Rossi 6 Oct 2011 Experiment Data Review

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BASIC DATA AND CALCULATIONS

The following is in regard to the Rossi 6 Oct 2011 E-cat experiment, as reported by Mats Lewan of NyTeknik here:

http://www.nyteknik.se/nyheter/energi_miljo/energi/article3284823.ece

http://www.nyteknik.se/incoming/article3284962.ece/BINARY/Test+of+E-cat+October+6+%28pdf%29

A spread sheet of the NyTeknik data is provided here:

http://www.mtaonline.net/~hheffner/Rossi6Oct2011.pdf

The format used is useful for calibration runs, where it is known there is no excess heat. If the protocol is good and sufficiently long, and the measurements good, then at the end of the run the COP ends up at 1.

A graph of this spread sheet data, Graph 1, is appended.

Note that an extra 0.8°C was added to the delta T value so as to avoid negative output powers at the beginning of the run. This extra 0.8°C compensates to some degree for bad thermometer calibration and location, but results in a net energy of 22.56 kWh vs 16.62 kWh for the test, and a COP of 3.229 vs 2.643, i.e. introduces a potential 37% error to the high side, which compounds any other such errors.

A spread sheet without the 0.8°C bias is here:

http://www.mtaonline.net/~hheffner/Rossi6Oct2011noBias.pdf

POTENTIAL IMPROVEMENTS INDICATED

The 22.56 kWh excess energy for the test amounts to 81.2 MJ excess above the 36.4 MJ input. This is extraordinary, scientifically speaking, if it is real. However, the lack of calibration and bad placement of the thermocouples makes the data unreliable. The experiment was closer than ever before to being credible. Just a few things might have made all the difference.

First, a pre-experiment run could have been made to iron out calorimetry problems. A lower flow rate and thus larger delta T would have improved reliability of the power out values.

Second, the lack of hand measurements of the cooling water temperatures Tin and Tout periodically was unfortunate, especially when the larger values of delta T were present. The thermometers should be relocated down the rubber hose a short distance and insulated.

Third, a kWh meter could have been fairly cheaply purchased or obtained and read at the same time the other electric meters were used.

Fourth, a filter to smooth any pulsed current demand from the E-cat power supply could have been used, or an oscilloscope used to ensure no such pulses were imposed on the input current.

Fifth, the flow meter volumes could have been manually recorded at the same times temperature readings were recorded.

GENERAL COMMENTS

A control calibration run was not made, as evidenced by a 0.8°C minimum error in the delta T for Tin and Tout.

No kWh meter was used to measure the total input energy. It is far better to record E(t) frequently and then derive power P(t) by

P(t) = d E(t)/dt

than to occasionally and sporadically take power measurements and integrate to obtain E(t).

Flow meters were used but apparently no one thought to record time stamped volume data for both circuits throughout the demonstration. Some volume data was recorded by Mats Lewan, who is a journalist and not part of the Rossi team.

It is much more accurate, depending on flow variations, to calculate flow f(t) from volume v(t) as:

f(t) = d V(t)/dt

than to integrate:

V(t) = integral f(t) dt

(or a similar integration to obtain energy) using occasional sporadic short interval flow measurements. This is the value of using volume meters. Because they monitor continuously, they catch brief excursions that might otherwise be missed. This appears to actually be a small point in this case, however, at least with respect to heat exchanger power, because fortunately some flow volumes were taken by Mats Lewan measured by meter, as well as flow rate, by periodic hand measurements, and total volume measured vs volume estimated from the flows does not appear to be an issue, at least compared to the other issues.

No measurements of volumes or flows into the E-cat were taken. It is unfortunate that the flow meter for the flow into the E-cat was not recorded frequently. This could provide some consistency checking with regards to pressure assumptions, T2 values, and types and quantities of flows expected at the heat exchanger input.

The secondary circuit flow rate chosen was too large, resulting in a maximum delta T of about 10.8°C at 16:50 (338 min.), and thus 11.6°C with 0.8°C correction added, and thus unreliable accuracy in the heat measurements. The measurements might have been more reliable if the thermocouples had not been placed on insulated metal parts, i.e. connected directly, metal to metal, to the heat exchanger itself. They should have been separated from the heat exchanger by low conductivity material, such as a short length of rubber hose, to avoid thermal wicking problems through the metal. The same applies to the output temperature measurement for the E-cat. This is the same problem as before, when the thermometer was buried in the earlier E-cats, but compounded. This makes the temperature data highly unreliable.

From the report:

"Room temperature was between 28.7 °C and 30.3 °C."

"18:53 Tin = 24.3 °C Tout = 29.0 °C T3 = 24.8 °C T2 = 116.4 °C"

"18:57 Measured outflow of primary circuit in heat exchanger, supposedly condensed steam, to be 328 g in 360 seconds, giving a flow of 0.91 g/s. Temperature 23.8 °C."

"19:22 Tin = 24.2 °C Tout = 32.4 °C T3 = 25.8 °C T2 = 114.5 °C"

"Measured outflow of primary circuit in heat exchanger, supposedly condensed steam, to be 345 g in 180 seconds, giving a flow of 1.92 g/s. Temperature 23.2 °C." (At 19:22)

These values indicate a significant problem with temperature measurement. One problem is the output temperature recorded for the "condensed steam". Perhaps that was a repeated recording error, i.e. an error which occurred at both 18:53 and 19:22. The "condensed steam" is measured leaving the heat exchanger at a temperature lower than room temperature by at least 5°C, and lower than the Tin of the exchanger by 1°C. Mats Lewan states this may be due to a calibration problem with the thermometer he brought and with which he made this measurement.

The report states: "In about 3:30 hours of self sustained mode (from 15:53 until 19:25), a total energy of Pheat x 3.5 = 10.5 kWh were then produced, or 38 MJ."

This implies a mean power production for that interval of (10.5 kWh)/(3.5 h) = 3 kW. However, the report immediately mentions conflicting data: "**Another way** to calculate the power produced is to consider all the water at the output from the primary circuit as condensed steam. At 18:57 output flow was measured to be 0.91 g/s."

"If this corresponds to the same flow being vaporized in the E-cat, and given that enthalpy of vaporization is 2260 J/g, this would require a heating power of 2260 x 0.91 ≈ 2 kW"

This means there is reason to suspect a 50% error in heat measurement for this period, i.e. 2 kW heat looking like 3 kW heat. This may be compounded at times with a 37% error added in this report spreadsheets due to 0.8°C added to delta T due to calibration errors.

ANOMALOUS FAST POWER OUTPUT INCREASE WHEN POWER CUT

It is notable that when the power is turned off, for example at time 14:20, and 14:51, and 15:56, the power Pout actually rises. This may be a confirmation that the Tout thermocouple is under the influence of the temperature of the incoming water/steam in the primary circuit. Water carries a larger specific heat. Cutting the power may introduce water into the output stream, as seen before. If the thermocouple within the E-cat is subject to thermal wicking, the water temperature may actually be 100°C, as before. This sudden flow of 100°C water could then account for the at most 11.6°C increased temperature from the Tout thermocouple, which is located close to the hot water/steam input.

The E-cat began leaking at the rate of about 2 kg per hour at 14:00 (168 min.). The water dropped from the lower edge of the wrapped E-cat. The insulation prevented knowing where the source of the leak. It seems highly coincidental that Pout and Eout began rising substantially right after 14:00 (168 min.) This may be an indication that water overflow via percolator effect began at about 14:00. The fact water or steam was leaking at such a large rate is an indication the E-cat should not have been under significant pressure after that time. The leak, plus the fact the primary water circuit is open following the heat exchanger, should make achieving a significant pressure unlikely.

Also anomalous is that all power was cut at 19:08 (476 min.) Hydrogen pressure was eliminated. By 19:22 the thermal power out measured jumped from 4.2 kW to 7.1 kW, a roughly 70% increase in power. This could be explained by a burst of nuclear power triggered by a high internal diffusion rate. It could also be explained by increased liquid water overflow. The latter is indicated as more probable by the fact that the internal E-cat temperature, T2, dropped from 116.6°C to 108.1°C during the apparent power burst.

In any case, it is nonsensical that when power is cut that output power quickly momentarily rises. This kind of mystery can be, should be, unraveled using a dummy device and then an inactive (no hydrogen) E-cat during calorimeter calibration sessions.

POSSIBLE SYSTEMATIC THERMOMETRY ERRORS

Regarding the Tout thermocouple, examine these photos of the hot end of the heat exchanger:

http://www.redmatica.com/media/Thermo1.jpg
http://www.redmatica.com/media/Thermo2.jpg

The central brass fitting is very thick. Given the hose ID is about 1.5 cm, perhaps over a cm thick. It appears from the wire length the thermocouple was placed not far from it.

