CiTy sensors

Technical Note # TN 02

CERAMIC SENSORS BEHAVIOR

Contents

This short paper is to describe typical behaviour of City Sensors **Ceramic Pressure Sensors** based on the **Thick Film Strain Gage Technology.**

It is dealing with:

¤ **Temperature behaviour:** - Thermal Zero Drift
- Thermal Sensitivity Shift

¤ **Time Influence** (Long Term Stability)

¤ **Mechanical Fatigue** (Life Time)

I) Temperature behaviour

As every physical measuring instrument, our Ceramic Pressure Sensors are temperature sensitive.

As a first approach, let us see what happens on any kind of instrument:

Temperature variations affect both: ¤ The Zero point (offset) at null pressure
¤ The sensitivity of the instrument

Please refer to drawing 1:

This drawing shows the calibration curve of the instrument at 3 different temperatures T1, T2 & T3

T1 supposed to be the room temperature (for example 20 °C) generates a Zero point Z1. Then when the Pressure increases from Zero to the FS (Full Scale),the curve S1 appears which exhibits the proportionality $\alpha 1$between the pressure applied and the output signal (mV for instance).

It is supposed that the response is linear, as shown.

When the Temperature increases from T1 to T2 (for example 100 °C), the Zero point moves from Z1 to Z2 and the response curve exhibits a new sensitivity coefficient $\alpha 2$ different of $\alpha 1$

CiTy Sensors S.A. 15, rue du Buisson aux Fraises – Z.I. de la Bonde – F- 91741 MASSY CEDEX
Telephone : +33 (0)164 471 555 • www.citysensors.com • E-mail : citysensors@orange.fr • Fax : +33 (0)164 470 777

When the Temperature decreases from T1 to T3 (for example - 40 °C), the Zero point moves from Z1 to Z3 and the response curve exhibits a new sentivity coefficient $\alpha 3$ different of $\alpha 1$.

The displacement of the Zero point from Z1 to Z2 or Z3 is called the **Thermal Zero Drift.** It is **expressed in % of the FSO / °C (FSO = Full Scale Output).**

The change of the angle α from $\alpha 1$ to $\alpha 2$ or $\alpha 3$ is called the **Thermal Sensitivity Shift.** It is **expressed in % / °C.**

Consequently, it is usually necessary to compensate both the Zero Drift and the Sensitivity Shift.

In the case of **our Ceramic Pressure Sensors,** the selection of materials used and their Heat Treatment (at very High Temperatures, up to about 900 °C), makes so that the **Thermal Sensitivity Shift is self compensated.**

In other words, the curves S2 and S3 are paralell to S1.

In practise, it means that the sensitivity variation is < 0.01 % / °C.

Consequently, it is only necessary to compensate the Zero Drift. This simplifies considerably the experiments (No need to submit the sensors to temperature and pressure variations simultaneously).

In order to facilitate the Zero Drift compensation, **our Ceramic Sensors are equipped with a Thermistor,** screen printed directly onto the ceramic diaphragm so that it takes the fluid temperature quite immediately (because Ceramic is a very good conductive material for Heat).

To know more about the thermal compensation method, please refer to the Technical Note # TN 04 based on the use of a screen printed Thermistor (NTC).

Whatever be the compensated type of sensor, this compensation generates a very little residual effect of temperature < +/- 1 % FSO / 100 °C (including Zero + Span).

¤ **Long Term Stability** (Time influence)

Even at null Pressure and constant Temperature, any kind of instrument exhibits a change of Zero point versus time.

This is generally due to long term changes of materials characteristics which generate changes of internal stresses resulting in changes of strain and consequently changes of appearent Zero.

For most of usual sensors and transducers, **the change of Zero point versus time is generally cumulative.** This is particularly important when it is not possible to release the Pressure on the Process from time to time in order to measure the drift of the Zero point.

In the case of our Ceramic Pressure Sensors, the Zero point versus time is a random value which always remain within a given "error band" See drawing 2.

This error band is typically < ± 0.2 % FS

This is particularly interesting because it means that the **Long Term Drift does not cumulate versus time.**

In other words, whatever you consider the Zero point today, or next week or within next year, it will always remain within the indicated error band.

Regarding the influence of time on Span (sensitivity), it does not exceed +/ - 0.01 % of the slope, without cumulative effect.

¤ **Life Time** (Mechanical Fatigue)

When a material is submitted to Fatigue Mechanical cycles, it cumulates a memory of fatigue and brakes after a certain number of cycles N1. See drawing 3. This phenomenon is weel known and the corresponding curve (Wöhler Curve) is typical of the material considered.

The breaking point N depends upon the stress level σ applied when the material is under fatigue.

If the fatigue cycles are performed on the sensor at a lower stress level σ than the nominal stress level σ Max corresponding to the FS (Full Scale), then the number of cycles before rupture increases from N1 to N2.

This is why, each time the fatigue aspect is important in an application, it is strongly recommended to select a higher range than normally requested for the sensor, in order to increase the Life Time.

