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JOHNSON GAS APPLIANCE COMPANY TEST REPORT

SCOPE OF WORK
EPA EMISSIONS TESTING FOR MODEL ECLIPSE-P II PELLET FUEL ROOM HEATER

REPORT NUMBER
105164443MID-002R3

TEST DATE(S)
10/25/22

ISSUE DATE	**[REVISED DATE]**
10/31/22	11/09/23

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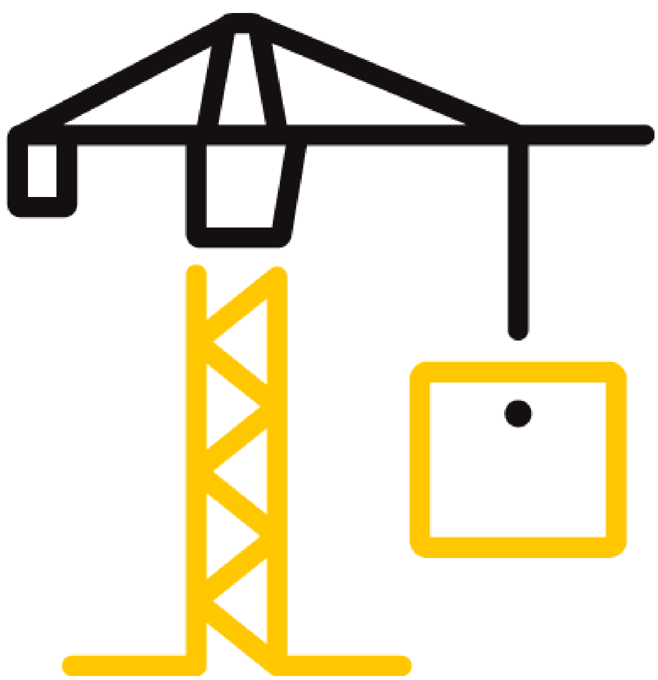

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TEST REPORT FOR JOHNSON GAS APPLIANCE COMPANY

Report No.: 105164443MID-002R3
Date: 11/09/23

REPORT ISSUED TO

JOHNSON GAS APPLIANCE COMPANY
1155 Sherman Road
Hiawatha, IA 52233

SECTION 1

SCOPE

Intertek Testing Services NA, Inc. dba Intertek Building & Construction (B&C) was contracted by Johnson gas Appliance Company, 1155 Sherman Road, Hiawatha, IA 52233 to perform testing in accordance with EPA 40 CFR Part 60, "Standards of Performance for New Residential Wood Heaters, New Residential Hydronic Heaters and Forced-Air Furnaces," ASTM E2515-2017, "Standard Test Method for Determination of Particulate Matter Emissions Collected by a Dilution Tunnel," ASTM E2779-2017, "Standard Test Method for Determining Particulate Matter Emissions from Pellet Heaters," and CSA B415.1-2010 (R2020), "Performance Testing of Solid-Fuel-Burning Heating Appliances" on their model Eclipse-P II Pellet Fuel Room Heater. Results obtained are tested values and were secured by using the designated test method(s). Testing was conducted at Intertek test facility in Middleton, WI.

Unless differently required, Intertek reports apply the "Simple Acceptance" rule also called "Shared Risk approach," of ILAC-G8:09/2019, Guidelines on Decision Rules and Statements of Conformity.

Intertek B&C will service this report for the entire test record retention period. The test record retention period ends four years after the test date. Test records, such as detailed drawings, datasheets, representative samples of test specimens (where required by Certification or Accreditation bodies), or other pertinent project documentation, will be retained for the entire test record retention period.

For INTERTEK B&C:

COMPLETED BY:	Ken Slater	**REVIEWED BY:**	Brian Ziegler
TITLE:	Associate Engineer – Hearth	**TITLE:**	Technical Team Leader- Hearth
SIGNATURE:	Ken Slater	**SIGNATURE:**	
DATE:	11/09/23	**DATE:**	11/09/23

AAA:bbb

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SECTION 2
SUMMARY OF TEST RESULTS

The appliance tests resulted in the following performance:

Particulate Emissions: 1.91 g/hr
Carbon Monoxide Emissions: 0.017 g/min
Heating Efficiency: 76.9% (Higher Heating Value Basis)

SECTION 3
TEST METHOD(S)

The specimen was evaluated in accordance with the following:

EPA 40 CFR Part 60-2015, *Standards of Performance for New Residential Wood Heaters, New Residential Hydronic Heaters and Forced-Air Furnaces*

ASTM E2515-2017, *Standard Test Method for Determination of Particulate Matter Emissions Collected by a Dilution Tunnel*

ASTM E2779-2017, *Standard Test Method for Determining Particulate Matter Emissions from Pellet Heaters*

CSA B415.1-2010 (R2020), *Performance Testing of Solid-Fuel-Burning Heating Appliances*

EPA ALT-146 *Dated 2/4/22, For alternate medium burn rates for pellet stoves*

SECTION 4
MATERIAL SOURCE/INSTALLATION

A sample was submitted to Intertek directly from the client. The sample was not independently selected for testing. The test unit was received at Intertek in Middleton, WI on 10/19/22 and was shipped via the client. The unit was inspected upon receipt and found to be in good condition. The unit was set up following the manufacturer's instructions without difficulty.

