2015 Ontario Stove Testing Camp

July 9 - 10, 2015

with Crispin Pemberton-Pigott
photo story by Norbert Senf

Back to Lopez Labs

The camp took place at Burt's Greenhouses near Kingston ON.
This is the shed that holds the 1.25 Megawatt chip fired boiler system.

Attendees came from as far away as New Mexico and Norway

Alex English, who runs the boilers at Burt's, introduces Crispin Pemberton-Pigott from [New Dawn Engineering]

We started with a live burn to demonstrate the concepts of a natural draft, top-lit updrafting gasifier (ND-TLUD) In this view the stove is upside down, showing the primary air inlet beneath the fuel bed.

The burn chamber sits inside an outer sleeve that is used to preheat the secondary air.


2015.07.09 08:46


2015.07.09 10:17

Secondary air holes at the top. Notice the initial long flaming of the wood gases.


2015 07 09 10 19

As the wood burns down to char at the bottom, the flaming is shorter and happens at the secondary air inlets.

A restrictor to prevent cold air downdrafting in the tube.

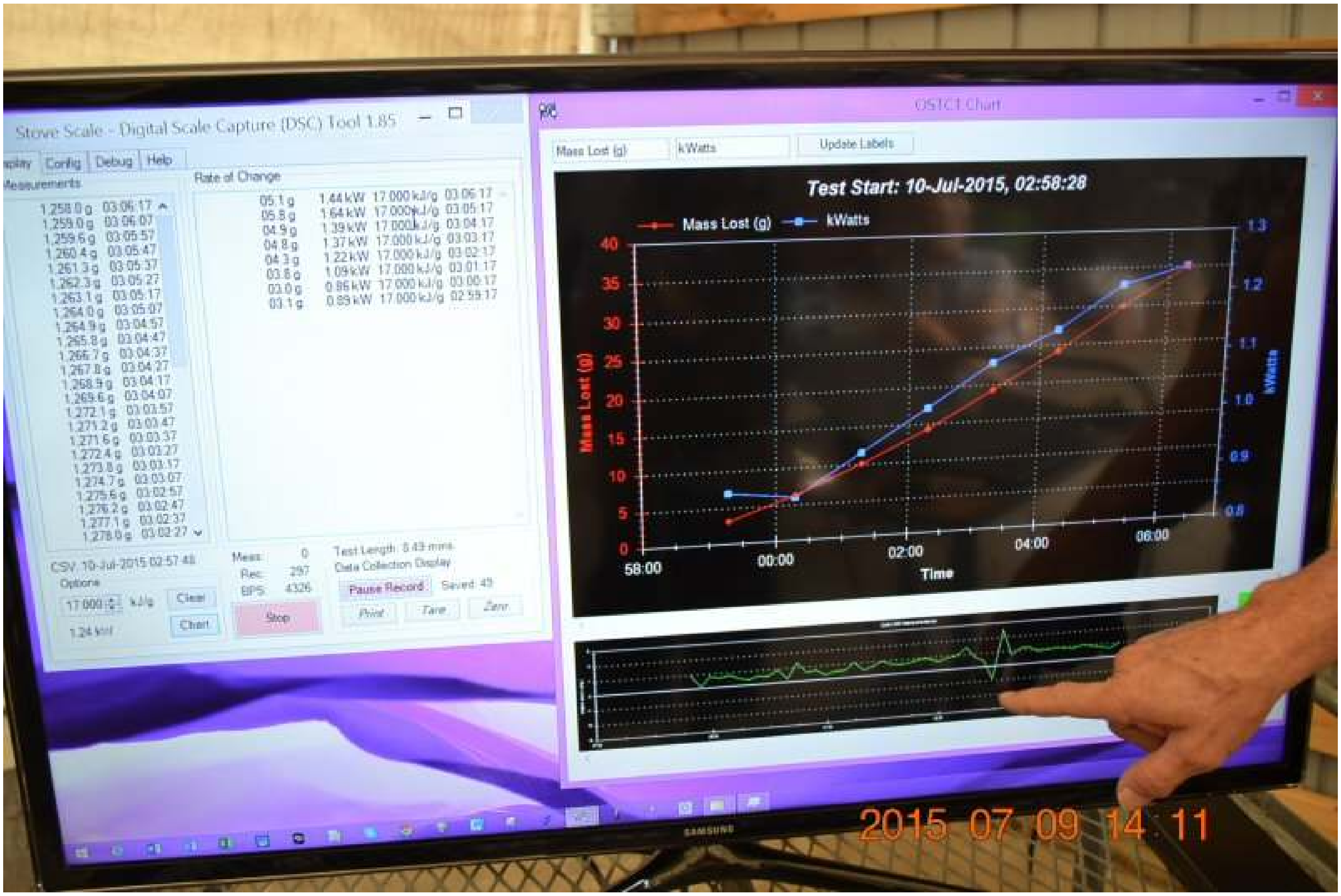

2015 07 09 10 20

An improved stove that Crispin designed for Mongolia to burn the local lignite coal, achieved a particulate emissions reduction of 99.9%,
A stove changeout program reduced the heavy air pollution in the Mongolian capital of Ulaanbaatar by 65%

MHA member Andrew Brunning attended the workshop, and brought down this precast rocket firebox.

A $1.00 stove developed by Crispin for Haiti. It is sitting on a digital scale that measures the weight loss from the fuel in order to
determine the burn rate and power output in real time.

To the left is Jan Sorensen from Norway, who manufactures stoves in Zambia, and is involved in a biochar project there.



This custom software takes data from the scale and converts it for stove testing use.

Notice the flamelets at the secondary air holes.


2015 07 09 14:50

Lighting another TLUD stove, burning pellets. The 4" pipe is used to accelerate the draft and help get the pellets lit.

The bottom of the pipe is touching the pellet bed, drawing air through the pellets from underneath.

Alex English shows the Condar portable dilution tunnel that he made many years ago after a visit to Lopez Labs.
He has done much innovative research into commercial biomass greenhouse heating, and has worked closely in the past with
CANMET, the Canadian government combustion laboratory.