In the case of Ceramic Sensors, no Litterature is available for Wöhler curves as it is for usual materials like steel.

This is why we have been forced to build our own Wöhler curve with different samples at different stress levels in order to know what happens with Ceramic.

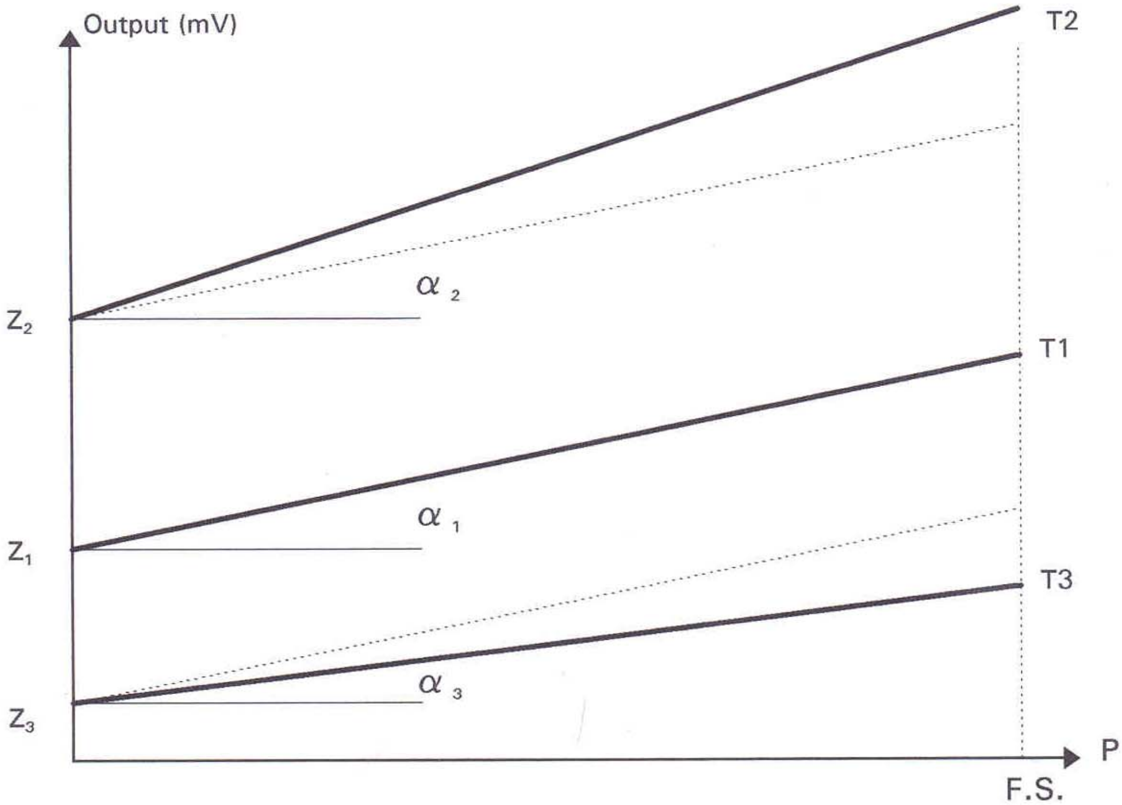
As a result of those investigations, we can guarantee that a **minimum 10 Million cycles Life Time can be expected at Maximum Stress level corresponding to the FS.**

For information, some of our Customers have found a Life Time over 40 Million Cycles at Full Scale without failure.

