QUARTZDYNE®
A DOVER COMPANY

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Long Term Temperature Stability of Quartzdyne® Pressure Transducers

November 2004

BACKGROUND

Quartz-crystal based pressure transducers have a notable reputation in the oilfield for providing high quality data. Leveraging the elasticity, resolution, and stability of crystalline quartz, Quartzdyne has been manufacturing high accuracy quartz crystals for 14 years. (Quartzdyne founders have been working in the quartz crystal industry for 25+ years.)

Long-term accuracy of the pressure measurement is a primary concern of our customers: the data is clearly less valuable to reservoir engineers if the sensor has drifted out of specification. We've written a technote on pressure drift improvements (available on our website.); this technote addresses drift in the temperature measurement.

The primary purpose of the quartz temperature sensor is for thermal correction of the quartz pressure measurement. The location of the temperature crystal has been optimized for this purpose--location is critical in temperature metrology. Naturally we encourage the use of our stable temperature measurement for other purposes since it's included with every transducer. Quartzdyne achieves this level of temperature precision by leveraging a proprietary design and special processing of the crystals that maintain ruggedness without adversely affecting the low aging properties of quartz.

The sources of drift in the temperature measurement are (1) the quartz temperature crystal, (2) the quartz reference crystal, and (3) the oscillator circuit. Due to robust construction, design, and material/component selection, the contribution of the oscillator circuit is insignificant. The quartz temperature and reference crystals are responsible for the majority of drift. Both crystals share similar construction (thickness-shear resonators in TO-5 cans); the quartz reference crystal contributes through the mixed temperature frequency ($f_{t,\,mix} = f_r - f_{t,\,raw}$).

Prior to 2000 Quartzdyne purchased temperature and reference crystals from an outside source. We acquired the capability to manufacture our own crystals in 1999, and developed a proprietary process to improve the ruggedness of these crystals. In 2001 we implemented further process and design changes that reduced the drift and allowed for higher temperature operation.

TEST RESULTS

In tests at 0°C and at 100°C, our quartz temperature crystal demonstrated stability better than 0.05°C per year (see Figures 1 and 2.)

The challenge of measuring temperature drift lies primarily in the stability of the test system. Without strict control of the temperature conditions, it becomes difficult to distinguish between drift and system conditions. In these stability tests, we used the following equipment:

- Hart Scientific Stirred-Liquid Bath
- Agilent 5335A / 53131A Universal Counter with GPS Linked Timebase
- 25-ohm Standard Platinum Resistance Thermometer (SPRT)
- Azonix RTD Thermometer Readout

The SPRT/Azonix system is top-notch: ±0.01℃ accuracy; drift 0.003℃/year. Our transducers' frequencies were measured with standard HP/Agilent counters, continuously referenced to GPS for frequency stability. We made every effort to minimize thermal paths between the devices in test (seven transducers plus the SPRT) and the outside air.

We used a stirred-liquid bath to achieve optimum stability or uniformity. Although the bath was rated to maintain a stability of 0.005℃, the bath controller proved to be unpredictable during the 100℃ test. Since our quartz temperature crystal readily resolves temperature changes smaller than 0.001℃, bath instabilities were very noticeable. Through several power outages and bath excursions, we managed to accumulate nearly 120 days of data at 100℃.

Figure 1: Temperature Drift at 0℃

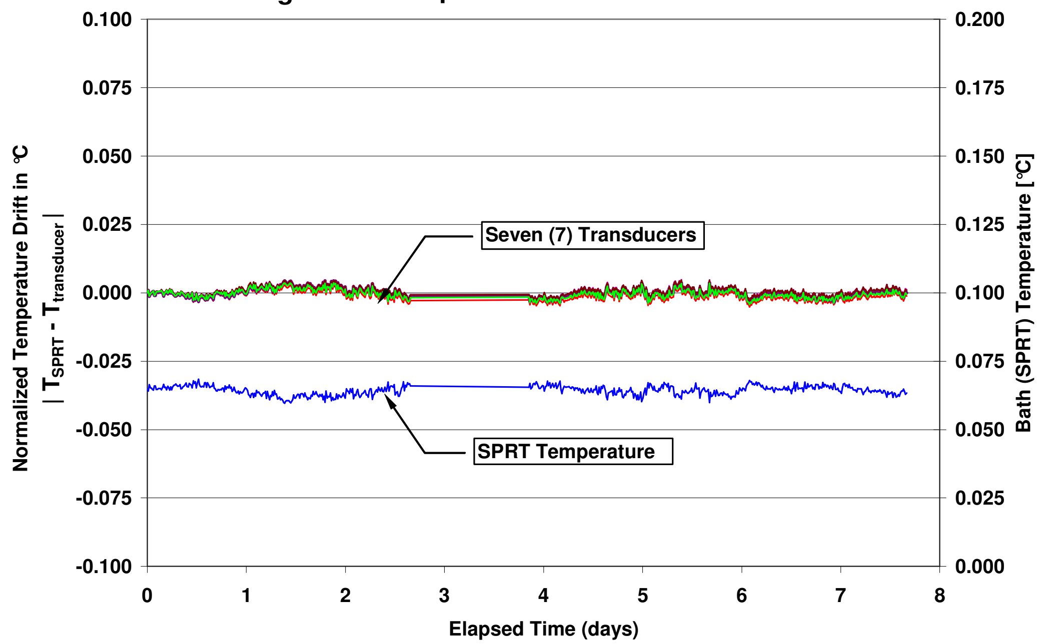

Figure 2: Temperature Drift at 100℃