Terrence Sauvé examines densified brickets that Alex has experimented with. On the right is Brian Burt, the owner
of the greenhouse operation.
Terrence is an engineer working for the Ontario Ministry of Agriculture, consulting on farm scale biomass systems.

In the black shirt is Nathan Jones, who is a field engineer for Combined Heat and Biochar, with [ClearStak](#)
He is demonstrating the Wohler real time particulate emissions analyzer.

Second from the left is Julien Winter, a soil scientist who is involved in a biochar project in Bangladesh.
Julien prepared [this summary of his recent TLUD research.](#)

Terrence Sauvé chats with Lance Grace, who is an aeronautical engineer and the principal at Clear Skies Unlimited

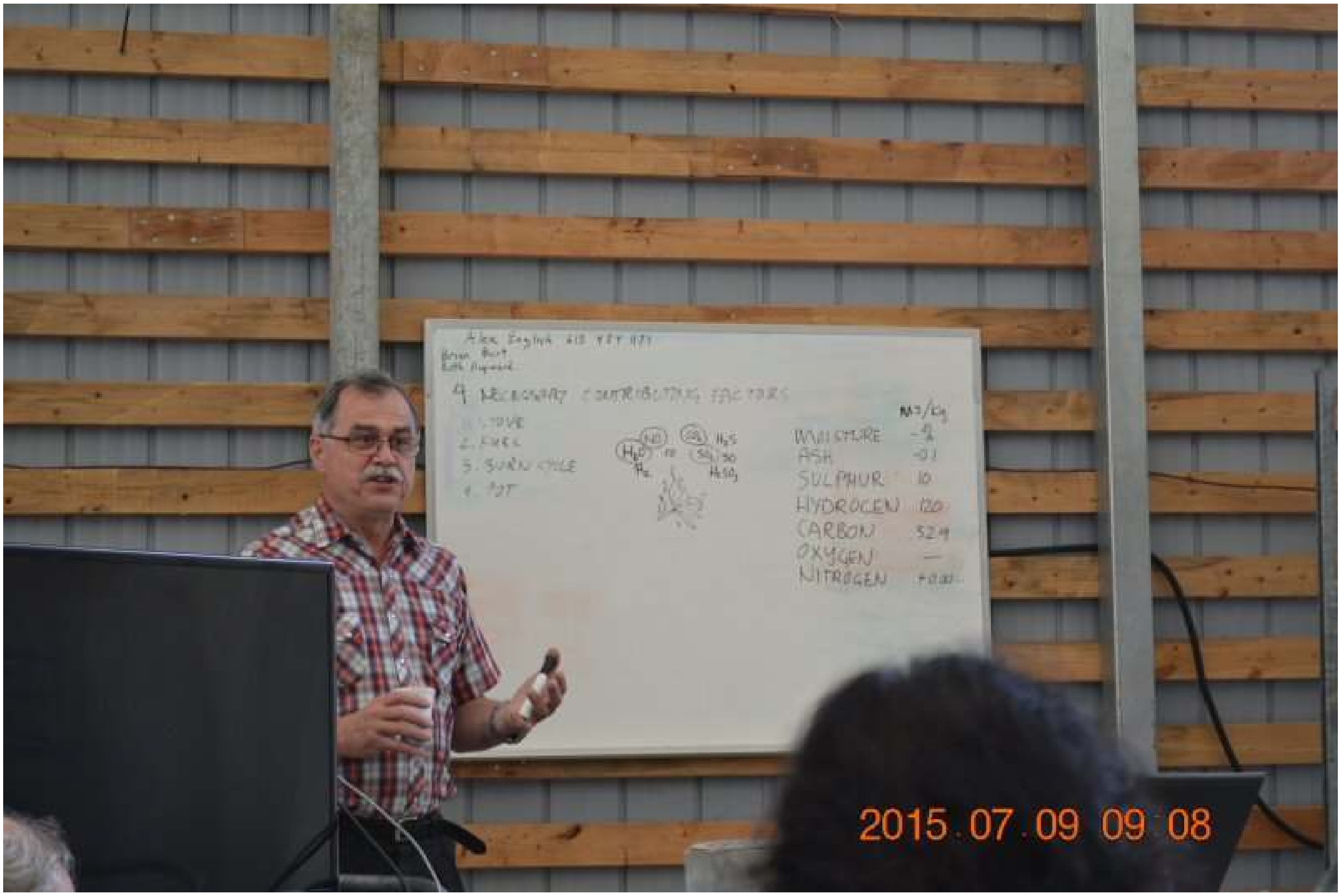
This is an experimental gravity feed pellet stove that Alex English built, and hooked up for a demo.
It needs no electricity. The sprocket in the front is connected to a manually operated shaker grate.

