

This Excel spreadsheet calculates solid fuel appliance efficiency and heat output in accordance with the procedure specified in CSA B415.1-09. In general the column headings correspond to the variables used in the Standard.

All data from a test run are entered on the "Data" sheet. The cells requiring data entry are highlighted. Please note that input data can be entered in either yard/pound or SI units. Select the units in cells F4 and F5 of the "Data" sheet.

Particulate emissions determined using the dilution tunnel method should be entered in cell C13 of the "Data" sheet as total grams of emissions.

Since oxygen concentrations are calculated for the efficiency determination, entry of measured oxygen data is optional. However, it might be useful to include the measured oxygen values for comparison to the calculated values for diagnostic purposes. A deviation of more than 1 or 2 percentage points can indicate inaccurate CO, CO₂, or fuel composition input data.

Selection of an appliance type in cell F2 of the "Data" sheet is needed for the air/fuel ratio calculation in accordance with Clause 16.3.5 of the Standard.

The "CSA B415.1 Calculations" and "Report" sheets include calculation of efficiencies based on the Lower Heating Value (LHV) of the fuel, which is not required in CSA B415.1-09. The LHV is calculated from the Higher Heating Value (HHV) and fuel composition data in accordance with ASTM E711.

The "CSA B415.1 Calculations" sheet is locked and password protected to prevent inadvertent modifications.

The "Chart" sheet includes a chart of flue gas composition data and fuel consumption. The range of cells in the "CSA B415.1 Calculations" sheet to be charted or plotted might need to be adjusted to correspond to the number of data points entered.

Please report any errors or problems to Tony Joseph at CSA.

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Version 2.2 14 December 2009

VERSION: 2.2 12/14/2009

Manufacturer: Natures Renewable

Model: 620-9

Date: 2/2/2016

Run: 3

Control #: G102067594

Test Duration: 360

Output Category: 1

Wood Moisture (% wet): 5.63

Load Weight (lb wet): 53.50

Burn Rate (dry kg/h): 3.82

Total Particulate Emissions: 57.45 g

Appliance Type: Pellet (Cat, Non-Cat, Pellet)

Temp. Units F (F or C)
Weight Units lb (kg or lb)

Default Fuel Values

| | D. Fir | Oak |
|-------------|--------|--------|
| HHV (kJ/kg) | 19,810 | 19,887 |
| %C | 48.73 | 50 |
| %H | 6.87 | 6.6 |
| %O | 43.9 | 42.9 |
| %Ash | 0.5 | 0.5 |

Fuel Data

| D. Fir | |
|--------|--------------|
| HHV | 19,832 kJ/kg |
| %C | 50 |
| %H | 6.6 |
| %O | 42.9 |
| %Ash | 0.5 |

Note 1: For other fuels, use the heating value and fuel composition determined by analysis of fuel sample in accordance with Clause 9.2.

Averages 0.06 3.78 16.70 301.04 62.03
Temp. (°F)