Following assembly, the unit was placed on the test stand. Prior to beginning the emissions tests, Johnson Gas Appliance Company staff operated the unit for a minimum of 48 hours at a medium burn rate to break in the stove. The unit was found to be operating satisfactory during this break-in. The 48 plus hours of pre-burning were conducted from 9/06/22 to 9/13/22. The fuel used for the break-in process was wood pellets.

Following the pre-burn break-in process the unit was allowed to cool and ash and residue was removed from the firebox. The unit's chimney system and laboratory dilution tunnels were cleaned using standard wire brush chimney cleaning equipment. On 10/25/22 the unit was set-up for testing.

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SECTION 5
EQUIPMENT

EQUIPMENT	INV NUMBER	CALIBRATION DUE	MU
Timer	646	4/5/23	0.06 sec
Timer	1213	4/5/23	0.06 sec
Pressure Transducer	1406	1/13/23	0.00006 (inH2O)
Data Acquisition	986	4/0/23	0.06 °F
Platform Scale	1134	4/01/23	.118 lbs
Hygrometer	1450	2/16/23	.033 inH2O; 0.35 %RH
Flow Meter	1413	3/20/23	0.0075 slpm
Flow Meter	1414	3/20/23	0.0075 slpm
Flow Meter	1519	3/20/23	0.0074 slpm
Balance	713	4/04/23	0.00007 g
Anemometers	1457	4/04/23	5 fpm
Mercurial Barometer	437	NA	0.05 in

SECTION 6
LIST OF OFFICIAL OBSERVERS

NAME	COMPANY
Ken Slater	Intertek B&C
Terry Krumrei	Johnson Gas Appliance Company

SECTION 7
TEST PROCEDURE

On 10/25/22, the unit was tested for EPA emissions. For pellet stoves, the test was conducted in accordance with ASTM E2779. The fuel used for the test run was premium-Grade Pellets (Marthwood).

The applicable EPA regulatory limits are:

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Step 1 – 2015 – 4.5 grams per hour.

Step 2 – 2020 – 2.0 grams per hour.

TEST SET-UP DESCRIPTION

A 3" vertical flue is connected by adapters to a standard 6" diameter vertical single wall pipe and insulated chimney system was installed to 15' above floor level. The singe wall pipe extended to 8 feet above the floor and insulated chimney extended the remaining height.

AIR SUPPLY SYSTEM

Combustion air enters a 2" inlet pipe located on the back of the heater, which is directed to the pellet burn pot. All gases exit through the 3" flue also located at the back of the heater. The exhaust gases are assisted by a combustion blower.

TEST FUEL PROPERTIES

Wood pellets used for the testing were Marth premium grade hardwood pellets, with a majority of the wood species consisting of oak and maple. The pellets have a measured heating value of 7968 Btu/hr (kJ/kg 18533) and a moisture content of 3.70% on a dry basis and 3.57% on a wet basis.

SAMPLING LOCATIONS

Particulate samples are collected from the dilution tunnel at a point 20 feet from the tunnel entrance. The tunnel has two elbows in the system ahead of the sampling section. (See Figure 3.) The sampling section is a continuous 13-foot section of 6 inch diameter pipe straight over its entire length. Tunnel velocity pressure is determined by a standard Pitot tube located 60 inches from the beginning of the sampling section. The dry bulb thermocouple is located six inches downstream from the Pitot tube. Tunnel samplers are located 60 inches downstream of the Pitot tube and 36 inches upstream from the end of this section. (See Figure 1.)

Stack gas samples are collected from the steel chimney section 8 feet ± 6 inches above the scale platform. (See Figure 2.)

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FIGURE 1 – DILUTION TUNNEL

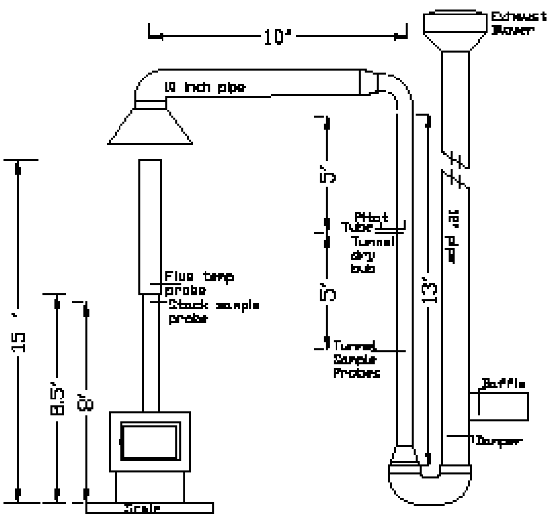
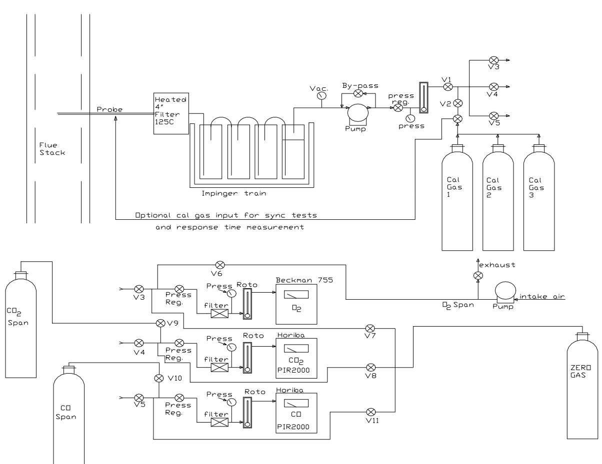