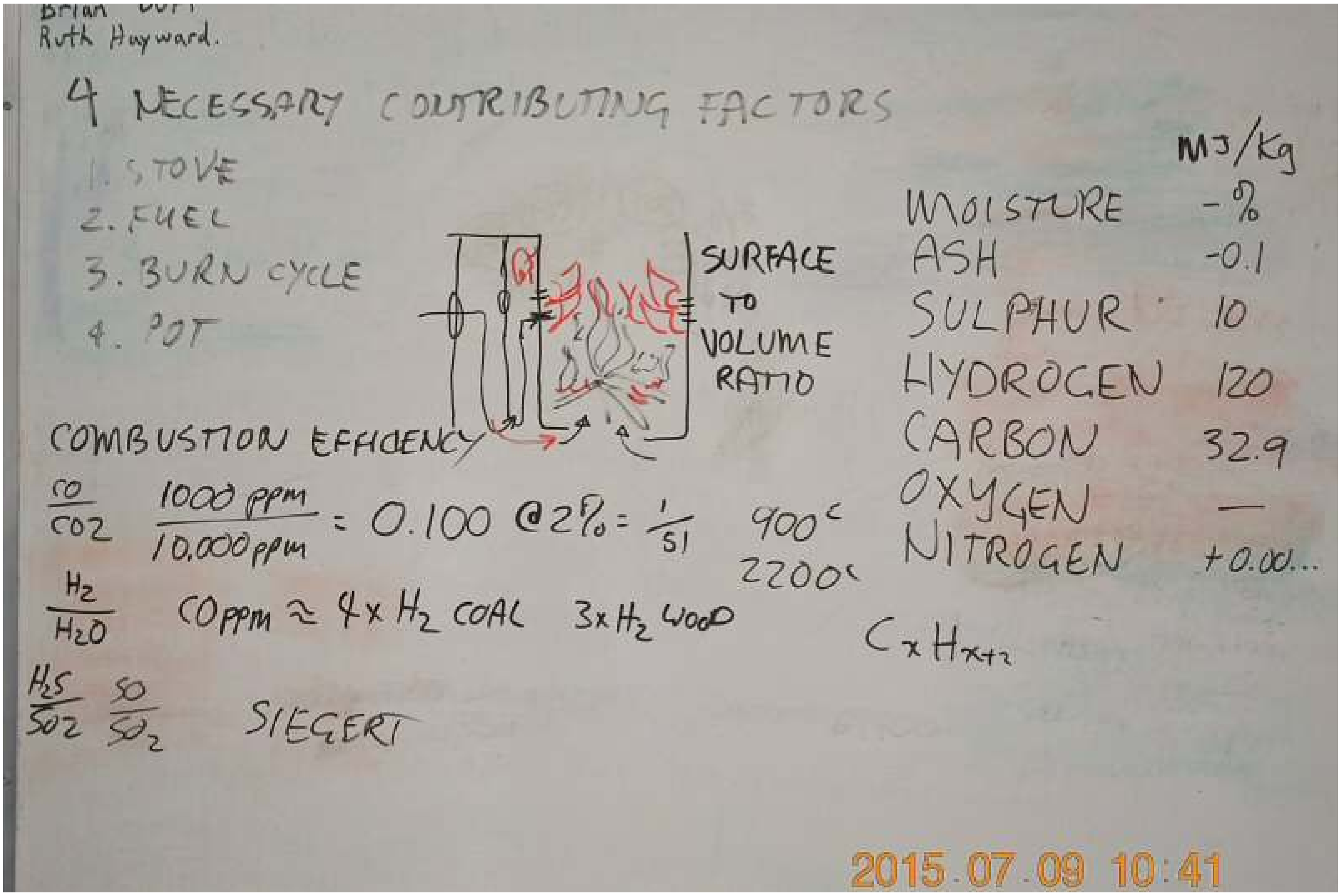
This is another prototype without a shaker grate.

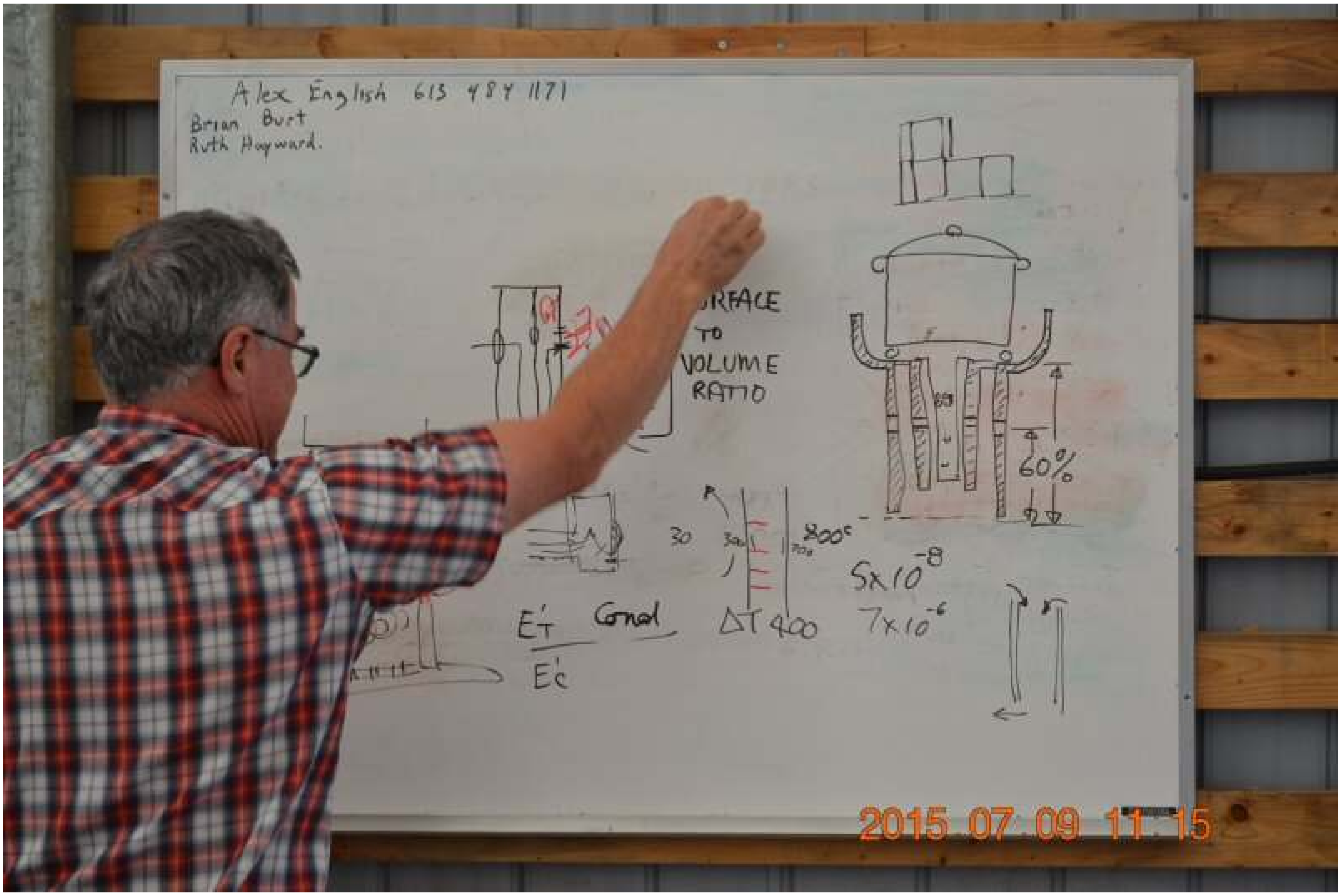
Notice the pyramid at the center of the mesh grate, with an air outlet in the center. It is designed to prevent ash clogging from the
pellets.