The intermediate section looks to be at least 0.75 cm thick

From the location of the tape, and the protruding thermocouple, in:

http://www.redmatica.com/media/Thermo2.jpg

it appears the thermocouple may have been taped to the large steel nut, possibly extending into the air beyond it.

Note: the steam/water inters the heat exchanger at the same end where the Tout thermocouple is located.

If we designate Thot to be the temperature of the water/steam arriving at the steam/hot water entry port, then there is some composite thermal resistance R1 from the Tout water to the Tout thermocouple, and a similar thermal resistance R2 to the Thot water/steam, then the thermocouple will be at a temperature of 24°C + (R2/(R1+R2)*100°C. To get an 10.8°C difference all is needed is for r=(R2/(R1+R2)) to satisfy:

r * (100°C-24°C) = 10.8°C

r = 10.8/76 = 0.14

It is notable that a 10.8°C systematic error is not necessary to explain the total heat output. Only enough systematic error is required to explain the excess heat to fully invalidate the test, i.e. to indicate there is no nuclear heat at all. It is not necessary to account for the power input in the power out. It is only the excess that is important to determine if nuclear energy is being produced.

This photo by Mats Lewan of NyTeknik of the 6 Oct Rossi Tout thermocouple that it can and probably did extend beyond the steel nut, toward the brass manifold:

http://www.mtaonline.net/~hheffner/LewanTcoupleClose.jpg

It was thus subject to the air temperature in the volume underneath the insulation and between the brass manifold and steel nut. It is especially notable that the frayed insulation, cut from around the probe tip, was not trimmed. This is very unusual. The frayed electrical insulation may have prevented good thermal contact of the thermocouple with the steel nut, and thus exposed the thermocouple primarily to the air temperature in the vicinity, which would be expected to be higher than that of the steel nut.

The effect of the steam/hot water on the delta T of the heat exchanger secondary circuit, due to misplacement of the thermocouple, is the application of a constant factor to delta T. Call this factor **Tadj**.

T2 THERMOCOUPLE LOCATION

Regarding the T2 probe, examine the two photos to the right of this article:

http://www.nyteknik.se/nyheter/energi_miljo/energi/article3284823.ece

The top one shows the E-cat with the T2 thermocouple probe inserted down through the T fitting located on top. The second photo shows the E-cat without insulation and the cover removed. The T fitting can clearly be seen. The top of the cooling fins almost reach the bottom of the lid when it is on. It appears from other analyses the fin tops are located between 3 and 4 cm below the bottom of the top cover. The probe itself is very long. The long probe may be resting on or against the reactor housing, making metal to metal contact, when it is in the T fitting. This would bias the T2 temperature upward, accounting for a 120°C reading at atmospheric pressure or close to it. The probe may actually rest on the horizontal extension where the top of the reactor housing is bolted to the bottom of the E-cat housing or to a bottom part of itself.

The length of the probe can be seen in Steve Krivit's New Energy Times photos here:

http://newenergytimes.com/v2/sr/RossiECat/AndreaRossiEnergyCatalyzerPhotoGallery-June.shtml

more specifically here:

http://newenergytimes.com/v2/sr/RossiECat/img/June2011/DSC_0025-BlueBox.JPG

Photo 1, appended, is a photo by Mats Lewan of NyTeknik, color faded, with some colored lines with pixel length measurements superimposed.

The water/steam exit port of the T on top of the lid faces the rear of the device when the lid is in place. The T2 thermocouple is mounted through the T and extends into the containment box. In Photo 1 the T is located a relative distance of 57 px / 313 px = 0.1821 from the back edge of the top (see red lines with red numbers.) Lengthwise (see blue lines) the maximum relative distance of the fin edges is 49 px/ 248 px = 0.1992. The probable distance (see 36 px magenta line), accounting for the depth to the top of the fins, is 36 px/248 px = 0.1452. If the length of the fins is 30 cm, as is represented by the orange line, then the length of the containment box, 284 pixels, is about (30 cm)*(248/132) = 56 cm. The back edge of the fins is located (see 49 px blue line) at most (30 cm)*(49/132) = 11.1 cm forward from the back of the lid, and probably located (30 cm)*(36/132) = 8.2 cm forward from the back of the lid.

Looking again at the lid, given the length of the lid is 56 cm, the setback of the T coupling is (56 cm)*(57/313) = 10.19 cm. Given a probe length of 25 cm, and approximate T fitting height of 10 cm, the probe extends to a depth of about 15 cm. This is about 10 cm beyond the top of the fins.
This means the probe probably rests against the back side of the reactor housing.

HEAT EXCHANGER EFFICIENCY ISSUE

If the heat exchanger were 70% efficient as estimated by some individuals, then the "condensed steam" water temperature should have been above Tin. In other words, if a perfect heat exchange is not occurring then the condensed steam water should leave the heat exchanger hot, hotter than the cooling water leaves the heat exchanger. Given a delta T of the cooling water of 32.4°C - 24.2°C = 8.2°C, we might expect a "condensed steam" temperature more like 34.8°C, not 23.2°C or even 24.2°C if the coupling of the two circuits were imperfect. The insulated condenser itself and the insulated flow lines do not appear to be a significant source of loss of energy at the thermal flows involved, and thus this aspect should not significantly affect measurement efficiency when large thermal flows are present. Further, the low temperature of the "condensed steam" water upon output from the primary circuit indicates no loss of energy in the heat exchange process due to dumped heat in the form of "condensed steam" going down the drain.

VOLUME CALCULATIONS

The Lewan report says: "The E-cat model used in this test was enclosed in a casing measuring about 50 x 60 x 35 centimeters." These are external measurements with wrapping, etc., obtained from Rossi's assistant.

"After cooling down the E-cat, the insulation was eliminated and the casing was opened. Inside the casing metal flanges of a heat exchanger could be seen, an object measuring about 30 x 30 x 30 centimeters. The rest of the volume was empty space where water could be heated, entering through a valve at the bottom, and with a valve at the top where steam could come out. "

The 30 x 30 x 30 cm is an estimate only.

Following is an analysis based on Photo 2, a photo by Mat Lewan of NyTeknik, modified to show lengths between various points in pixels.

All lengths below are in in pixels unless otherwise specified.

The ratio of the magenta lines is 244/195 = 1.319. The ratio of the red lines is 179/154 = 1.162. This is due to perspective, assuming all the angles are right angles.

The mid-line width of the inside of the container box (magenta lines) is (195+244)/2 =219.5. The mid-line width of the reactor box (red lines) is (179+154)/2 = 166.6 The ratio of the width of the box to the width of the reactor is 219.5/166.6 = 1.3145. If the reactor is 30 cm wide then the box interior is 1.3145*(30 cm) = 39.4 cm wide. This gives a mean sideways gap width of (39.4 cm - 30 cm)/2 = 4.7 cm.

The average length of the reactor (blue lines) is (155+154)/2 =154.5. The average length of the inside of the container box (orange lines) is (229+237)/2 = 233. Adjusting the orange line lengths for perspective, we have a length of (1.162/1.319)*233 = 205. The ratio of length of the interior of the container to the reactor box is 205/154.5 = 1.6181. If the reactor length is 30 cm then the length of the box is 48.5 cm. This gives a mean lengthwise gap width of (48.5 cm - 30 cm)/2 = 9.25 cm.

Using a gap between the top of the reactor and the bottom of the lid of 3.5 cm, determined elsewhere, we have a container interior dimensions of 34.9 cm x 48.5 cm x 33.5 cm, for a volume of 56703 cm^3 = 56.7 liters. The volume of the reactor box is (30 cm^3) = 27000 cm^3 = 27 liters. From this we need to subtract the water spaces between the fins.

It looks like about (1/9)*30 cm = 3.3 cm is cooling fins. About 50% of the 3.3 cm x 30 cm x 30 cm = 3 liters should be water, giving a total finned structure volume of 27 liters - 3 liters = 24 liters. The net water maximum volume of the box is thus 56.7 liters - 24 liters = **32.7 liters**. This volume should be reduced some for the many bolt heads that bolt the reactor case to the box, or bolt the reactor case together. Rossi stated in his blog that this internal volume is 30 liters. The measurements estimated for the device based on a 30 cm^3 reactor appear to be roughly consistent with Rossi's statement. It is of course important to obtain accurate measurements of these values to make consistent sense of the data.