FIGURE 1

FIGURE 2 – STACK GAS SAMPLE TRAIN



ITS FLUE GAS SAMPLE TRAIN

FIGURE 2

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FIGURE 3 – DILUTION TUNNEL SAMPLE SYSTEMS

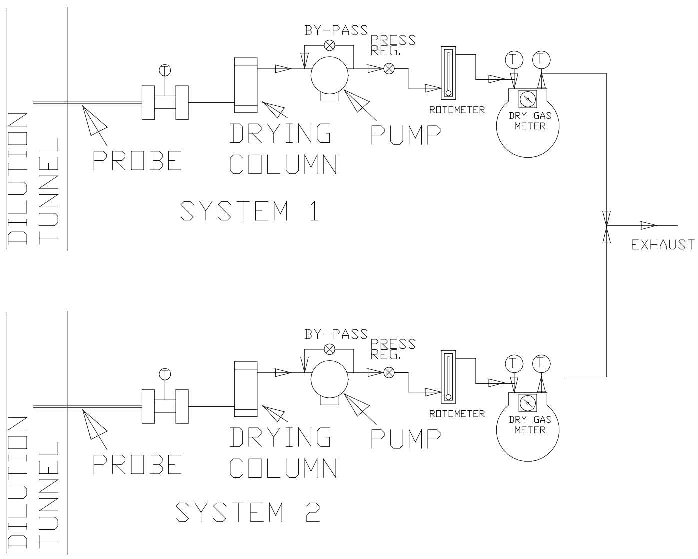

Figure 3

SAMPLING METHODS

PARTICULATE SAMPLING

Particulates were sampled in strict accordance with ASTM E2515. This method uses two identical sampling systems with Merck Millpore AP4004700 Glass Fibre, 47-mm diameter filters. The dryers used in the sample systems are filled with "Drierite" before each test run. In order to measure first-hour emissions rates a third filter sample train is prepared separate of the required two train system for the total emissions rate. The filter set are analyzed individually to determine the first hour and total emissions rate.

INSTRUMENT CALIBRATION

DRY GAS METERS

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At the conclusion of each test program the dry gas meters are checked against our standard dry gas meter. Three runs are made on each dry gas meter used during the test program. The average calibration factors obtained are then compared with the six-month calibration factor and, if within 5%, the six-month factor is used to calculate standard volumes. Results of this calibration are contained in Appendix D.

An integral part of the post-test calibration procedure is a leak check of the pressure side by plugging the system exhaust and pressurizing the system to 10" W.C. The system is judged to be leak free if it retains the pressure for at least 10 minutes.

The standard dry gas meter is calibrated every 6 months using a Spirometer designed by the EPA Emissions Measurement Branch. The process involves sampling the train operation for 1 cubic foot of volume. With readings made to .001 ft^3, the resolution is .1%, giving an accuracy higher than the ±2% required by the standard.

STACK SAMPLE ROTAMETER

The stack sample rotometer is checked by running three tests at each flow rate used during the test program. The flow rate is checked by running the rotometer in series with one of the dry gas meters for 10 minutes with the rotometer at a constant setting. The dry gas meter volume measured is then corrected to standard temperature and pressure conditions. The flow rate determined is then used to calculate actual sampled volumes.

GAS ANALYZERS

The continuous analyzers are zeroed and spanned before each test with appropriate gases. A mid-scale multi-component calibration gas is then analyzed (values are recorded). At the conclusion of a test, the instruments are checked again with zero, span and calibration gases (values are recorded only). The drift in each meter is then calculated and must not exceed 5% of the scale used for the test.

At the conclusion of each unit test program, a three-point calibration check is made. This calibration check must meet accuracy requirements of the applicable standards. Consistent deviations between analyzer readings and calibration gas concentrations are used to correct data before computer processing. Data is also corrected for interferences as prescribed by the instrument manufacturer's instructions.

TEST METHOD PROCEDURES

LEAK CHECK PROCEDURES

Before and after each test, each sample train is tested for leaks. Leakage rates are measured and must not exceed 0.02 CFM or 4% of the sampling rate. Leak checks are performed checking the

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entire sampling train, not just the dry gas meters. Pre-test and post-test leak checks are conducted with a vacuum of 10 inches of mercury. Vacuum is monitored during each test and the highest vacuum reached is then used for the post-test vacuum value. If leakage limits are not met, the test run is rejected. During, these tests the vacuum was typically less than 2 inches of mercury. Thus, leakage rates reported are expected to be much higher than actual leakage during the tests.