| Elapsed Time (min) | Fuel Weight Remaining (lb) | Flue Gas Composition (%) | | | Flue Gas | Room Temp |
|--------------------|----------------------------|--------------------------|-----------------|----------------|----------|-----------|
| | | CO | CO ₂ | O ₂ | | |
| 0 | 53.50 | 0.01 | 4.52 | 15.78 | 443.8 | 61.2 |
| 1 | 53.35 | 0.01 | 5.02 | 15.29 | 468.9 | 61.8 |
| 2 | 53.20 | 0.01 | 5.58 | 14.74 | 487.5 | 62.6 |
| 3 | 53.05 | 0.01 | 6.55 | 13.71 | 506.4 | 62.8 |
| 4 | 52.91 | 0.03 | 7.19 | 13.07 | 418.5 | 63.6 |
| 5 | 52.76 | 0.06 | 7.73 | 12.47 | 310.9 | 63.6 |
| 6 | 52.61 | 0.33 | 6.54 | 13.71 | 277.7 | 64.0 |
| 7 | 52.46 | 0.18 | 4.22 | 16.29 | 262.3 | 64.1 |
| 8 | 52.31 | 0.04 | 3.56 | 17.02 | 253.6 | 64.3 |
| 9 | 52.16 | 0.01 | 3.25 | 17.34 | 245.8 | 65.0 |
| 10 | 52.01 | 0.01 | 3.06 | 17.52 | 239.3 | 64.2 |
| 11 | 51.87 | 0.01 | 2.98 | 17.60 | 233.3 | 64.0 |
| 12 | 51.72 | 0.01 | 2.94 | 17.63 | 228.4 | 64.2 |
| 13 | 51.57 | 0.01 | 2.88 | 17.68 | 225.1 | 64.2 |
| 14 | 51.42 | 0.01 | 2.80 | 17.77 | 221.0 | 64.1 |
| 15 | 51.27 | 0.01 | 2.69 | 17.89 | 218.6 | 63.3 |
| 16 | 51.12 | 0.01 | 2.57 | 18.01 | 215.0 | 64.3 |
| 17 | 50.97 | 0.01 | 2.54 | 18.05 | 210.6 | 63.8 |
| 18 | 50.83 | 0.01 | 2.49 | 18.09 | 208.0 | 64.1 |

Note 2: In cases where the "Fuel Weight Remaining" is the same for three or more readings in a row, a "divide by zero error" will occur in the calculation sheet. In such cases, adjust the weight values by interpolation between the first occurrence and the next reading showing a decrease in weight.

Manufacturer: Atmos Renewable
Model: 620-9
Date: 02/02/16
Run: 3
Control #: G102067594
Duration: 360 min

Note: In the "Input data", "Calc. % O₂", "Fuel Properties", and "Mass Balance" columns, [e], [d], [g], [a], [b], [c], [h], [u], [w], [j], and [k] refer to their respective variables in Clauses 13.7.3 to 13.7.5.

Ultimate CO₂
 CO_{2-ult} 19.80
 F_o
 #DIV/0!

Overall Heating Efficiency: #DIV/0!
 Combustion Efficiency: #DIV/0!
 Heat Transfer Efficiency: #DIV/0!
 Heat Output: #DIV/0! Btu/h #DIV/0! kJ/h
 Heat Input: 71,825 Btu/h 75,717 kJ/h
 Burn Duration: 6.00 h
 Burn Rate: 8.41 lb/h 3.818 kg/h
 Stack Temp: 110.4 Deg. F 43.6 Deg. C

| Air Fuel Ratio (A/F) | |
|---|---------|
| Dry Molecular Weight (M _d) | #DIV/0! |
| Dry Moles Exhaust Gas (N _d) | 3003.01 |
| Air Fuel Ratio (A/F) | #DIV/0! |

| | HHV | LHV |
|-----------|---------|---------|
| Eff | #DIV/0! | #DIV/0! |
| Comb Eff | #DIV/0! | #DIV/0! |
| HT Eff | #DIV/0! | #DIV/0! |
| Output | #DIV/0! | kJ/h |
| Burn Rate | 3.82 | kg/h |
| Grams CO | #DIV/0! | g |
| Input | 75,717 | kJ/h |
| MC wet | 5.63 | |
| Averages | 0.02 | 1.39 |

