Attachment 2 – Sample Calculations for Heating Value Weighted Averages

The heating value shown on OGOR-B may be taken directly from a gas analysis or it may have to be calculated as an average value depending on the situation. If the case being verified contains a single measurement point and no gas samples and analyses were conducted during the month being verified, then the heating value shown on OGOR-B should match the dry/real heating value from the most recent gas analysis for that measurement point. This is the case for the examples given in Attachment 1.

There are two situations where an average heating value must be calculated: 1) the case being verified has multiple measurement points and 2) a gas sample was taken and an analysis was conducted at one or more of the measurement points during the month being reviewed. In both situations, a volume-weighted average heating value must be calculated in order to verify the heating value reported on OGOR-B.

In mathematical terms, a volume-weighted average heating value is calculated as follows:

$$HV_{vwa} = \frac{\sum_{i=1}^{i=n} V_i HV_i}{\sum_{i=1}^{i=n} V_i}$$

Where:

HV_{vwa}	is the volume-weighted average heating value (Btu/scf)
i	represents a measurement point on the case being verified
n	represents the total number of measurement points on the case being verified
V_i	is volume from measurement point i for the month being verified, Mcf
HV_i	is the most recent heating value for measurement point i, for the month being verified, Btu/scf

It should be noted that the BLM does not have any regulations or other requirements for how average heating value content is determined; however, MMS requires the use of volume-weighted averages for heating value in the *Mineral Production Reporter Handbook, Release 1.1* (February 2002). If calculated and reported heating values do not match the procedures in IM 2009-174, "Request for Modified or Missing Oil and Gas Operations Report from the Minerals Management Service" should be followed.

Example 1 – Multiple Measurement Points

You are verifying the April 2008 OGOR-B reported heating value for a lease that has three wells and the wellhead meters are the measurement points for the lease. You request copies of the volume statements and most recent gas analyses for the month of April 2008. From these reports you determine the following:

Point of Measurement	Volume (Mcf)	Heating Value[1] (Btu/scf)
Well 13-1	3,330	1,010
Well 22-2	4,008	998
Well 12-1	5,650	1,040

What heating value should be indicated on OGOR-B?

Solution

You must calculate the volume-weighted average heating value as follows:

$$HV_{vwa} = \frac{(V_{13-1} \times HV_{13-1}) + (V_{22-2} \times HV_{22-2}) + (V_{12-1} \times HV_{12-1})}{V_{13-1} + V_{22-2} + V_{12-1}}$$

$$= \frac{(3{,}380 \times 1{,}010) + (4{,}008 \times 998) + (5{,}650 \times 1{,}040)}{3{,}380 + 4{,}008 + 5{,}650} = 1{,}019 \frac{Btu}{scf}$$

The reported heating value on OGOR-B should be 1,019 Btu/scf.

Example 2 – Gas Spot Sample Taken mid-Month

You are verifying the October 2008 OGOR-B heating value for a lease which has a single lease master meter that is the measurement point. You request copies of the volume statement and most recent gas analysis for the lease master meter for October 2008. The volume statement indicates a total volume for the month of October as 14,440 Mcf. In addition, the operator submits two gas analyses, one taken on March 22, 2008, that gives a dry heating value of 1,144 Btu/scf, and one taken on October 19, 2008, that gives a dry heating value of 1,131 Btu/scf.

What heating value should be reported on OGOR-B for this lease?

Solution

Because a spot sample was taken and a new analysis obtained during the month being verified, an average heating value must be calculated. Whenever a measurement point has a gas spot sample and analysis taken in the middle of the month that you are verifying, split the volume statement into two segments and treat each segment as a separate meter. Then, just as in the previous example, you will calculate a volume weighted average.

[1] Dry/real heating value at 14.73 psi and 60°F

Volume statements and integration statements will typically provide a breakdown of the volume measured each day of the month. From these statements, you can determine the volume produced between October 1 and October 19, and the volume produced from October 20 through October 31. For this example, assume that the volume statement indicates that 9,010 Mcf was measured between the October 1 and the October 19 and 5,430 Mcf was measured from the October 20 through the October 31. These data are summarized below:

Period	Volume (Mcf)	Heating Value (Btu/scf)
October 1-19	9,010	1,144
October 20-31	5,430	1,131

The volume-weighted average heating value is determined in the same manner as it was for the previous example:

$$HV_{vwa} = \frac{(9{,}010 \times 1{,}144) + (5{,}430 \times 1{,}131)}{9{,}010 + 5{,}430} = 1139.1 \frac{Btu}{scf}$$

The reported heating value on OGOR B should be 1,139 Btu/scf.

