

Method 28 Fuel Moisture Measurement Evaluation

prepared by:

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1. Summary

Quality fuel moisture data are needed for particulate emission and efficiency determinations. Key reasons for the need for accurate and precise measurements include:

- Method 28 testing of wood heaters – “Burn rate means the rate at which test fuel is consumed in a wood heater measured in kilograms or lbs of wood (**dry basis**) per hour (Kg/hr or lb/hr).” 40 CFR Part 60 Appendix A Method 28.
- Emission factors is the reporting convention for fireplaces as per ASTM 2515/2558 (g/**dry** Kg fuel).
- Emissions per unit of energy is the reporting convention for hydronic heaters (Method 82-OWH). Energy in fuel is dependent on the moisture content.
- Appliance operation and performance are affected by moisture content.
- The new NSPS method for solid-fuel appliance certification may report particulate emissions on a mass particles per mass dry fuel or per unit of energy basis. Further efficiency determination may be part of its requirements.

To evaluate the accuracy and precision of moisture measurements, OMNI employed an electrical resistance moisture meter as specified in Method 28, “Determine the test fuel moisture content with a calibrated electrical resistance meter or other equivalent performance meter.Determine fuel moisture for each fuel piece (not including spacers) by averaging at least three moisture meter readings, one from each of three sides, measured parallel to the wood grain. Average all readings for all the fuel pieces in the test fuel charge...”

For the evaluation, four tests were conducted by OMNI: (1) Variation in moisture within a given fuel piece, (2) Difference in results obtained from the electrical resistance moisture meter and moisture determined by drying (ASTM D4442-07, Method B), (3) Variation in moisture in ten pieces of 2 X 4 removed from a single 4 X 4 selected for its uniformity in moisture and grain, and (4) Variation in moisture for a given piece of fuel as determined independently by five trained technicians.

Table 1 is a summary of the range in data obtained. Following sections 2, 3 and 4 provide more detail of the tests.

Table 1
Summary of Range of Moisture Measurements

Description of Test	Range in Moisture (dry basis)
Individual 18-inch 2 X 4 fuel piece	18.3 – 26.5% (30 pin points)
	23.4 – 28.4% (9 sawdust samples removed by cutting across 2 X 4)
Ten 2 X 4 fuel pieces from one 4 X 4	19.2 – 24.1% (range in average of 10 pieces)
	15.1 – 26.0% (range in 30 pin points)
Five technician's measurements on one 2 X 4 fuel piece	21.1 – 23.1% (range in average of 5 individual determinations)
	18.8 – 24.6% (range in 15 pin points)



Figure 1. Delmhorst J-2000 digital moisture meter and 18-inch 2 X 4 section of main fuel load.

2. Variation in Moisture Readings within an Individual Fuel Piece and Comparison with Loss on Drying



Figure 2. Moisture measurement with digital moisture meter.

Side 1 - "Top"

24.2 a				26.4 a				25.7 a
22.0 b	25.2	25.2	26.5	25.4 b	26.4	26.0	25.6	25.4 b
21.3 c				25.2 c				24.9 c

Side 2 - "Bottom"

18.3 a				22.0 a				23.3 a
19.5 b	23.8	24.2	24.5	24.2 b	24.6	24.3	24.3	23.8 b
21.9 c				25.5 c				24.6 c

Figure 3. Diagram of moisture pinning points on an 18-inch section of 2 X 4 dimensional lumber showing percent moisture measurements.

Table 2
Summary of Moisture Data from Individual 18-inch 2 X 4

	Moisture Meter*			Loss on Drying**
	Side 1 – “Top”	Side 2 – “Bottom”	Cumulative	
Mean	25.0	23.2	24.1	27.5
n	15	15	30	9
St. Dev	1.51	2.01	1.97	1.55
Range	21.3 – 26.5	18.3 – 25.5	18.3 – 26.5	23.4 – 28.4

Note: All moisture data are reported on a dry basis

*Delmhorst J-2000 digital moisture meter using insulated pins

**ASTM D 4442-07, Method B, sawdust for drying removed by saw

3. Variation in Moisture Meter Readings among 10 2 X 4 Pieces Cut from a Single 4 X 4



Figure 4. Moisture meter measurements made on 10 2 X 4 pieces cut from a single 4 X 4.

Table 3
Summary of Moisture Readings among 10 2 X 4 Pieces Cut from a Single 4 X 4

Piece Number	Section #1	Section #2	Section #3	Mean
1	20.4	22.2	15.1	19.2
2	23.9	22.1	22.0	22.8
3	23.0	22.4	26.0	23.8
4	23.8	21.5	25.4	23.6
5	23.8	20.8	26.0	23.5
6	24.8	23.3	24.1	24.1
7	24.4	23.8	22.1	23.4
8	21.6	23.0	17.0	20.5
9	23.8	23.8	22.1	23.2
10	21.9	23.8	20.0	21.9
Mean of 10 piece average				22.6
n				10
St. Dev.				1.60
Range				19.2 – 24.1
Mean of Individual Measurements				22.6
n				30
St. Dev.				2.34
Range				15.1 – 26.0

4. Moisture Meter Measurements Independently Made on a Single Fuel Piece by Five Different Technicians

Table 4
Moisture Measurements Independently Made on a Single Fuel Piece by Five Different Technicians Following EPA Method 28

Technician	Moisture Reading (% moisture, dry basis)			Mean
	1	2	3	
1	20.9	22.5	20.0	21.1
2	24.6	19.5	22.0	22.0
3	23.1	22.0	18.8	21.3
4	24.2	18.9	23.8	22.3
5	23.2	22.0	24.2	23.1
Mean of average reported by five technicians				22.0
n				5
Standard deviation				0.805
Range				21.1 – 23.1
Mean of Individual measurements				22.0
n				15
Standard deviation				1.96
Range				18.8 – 24.6