The current E-cat weighed 98 kg on a bathroom scale. In the prior test an estimate of 85 kg was provided by Rossi or his assistant.

POSSIBLE PRESSURE RELIEF VALVE

The obviously high pressure at the end of the previous test of this E-cat model , when water was released, indicated a pressure valve or obstruction may have been present. Looking at Mats Lewan's photo of the lid of the device, a thick extension on the T connector water/steam leg, the output tap, can be seen. This may be a pressure relief valve. This would permit pressure to build to a critical point and then release steam/water. This may in part account for the variability of the Tout measurements despite the stability of the T2 measurement. It may also account for at least some of the temperature above 100°C measured by T2.

Mats Lewan stated he tried to blow through the output tap. It was obstructed. Rossi later told him that a piece of insulation had gotten there and Rossi said it should be open.

STATEMENT OF PRIMARY CIRCUIT FLOW RATE

Quote from Rossi's blog at:

http://www.journal-of-nuclear-physics.com/?p=510&cpage=21#comment-95384

Andrea Rossi

October 12th, 2011 at 1:47 AM

Dear Vinnie Jones:
That's the flow of the condensate water, and it is not constant. The energy produced has been measured on the secondary circuit, so I didn't take a record of the primary flow rate. In any case, the flow rate of the pump of the primary circuit is regulated at 15 l/h.
Warm Regards,
A.R.

Rossi's statement implies the primary circuit flow rate is (15 liters/hr) *(1 hr/(60 s))*(1000 ml/liter) = 4.17 ml/s.

COMPUTED PRIMARY CIRCUIT FLOW RATE

In the ecat.com video at:

http://www.youtube.com/watch?v=EhvD4KuAEmo

at time 0:29, there were 30 strokes in 40 seconds, or about 45 strokes per minute. That is a maximum flow rate of (30 str/(40 s))*(2 ml/str) = 1.5 ml/sec, or 5.4 liters per hour, if the pump stroke were set at the maximum 2 ml.

The earlier noted flow measurement of 0.9 g/s, by Lewan, was at the output of the water/steam from the condenser heat exchanger. It might have had nothing to do with with the actual pump rate. It only had to do with the volume of steam being output, which is independent of the volume of water being pumped in - unless overflow is occurring, which seems unlikely at the early stage.

The Lewan video at:

http://www.youtube.com/watch?NR=1&v=NNCuLAZKvL4

at "one hour or so" into self sustained mode, at the beginning of the video, there were 62 strokes in 90 seconds, or about 41 strokes per minute. This represents a lower flow rate than the above video, a maximum of 1.38 ml/sec, or 5 liters per hour.

SECONDARY CIRCUIT FLOW RATES

Mats Lewan provided the following actual volume data from the water meter.

Time	m3
11:57	8.8112
13:40	9.9205
15:00	10.7706
15:55	11.3294
18:51	13.2318
19:03	13.3655

This produces the following data:

Secondary circuit flow measurements Data from Mats Lewan

Time Hour	Time Min	Elapsed (min)	Interval (min)	Volume (m^3)	Delta Vol. (liters)	Flow (liters/hr)	Flow (ml/s)	
11	12	0						
11	57	45	45	8.8112	480.6	640.800	178.0	**
13	40	148	103	9.9205	1109.3	646.194	179.5	
15	0	228	80	10.7706	850.1	637.575	177.1	
15	55	283	55	11.3294	558.8	609.600	169.3	

18	51	459	176	13.2318	1902.4	648.545	180.2
19	3	471	12	13.3655	133.7	668.500	185.7

** - row estimated from manual tests

NO HEAT TRANSFER TO HEAT EXCHANGER UNTIL 13:22

The heat showed up in the heat exchanger at about 146 minutes, or 8760 seconds into the run. See appended Graph 1, or see spreadsheet at:

http://www.mtaonline.net/~hheffner/Rossi6Oct2011.pdf

A flow of 1.5 ml/sec means the flow filled a void of (8760 s)*(1.5 ml/s) = 13.1 liters, or about 13 liters before hot water began to either overflow or percolate out of the device, and thus make it to the heat exchanger.

If overflow started after 13 liters then it would appear 32.7 liters - 13 = 19.7 liters were already present. The device weighed in at 98 kg before the test and 99 kg after, when the water was drained, making this impossible. This means steam hit the heat exchanger at 13:22.

If the E-cat cold water input is 24°C and 13 liters were input, it takes (4.2 J/(gm K)) *(13,000 gm))*(76K) = 4.15 MJ = 1.15 kWh to heat the water to boiling.

CHARACTERISTICS OF THE CENTRAL MASS

Looking at the spread sheet, by time 146 the input energy Ein reached was 4.446 kWh. This implies about 4.446 kWh - 1.15 kWh = 3.3 kWh = 11.88 MJ was required to heat up the thermal mass of metal in the center of the E-cat, and immediately surrounding area.

Suppose there is a mass of cast iron between the cooling fins and heater. There might also be a layer of higher thermal resistance between the iron and the cooling fins. Use 50 kg as a rough guess at the mass of the iron.

The specific heat capacity of iron is 0.46 J/(gm °C). The heat capacity of 50 kg of iron is thus (0.46 J/(gm °C)) * (50,000 gm) = 2.3x10^4 J/°C.

Storing the 11.88 MJ requires a mean storage Delta T of (1.188x10^7 J)/(2.3x10^4 J/°C) = 516°C. Assuming the metal started out at 27°C that means an iron temperature of 543°C.

If this is the only energy stored then it sets a limit on the period of heat after death boiling that can occur. If the central metal is heated to 543°C, then energy stored for boiling is 443°C * (2.3x10^4 J/°C) = 10.2 MJ.

To last through the heat after death period from 284 min. to 476 min. = 192 min., the water boiling power output is limited to an average of 10.2 MJ/(192 min.) = 885 W. Limiting the mean thermal output of the stored thermal mass to a mean output of 885 W requires a significant degree of thermal resistance between the thermal mass and the water heat exchanger above the thermal mass.

At a midpoint of heat after death, thus a thermal mass delta T of 443°C/2 = 222°C, i.e. delta T of 22°C to the boiling water, the thermal resistance required between the thermal mass and the water is (222°C)/(885 W) = 0.025 °C/W.

The density of iron is 7.874 gm/cm^3. The 50 kg of iron represents 6350 cm^3, which distributed over a 30 cm x 30 cm area is 7 cm thick. This readily fits in the 30 cm x 30 cm x 30 cm interior mass. It can serve a dual role as shielding.

Thin layers of insulation can be placed between the iron and the catalyst, and the catalyst and the water, in order to maintain the catalyst at a desired temperature above 100°C.

Registering a multi-kilowatt heat output at the heat exchanger then requires that the Tout thermocouple be under the influence of the steam/water mix, due to its about 3 cm proximity and the very thick nature of the brass connector, and that a mean output of 885 W provides a steam/water mix that can drive the Tout reading up about 8°C.

SAMPLE SPREADSHEET INCORPORATING POWER ADJUSTMENT FACTOR

A sample spreadsheet incorporating flow rates based on water meter readings, and having a delta T, and thus output power, adjustment factor Tadj = 0.25 is located at:

http://www.mtaonline.net/~hheffner/Rossi6Oct2011vol1sim.pdf

A graph of the important values can be found in Graph 5, appended.

A large scale version of Graph 5 can be found at:

http://www.mtaonline.net/~hheffner/Graph5.png

One key thing to note regarding Graph 5 is that Eout at the end of the run is less than Ein by about a kWh. This reflects energy stored in the heat remaining in the E-cat.

Maximum stored energy, 6.727 kWh, 24.2 MJ, occurs right before 15:53, 280 minutes into the run, right before power is turned off, and the “self sustaining running” begins.

Storing the 24.2 MJ requires a mean storage Delta T of (2.42x10^7 J)/(2.3x10^4 J/°C) = 1052°C. Assuming the metal started out at 27°C that means an iron temperature of 1079°C.

This sets a limit on the period of heat after death boiling that can occur. If the central metal is heated to 1079°C then energy stored for boiling is 979°C * (2.3x10^4 J/°C) = 22.5 MJ.

To last through the heat after death period from 280 min. to 476 min. = 196 min., the water boiling power output is limited to an average of 22.5 MJ/(196 min.) = 1148 W. Limiting the mean thermal output of the stored thermal mass to a mean output of 1148 W requires a significant degree of thermal resistance between the thermal mass and the water heat exchanger above the thermal mass.