TUNNEL VELOCITY/FLOW MEASUREMENT

The tunnel velocity is calculated from a center point Pitot tube signal multiplied by an adjustment factor. This factor is determined by a traverse of the tunnel as prescribed in EPA Method 1. Final tunnel velocities and flow rates are calculated from EPA Method 2, Equation 6.9 and 6.10. (Tunnel cross sectional area is the average from both lines of traverse.)

Pitot tubes are cleaned before each test and leak checks are conducted after each test.

PM SAMPLING PROPORTIONALITY

Proportionality was calculated in accordance with ASTM E2515-2017. The data and results are included in Appendix C.

DEVIATIONS FROM STANDARD METHOD:

EPA ALT-146 was used for the medium burn rate determination. The manufacturer determined that the model Eclipse-P II could not meet ≤50% requirement for the medium burn rate outlined in Clause 9.4.1.2 of ASTM E2779-2017; therefore, EPA ALT-146 was used to determine the medium burn rate. The calculation to determine the medium burn rate in ALT-146 is to be ≤50% of the difference between the maximum burn rate and the minimum burn rate. 2.91 kg/hr (high) + 1.26 kg/hr (low)/2 = 2.09 kg/hr. The Eclipse-P II operated at a 1.86 kg/hr burn rate for the medium setting, which is less than 2.09 kg/hr.

SECTION 8
TEST CALCULATIONS

WEIGHT OF TEST FUEL BURNED (DRY) – ASTM E2779

$$M_{Bdb} = (M_{Swb} - M_{Ewb})(100/(100 + FM))$$

where:

FM = average fuel moisture of test fuel, % dry basis,
M_{Swb} = weight of test fuel in hopper at start of test run, wet basis, kg (lb),
M_{Ewb} = weight of test fuel in hopper at end of test run, wet basis, kg (lb), and
M_{Bdb} = weight of test fuel burned during test run, dry basis, kg (lb).

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WEIGHT OF TEST FUEL BURNED PER TEST SEGMENT (DRY) – ASTM E2779

$$M_{BSidb} = (M_{SSiwb} - M_{ESiwb}) (100/(100 + FM))$$

where:
M_{SSiwb} = weight of test fuel in hopper at start of test run segment *i*, wet basis, kg (lb),
M_{ESiwb} = weight of test fuel in hopper at end of test run segment *i*, wet basis, kg (lb),
M_{BSidb} = weight of test fuel burned during test run segment *i*, dry basis, kg (lb), and
i = test run segments in accordance with 9.4, Table 1.

AVERAGE BURN RATE FOR FULL TEST (DRY) – ASTM E2779

$$BR = 60\ M_{Bdb}/\theta$$

where:
BR = average dry burn rate over the full integrated test run, kg/h (lb/h), and
θ = total length of full integrated test run, min.

AVERAGE BURN RATE PER TEST SEGMENT (DRY) – ASTM E2779

$$BR_{Si} = 60\ M_{BSidb}/\ \theta_{Si}$$

where:
BR_{Si} = average dry burn rate over test run segment *i*, kg/h (lb/h), and
θ_{Si} = total length of test run segment *i*, min.

AVERAGE EMISSION RATE FOR FULL TEST (g/hr) – ASTM E2779

$$PM_R = 60(E_T/\theta)$$

where:
E_T = total particulate emissions for full integrated test run measured using Test Method E2515, g (lb),
θ = total length of test run, min, and
PM_R = average particulate emission rate over the full integrated test run, g/h.

AVERAGE EMISSION FACTOR FOR FULL TEST (g/kg dry) – ASTM E2779

$$PM_F = E_T/M_{Bdb}$$

where:
PM_F = average particulate emission factor over the full integrated test run, g/dry kg of fuel burned.

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AVERAGE EMISSIONS FOR FULL TEST (g/MJ or lb/MMBtu) – ASTM E2779

$$PM_H = E_T/E_O$$

where:

E_O = average measured overall heat output over the full integrated test run from Annex A1, MJ (MMBTU), and

PM_H = average particulate emissions in accordance with unit of average heat output over the full integrated test run, g/MJ (lb/MMBtu).

NOMENCLATURE FOR ASTM E2515:

A = Cross-sectional area of tunnel m2 (ft2).

B_{ws} = Water vapor in the gas stream, proportion by volume (assumed to be 0.02 (2.0 %)).

C_p = Pitot tube coefficient, dimensionless (assigned a value of 0.99).

c_r = Concentration of particulate matter room air, dry basis, corrected to standard conditions, g/dscm (gr/ dscf) (mg/dscf).

c_s = Concentration of particulate matter in tunnel gas, dry basis, corrected to standard conditions, g/dscm (gr/dscf) (mg/dscf).

E_T = Total particulate emissions, g.

F_p = Adjustment factor for center of tunnel pitot tube placement.

$F_p = V_{strav}/V_{scent}$

K_P = Pitot Tube Constant, 34.97 $\frac{m}{\text{sec}}[\frac{(\frac{g}{g}\blacksquare mole)(mm\ Hg)}{(K)(mm\ water)}]^{\frac{1}{2}}$

or

= Pitot Tube Constant, 85.49 $\frac{ft}{\text{sec}}[\frac{(\frac{lb}{lb}-mole)(in\ Hg)}{(R)(in\ water)}]^{\frac{1}{2}}$

L_a = Maximum acceptable leakage rate for either a pretest or post-test leak- check, equal to 0.0003 m3/min (0.010 cfm) or 4 % of the average sampling rate, whichever is less.

