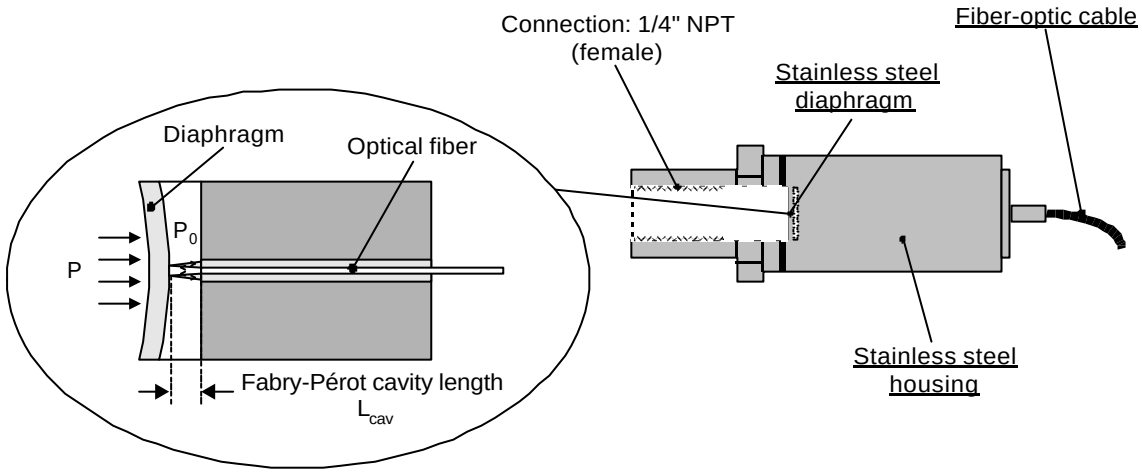
PRESSURE TRANSDUCER
MC-00067R1

1.0 PRINCIPLE OF THE FIBER-OPTIC PRESSURE TRANSDUCER

The sensing element of the pressure transducer is essentially a Fabry-Pérot type optical interferometer. The two mirrors of the interferometer are defined on one side by the internal surface of a diaphragm and on the other side by the tip of an optical fiber. The applied pressure P causes the deflection of the diaphragm which directly converts into a variation of the cavity length L_{cav} of the Fabry-Pérot interferometer.



The geometry and material of the transducer are selected in order to obtain a linear relationship between the deflection of the diaphragm and the applied pressure.

This relation is expressed as follow:

$$L_{cav}(P) = L_0 + (P - P_0)\, S \qquad (1)$$

where: P is the pressure applied on the external surface of the diaphragm (in psi);
P_0 is the pressure inside the Fabry-Pérot cavity (in psi);
L_{cav} is the cavity length measured by the signal conditioner (in nm);
L_0 is the cavity length that fix the origin of the zero (in nm), usually defined at $P = P_0$;
S is the sensitivity of the transducer (in nm/psi).

The pressure transducer comes in three different type: 1) gauge type, 2) absolute type and 3) differential type. In the case of gauge type transducer, P_0 is equal to ambient or atmospheric pressure. The gauge type transducer is offered with a) a vent hole, which keeps the cavity at ambient pressure or b) a cavity, sealed at the atmospheric pressure. In the case of the absolute type transducer, P_0 is equal to zero. The cavity is thus factory-sealed under vacuum. In the case of differential type transducer, P_0 is equal to an arbitrary pressure. This type of transducer comes with a vent connection which can be used to maintain a given pressure in the cavity.

2.0 SIGNAL CONDITIONING

2.1 Principle

The conditioning of all Fiso Technologies' transducer is based on white-light interferometry. The signal conditioner (model n° FTI-100i, FTI-10, etc.) converts the optical signal coming from the transducer into absolute Fabry-Pérot cavity length. This cavity length L_{cav} is said absolute because it does corresponds to the physical cavity length of the Fabry-Pérot interferometer at the time at which the optical signal was measured. (as opposed to a relative measurement of the cavity length *DL* in which case it is determined to an arbitrary origin). This distinction is important because many fiber-optic sensing techniques, in particular those based on single wavelength interferometry (as opposed to white-light), can only measure length variation *DL*. The absolute measurement is essential in all applications where long term or static measurements are required.