Example 3 – Multiple Measurement Points and Gas Spot Sample Taken mid-Month

You are verifying the August 2008 heating value on OGOR-B for a lease that has three wellhead measurement points: well 6-6, well 6-8, and well 6-1. You obtain volume statements and gas analyses for the each measurement point for August 2008 and notice that two gas analyses for well 6-8 were submitted; one taken on February 3, 2008 (1,155 Btu/scf), and one taken on August 6, 2008 (1,168 Btu/scf). The gas analyses for well 6-6 and 6-1 were taken on July 28, 2008, and July 3, 2008, respectively. From the volume statements for August 2008, well 6-6 measured 2,889 Mcf, well 6-8 measured 4,386 Mcf, and well 6-1 measured 4,082 Mcf.

What heating value should be reported on OGOR-B for this lease?

Solution

The volume weighted average heating value is determined using the same procedure as in the previous two examples. Whenever a measurement point has a gas spot sample and analysis conducted in the middle of the month that you are verifying, split the volume statement into two segments and treat each segment as a separate meter. In this case, well 6-8 is split into two segments; one for August 1 through August 6 (assume 540 Mcf) and one for August 7 through August 31 (assume 3,846 Mcf). This information is summarized as follows:

Point of Measurement	Volume (Mcf)	Heating Value (Btu/scf)
Well 6-6	2,899	1,114
Well 6-8 (8/1 – 8/6)	540	1,155
Well 6-8 (8/7 – 8/31)	3,846	1,168
Well 6-1	4,082	1,139

The volume weighted average heating value is then calculated the same as it would be for multiple measurement points:

$$HV_{vwa} = \frac{(2{,}899 \times 1{,}114) + (540 \times 1{,}155) + (3{,}846 \times 1{,}168) + (4{,}082 \times 1{,}139)}{2{,}899 + 540 + 3{,}846 + 4{,}082} = 1143.2 \frac{Btu}{scf}$$

The reported heating value on OGOR B should be 1,143 Btu/scf.

Composite Samples and Online Gas Chromatographs

Examples 2 and 3 assume the use of spot samples to determine heating value. While this is by far the most common method for onshore production, two other methods can also be used. Composite samples are taken by attaching a sample container to the sample probe for the duration of the sampling period. An automatic valve between the sample container and sample probe opens for brief periods at set intervals to slowly fill the sample container. At the end of the sampling period, the sample container is removed and analyzed to determine the composition and heating value in the same manner as a spot sample. If the valve is actuated at set time intervals (once per hour, for example), the composite sample will be a time-weighted sample. If the valve is actuated at set volume intervals (once every 10 Mcf, for example), the sample will be a volume-weighted average. While volume-weighted composite samples are preferred, neither the BLM nor MMS requires volume-weighted composite samples for onshore operations.

The most accurate way to determine heating value is with the use of an online gas chromatograph (GC). Because of the expense involved, this method is typically reserved for high-volume sales meters. An online GC automatically samples and analyzes the gas stream at frequencies as high as 20 times per hour. The gas composition and heating value is then fed directly into a flow computer to automatically determine the total energy content (MMBtu) of the gas over a month. Dividing the total energy of the gas by the total volume of the gas over the same time period yields a volume-weighted heating value.

For both composite samples and online GCs, the reported heating value represents an average over the entire sampling or reporting period and no further calculations are required. Composite samples can sometimes be identified by the "Sample Date" on the gas analysis. For example, on the sample gas analysis included in Attachment 1, the "Sample Date(s)" from 10/21/2004 through 10/21/2004, indicates a spot sample. If the "Sample Date(s)" were from 10/01/2004 to 11/01/2004, this would indicate a composite sample. Online GCs can usually be identified by examining the configuration log of the Electronic Flow Computer. For example, the relative

density listed in a configuration log of a flow computer using an on-line GC would be shown as "Live."