

Aeon Petroleum Consultants Quarterly Newsletter

Welcome to the very first Aeon Petroleum Consultants Quarterly Newsletter. Aeon Petroleum Consultants is a professional engineering firm registered in the State of Texas. We specialize in estimating resources and reserves. Our intent on publishing this newsletter is to highlight topics of interest to those involved in estimating, reviewing, or reporting oil and gas resources and reserves.

In this first issue, we will discuss the following:

- Aeon Petroleum Consultants website
 - Useful information on our website
- Resource estimation using stochastic methods
 - How is it done
 - Software to use for calculations available from Aeon Petroleum Consultants
- Gas composition, z-factor, and gas viscosity calculations
 - What can be gleaned from gas composition
 - Calculation methods for z-factor and gas viscosity
 - Free download of calculator is available from Aeon Petroleum Consultants website

We hope to make this quarterly newsletter informative and useful. If you have any topics you would like us to discuss in future newsletters, please contact us on our website and let us know.

Aeon Petroleum Consultants Website

The website for Aeon Petroleum Consultants can be found at:

www.aeon-petro.com

The website contains topics and items that should be of interest to those estimating, reviewing or reporting oil and gas resources and reserves. Besides listing the services that Aeon Petroleum Consultants can provide to the oil and gas industry, there are items available for download, software created by Aeon Petroleum Consultants available for purchase or demo, videos, and resource and reserve guidelines for viewing and download.

At present, we have available for purchase our Stochastic Resource Calculators that aid in estimating oil and gas resources using the stochastic (Monte Carlo) method. These are low-cost easy-to-use Excel-based solutions to using this method. If you are interested, request a demo copy and try it out.

We also have available for free download an Excel-based workbook that will calculate gas composition parameters, z-factor and gas viscosity using industry standard methods.

One of the most important things on our website is our contact information. Please feel free to contact us regarding our services, software, or items you would like us to discuss in these newsletters.

Estimating Resources using the Stochastic Method

There are two basic methods used to make volumetric estimates of resources; the deterministic method and the stochastic method.

The deterministic method uses specific values for each of the parameters (i.e., area, thickness, porosity, recovery factor, etc.) and directly calculates a resource volume. The deterministic method is most commonly used when estimating reserves because more information is available on the input parameters and the range of those parameters has been significantly narrowed.

Instead of using a single value for an input parameter, the stochastic method (sometimes referred to as the Monte Carlo method) uses ranges of input parameters to calculate resource volumes. This method is typically used when there is a level of uncertainty regarding the input variables. It is common to use this method when estimating prospective or contingent resources where fewer or widely-paced data points are available. This method requires a great deal of care when choosing the data endpoints and data distributions. We will not discuss how to choose the endpoints or distributions as there is significant literature available on those subjects.

The types of distributions used for input parameters are the normal, log-normal, and uniform distributions. An easy way to discuss each of these distributions is to use dice rolls as examples. Each die has six sides and there is an equal chance of rolling each of the six values. Since the chance for any value is equal, this is a uniform distribution. If we roll two dice a large number of times (each with a uniform distribution) and add the resulting values together after each roll, we will arrive at a normal distribution of the sums. If, after each roll we multiplied the values of the dice, we would see the distribution of these values form a log-normal distribution. In the case of calculating resource volumes, we are multiplying the input variables and the resulting distribution of these resource volumes will be a log-normal distribution.

The stochastic method operates by randomly generating a value for each parameter (based on the endpoints and distributions) and calculating a resource volume for each iteration. After a given number of iterations (say 10,000), the process ceases. The resource volumes calculated by each iteration can then be sorted from low to high, and certain key points selected. In the case of prospective resources, the low, best, high, and mean correspond to the P90 (10th percentile), P50 (50th percentile), P10 (90th percentile), and mean (average). In contingent resources estimates the 1C is the P90, 2C is the P50, and 3C is the P10.

By illustration, if the resources volumes calculated from 10,000 iterations of input parameters is sorted from low to high, the P90 (10th percentile) of the sort would be the 1,000th volume in the sort. The P50 would be the 5,000th volume and the P10 would be the 9,000th volume. From this illustration, it is easily seen that the P90 indicates that 90% of the volumes calculated using the stochastic method are greater than the P90 volume. The P50 volume is the median as there are 50% of the volumes greater than the P50 and 50% of the volumes less than this volume. By contrast, only 10% of the volumes calculated are greater than the P10 volume.