| INPUT DATA | | | | Oxygen Calculation | | | Input Data | | Combust | Heat | Net | Air | Wet Wt | % Wet | Dry Wt. | % Dry | Total | Carbon |
|--------------|-----------------------|----------|-----------------------|--------------------|----------------------|----------------------------|---------------|----------------|---------|------------|-------|------------|--------|------------|---------|------------|-------|----------|
| Elapsed Time | Weight Remaining (kg) | % CO [e] | % CO ₂ [d] | Excess Air EA | Total O ₂ | Calc. % O ₂ [g] | Flue Gas (°C) | Room Temp (°C) | Eff % | Transfer % | Eff % | Fuel Ratio | Now | x Consumed | Now | y Consumed | Input | /12= [a] |
| 0 | 24.27 | 0.01 | 4.52 | 336.3% | 20.68 | 16.15 | 228.8 | 16.2 | 100.8% | 61.1% | 61.6% | 26.8 | 24.27 | 0.00 | 22.91 | 0.00 | 0 | 4.17 |
| 1 | 24.21 | 0.01 | 5.02 | 293.6% | 20.65 | 15.63 | 242.7 | 16.6 | 100.7% | 62.1% | 62.6% | 24.2 | 24.21 | 0.28 | 22.84 | 0.28 | 1893 | 4.17 |
| 2 | 24.14 | 0.01 | 5.58 | 254.4% | 20.62 | 15.04 | 253.1 | 17.0 | 100.6% | 63.6% | 64.0% | 21.8 | 24.14 | 0.56 | 22.78 | 0.56 | 1262 | 4.17 |
| 3 | 24.07 | 0.01 | 6.55 | 201.8% | 20.56 | 14.01 | 263.6 | 17.1 | 100.5% | 66.4% | 66.7% | 18.6 | 24.07 | 0.83 | 22.72 | 0.83 | 1262 | 4.17 |
| 4 | 24.00 | 0.03 | 7.19 | 174.3% | 20.53 | 13.32 | 214.7 | 17.6 | 100.2% | 73.3% | 73.4% | 16.9 | 24.00 | 1.11 | 22.65 | 1.11 | 1262 | 4.17 |
| 5 | 23.94 | 0.06 | 7.73 | 154.1% | 20.49 | 12.73 | 154.9 | 17.6 | 99.8% | 79.8% | 79.7% | 15.6 | 23.94 | 1.39 | 22.59 | 1.39 | 1262 | 4.17 |

Moisture Content M_{cwb} : 5.63

Combustion Efficiency: #DIV/0!
 Total Input (kJ): 454,300 430,882 (Btu)
 Total Output (kJ): #DIV/0! #DIV/0! (Btu)
 Efficiency: #DIV/0!
 Total CO (g): #DIV/0!

Moisture of Wood (wet basis): 5.63
 Initial Dry Weight W_{do} (kg): 22.91
 Moisture Content Dry 5.97

Dry kg : 22.91
 CA: 50
 HY: 6.6
 OX: 42.9

Load Weight (kg): 24.27
 Fuel Heating HHV LHV HHV LHV
 Value in kJ/kg - CV: 19,832 18,409 Btu/lb 8531.9 7919.7