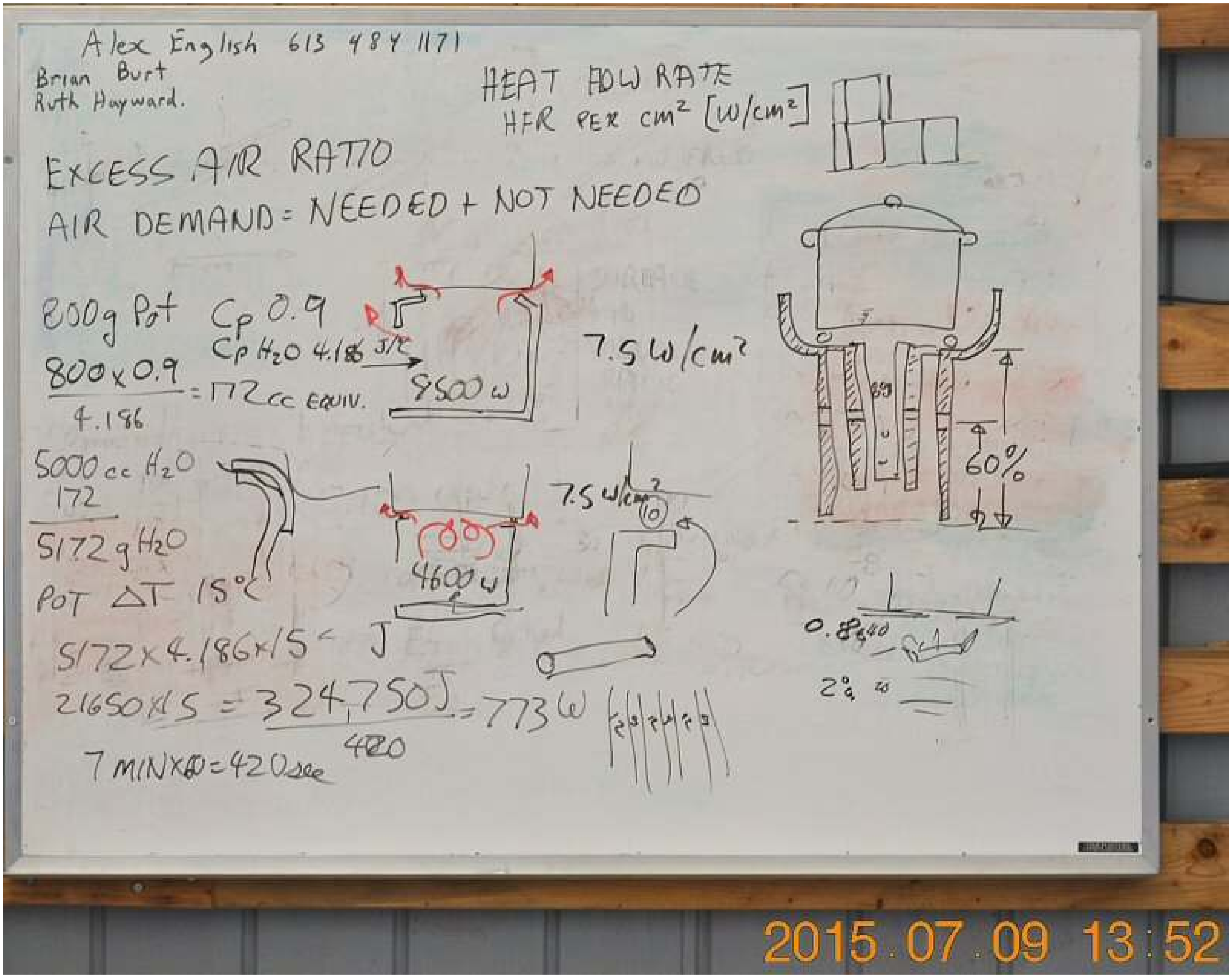
Checking the combustion with a Testo. It was very clean, with very low CO.