¤¤¤¤¤¤¤¤¤¤¤¤¤¤¤¤¤¤¤¤¤¤¤¤¤¤¤¤¤¤

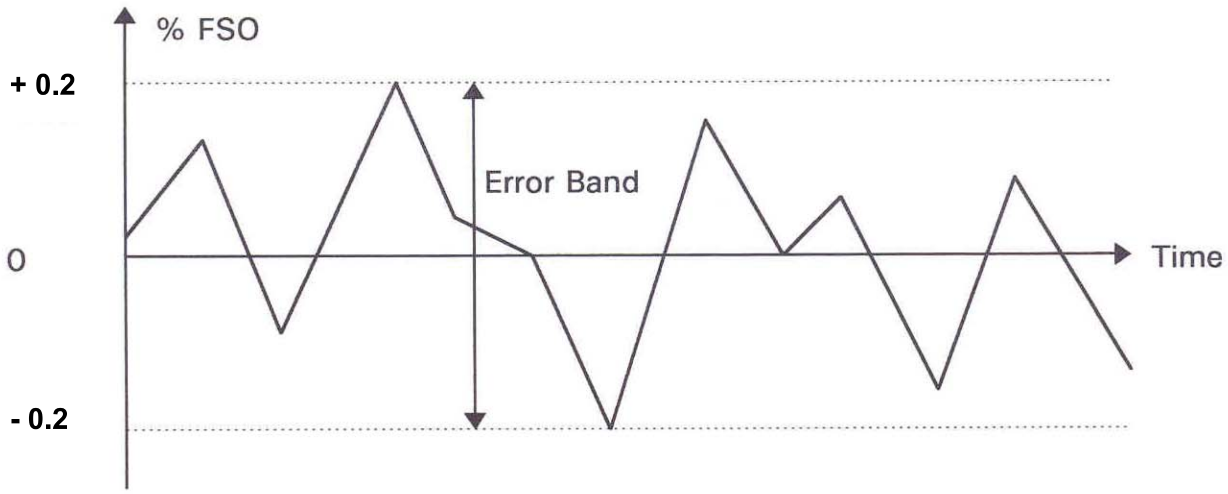
¤¤¤¤¤¤¤¤¤¤¤¤¤¤¤¤¤¤¤¤¤

CiTy Sensors S.A. 15, rue du Buisson aux Fraises – Z.I. de la Bonde – F- 91741 MASSY CEDEX
Telephone : +33 (0)164 471 555 • www.citysensors.com • E-mail : citysensors@orange.fr • Fax : +33 (0)164 470 777



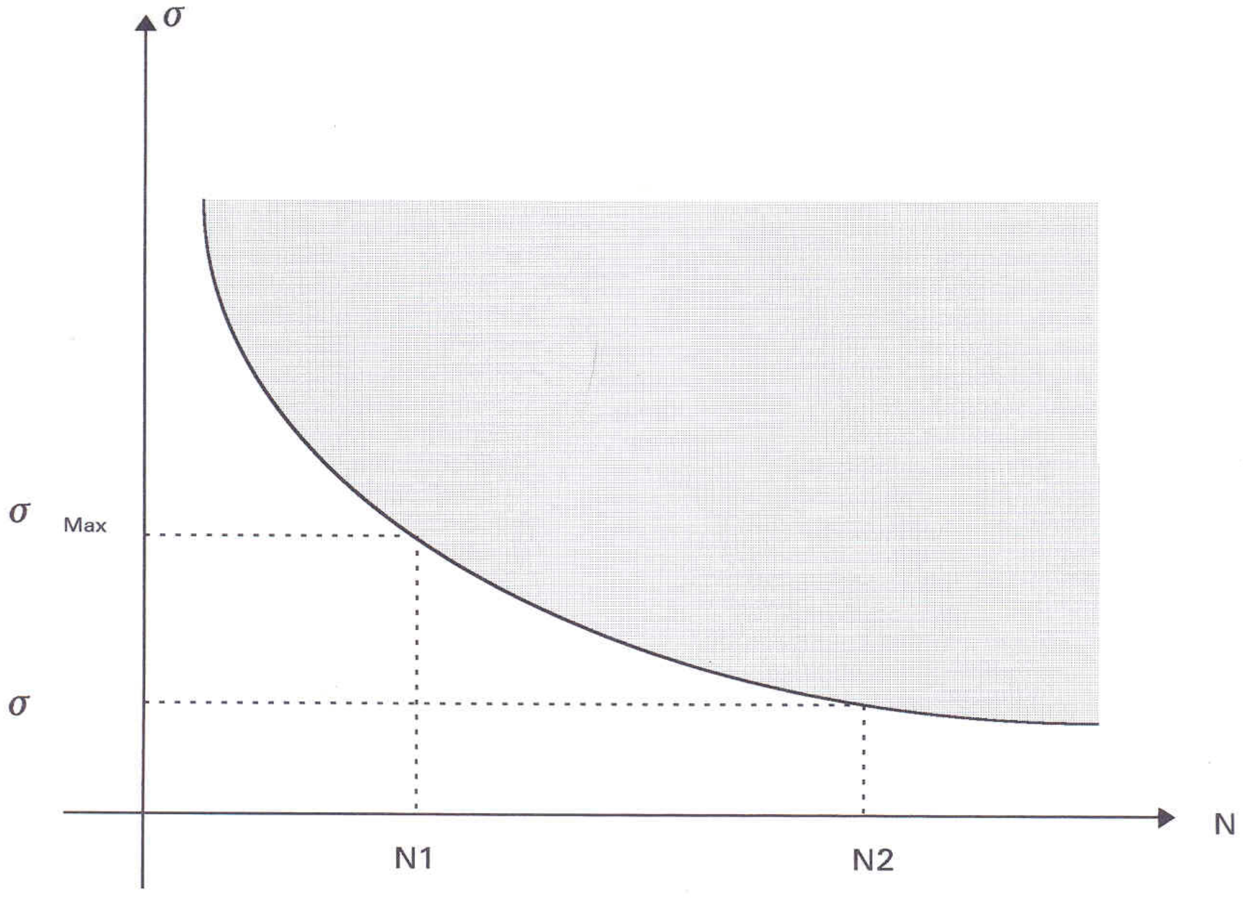
Drawing 1

Temperature Influence



Drawing 2

Long term Stability



Drawing 3

Number of Cycles before Rupture