| 6.60 | 2.68 | 19832.00 | 5.63 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | 3.31 | 316.92 | 1994.84 | 1479.77 | 1433.68 | 1418.90 |
|-----------------|----------|-----------|------------|-------------------------------|---------|---------|---------|---------|--------------|--------------------------|----------------|---------|---------|----------------|------------------|----------|--------|--|----------------|---------|----------------|
| Fuel Properties | | | Mw | Mass Balance | | | | | kg Wood per | Moles per kg of Dry Wood | | | | | | Moisture | Stack | Heat Content Change - Ambient to Stack | | | |
| Hydrogen | Oxygen | Calorific | Moisture | (moles/100 mole dry flue gas) | | | | | 100 mole dfp | | | | | | | Present | Temp | Flue Gas Constituent | | | |
| /1= [b] | /16= [c] | Value | Fuel Burnt | [h] | [u] | [w] | [j] | [k] | Nk | CO ₂ | O ₂ | CO | HC | N ₂ | H ₂ O | | K | CO ₂ | O ₂ | CO | N ₂ |
| 6.60 | 2.68 | 19832.00 | 5.63 | 79.31 | 21.04 | 1.08 | 3.62 | -0.02 | 0.11 | 41.96 | 149.76 | 0.13 | -0.22 | 735.57 | 33.60 | 3.31 | 501.94 | 8719.13 | 6450.59 | 6245.40 | 6181.92 |
| 6.60 | 2.68 | 19832.00 | 5.63 | 79.34 | 21.05 | 1.20 | 4.01 | -0.02 | 0.12 | 41.98 | 130.66 | 0.09 | -0.19 | 663.48 | 33.55 | 3.31 | 515.88 | 9322.52 | 6876.84 | 6653.05 | 6586.49 |
| 6.60 | 2.68 | 19832.00 | 5.63 | 79.38 | 21.05 | 1.34 | 4.45 | -0.02 | 0.13 | 41.96 | 113.13 | 0.08 | -0.17 | 597.20 | 33.50 | 3.31 | 526.20 | 9767.73 | 7189.55 | 6951.65 | 6882.93 |
| 6.60 | 2.68 | 19832.00 | 5.63 | 79.43 | 21.07 | 1.57 | 5.22 | -0.02 | 0.16 | 41.94 | 89.70 | 0.07 | -0.13 | 508.63 | 33.43 | 3.31 | 536.72 | 10235.99 | 7518.03 | 7265.19 | 7194.23 |
| 6.60 | 2.68 | 19832.00 | 5.63 | 79.46 | 21.08 | 1.73 | 5.74 | -0.02 | 0.17 | 41.80 | 77.44 | 0.17 | -0.10 | 461.96 | 33.36 | 3.31 | 487.86 | 8049.71 | 5970.95 | 5784.92 | 5725.30 |
| 6.60 | 2.68 | 19832.00 | 5.63 | 79.48 | 21.08 | 1.87 | 6.19 | -0.01 | 0.19 | 41.62 | 68.51 | 0.32 | -0.06 | 427.75 | 33.29 | 3.31 | 428.09 | 5489.68 | 4123.38 | 4007.72 | 3963.71 |

| | | | SUMS | | | | | | | AVERAGE | SUMS | | | | | | |
|-----------------|------------------|-----------|-----------------------------------|----------------|---------|----------------|-----------------|-----------------------|--------------------------|-----------------|------------|-----------------|--------------------------|--------------|-------------|----------------|-------|
| 1967.41 | 1713.95 | 268.05 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | 148534.93 | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | |
| Temperature | | Room Temp | Energy Losses (kJ/kg of Dry Fuel) | | | | | | | Total Loss Rate | Total Loss | Chemical Loss 1 | Sensible and Latent Loss | Total Output | Chem Loss 2 | Grams Produced | |
| CH ₄ | H ₂ O | K | CO ₂ | O ₂ | CO | N ₂ | CH ₄ | H ₂ O Comb | H ₂ O Fuel MC | | | | | | CO | HC | |
| 8636.94 | 7464.94 | 289.35 | 365.88 | 966.01 | 38.32 | 4547.26 | -196.85 | 1728.38 | 170.47 | 7619.47 | 0.00 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 |
| 9278.79 | 7950.59 | 289.72 | 391.33 | 898.54 | 26.99 | 4369.99 | -174.78 | 1742.13 | 172.08 | 7426.28 | 708.82 | -14 | 722.81 | 1184 | -14 | 0.25 | -0.30 |
| 9756.29 | 8306.16 | 290.14 | 409.85 | 813.34 | 24.36 | 4110.46 | -150.98 | 1751.29 | 173.26 | 7131.59 | 453.80 | -8 | 461.78 | 808 | -8 | 0.15 | -0.17 |
| 10259.46 | 8679.49 | 290.26 | 429.27 | 674.37 | 20.73 | 3659.20 | -119.15 | 1760.06 | 174.50 | 6598.99 | 419.90 | -6 | 426.11 | 842 | -6 | 0.13 | -0.13 |
| 7939.64 | 6915.79 | 290.71 | 336.52 | 462.38 | 49.04 | 2644.87 | -88.61 | 1697.68 | 168.65 | 5270.53 | 335.37 | -3 | 337.90 | 927 | -3 | 0.30 | -0.10 |
| 5302.17 | 4795.25 | 290.72 | 228.48 | 282.49 | 91.60 | 1695.46 | -56.37 | 1623.45 | 161.62 | 4026.73 | 256.23 | 2 | 254.05 | 1006 | 2 | 0.57 | -0.06 |

ABC Laboratories, Inc.