Calculating a deterministic volume with a hand calculator is pretty straightforward. However, using a hand calculator to perform stochastic calculations would take an awful long time. To use the stochastic method, one must use a computer and either write a program or purchase commercial software for the task. Most of the software programs available are off-the-shelf statistical packages that must be specifically modified to perform resource estimates. Using these programs requires naming and specifying variable, writing the calculations, preparing the output format, etc. Because they are general statistical programs that include a lot of things besides random variable generation, they are expensive and usually require an annual maintenance fee.

Our experience has taught us that most individuals who estimate resources want to use software to help make those estimates – not write software hoping they got it right. To that end, Aeon Petroleum Consultants has created low-cost and easy-to-use software specifically for the purpose of estimating

oil and gas resources using the stochastic method. The software is user friendly and Excel-based. The units for input parameters and resource volumes are pre-selected based on industry standards. Stochastic calculators have been designed for each type of reservoir for which resources are to be estimated and each is contained in an individual workbook. Each workbook can be copied for projects as many times as needed on an individual computer. The following reservoirs are available:

- Natural Gas
- Oil
- Coalbed Methane
- Helium
- CO₂

Shown below is an example parameter input page from Aeon’s Natural Gas Stochastic Calculator. The items labeled in green are the parameter end points of P99 and P01.

Stochastic Estimation of Natural Gas and Condensate Resources

Log Normal H P₉₉ (ft) H P₀₁ (ft) Distribution Type 12 50 L			Log Normal A P₉₉ (acres) A P₀₁ (acres) Distribution Type 640 3840 L			Calculate							
Log Normal Porosity P₉₉ (%) Porosity P₀₁ (%) Distribution Type 14.0 24.0 L			Normal Sw P₉₉ (%) Sw P₀₁ (%) Distribution Type 50 22 N						Normal Shrink P₉₉ (%) Shrink P₀₁ (%) Distribution Type 5.0 3.0 N			Risk Factor Source Migration Trap Seal Total 0.80 0.80 0.75 0.68 0.33	
Log Normal Eg P₉₉ (scf/ft ³) Eg P₀₁ (scf/ft ³) Distribution Type 75 155 L			Normal Condensate Yield P₉₉ (STB/MMscf) Condensate Yield P₀₁ (STB/MMscf) Distribution Type 2.5 5.0 N						Log Normal RF P₉₉ (%) RF P₀₁ (%) Distribution Type 65 90 L				

Each workbook can be purchased individually or as a package for a discount directly from our website. If you are not ready to purchase, go to our website and request a demo copy and try it out. A video on our website shows just how easy it is to use the software.

Gas Composition, z-Factor, and Gas Viscosity

In estimating resources and reserves in gas reservoirs, it is necessary to know the values of the gas composition, z-factor, and, for dynamic calculations the gas viscosity. It is not only necessary to know the z-factor and gas viscosity at initial reservoir conditions, but at all pressures between the initial and final (abandonment) reservoir pressures.

The gas composition is needed in order to calculate the critical pressure and temperature, liquid yield (NGL and condensate), natural gas heating value, and volume shrinkage due to inert components and liquid processing. The various components of a gas can be obtained from analysis of a gas sample. Once those components are determined, they can be input into a spreadsheet to calculate the items listed above. Shown below is the composition of a gas with calculation of the critical pressure and temperature, liquid yield, heating value, and shrinkage:

