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Gas Measurement Accuracy on the Hawk 9000

Accurate estimates of gas reserves are important for both public and private companies. Financial analysts, banks, as well as investors need the assurance of accurate reserves estimates. Whether someone wishes to invest in an exploratory prospect, purchase a producing field or determine the value of a company, proven reserves is one of the single most important factors in the decision. The foundation of proper engineering evaluations of reserves the linchpin of any strategy for optimizing gas extraction is accurate test data backed with proven gas flow calculations.

There are four key elements of accurate gas flow measurement, determination of gas composition, accurate measurement of pressure, temperature, and robust gas compression and flow equations.

Gas Composition

Since the gas flow calculations depend on the actual gas composition of the gas measured, an accurate analysis by a mass spectrometer or equivalent is needed. Though an estimate of the gas composition is acceptable for a field test, actual engineering analysis requires the correct numbers or the flow rate will be incorrect.

Pressure Measurement

Gas is a highly compressible fluid. Any change in pressure has a large impact on the apparent volume. As a result, accurate pressure measurement is of utmost importance for calculating gas flow correctly. To provide this, the Hawk9000's pressure sensors are rated to 0.024% Full-Scale accuracy. This is achieved in two ways: calibration with a primary pressure reference with excellent long-term stability and digital compensation of the pressure senor itself.

For high pressures, the Hawk9000 is calibrated using a *DHI 5304 Pressure Reference*, which is rated to 20000 psi ±50ppm. For pressures less than 1000 psi, a state-of-the-art *DHI PG7601 Pressure Reference* with accuracy between ±20 ppm and ±50ppm. Both of these deadweights have been calibrated by an accredited lab that is NIST traceable to ensure accuracy.

Unfortunately an accurate deadweight alone is not enough to ensure this accuracy. All of CalScan's tools are calibrated with a multipoint calibration over a wide range of temperatures and pressures. For example a 1500 psi Hawk would be calibrated with 7 pressure steps at each of 6 temperatures for a total of 42 calibration points. This data is then used to produce a digitally compensated tool, that has high accuracy even during extreme temperature transitions where simple two point calibrated tools will fall beyond its specification.

Temperature Measurement

Though less important than pressure, temperature is an important factor in calculating gas flow. To ensure accurate temperature measurement, all of our environmental chambers and baths are calibrated with an *F250 Mk II Precision Thermometer* accurate to ±0.01°C. Furthermore the temperature in each chamber is monitored to capture the precise value at the time the unit is calibrated.

Gas Flow Algorithms

The Hawk9000 uses only industry standard gas flow rate equations and gas equations of state. Flow rate equations are the mathematical algorithms that compute the gas flow from basic measurements such as pressure, temperature and differential pressure. Since no gas is truly ideal, the equation of state corrects for deviations from the ideal gas law. These algorithms have been verified with test cases from the Alberta Governments *Energy Utilities Board* as well as *FlowCheck* Version 3.1b by Emerson Process Management.

Earlier Hawk9000's with version 3.XX firmware use AGA3 1985 for the orifice gas flow, AGA7 1994 for turbine gas flow, and AGA8 1990 Detailed or Gross for the equation of state. It is important to note that the gas flow rate on these versions of the Hawk is an estimation of the gas rate; the actual gas rate is calculated to maximum precision when downloaded with our CalWin Windows software. The rate displayed on the Hawk is within 2% of the actual flow rate. Therefore no accumulation is shown on the display as the results would be less accurate than shown in CalWin.

In response to customers who want more accurate on the spot flow rates, the newest generation of the Hawk9000 with firmware version 4.32+ incorporates some advanced software features and the latest in gas flow algorithms. The operator can use AGA7 1994 for turbine gas flow, and a choice of AGA3 1990 or internationally recognized ISO5167 2003 for orifice gas flow calculations. The equation of state can be AGA8 1990 Detailed or Gross or an implementation of the Redlich-Kwong equation of state with Wichert-Aziz correction for sour gas. The full calculations are done onboard in real-time allowing the operator to use the accumulation displayed on the Hawk for the test, or it can be download with CalWin and viewed on a PC as usual.

The flow equations on the Hawk and in CalWin 5.62+ can be verified with third party results by putting in your own pressure, temperature and gas flow measurement values. These will be processed by our algorithms with the results displayed on the PC. Therefore an operator or engineer can verify that the numbers coming out are correct.