Manufacturer:atures Renewable
Model: 620-9
Date: 02/02/16
Run: 3
Control #: G102067594
Test Duration: 360
Output Category: 1

Technicians: _____

Test Results in Accordance with CSA B415.1-09

| | HHV Basis | LHV Basis |
|--------------------------|-----------|-----------|
| Overall Efficiency | #DIV/0! | #DIV/0! |
| Combustion Efficiency | #DIV/0! | #DIV/0! |
| Heat Transfer Efficiency | #DIV/0! | #DIV/0! |

| | | | |
|--------------------|---------|---------|---------|
| Output Rate (kJ/h) | #DIV/0! | #DIV/0! | (Btu/h) |
| Burn Rate (kg/h) | 3.82 | 8.41 | (lb/h) |
| Input (kJ/h) | 75,717 | 71,825 | (Btu/h) |

| | | | |
|---------------------------|---------|-------|--------|
| Test Load Weight (dry kg) | 22.91 | 50.49 | dry lb |
| MC wet (%) | 5.63 | | |
| MC dry (%) | 5.97 | | |
| Particulate (g) | 57.45 | | |
| CO (g) | #DIV/0! | | |
| Test Duration (h) | 6.00 | | |

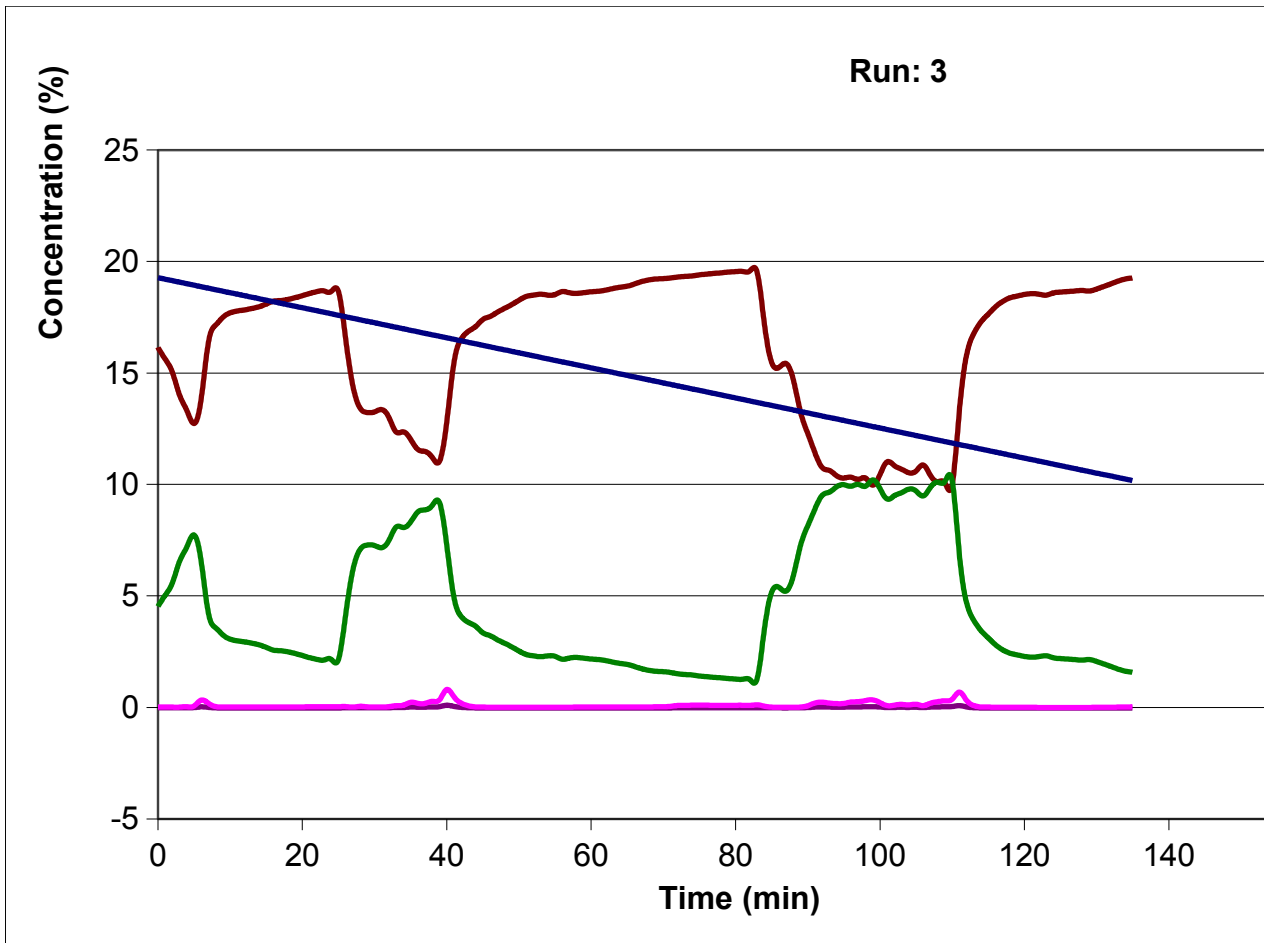
| Emissions | Particulate | CO |
|------------------|-------------|---------|
| g/MJ Output | #DIV/0! | #DIV/0! |
| g/kg Dry Fuel | 2.51 | #DIV/0! |
| g/h | 9.58 | #DIV/0! |
| lb/MM Btu Output | #DIV/0! | #DIV/0! |