At a midpoint of heat after death, thus a thermal mass delta T of 979°C/2 = 490°C to the boiling water, the thermal resistance required between the thermal mass and the water is (490°C)/(1148 W) = 0.426 °C/W.

LOW POWER FREQUENCY PRODUCING DEVICE

Noted in report: "15:53 Power to the resistance was set to zero. A device “producing frequencies” was switched on. Overall current 432 mA. Voltage 230 V." Mats Lewan tested the device at about 300 mA and it seemed very stable. The balance of power requirements, 132 mA, is apparently from the blue box.

CALORIMETRY AND THE SPREAD SHEET FORMAT

Meaningful calorimetry data can only be obtained through the performance of well calibrated, and preferably dual method, calorimetry on the device, as a black box, that establishes a complete energy balance for each run. Use of control experiments is a standard feature of the scientific method, and useful for calibrating the calorimetry. A thermal pulse method is also a useful check on calorimetry functions during run times. Anything less than this kind of professional calorimetry can not be relied upon. Anyone who has actually done calorimetry is keenly aware of the difficulty of getting it right.

The format of the data spread sheets provided is useful to evaluate control runs.

The experiment protocol is run, and problems fixed, until the control run COP is 1. Then when a live run has a COP above 1, i.e. Eout > Ein, not a momentary Pout > Pin, it is a true sign of excess energy. Without a control run, the data is meaningless. Calorimetry is subject to many kinds of artifacts - about as many as there are specific calorimeters.

DISCUSSION OF GRAPH 1

The Graph 1 legend tags are:

red line - Pin (kW) [power in] vs Elapsed Time
blue line - Pout (kW) [power out] vs Elapsed Time
green line - Ein (kWh) [energy in] vs Elapsed Time
orange line - Eout (kWh) [energy out] vs Elapsed Time

The x axis shows elapsed time in minutes. The Y axis shows kw for Pin and Pout, kWh for Ein and Eout.

It is important to show these values all on the same graph because it clearly shows that once hot water is flowing, i.e. power is turned off, quickly eliminating much steam volume, the excess heat values show up immediately. Eout only crosses Ein, i.e. COP>1 occurs, only once the electric power is mostly shut down.

The time T168 vertical line marks the beginning of the power turn-on turn-off phase of the experiment. The time T281 line marks the turning off of heater power and turn on of the approximately 300 mA “frequency generator” power. The time 476 vertical line marks the turn off of all power, the increase in primary circuit flow, and drop of hydrogen pressure to atmospheric pressure.

During the first 130 minutes there is no hot water flow into the heat exchanger because the E-cat is still filling up, and still heating up, thus the blue line remains flat near zero. Once the flow begins the over unity power begins. The blue curve is quickly elevated when the input power is turned off.

Notice the steep decline trend of the blue curve from 350 minutes to 550 minutes. This corresponds roughly to the drop in T2 (as shown in Graph 2), which likely corresponds somewhat to a drop in the internal temperature of the large thermal mass of hot metal inside. It is notable the experiment was terminated when the internal temperature T2 approached 100°C instead of letting the E-cat cool and collecting the remaining thermal energy.

Due to bad calorimetry, there is an "excess energy" explanation for all the Rossi tests if one thinks in terms of how the output thermometer can be affected by thermal wicking - an old problem discussed many years ago with regards to metal thermometer wells in CF cells.

The thermometer attached to the heat exchanger is right next to the water/steam input to the heat exchanger. There is an insulated thick metal heat conduit from the steam inlet to the Tout thermometer. When steam goes into the heat exchanger it does not have enough specific heat to provide a large false reading for Tout, which is maintained at a lower temperature by the competing cold water flow. However, when power is cut back, and pure nearly 100°C water is pumped to the heat exchanger from the E-cat, that water has the thermal power to drive up a large false temperature reading for Tout. This explains why there is an upward temperature movement almost immediately every time the electric power is cut back. The steam quickly abates, leaving only a water flow due to the pump. The Tout thermocouple is placed directly on the metal and under insulation, not placed in the water, so this is a perfect situation in which to obtain false temperature readings. This placement was described by Rossi in NyTeknik video shown in the URL referenced above.

There is still enough energy stored in the metal thermal mass to produce a bit of steam for 3.5 hours, on the order of 100 W or so. This is enough to generate a percolator effect which makes the blue line erratic as shown, due to slugs of water moving through the line.

It is notable that if a calibration run were made then this kind of measuring error, if it exists, would show up as soon as the test device were full and up to temperature and then the power cut back.

In the case of the thermometer hidden inside the Rossi device, and previous devices, they are likely subject to direct wicking from a large insulated metal thermal mass which heats up well beyond 100°C. Also, steam present above the water line in the device, especially in the chimney of the earlier devices, when the flow is reduced, is subject to superheating to some degree. The 120°C temperature recorded may just be a thermometry problem - easily solved by measuring outlet temperature a small distance down the hose away from the device itself, where the thermometer is not subject to direct metal to metal thermal wicking.

It is notable that in this test the primary flow circuit is open. Pressure should not build up inside the E-cat, unless a pressure valve is present. However, the water "condensed steam" flow through the heat exchanger was manually verified, indicating a significant flow was present, indicating the pressure should not be high inside the E-cat. Yet a higher than 100°C reading was present for the thermometer inside the E-cat. That indicates a good possibility that this high reading is merely a systematic false reading.

This is a hypothetical explanation of the graph. Others, involving genuine excess energy, have been made.

DISCUSSION OF GRAPH 2

Graph 2 shows a scaled plot of T2 overlaid on a plot of Pout and Pin. In addition, an LOESS least squares fit curve of Pout is shown in black, to show the general tend of the Pout curve.

Notice the steep decline trend of the blue curve from 350 minutes to 550 minutes. This corresponds roughly to the drop in T2, which likely corresponds somewhat to a drop in the internal temperature of the large thermal mass of hot metal inside. It is notable the experiment was terminated when the internal temperature T2 approached 100°C.

There is a notable lack of correlation of internal E-cat temperature and Pout, especially a shown by the moving average of Pout, for the initial 100 minutes after the electric power was turned off.

DISCUSSION OF GRAPH 3

Graph 3 shows a scaled plot of T2 (i.e. T2/1000) overlaid on a plot of Pin for the period in which the RF (frequency generator) source was on. The RF (frequency generator) power was on from 15:53 to 19:08, time 281 to 476.

It appears the RF (frequency generator) power was ramped up at 16:38 (326 min) and down at 18:53 (461 min). The T2 curve mysteriously responds, despite the input RF (frequency generator) power being nominal. The thermal mass of the metal and water is huge. This response of T2 to RF (frequency generator) Pin should not be possible unless the T2 thermocouple reading is directly affected by the RF (frequency generator) , or the 300 mA power of the signal controls a device in the E-cat which opens a thermally conductive pathway between the hot metal mass and the water in the E-cat.

DISCUSSION OF GRAPH 4

Graph 4 shows Pout for the initial period before any steam came from the E-cat. The red line in the graph shows about a negative 0.5 kW Pout for no heat input. The blue line shows Pout after a 0.8°C adjustment to Delta T. No negative power is produced. However, some nonexistent positive power is produced. The net effect Ebias on total energy out of the 0.8C bias over the 526 minutes of the test is

Ebias = (0.8K)*(178gm/s)*(4.2 J/(gm K))*(526 min)*(60 s/min) = 19 MJ = 5.3 kWh

Without the bias the COP for the test drops from 3.2 to 2.6.

DISCUSSION OF GRAPH 5

Graph 5 is the equivalent to Graph 1, but with more accurate flow data, and, most importantly, a delta T adjustment factor Tadj of 0.25. This implies only 25% of the delta T = Tout - Tin reading reflects actual energy through the heat exchanger, due to heat leakage affecting the Tout reading.

One key thing to note regarding Graph 5 is that Eout at the end of the run is less than Ein by about a kWh. This reflects energy stored in the heat remaining in the E-cat. It is possible the true COP is actually less than 1 for the test, which is to be expected if no nuclear power were produced. Also, some energy can be expected to leak through the insulation into the room. A calibration run would assist in determining the value of the leakage in various conditions. The water leakage under the insulation of about 2 kg per hour starting at time 168 should also account for significant unmeasured heat loss.

This factor (Tadj of 0.25) is very low, thus indicating a good possibility some nuclear energy is present. The problem is lack of proof of nuclear energy.

