Thermal Compensation of High-Precision Pressure Gauges

Precision pressure gauges based on the electrical resonance property of quartz crystal are considered the highest accuracy pressure gauges available.

However, the properties of quartz are highly temperature dependent. In addition, the electrical circuits that are used to measure the changes in the quartz crystal resonance are also sensitive to temperature change. It is therefore necessary to compensate for temperature changes in the quartz crystal and the measuring circuitry to fully realize the potential accuracy of the quartz crystal based pressure gauge. Thermal compensation is also a requirement for pressure gauges that rely on non-quartz sensors. The time required for thermal compensation is an important consideration for a gauge intended for measuring the rate of pressure response. Compensation time is dependent on the ability to minimize the exposure of the sensing element and the electronics from temperature change and the compensation mechanism. Temperature changes are inevitable during the pressure transient test process. During the thermal compensation process, the pressure readings of a down-hole will be in error.

Since down-hole gauges must travel through the production tubing and any restrictions in the tubing, they are limited in diameter to about 1.25". This limitation means that the pressure sensor and the measurement electronics will be directly exposed to the temperatures in the well. These temperatures can sometimes exceed 400F. When a downhole gauge is subjected to a dramatic rate change such as occurs during a build-up or draw down, the gauge is subjected to a thermal step which typically takes 15-30 minutes for the compensation mechanism to fully respond. When reviewing data collected from a downhole gauge during a rate change, it is impossible to de-couple the thermal response of the gauge from the pressure response. However a SPIDR® precision pressure gauge connected at the well-head by a length of capillary tubing is not exposed temperature changes within the well, only ambient temperature changes. The construction of the SPIDR® gauge is such that the quartz pressure and temperature crystals are buried inside an insulated 6" diameter by 9" tall housing. Ambient temperature changes are very effectively damped and compensated. Due to the thermal response of the downhole gauge during rate changes, it is often the case that SPIDR® gauge surface data does not coincide with downhole data during the early time of a draw down or build-up.

The temperature sensitivity of a down-hole pressure gauge is such that it should never be used for wellhead pressure transient measurements. The pressure response to ambient temperature change is so significant that it will mask reservoir response in all but the lowest permeability wells. The thermal sensitivity of downhole gauges is often seen when taking gradient stops after a build-up test. At each stop on the way up the hole, if the stop does not last at least 15 minutes, the indicated gauge pressure never stabilizes.

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