Gas Composition

Component	Mole Fraction (%)	Molecular Weight	Critical Pressure (psia)	Critical Temperature (°R)	Heating Value (Mbtu/scf)	Liquid Content (gal/Mcf)	Mole Fraction Weighted				
							Molecular Weight	Critical Pressure (psia)	Critical Temperature (°R)	Heating Value (Mbtu/scf)	Liquid Content (gal/Mcf)
Methane	71.90	16.40	673	344	1,010	0.00	11.79	484	247	726	0.00
Ethane	12.30	30.07	709	550	1,769	0.00	3.70	87	68	218	0.00
Propane	7.08	44.09	618	666	2,518	27.95	3.12	44	47	178	1.98
Iso-Butane	2.59	58.12	530	733	3,256	33.67	1.51	14	19	84	0.87
N-Butane	2.40	58.12	551	766	3,264	32.50	1.39	13	18	78	0.78
Iso-Pentane	1.06	72.15	482	830	4,001	38.21	0.76	5	9	42	0.41
N-Pentane	1.04	72.15	485	847	4,009	37.94	0.75	5	9	42	0.39
Hexane	0.75	86.17	434	915	4,756	43.80	0.65	3	7	36	0.33
Heptane	0.88	100.20	397	973	5,503	50.13	0.88	3	9	48	0.44
Octane	0.00	114.20	370	1,025	6,250	56.27	0.00	0	0	0	0.00
Nonane	0.00	128.30	355	1,073	6,996	62.97	0.00	0	0	0	0.00
Decane	0.00	142.30	312	1,115	7,743	69.93	0.00	0	0	0	0.00
Air	0.00	28.97	547	239	0	0.00	0.00	0	0	0	0.00
Nitrogen	0.00	28.02	492	227	0	0.00	0.00	0	0	0	0.00
Oxygen	0.00	32.00	732	278	0	0.00	0.00	0	0	0	0.00
CO ₂	0.00	44.01	1,072	548	0	0.00	0.00	0	0	0	0.00
H ₂ S	0.00	34.08	1,306	673	0	0.00	0.00	0	0	0	0.00
H ₂	0.00	2.00	189	60	325	0.00	0.00	0	0	0	0.00
Argon	0.00	39.95	707	272	0	0.00	0.00	0	0	0	0.00
Helium	0.00	4.00	33	9	0	0.00	0.00	0	0	0	0.00
Total	100.00						24.56	659	433	1,453	5.20

Sp. Gravity = 0.848

Shrinkage of gas for Methane only residue gas: 28.1 %

Shrinkage of gas for Methane plus Ethane residue gas: 15.8 %

Heating value of Residue Gas containing Methane plus Ethane: 1,121 MMBtu/Mcf

NGL yield: 124 bbl/MMcf

This spreadsheet can be downloaded from the Aeon Petroleum Consultants website at no cost.

The z-factor is a modification of the Ideal Gas Law that relates volume, pressure and temperature. Because hydrocarbon gases don't behave under ideal conditions except at low pressures and temperatures, an adjustment factor must be used to accommodate this behavior in order to calculate the proper relationship between volume, pressure, and temperature. The method taught at the time we were being educated was to calculate the critical pressure and temperature of the gas, calculate the ratio of the reservoir pressure and temperature to the critical values, and lookup and interpolate the z-factor in a table or on a graph. Since that time, digital methods have been developed to allow direct calculations. The z-factor is critical to the calculation of correct volumes under both static and dynamic conditions.

The gas viscosity can be measured from gas samples. Those measurements, however, won't be made at reservoir conditions. Since gas viscosity changes with pressure, it is necessary to obtain it at various pressures so that gas flow rates can be correctly calculated.

Shown below is an example spreadsheet showing the calculations of z-factor and gas viscosity at various reservoir pressures:

Gas Z-Factor and Viscosity Calculation Worksheet
Z-Factor based on Beggs and Brill Method
Viscosity based on the Lee Method

Reservoir Pressure (psia)	Reservoir Temperature (°F)	Gas Gravity	Molecular Weight	Non-Hydrocarbon Content			Pc (psia)	Tc (°R)
				N ₂ (decimal)	CO ₂ (decimal)	H ₂ S (decimal)		
1,200	180	0.690	19.98	0.034	0.015	0.000	664	373
Reservoir Pressure (psia)	z	P/z (psia)	Gas Density (g/cc)	Gas Viscosity (cp)				
1,200	0.903	1,328	0.062	0.0146				
1,100	0.911	1,208	0.056	0.0144				
1,000	0.918	1,089	0.051	0.0142				
900	0.926	972	0.045	0.0140				
800	0.934	856	0.040	0.0138				
700	0.942	743	0.035	0.0137				
600	0.951	631	0.029	0.0135				
500	0.959	521	0.024	0.0134				
400	0.968	413	0.019	0.0132				
300	0.976	307	0.014	0.0131				
200	0.984	203	0.009	0.0130				
100	0.992	101	0.005	0.0130				
15	0.999	15	0.001	0.0129				

In addition to calculating the z-factor and gas viscosity, the spreadsheet also provides a calculation of P/z and gas density. The spreadsheet will calculate the values of z-factor, P/z, gas density, and gas viscosity beginning at the specified reservoir pressure and at each decreasing 100 psi down to 15 psia.

We provide a download, at no cost, of an Excel worksheet that can calculate gas properties from gas composition, and a second spreadsheet that will calculate z-factor and gas viscosity at various reservoir pressures. These are both contained in a single workbook. For a free download, visit our website at:

www.aeon-petro.com/wcms/downloads