Another problem is explaining the wild excursions of apparent output energy during the run. One possible explanation is slugs of hot water (vs steam) are affecting Tadj. However, at 1.5 ml/sec flow, a 32.7 liter volume can not be filled in 4 hours. The fact leaking began at 14:00 (168 min.) indicates possibly the input flow, at least initially, before pressure developed, was much higher, and that after time 168 the primary circuit flow was higher due to a pressure drop caused by the leak.

Another explanation for thermal transients is that at high heat output the pressure relief valve cuts in frequently and affects the apparent thermal power production as measured at the heat exchanger. Another explanation is the power applied to the heater and power applied to by the “frequency generator” close some form of thermal conduction pathway between the hot metal mass and the water internal to the E-cat.

Much more work is required to develop a fully consistent simulation of the E-cat. This may be difficult to impossible to do accurately due to lack of critical information.

GENERAL DISCUSSION OF THE GRAPHS

Graphs 2 and 3 have much to say about how well controlled the nuclear reaction is, if there indeed is one. In Graph 2 we can see the E-cat temperature is very well controlled. In the time 220 - 280 the red line T2 is fairly flat. There is no sign of any runaway reaction - even though the power was applied for a long period. T2 even looks fairly flat for the period 200-280. The output power Pout detected at the heat exchanger, however, is anything but flat. This variation looks to be likely due to periods of water slugs moving through the exchanger, not variations from the nuclear reaction output.

The most interesting relationship is shown in Graph 3. The blue line shows a scaled version of the E-cat temperature T2. The red line is the power applied to the blue box and RF (frequency generator) generator. Assuming the power to the blue box is constant at this point, it is the change in power that is of interest. A change in input power of a mere 25 W has a large effect on the T2 decline. T2 is located inside the E-cat, in the midst of a very large thermal mass. Yet it appears to respond immediately to the mere 25 W increase in Pin. Between times 450 and 470 a response to a mere 3 W change can be seen. This appears to be a reactor under the finest imaginable control. However, when we look a Graph 2, we see the heat exchanger view of this is very different. The blue Pout line varies wildly. After about time 350 the trend of the blue Pout line (represented roughly by the black LOESS least squares fit line to Pout in Graph 2) begins to mimic to some degree, with a lag, the T2 line.

It appears the variability of the Pout blue line in Graph 2 is not due to reaction rate changes, but to calorimeter or internal transients. Some transients may be due to oscillating pressures and water levels and associated variations of exposure of water to the top cooling fins. However, if the major Pout increase upon cut off of heater electric power is not all due to calorimetry error due to thermocouple placement, but possibly is due to the application of the RF (frequency generator) signal with a resulting nuclear effect, then the black line in Graph 2 has much significance with regard to actual reaction power generation. The tail off of the black LOESS least squares fit curve in Graph 2 along with the tail-off of the T2 temperature do indicate a limited time of reaction, however. It appears the reaction, if real, is not nearly as difficult to control as the Pout lines would indicate.

ACTIVE CONTROL

To make any sense of the data with a non-nuclear explanation, it appears the electric heating power must be separated into two parts, one part which heats the water directly, and one part which heats an internal mass. In addition, it appears there needs to be an active control which affects the thermal conductivity between a large thermal mass and the water, and thus division of the input power into a third part. This control must produce minimum thermal resistance between a hot thermal mass and the water when no power is applied to it. Further, it must be controlled with about 300 mA * 240 V = 7.2 watts of power, because the power from the “frequency generator” must be enough to regulate the thermal output power. When main heater power was cut and when the “frequency generator” power was cut, there was an immediate surge of thermal power out. In both cases, a power cut to the heater(s), and a power cut to the frequency generator, a large thermal pulse resulted immediately upon the power cut.

One means of achieving the necessary power control is to use the actuator from a zone valve to make or release contact between large area (e.g. 29 cm by 29 cm) slabs of thermal conductors. This can be accomplished by spring loading the slabs to a closed position and using the actuator from a zone valve (.e.g. Taco Power Head) to press the plates apart. A typical US residential zone valve operates in the appropriate power range, and is activated by about 24 V at less than 1 A. A 40 VA transformer supplies enough power for 3 Taco zone valves in normal operation. A partial activation can be obtained through use of less power, and through use of either AC or DC power. The power is applied to a resistive material which expands thermally to open a zone valve. In a hot environment such an actuator could expand with less than normal power. An alternative to changing slab separation is to control convective flow of a thermal transfer fluid. In this case when power is applied then flow must be cut off. Motor driven zone valves are available in normally open or normally closed configurations and operate on DC at very low power requirements.

DYNAMIC FEA SIMULATION

A dynamic linear FEA simulation program is being developed to look at potential thermal storage mechanisms. A sample of some run input data is located here:

http://www.mtaonline.net/~hheffner/RptR4

Some sample graphs of ouput data, corresponding to Graph 2 and Graph 5, are shown here:

http://www.mtaonline.net/~hheffner/Graph2S.png

http://www.mtaonline.net/~hheffner/Graph5S.png

http://www.mtaonline.net/~hheffner/Graph6S.png

Report of the results will be made separately from this review.

COMMERCIAL VALUE

Based on all the above, the temperature measurements lack the degree of credibility required to make any reliable assessment of commercial value. The true COP could be anything from negative to positive.

Even if it is real, a COP of 3 is marginal for commercial application. It is much more difficult to achieve self powering with a COP of 3 vs 6. Unfortunately the temperature data is unreliable, and the COP does not look to be anywhere near the advertised 6 or even 3 due to likely temperature measurement errors. Further, the apparent power tailed off after less than 4 hours of no power input. The device should not have been shut down at the time it was, but reenergized, or possibly permitted to run out much longer. To be shown to have any commercial value the device should be shown producing net energy for an extended period, like the 24 hours originally touted for the test. Only proof of net energy out over a long period, not net power out for a short period, is useful for commercial validation. The claim is the E-cat can run for 6 months without refueling. This test was not useful as a demonstration of commercial value.

SUMMARY

This test incorporated many improvements over prior tests. However, as in the numerous prior demonstrations of the E-cats, we are left tantalized by a strong indication of possible excess energy, and disappointed that, with a little extra effort, high quality proof might have finally been at hand.

GRAPHS

High resolution versions of Graphs 1 through 5 can be found at the following URLs:

http://www.mtaonline.net/~hheffner/Graph1.png

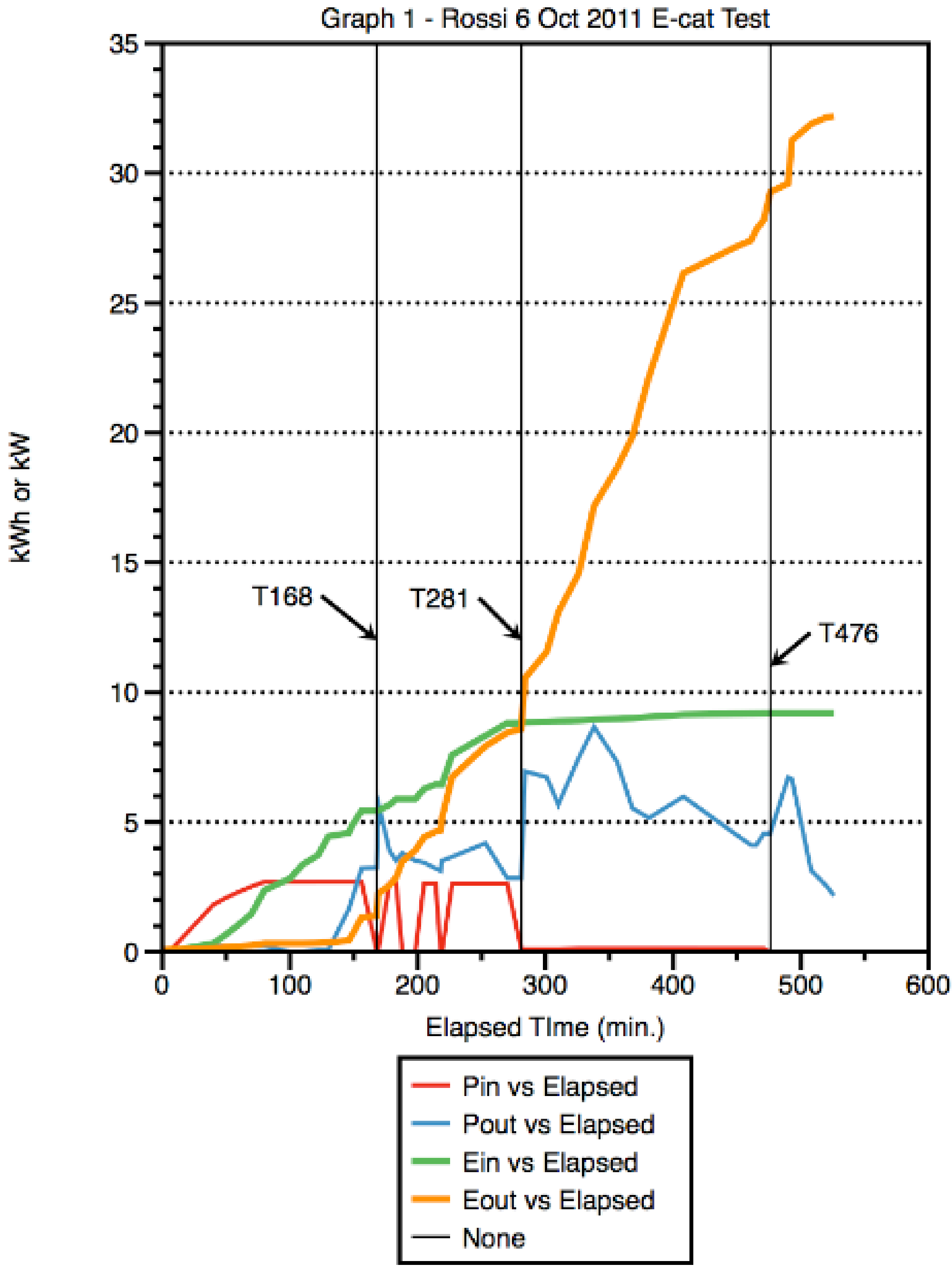
http://www.mtaonline.net/~hheffner/Graph2.png