L_p = Leakage rate observed during the post-test leak-check, m3/min (cfm).

m_p = mass of particulate from probe, mg.

m_f = mass of particulate from filters, mg.

m_g = mass of particulate from filter gaskets, mg.

m_r = mass of particulate from the filter, filter gasket, and probe assembly from the room air blank filter holder assembly, mg.

m_n = Total amount of particulate matter collected, mg.

M_s = the dilution tunnel dry gas molecular weight (may be assumed to be 29 g/g mole (lb/lb mole).

P_{bar} = Barometric pressure at the sampling site, mm Hg (in. Hg).

P_g = Static Pressure in the tunnel (in. water).

P_R = Percent of proportional sampling rate.

P_s = Absolute average gas static pressure in dilution tunnel, mm Hg (in. Hg).

P_{std} = Standard absolute pressure, 760 mm Hg (29.92 in. Hg).

Q_{std} = Average gas flow rate in dilution tunnel.

$Q_{std} = 60\ (1 - B_{ws})\ V_s\ A\ [T_{std}\ P_s/T_s\ P_{std}]$
dscm/min (dscf/min).

T_m = Absolute average dry gas meter temperature, K (R).
T_{mi} = Absolute average dry gas meter temperature during each 10-min interval, *i*, of the test run.

$$T_{mi} = (T_{mi(b)} + T_{mi(e)})/2$$

where:
$T_{mi(b)}$ = Absolute dry gas meter temperature at the beginning of each 10-min test interval, i, of the test run, K (R), and
$T_{mi(e)}$ = Absolute dry gas meter temperature at the end of each 10-min test interval, i, of the test run, K (R).
Ts = Absolute average gas temperature in the dilution tunnel, K (R).
Tsi = Absolute average gas temperature in the dilution tunnel during each 10-min interval, i, of the test run, K (R).

$$T_{si} = (T_{si(b)} + T_{m=si(e)})/2$$

where:
$T_{si(b)}$ = Absolute gas temperature in the dilution tunnel at the beginning of each 10-min test interval, i, of the test run, K (R), and
$T_{si(e)}$ = Absolute gas temperature in the dilution tunnel at the end of each 10-min test interval, i, of the test run, K (R).
V_m = Volume of gas sample as measured by dry gas meter, dcm (dcf).
V_{mc} = Volume of gas sampled corrected for the post test leak rate, dcm (dcf).
V_{mi} = Volume of gas sample as measured by dry gas meter during each 10-min interval, i, of the test run, dcm.
$V_{m(std)}$ = Volume of gas sample measured by the dry gas meter, corrected to standard conditions.

$$V_{m(std)} = K_1\ V_m\ Y\ [(P_{bar} + (\Delta H/13.6))/T_m]$$

where:
K_1 = 0.3855 K/mm Hg for SI units and = 17.64 R/in. Hg for inch-pound units.

$$V_{m(std)} = K_1\ V_{mc}\ Y\ [(P_{bar} + (\Delta H/13.6))/T_m]$$

where:
V_{mc} = Vm– (Lp– La)u
V_{mr} = Volume of room air sample as measured by dry gas meter, dcm (dcf), and
$V_{mr(std)}$ = Volume of room air sample measured by the dry gas meter, corrected to standard conditions.

$$V_{m(std)} = K_1\ V_{mr}\ Y\ [(P_{bar} + (\Delta H/13.6))/T_m]$$

Where:
K_1 = 0.3855 K/mm Hg for SI units and = 17.64 R/in. Hg for inch-pound units, and
V_s = Average gas velocity in the dilution tunnel.

$$V_s = F_p\ K_p\ C_p\ (\sqrt{\Delta P_{avg}})(\sqrt{(T_s/P_s\ M_s)})$$

V_{si} = Average gas velocity in dilution tunnel during each 10-min interval, i, of the test run.

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$$V_{si} = F_p\, K_p\, C_p\, (\sqrt{\Delta P_i})(\sqrt{(T_{si}/P_s\, M_s)})$$

V_{scent} = Average gas velocity at the center of the dilution tunnel calculated after the Pitot tube traverse.
V_{strav} = Average gas velocity calculated after the multipoint Pitot traverse.
Y = Dry gas meter calibration factor.
ΔH = Average pressure at the outlet of the dry gas meter or the average differential pressure across the orifice meter, if used, mm water (in. water).
ΔP_{avg} = Average velocity pressure in the dilution tunnel, mm water (in. water).
ΔP_i = Velocity pressure in the dilution tunnel as measured with the Pitot tube during each 10-min interval, i, of the test run.

$$\Delta P_i = (\Delta P_{i(b)} + \Delta P_{i(e)})/2$$

where:
$\Delta P_{i(b)}$ = Velocity pressure in the dilution tunnel as measured with the Pitot tube at the beginning of each 10-min interval, i, of the test run, mm water (in. water), and
$\Delta P_{i(e)}$ = Velocity pressure in the dilution tunnel as measured with the Pitot tube at the end of each 10-min interval, i, of the test run, mm water (in. water).
θ = Total sampling time, min.
10 = ten min, length of first sampling period.
13.6 = Specific gravity of mercury.
100 = Conversion to percent.

