also claims a reduction in soot production.

PMI proposed to test these claims and analyze the results prior to suggesting such an installation to any of their customers who are currently renting or operating oil fired boilers.

## **Preparation:**

PMI set up a new Columbia boiler Model WL 140 (PowerFlame Burner Model CR2-GO-20A) which had been recently procured & installed in a modified shipping container on a trailer and then used as the test boiler in this study. CVX shipped a Cavitronix E2C 25 including the control panel and distribution manifold to PMI, which installed the CavitroniX unit in the shipping container on a movable cart. On July 5, 2011, Charles Markert, CVX Chief Engineer, arrived and determined the setup to be correct and assisted in priming the system in preparation for testing. On the next day PMI installed a steam flow-meter on the steam output line of the test boiler to compare runs on straight oil to runs on emulsion.

John Haytko supervised the test and was assisted by Clay Richtor and Dean Courter in the installation, setup and operation. Charles Markert assisted in the setup and operation of the E2C®. The Instrumentation and the testing protocol were a collaboration between Mr. Haytko and Mr. Markert so both parties (PMI & CVX) agreed as the process.

## **Operation:**

PMI fired up the boiler on July 5, 2011 and initiated the E2C® operation. Once the boiler was running properly, the E2C was inserted into the fuel train and provided straight 'oil only' through the system to ensure proper fuel delivery capacity. Steam was vented through a chamber to atmosphere and the steam outflow valve was adjusted to ensure adequate steam pressure for the test.

The test proceeded with the steam outflow valve left in the same position for both test fuels (oil & emulsion). The tests on day 1 were mostly done at the low fire setting. The nozzle was an 8 gph nozzle even though low fire capability on the PowerFlame Burner was listed as 5.5 gph.

At the beginning of day 2, it was determined that in order to know the true savings, it would be necessary to install a PMI flow meter in the steam output line. PMI fabricated piping and installed the steam line flow meter.

Testing resumed at High Fire while waiting for the Steam meter to be installed. The steam pressure was brought up to 5 psi before the high fire test measurements were started. The system was balanced to maintain constant pressure by opening the main steam valve to let out the exact amount of steam as that produced.

Upon installation of the Steam meter on the outflow line, one last series of measurements were taken on high fire for each fuel (straight oil and water-in-oil emulsion). It was verified that the quantity of the steam produced by the boiler when running on emulsion was at least as great as the steam produced when the boiler was running on straight fuel oil. In fact, the testing showed that the quantity of the steam (and therefore the energy output of the boiler) was slightly greater on emulsion than on straight fuel oil. Therefore, the testing team concluded that the use of emulsion did not cause any derating of the boiler.

### Equipment:

#### E2C®

Cavitronix E2C 25 System, Model M-25, Maximum Capacity 25 gph

### Instrumentation:

Bacharach Electronic Combustion Analyzer, Model PCA2

Steam Flow Meter, Model "Microtel Smart TX"

PM Measurement Device (Filter Paper and Hand Vacuum Pump) by Bacharach

### Results:

The following summary data tables were taken from the analysis computations contained in the Spreadsheet shown in the Appendix.

Low Fire Oil (gph)	Percent Water-in-oil	Percent Change % Efficiency	Percent Change % CO2	Percent Change Stack Temp	Percent Change ppm NOx	Change in Oil Consumed (%)
8.3	20.5	1.3	-5.9	-8.0	-30.1	-15.4
8.3	14.8	0.8	-1.7	-3.3	-16.5	-15.4
8.3	8.7	1.7	0.8	-7.1	-14.0	-3.3

Hi Fire Oil (gph)	Percent Water-in-oil	Percent Change % Efficiency	Percent Change % CO2	Percent Change Stack Temp	Percent Change ppm NOx	Change in Oil Consumed (%)
12.5	9.8	-0.7	-10.2	-3.8	-30.6	-11
12.5	6.9	-0.2	-6.3	-2.7	-19.4	-7.4
12.5	6.5	-1.0	-8.2	-1.8	-21.1	-7.0

Note: Measured Steam Output Flow (lb/hr) Generated by Emulsion, was +0.08% more than with straight oil.

Note: Soot was not determined for either fuel given the lack of equipment sensitivity to measure soot.

### **Observations:**

Power Mechanical Inc. completed a series of tests on the Cavitronix E2C 25 Emulsion to Combustion System that had been installed on a new mobile boiler.

1. Fuel consumption is reduced while steam production is not. The results of measuring the steam output confirmed an increase (albeit minor) in steam production using emulsion, therefore, the use of emulsion did not cause a de-rating of the boiler.
2. Savings in fuel varies depending on the percentage of water added to the fuel.
3. The system does not send emulsion (water) back to the fuel tank.
4. NO<sub>x</sub> is reduced significantly while using emulsion.
5. Reduction in NO<sub>x</sub> varies depending on the percentage of water added to the fuel.
6. The percentage of water in the emulsion necessary to achieve maximum fuel economy is different from the percentage necessary to achieve maximum reduction in NO<sub>x</sub>. The formula for the emulsion could be varied to optimize either fuel economy or NO<sub>x</sub> reduction. .
7. The system was relatively easy to install given the installation instructions.
8. The system works as claimed by Cavitronix Corporation.

**The bottom line from the tests at the end of the two days is that the emulsion maintains boiler efficiency and shows the following specifics taken from the summary table:**

9. At low fire and 14.8% water NO<sub>x</sub> is reduced by 16.5% and fuel consumption is reduced by 15.4%
10. At high fire and 9.8% water, NO<sub>x</sub> is reduced by 30.6% and fuel consumption is reduced by 11.0%

This test supports the idea that by replacing some of the oil with water in the form of emulsion (not water injection) using the E2C® technology produces the same energy output. According to Cavitronix, this is a result of the secondary atomization caused by the water droplets violent conversion to steam, breaking the oil droplet into a finer, more combustible mist resulting in a more complete burn. Based on this test, PMI concludes that the Cavitronix E2C® offers both significant fuel savings and very substantial reduction of NO<sub>x</sub> emissions to end users with fuel oil boilers or furnaces.

# Appendices

## Photos