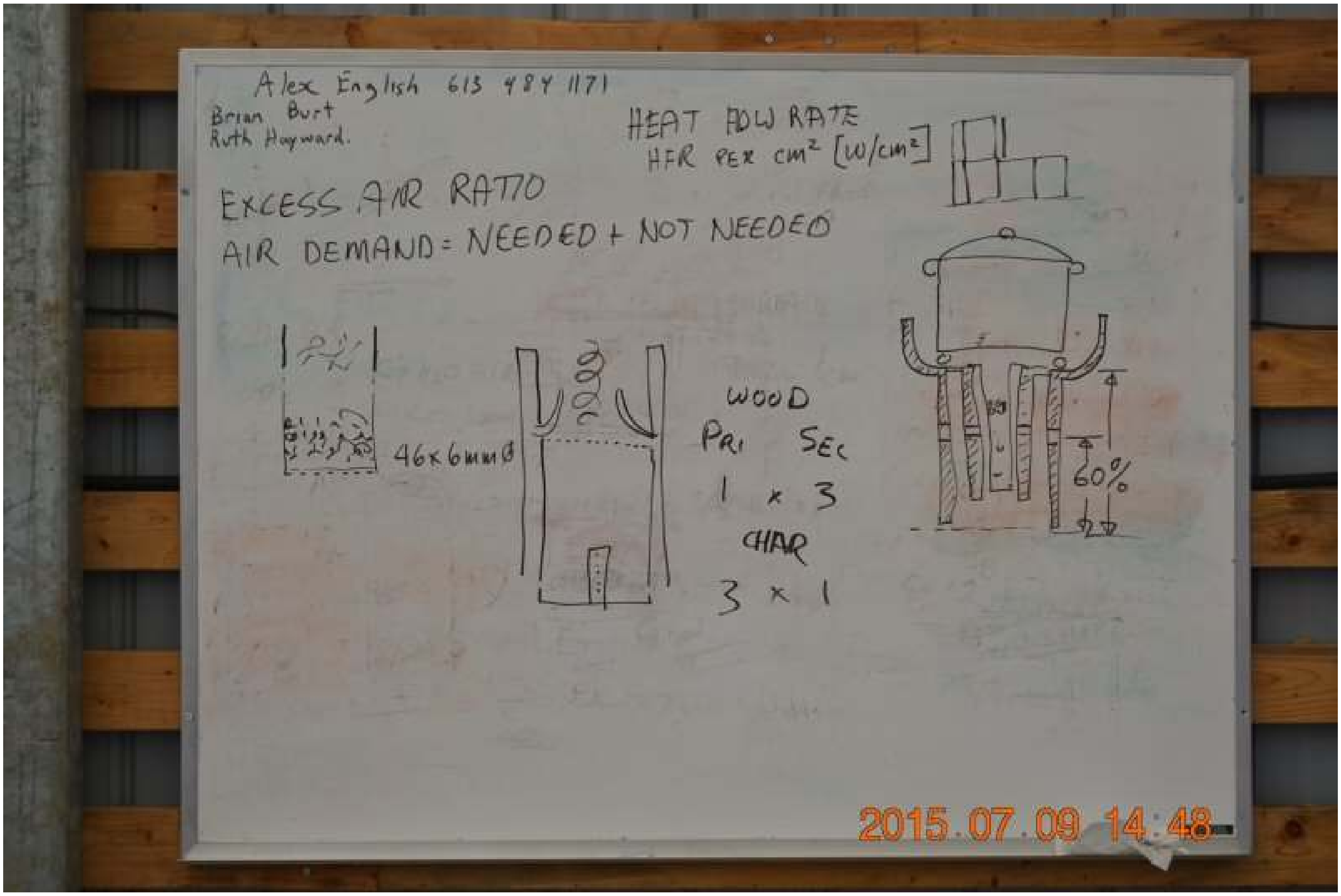

2015.07.10 08:49

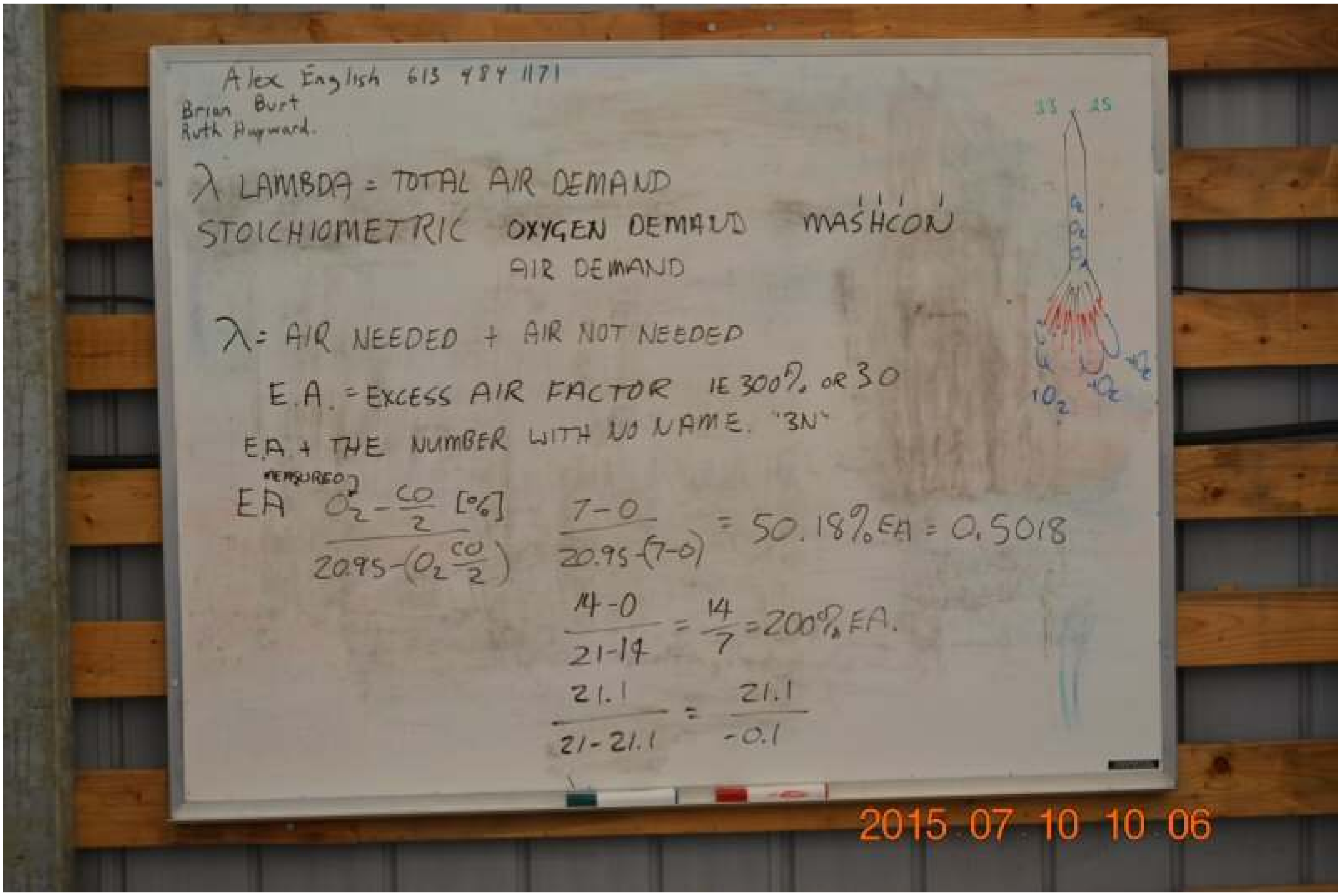

2. FUEL
3. BURN CYCLE
ASH
SULPHUR 10
HYDROGEN 120
CARBON 529
OXYGEN
NITROGEN
2015.07.09 09:08

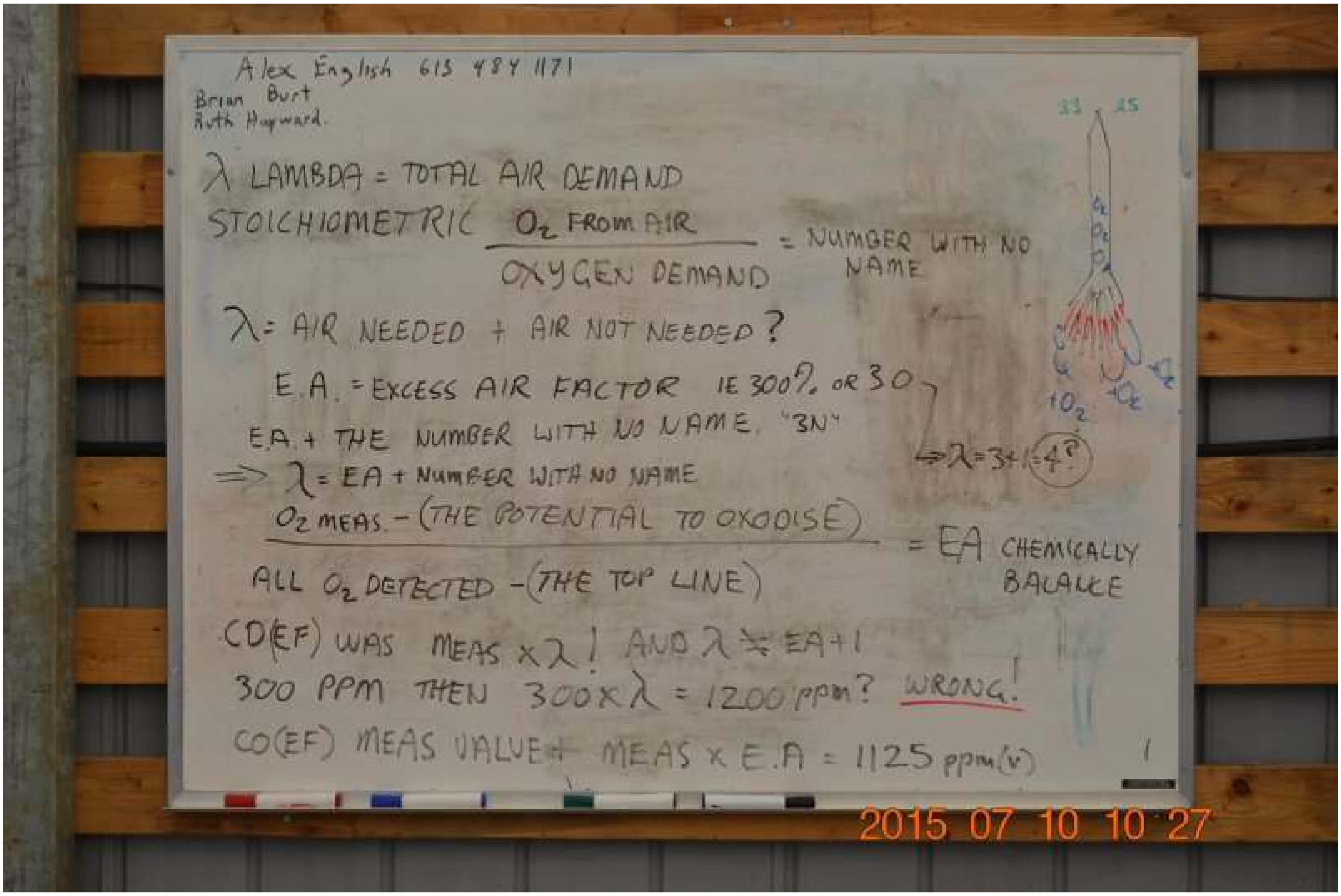

Ruth Hayward.
4 NECESSARY CONTRIBUTING FACTORS
1. STOVE
2. FUEL
3. BURN CYCLE
4. POT
MJ/Kg
MOISTURE -%
ASH -0.1
SULPHUR 10
HYDROGEN 120
CARBON 32.9
OXYGEN —
NITROGEN +0.00...
SURFACE TO VOLUME RATIO
COMBUSTION EFFICIENCY
CO/CO2 1000 ppm/10,000 ppm = 0.100 @2% = 1/51
900c
2200c
H2/H2O
COppm ≈ 4x H2 COAL 3x H2 WOOD
CxHx+2
H2S/SO2 SO/SO2
SIEGERT
2015.07.09 10:41


Alex English 613 484 1171
Brian Burt
Ruth Hayward.
SURFACE
TO
VOLUME
RATIO
60%
30
800°
5x10^-8
7x10^-6
E'T
E'c
Cond
ΔT 400
2015 07 09 11 15


Alex English 613 484 1171
Brian Burt
Ruth Hayward.
HEAT FLOW RATE
HFR PER cm² [W/cm²]
EXCESS AIR RATIO
AIR DEMAND = NEEDED + NOT NEEDED
800g Pot Cp 0.9
Cp H2O 4.186 J/C
800 x 0.9 / 4.186 = 172 cc EQUIV.
9500 W
7.5 W/cm²
5000 cc H2O
172
5172 g H2O
POT ΔT 15°C
4600 W
7.5 W/cm²
5172 x 4.186 x 15
21650 x 15 = 324,750 J / 420 = 773 W
7 MIN x 60 = 420 sec
60%
2015.07.09 13:52