TOTAL PARTICULATE WEIGHT – ASTM E2515

$$M_n = m_p + m_f + m_g$$

PARTICULATE CONCENTRATION – ASTM E2515

$$C_s = K_2(m_n/V_{m(std)}) \text{ g/dscm (g/dscf)}$$

where:
K_2 = 0.001 g/mg

TOTAL PARTICULATE EMISSIONS (g) – ASTM E2515

$$E_T = (C_s - C_r)Q_{std}\theta$$

PROPORTIONAL RATE VARIATION (%) – ASTM E2515

$$PR = [\theta(V_{mi}\, V_s\, T_m\, T_{si})/(10(V_m\, V_{si}\, T_s\, T_{mi})] \times 100$$

MEASUREMENT OF UNCERTAINTY – ASTM E2515

$$MU_{weighing} = \sqrt{0.1^2} \bullet X$$

GENERAL FORMULA – ASTM E2515

$$uY = \sqrt{((\delta Y/\delta x_1) \times u_1)^2 + \ldots + ((\delta Y/\delta x_n) \times u_n)^2}$$

Where:
$\delta Y/\delta x_i$ = Partial derivative of the combining formula with respect to individual measurement xi,
u_i = is the uncertainty associated with that measurement.

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TOTAL PARTICULATE EMISSIONS – ASTM E2515

$E_T = (c_s - c_r)\, Q_{std}\, \theta$

where:

c_s = sample filter catch/(sample flow rate x test duration), g/dscf,
c_r = room background filter catch/(sample flow x sampling time), g/dscf,
Q_{std} = average dilution tunnel flow rate, dscf/min, and
θ = sampling time, minutes.

MU OF c_s

$c_s = F_c/(Q_{sample} \text{ x } \theta) = 0.025/(0.25 \text{ x } 180) = 0.0005555$
$\delta c_s/\delta F_c = 1/Q_{sample} \bullet \Theta = 1/0.25 \bullet 180 = 0.0222$
$\delta c_s/\delta Q_{sample} = -F_c/Q^2{}_{sample} \bullet \Theta = -0.025/0.25^2 \bullet 180 = -0.00222$
$\delta c_s/\delta \Theta = -F_c/Q_{sample} \bullet \Theta^2 = -0.025/0.25 \bullet 180^2 = -0.000003$
$MUc_s = \sqrt{}(0.00027 \bullet 0.0222)^2 + (0.0025 \bullet - 0.00222)^2$
$\sqrt{} + (0.1 \bullet - 0.000003)^2 = 0.0000091\text{g}$

Thus, c_s would be 0.555 mg/dscf ± 0.0081 mg/dscf at 95% confidence level.

MU OF c_r

$c_r = BG_c/(QBG \text{ x } \theta) = 0.002/(0.15 \text{ x } 180) = 0.000074$
$\delta c_r/\delta BG_c = 1/Q_{BG} \bullet \Theta = 1/0.15 \bullet 180 = 0.03704$
$\delta c_r/\delta Q_{BG} = -BG_c/Q^2{}_{BG} \bullet \Theta = -0.002/0.15^2 \bullet 180 = -0.0004938$
$\delta c_r/\delta \Theta = -BG_c/Q_{BG} \bullet \Theta^2 = -0.002/0.15 \bullet 180^2 = -0.0000004$
$MUc_r = \sqrt{}(0.00027 \bullet 0.03704)^2 + (0.0015 \bullet - 0.0004938)^2$
$\sqrt{} + (0.1 \bullet - 0.0000004)^2 = 0.00001\text{g}$

Thus, c_r would be 0.074 mg/dscf ± 0.01 mg/dscf at 95% confidence level.

E_T AND MU_{ET}

$E_T = (c_s - c_r)\, Q_{sd}\, \theta = (0.000555 - 0.000074) \text{ x } 150 \text{ x } 180 = 13.00\text{g}$
$\delta E_T/\delta c_s = Q_{std} \bullet \Theta = 150 \bullet 180 = 27{,}000$
$\delta E_T/\delta c_r = Q_{std} \bullet \Theta = 150 \bullet 180 = 27{,}000$
$\delta E_T/\delta Q_{std} = c_s \bullet \Theta - c_r \bullet \Theta = 0.000555 \bullet 180 - 0.000074 \bullet 180 = 0.08667$
$\delta E_T/\delta \Theta = c_s \bullet Q_{std} - c_r \bullet Q_{std} = 0.000555 \bullet 180 - 0.000074 \bullet 180 = 0.07222$
$MU_{ET} = \sqrt{}(27{,}000 \bullet 0.0000081)^2 + (27{,}000 \bullet 0.00001)^2\ (0.08667 \bullet 3)^2$
$\sqrt{} + (0.07222 \bullet 0.1)^2 = 0.436$

Thus the result in this example would be:
ET = 13.00g ± 0.44 g at a 95% confidence level.