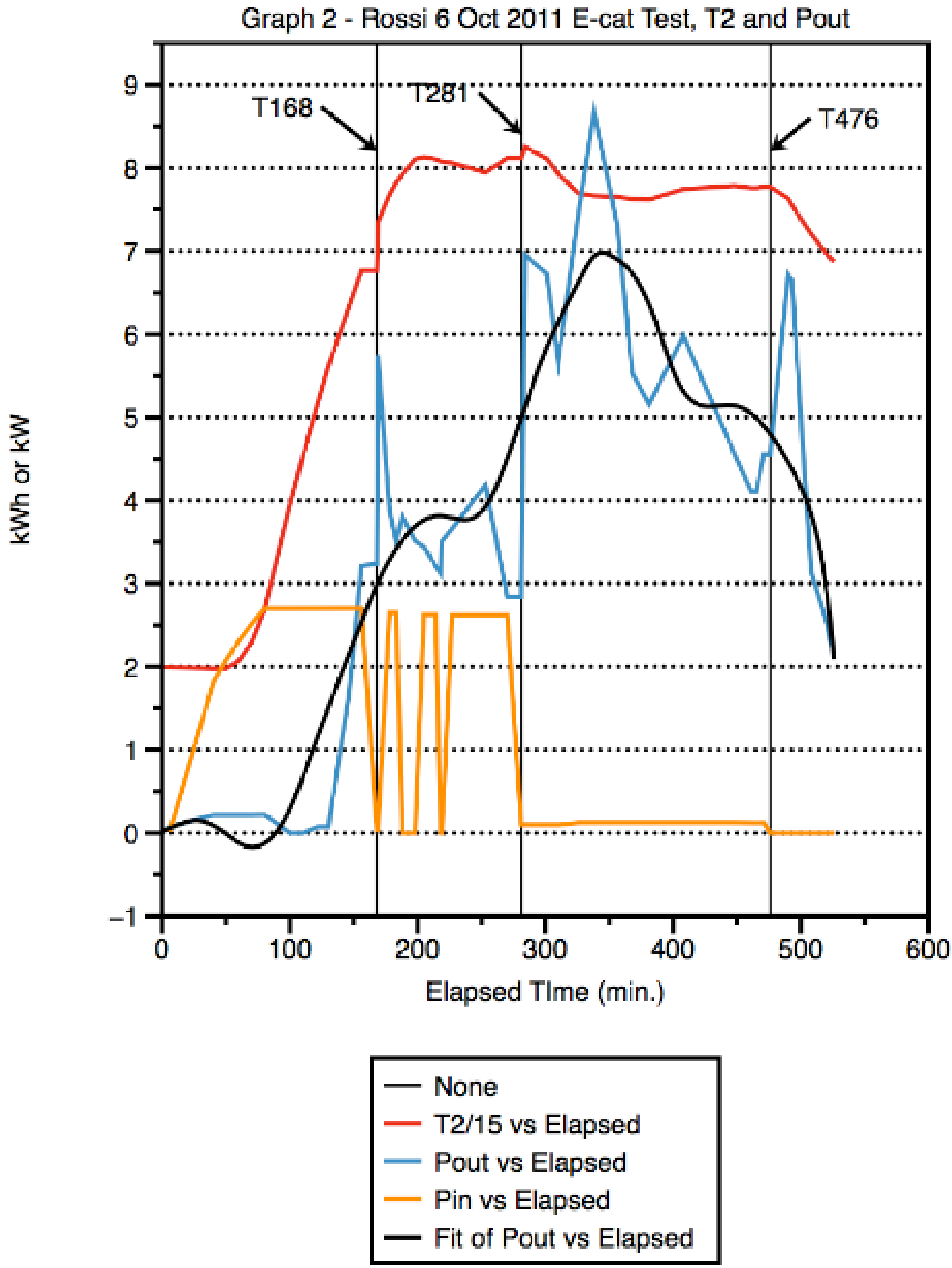
http://www.mtaonline.net/~hheffner/Graph3.png

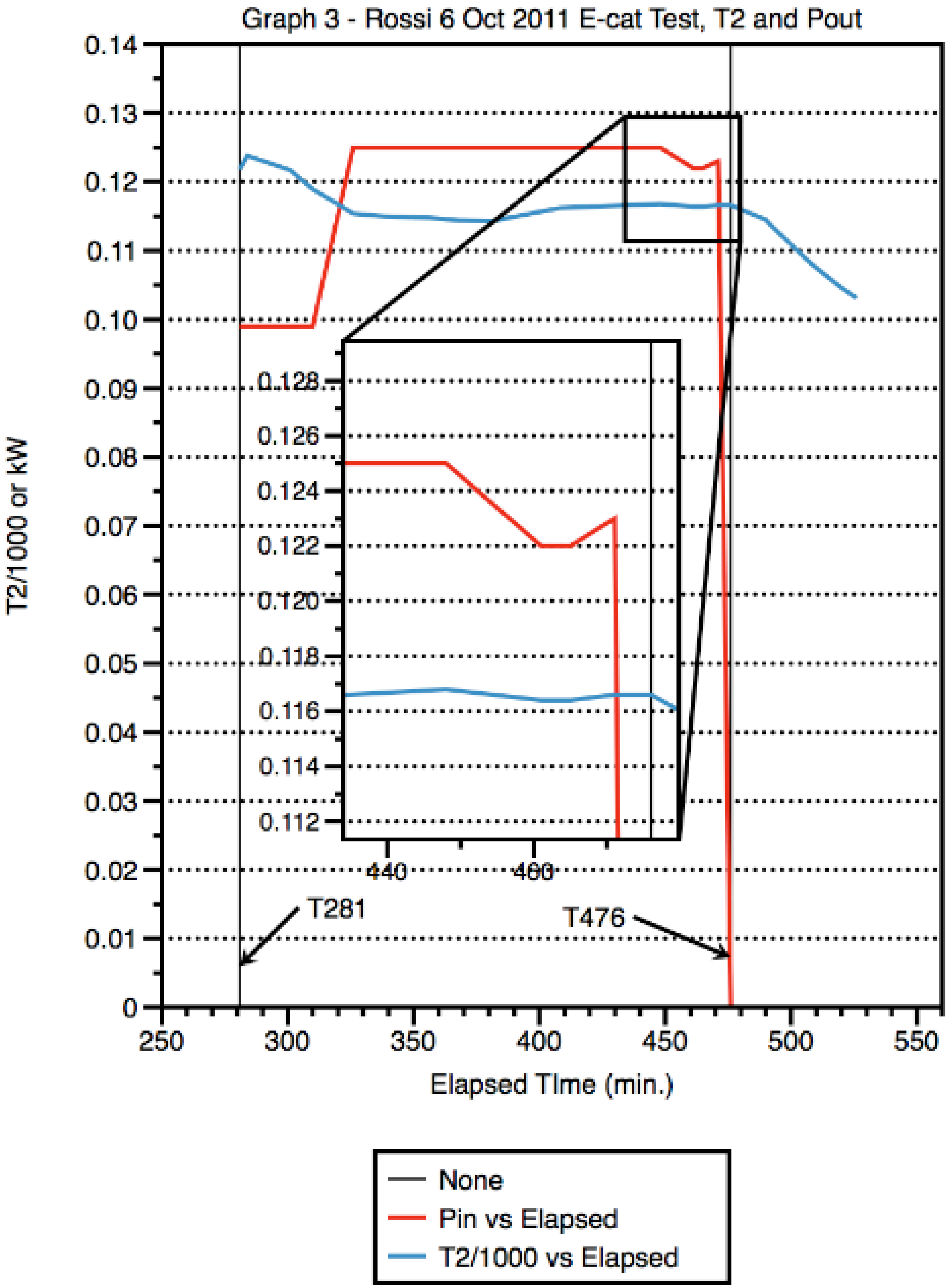
http://www.mtaonline.net/~hheffner/Graph4.png