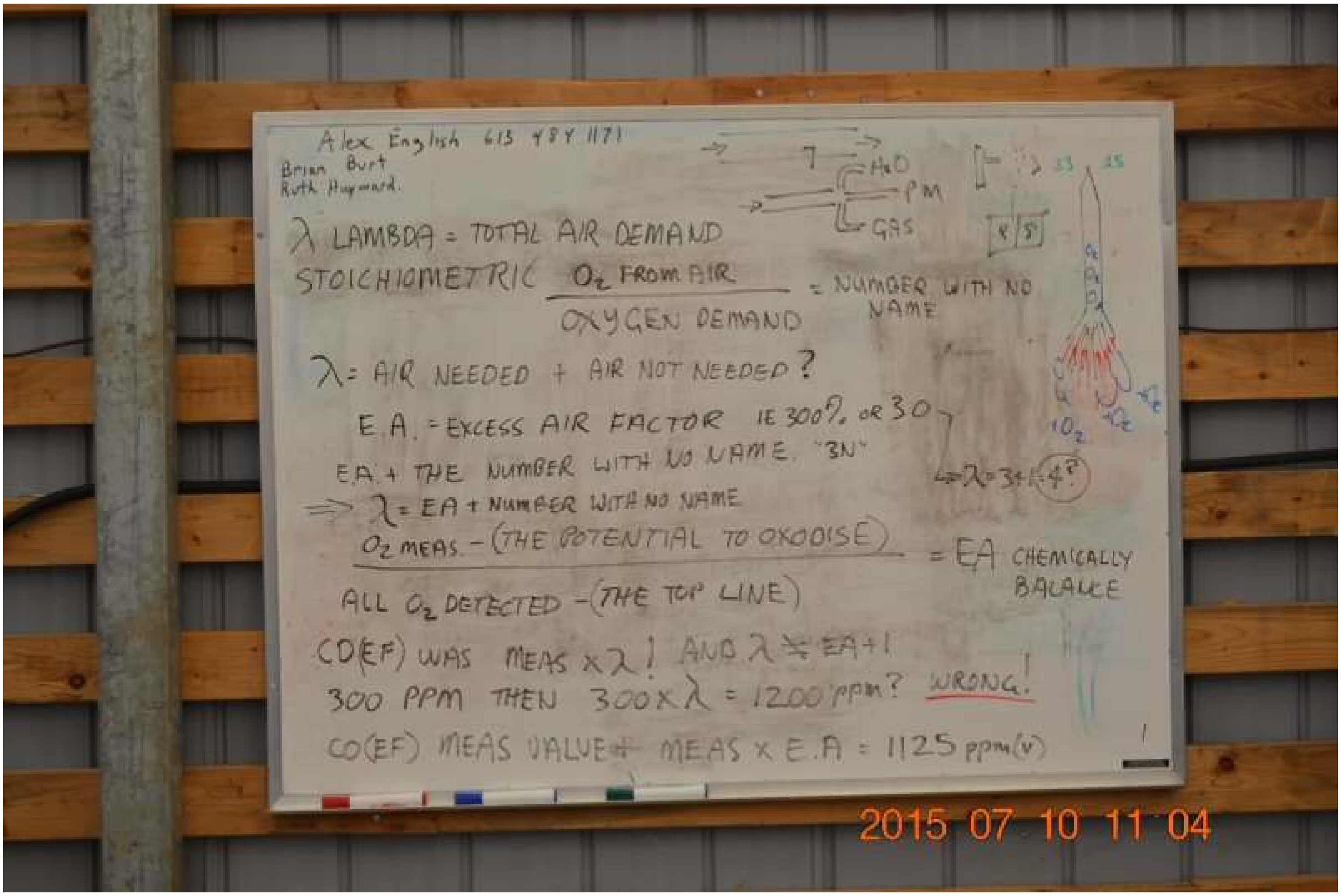

Alex English 613 484 1171
Brian Burt
Ruth Hayward.
HEAT FLOW RATE
HFR PER cm² [W/cm²]
EXCESS AIR RATIO
AIR DEMAND = NEEDED + NOT NEEDED
46x6mmØ
WOOD
PRI SEC
1 x 3
CHAR
3 x 1
60%
2015 07 09 14 48


Alex English 613 484 1171
Brian Burt
Ruth Hayward.
λ LAMBDA = TOTAL AIR DEMAND
STOICHIOMETRIC OXYGEN DEMAND MASHCON
AIR DEMAND
λ = AIR NEEDED + AIR NOT NEEDED
E.A. = EXCESS AIR FACTOR IE 300% OR 3.0
EA + THE NUMBER WITH NO NAME. "3N"
MEASURED
EA O2 - CO/2 [%] / 20.95 - (O2 CO/2)
7 - 0 / 20.95 - (7 - 0) = 50.18% EA = 0.5018
14 - 0 / 21 - 14 = 14/7 = 200% EA.
21.1 / 21 - 21.1 = 21.1 / -0.1
2015 07 10 10 06



Crispin presented results for the first time from very recent research, indicating significant error in how emission analyzers have calculated excess air ratios up to now, which induces corresponding errors in reported emissions and efficiency calculations.

Wood is 40% oxygen, and since this is much higher compared to other fuels, and has no associated nitrogen, this is can be
a significant source of error when using conventional excess air calculations intended for other fuels at steady state.



Alex English
Brian Burt
Ruth Hayward
H2O
PM
GAS
λ LAMBDA = TOTAL AIR DEMAND
STOICHIOMETRIC O2 FROM AIR / OXYGEN DEMAND = NUMBER WITH NO NAME
λ = AIR NEEDED + AIR NOT NEEDED?
E.A. = EXCESS AIR FACTOR IE 300% OR 3.0
EA + THE NUMBER WITH NO NAME "3N"
λ = 3+1 = 4?
λ = EA + NUMBER WITH NO NAME
O2 MEAS − (THE POTENTIAL TO OXIDISE) / ALL O2 DETECTED − (THE TOP LINE) = EA CHEMICALLY BALANCE
CO(EF) WAS MEAS × λ! AND λ ≈ EA+1
300 PPM THEN 300 × λ = 1200 ppm? WRONG!
CO(EF) MEAS VALUE + MEAS × E.A = 1125 ppm(v)
2015 07 10 11 04

Alex gave us a tour of his chip burning operation. This building is normally filled with fuel, and he is showing us the automated
fuel conveyor system that he developed and built. An auger has sensors that allow it to detect where the fuel pile is, and orient itself
to convey chips to a conveyor trough.