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EFFICIENCY – CSA B415.1

The change in enthalpy of the circulating air shall be calculated using the moisture content and temperature rise of the circulating air, as follows:

$$\Delta h = \Delta t\,(1.006 + 1.84x)$$

Where:
Δh = change in enthalpy, kJ/kg
Δt = temperature rise, °C
1.006 = specific heat of air, kJ/kg °C
1.84 = specific heat of water vapor, kJ/kg °C
x = humidity ratio, kg/kg

The equivalent duct diameter shall be calculated as follows:

$$ED = 2HW/H+W$$

Where:
ED = equivalent duct diameter
H = duct height, m
W = duct width, m

The air flow velocity shall be calculated as follows:

$$V = F_p \times C_p \times 34.97 \times \sqrt{}T/28.56(P_{baro} + P_s)$$

where
V = velocity, m/s
F_P = Pitot tube calibration factor determined from vane anemometer measurements
C_P = Pitot factor
= 0.99 for a standard Pitot tube or as determined by calibration for a Type S Pitot tube
34.97 = Pitot tube constant
Note: The Pitot tube constant is determined on the basis of the following units: m/s[g/g mole (mm Hg)/(K)(mm H_2O)]$^{0.5}$
ΔP = velocity pressure, mm H2O
T = temperature, K
28.56 = molecular weight of air
P_{Baro} = barometric pressure, mm Hg
P_s = duct static pressure, mm Hg

The mass flow rate shall be calculated as follows:

$$m = 3600VAp$$

where:

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m = mass flow rate, kg/h
V = air flow velocity, m/s
3600 = number of seconds per hour
A = duct cross-sectional area, m2
p = density of air at standard temperature and pressure (use 1.204 kg/m3)

The rate of heat release into the circulating air shall be calculated using the air flow and change in enthalpy, as follows:

$$\Delta e = \Delta h \times m$$

Where:
Δe = rate of heat release into the circulating air, kJ/h
Δh = change in enthalpy of the circulating air, kJ/kg
m = mass air flow rate, kg/h

The heat output over any time interval shall be calculated as the sum of the heat released over each measurement time interval, as follows:

$$E_t = \sum(\Delta e \times i) \text{ for } i = t_1 \text{ to } t_2$$

Where:
Et = delivered heat output over any time interval $t_2 – t_1$, kJ
i = time interval for each measurement, h

The average heat output rate over any time interval shall be calculated as follows:

$$e_t = E_t / t$$

where
e_t = average heat output, kJ/h
t = time interval over which the average output is desired, h

The total heat output during the burn shall be calculated as the sum of all the heat outputs over each time interval, as follows:

$$E_d = \sum(E_t) \text{ for } t = t_0 \text{ to } t_{final}$$

Where:
E_d = heat output over a burn, kJ/h (Btu/h)
E_t = heat output during each time interval, kJ/h (Btu/h)

The efficiency shall be calculated as the total heat output divided by the total energy input, expressed as a percentage as follows:

$$\text{Efficiency, \%} = 100 \times E_d / I$$

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Where:

E_d = total heat output of the appliance over the test period, kJ/kg

I = input energy (fuel calorific value as-fired times weight of fuel charge), kJ/kg (Btu/lb)

SECTION 9
TEST SPECIMEN DESCRIPTION

The model Eclipse-P II Pellet Fuel Room Heater is constructed of sheet steel. The outer dimensions are 26.125-inches/664mm deep, 35.125-inches/892mm high, and 25-inches/635mm wide. The heat exchanger is located directly above the firebox with outlet air grille positioned above the firebox access door. A galvanized steel fuel hopper located at the top back of the unit.

SECTION 10
TEST RESULTS

DESCRIPTION OF TEST RUNS:

RUN #1 (10/25/22): The test for pellet heaters is a continuous test with three separate burn rates. At 8:30 am the unit was started and operated for a minimum of 1 hour for the pretest operation. At 9:30 am the unit was set to the maximum feed rate (level 5) with a burn rate of 2.91 kg/hr (wet), the scale was tared and a 25-lb weight was added to the scale to determine feed rate of the fuel, and the sampling system was started. At 10:30 am, the system #3 sampling filter was changed out and the unit was set to ≤50% feed rate (level 3) with a burn rate of 1.86 kg/hr (wet). At 12:30 pm, the heater was changed to the minimum feed rate (level 1) with a burn rate of 1.26 kg/hr (wet). At 3:30 pm, testing was completed. The total burn time was 360 minutes.

The test run has been found to be appropriate, with no anomalies, and the test run has been validated and is deemed compliant. No negative weight was found on the filters, as the filters and gaskets are weighed together to eliminate filter material transfer to gaskets. All weightings were handled property, with no negative weight on gaskets or probes.

TABLE 1 – EMISSIONS

RUN #	TEST DATE	BURN RATES (kg/hr)(wet)		PARTICULATE EMISSION RATE (g/hr)	1st HOUR EMISSIONS (g)	CO EMISSIONS (g/min)	HEATING EFFICIENCY (%HHV)
1	10/25/22	H*	2.91	1.91	2.20	0.017	76.9%
		M*	1.86				
		L*	1.26				
		OA*	1.73				

*Notes: H= High burn rate, M= Medium burn rate, L= low burn rate, OA= overall burn rate.