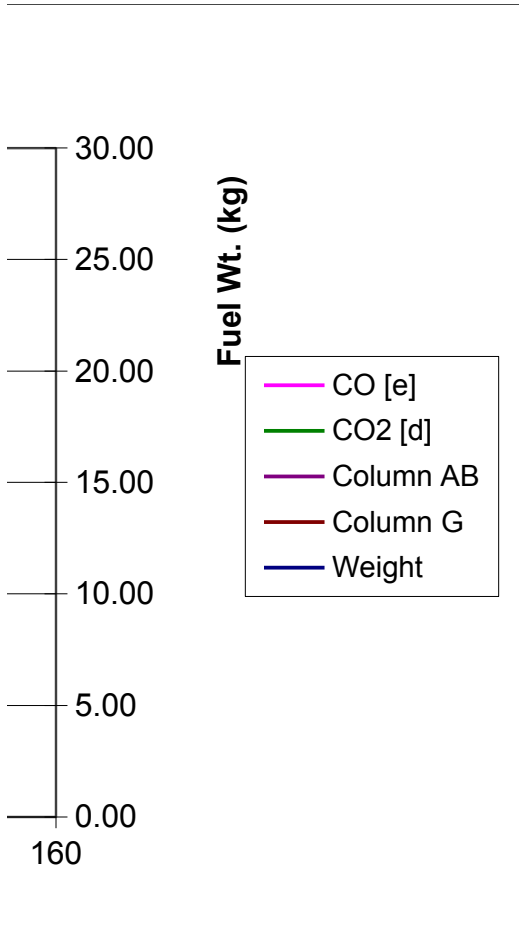
| | |
|----------------------|---------|
| Air/Fuel Ratio (A/F) | #DIV/0! |
|----------------------|---------|

VERSION:

2.2

12/14/2009





Note: In the legend, [d], [e], [g], and [k] refer to their respective variables in Clauses 13.7.3 and 13.7.5