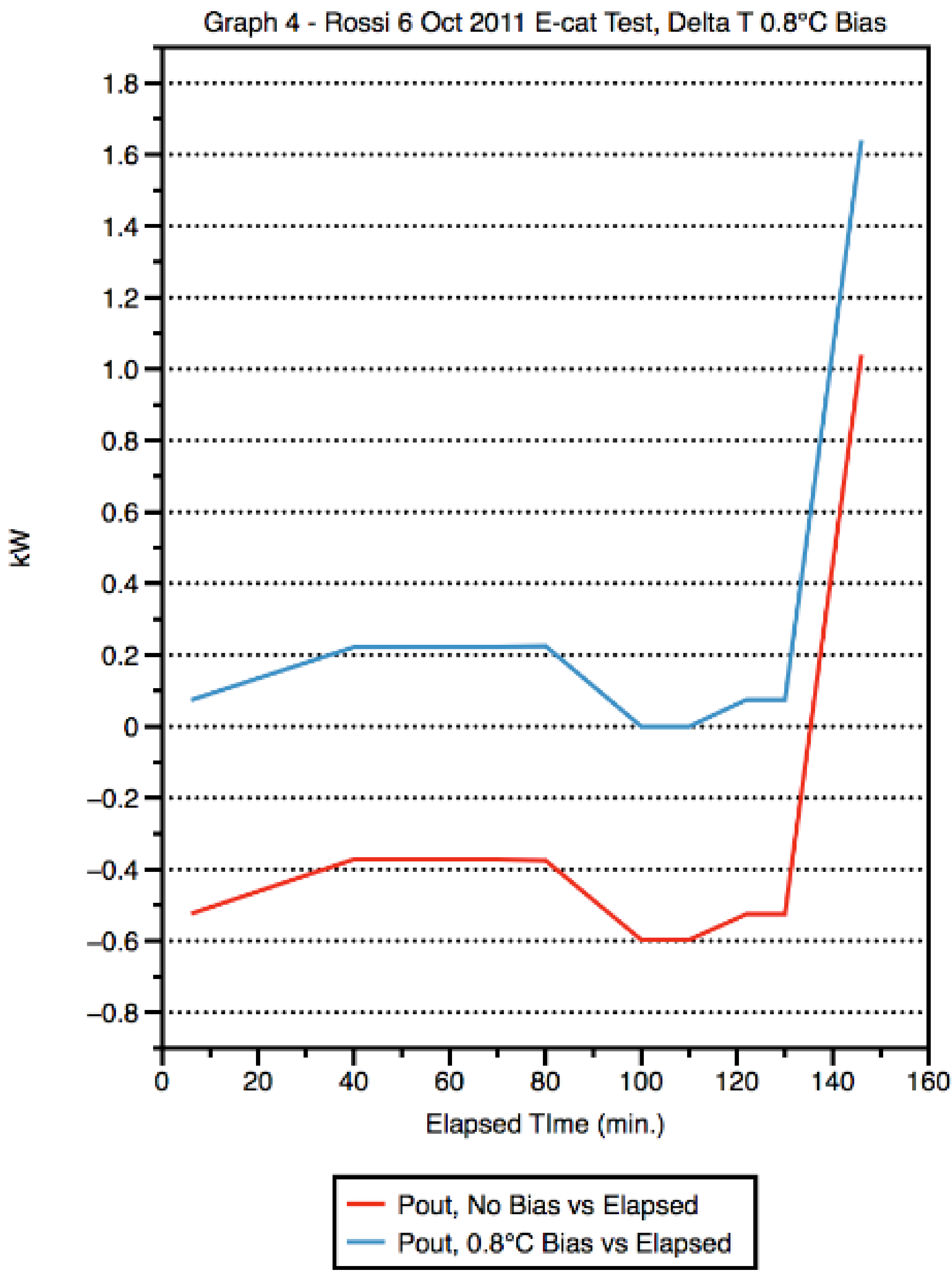
http://www.mtaonline.net/~hheffner/Graph5.png

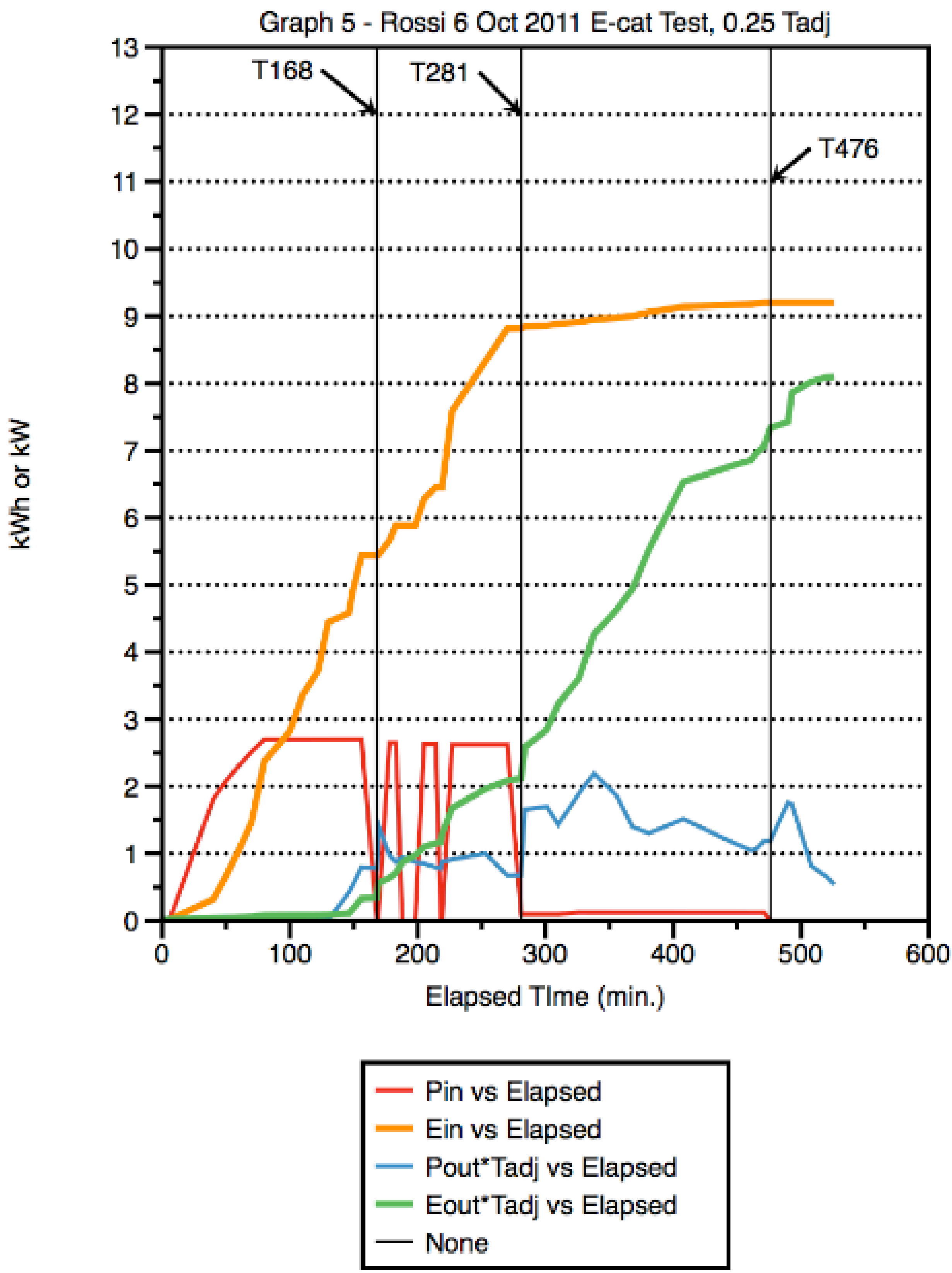
Graphs and photos follow.