The PLC control system for the boiler.


BOILERSMITH
2015 07 10 12 18

The moving chain grate.


2015 07 10 12 21

The boiler can be used to make biochar, by closing the primary air supply.


2015 07 10 12:21

Four auger at the end are ganged in opposite directions, and feed the chips into the fire chamber.


2015 07 10 12:26

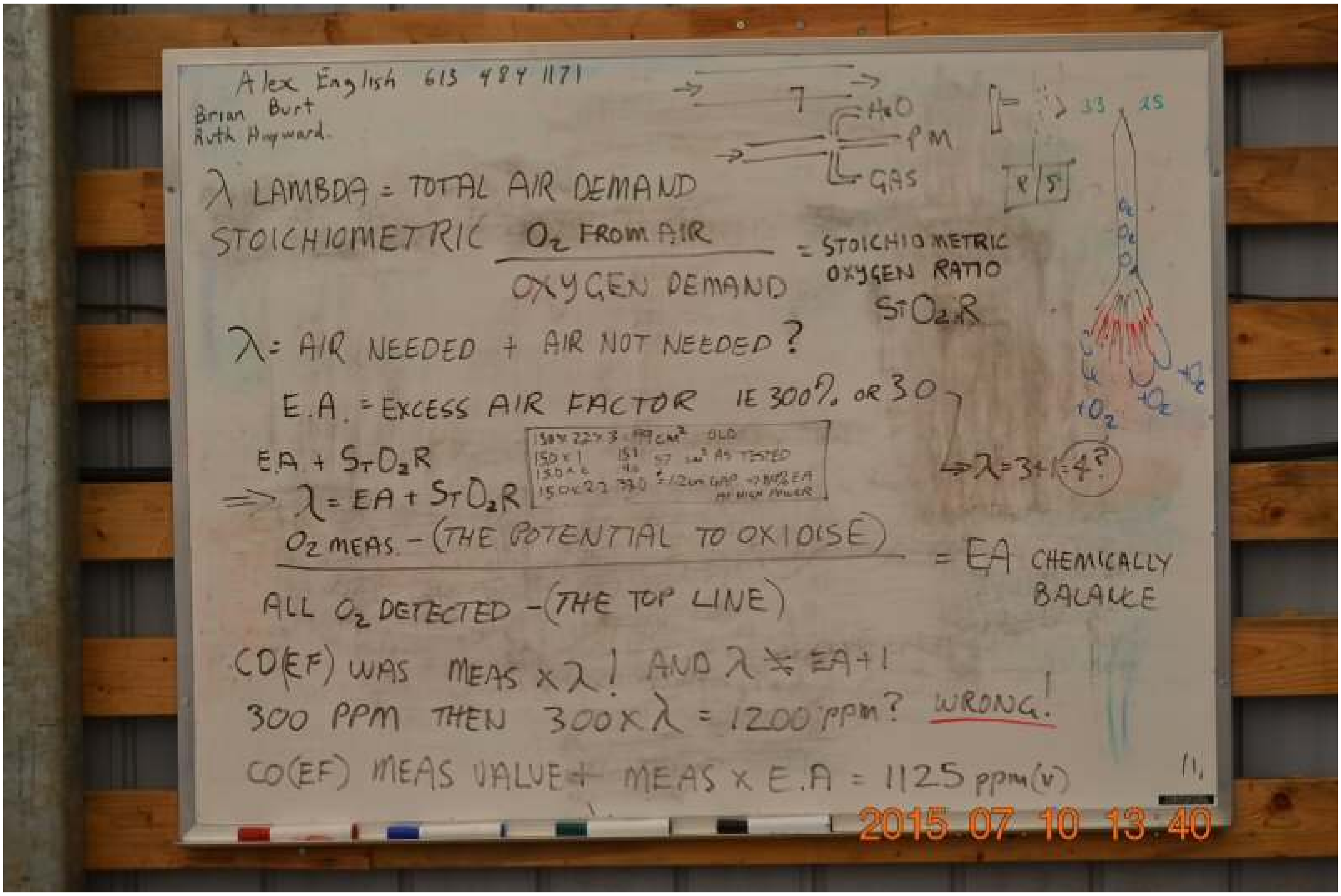
A prototype biochar takeoff. The square duct contains an airtight auger, that drops off the biochar into a drum.

Biochar in a drum.

Bagged biochar.

One of the participants, Rebecca Vermeer, is originally from Indonesia and does stove work there. Here we have her clay stove
set up underneath an improvised hood using a steel drum. Note the hose from the Wohler sampler to the blue drum hood.

Rebecca and Nathan watch the real time data on her stove.


Alex English 613 484 1171
Brian Burt
Ruth Hayward
H2O
PM
GAS
λ LAMBDA = TOTAL AIR DEMAND
STOICHIOMETRIC O2 FROM AIR
OXYGEN DEMAND
= STOICHIOMETRIC OXYGEN RATIO
STO2R
λ = AIR NEEDED + AIR NOT NEEDED?
E.A. = EXCESS AIR FACTOR IE 300% OR 3.0
EA + STO2R
⇒ λ = EA + STO2R
λ = 3+1 = 4?
O2 MEAS. − (THE POTENTIAL TO OXIDISE)
ALL O2 DETECTED − (THE TOP LINE)
= EA CHEMICALLY BALANCE
CO(EF) WAS MEAS x λ! AND λ ≠ EA+1
300 PPM THEN 300 x λ = 1200 PPM? WRONG!
CO(EF) MEAS VALUE + MEAS x E.A = 1125 ppm(v)
2015 07 10 13:40

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