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TABLE 2 – TEST FACILITY CONDITIONS

RUN #	ROOM TEMP BEFORE (°F)	ROOM TEMP AFTER (°F)	BARO PRES BEFORE (in/Hg)	BARO PRES AFTER (in/Hg)	R. H. BEFORE (%)	R. H. AFTER (%)	AIR VEL BEFORE (ft/min)	AIR VEL AFTER (ft/min)
1	71	70	28.78	28.75	50.2	36.1	0	0

TABLE 3 – DILUTION TUNNEL FLOW RATE MEASUREMENTS AND SAMPLING DATA

RUN #	BURN TIME (min)	VELOCITY (ft/sec)	VOLUMETRIC FLOW RATE (dscf/min)	AVG TEMP (°R)	SAMPLE VOLUME (dscf)		PARTICULATE CATCH (mg)	
					1	2	1	2
1	360	21.46	227.78	551.71	47.95	48.81	6.90	6.60

TABLE 4 - DILUTION TUNNEL DUAL TRAIN PRECISION

RUN #	SAMPLE RATIOS		TOTAL EMISSIONS (g)		DEVIATION (%)	DEVIATION (g/kg)
	TRAIN 1	TRAIN 2	TRAIN 1	TRAIN 2		
1	1710.08	1679.94	11.80	11.09	3.11	0.068

TABLE 5 - GENERAL SUMMARY OF RESULTS

RUN #	BURN RATE (kg/hr)(dry) (OVERALL)	INITIAL DRAFT (in/H_2O)	RUN TIME (min)	AVERAGE DRAFT (in/H_2O)
1	1.73	0.032	360	0.029

TABLE 6 - CSA B415.1 RESULTS

BURN RATE (kg/hr)(dry)	CO EMISSIONS (g/min)	HEATING EFFICIENCY (% HHV)	HEAT OUTPUT (Btu/hr)
HIGH – 2.80	0.041	76.4	37,669
MEDIUM – 1.80	0.012	77.9	24,606
LOW – 1.21	0.013	74.0	15,784
OVERALL – 1.67	0.017	76.9	22,619

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SECTION 11
CONCLUSION

This test demonstrates that this unit is an affected facility under the definition given in the regulation. The emission rate of 1.91 g/hr meets the EPA requirements for the Step 2 limits.

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SECTION 12
PHOTOGRAPHS

Photo No. 1
Emissions Test # 1

Photo No. 2
Security Label Front side

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Photo No. 3
Security Label Back Side

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Photo No. 4
Intertek Security Signature

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Photo No. 5
Security Label Numbers

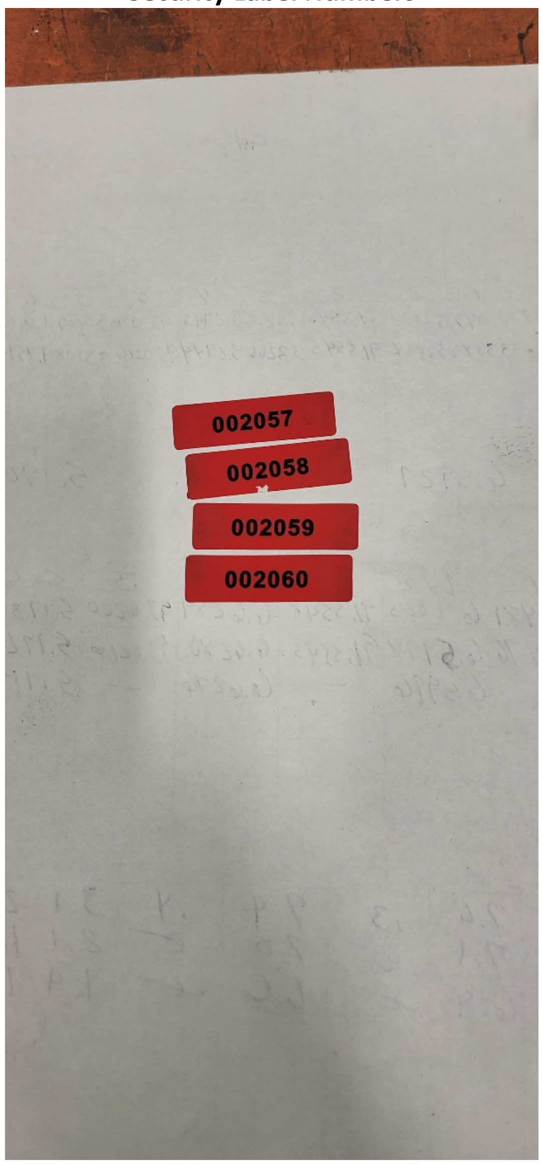

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Photo No. 6
Wrapped Unit

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SECTION 13
REVISION LOG

REVISION #	DATE	SECTION	REVISION
0	10/31/22	N/A	Original Report Issue
1	12/12/22	1	Updated to new company address
2	02/24/23	7	Updated Deviation from standard method to include EPA ALT-146 for the medium burn rate calculation.
		4	Updated Section 4 information to specify the conditioning burn was performed at a medium setting.
3	11/09/23	Appendix F	Updated Appendix F to identify medium burn setting used for the conditioning burn.