Graph 1 - Rossi 6 Oct 2011 E-cat Test
35
30
25
20
15
10
5
0
kWh or kW
T168
T281
T476
0
100
200
300
400
500
600
Elapsed TIme (min.)
Pin vs Elapsed
Pout vs Elapsed
Ein vs Elapsed
Eout vs Elapsed
None


Graph 2 - Rossi 6 Oct 2011 E-cat Test, T2 and Pout
kWh or kW
Elapsed TIme (min.)
T168
T281
T476
9
8
7
6
5
4
3
2
1
0
−1
0
100
200
300
400
500
600
None
T2/15 vs Elapsed
Pout vs Elapsed
Pin vs Elapsed
Fit of Pout vs Elapsed


Graph 3 - Rossi 6 Oct 2011 E-cat Test, T2 and Pout
0.14
0.13
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
T2/1000 or kW
0.128
0.126
0.124
0.122
0.120
0.118
0.116
0.114
0.112
440
460
T281
T476
250
300
350
400
450
500
550
Elapsed TIme (min.)
None
Pin vs Elapsed
T2/1000 vs Elapsed


Graph 4 - Rossi 6 Oct 2011 E-cat Test, Delta T 0.8°C Bias
kW
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
–0.2
–0.4
–0.6
–0.8
0
20
40
60
80
100
120
140
160
Elapsed TIme (min.)
Pout, No Bias vs Elapsed
Pout, 0.8°C Bias vs Elapsed


Graph 5 - Rossi 6 Oct 2011 E-cat Test, 0.25 Tadj
T168
T281
T476
kWh or kW
0
1
2
3
4
5
6
7
8
9
10
11
12
13
0
100
200
300
400
500
600
Elapsed TIme (min.)
Pin vs Elapsed
Ein vs Elapsed
Pout*Tadj vs Elapsed
Eout*Tadj vs Elapsed
None

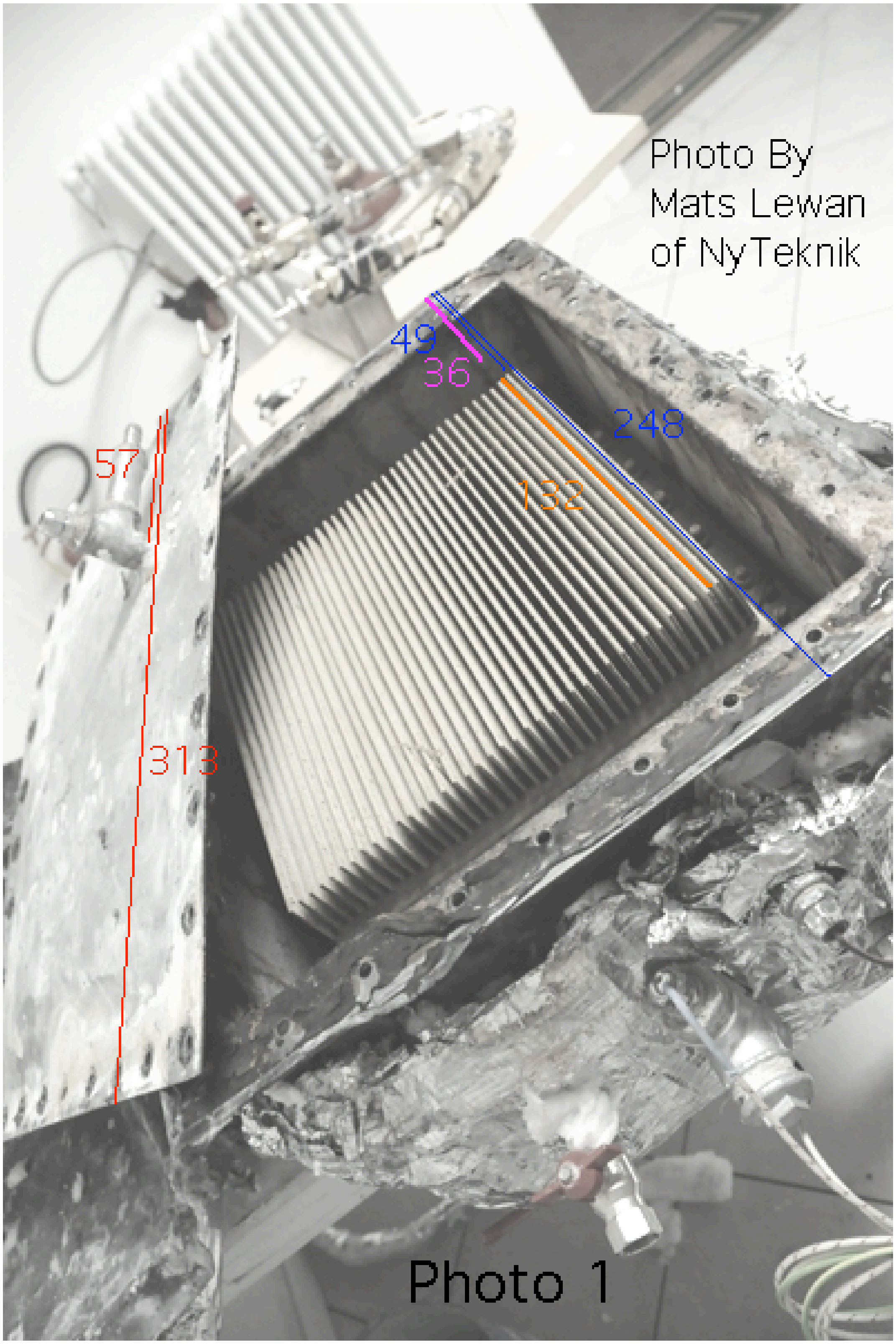


Photo By
Mats Lewan
of NyTeknik
49
36
248
132
57
313
Photo 1

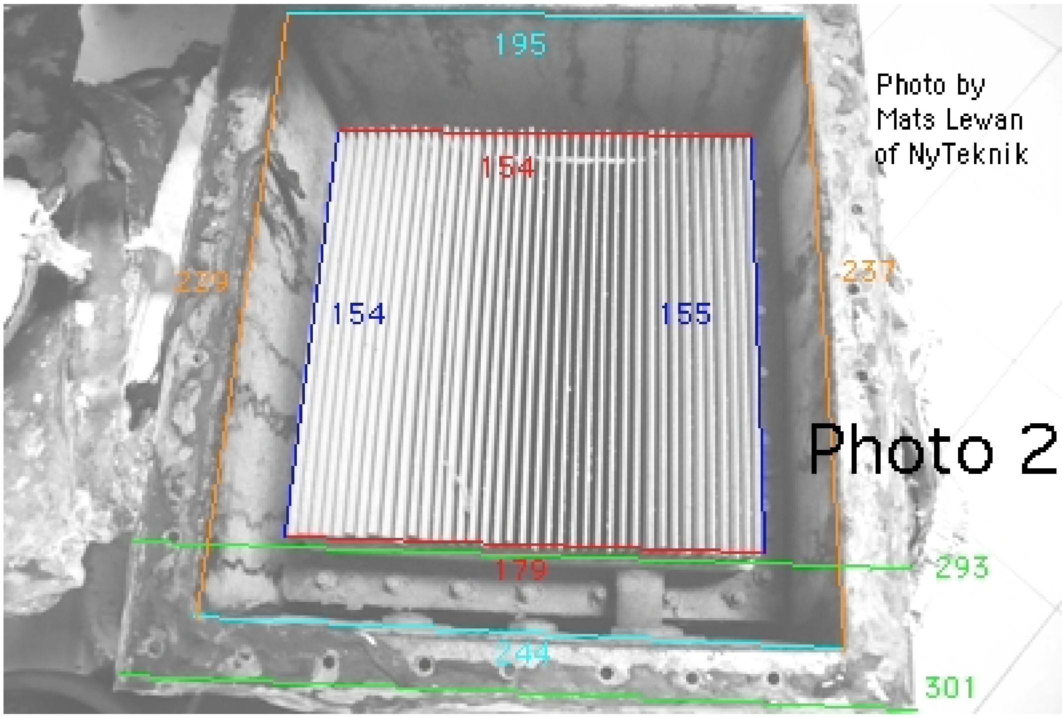

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Photo by
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Photo 2
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