The optical signal is converted at a frequency given by the sampling rate of the conditioner. The accuracy of the conversion is ± 1 nm over a working range of 10 000 nm in case of the pressure transducer.

Once the cavity length L_{cav} has been measured, the conditioner calculates the P-P_0 value according to the following equation:

$$(P - P_0) = \frac{(L_{cav} - L_0)}{S} \qquad (2)$$

This pressure value is then recorded and displayed by the conditioner in Imperial (psi) or SI units (bar).

The sensitivity S (given by the gauge serial number) and the initial definition of L_0 provides all the necessary information to convert the measured cavity length L_{cav} into pressure.

2.2 Gauge serial number

The gauge serial number (printed near the fiber-optic connector of the transducer) has 7 digits and starts with the digit 6 in the case of the pressure transducer. The meaning of the gauge serial number of the pressure transducer, that is 6XYZZZZ, is as following:

- The digit 6 is reserved for the pressure transducer (e.g. 4 is reserved for temperature);
- The digit X is used only to differentiate in a batch of transducers those with same sensitivity;
- The number ZZZZ provides the sensitivity S multiply by a scale factor, that is ZZZZ $= S \cdot 10^{(n+1)}$ where n = 0, 1, 2 or 3;
- The digit Y gives the n value of the scale factor, that is Y = n.

Fiso Technologies' signal conditioners come with a complete set of functions that allow the user to store, erase or select different gauge serial numbers from the conditioner memory. These functions are

accessed using the front panel push-button control keys or using the Remote Control Commands of the RS-232 serial link. Up to 50 gauges serial number can be stored into the memory of the conditioner.

2.2 Definition of L_0

The cavity length L_0 is defined differently depending of the type of pressure transducer.

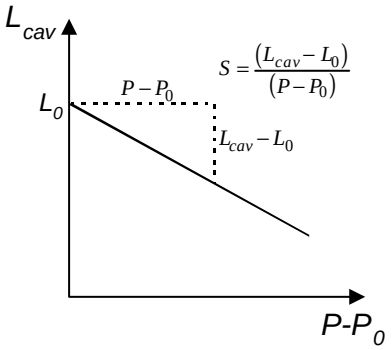
Gauge type: The signal conditioner (FTI-10, FTI-100i, etc.) allows the user to define himself the value of the cavity length L_o (by default equal to zero), thus to set the origin of the measurements. This is done with the **ZERO** or **NULL** function of the conditioner. When the user select the **ZERO** or **NULL** command, the conditioner immediately records the cavity length of the transducer and assigns this value to L_0. Usually this definition is done at ambient or atmospheric pressure. The conditioner will keep in memory this definition until the next modification by the user. Note: in case of memory lost or malfunction of the conditioner, the user can always reassign (using the **OFFSET** function in internal units) a previously defined value of L_0.

Absolute type: In this case, the transducer comes with a factory-calibrated cavity length L_0. The user enter this value into the conditioner memory using the **OFFSET** function in internal units.

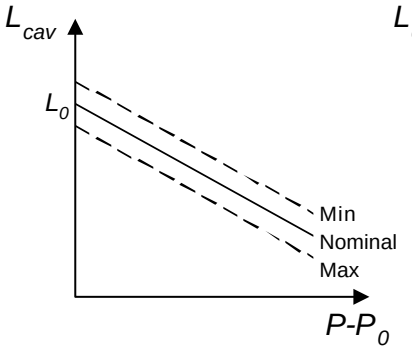
Differential type: the procedure is the same as with the gauge type.

3.0 ACCURACY

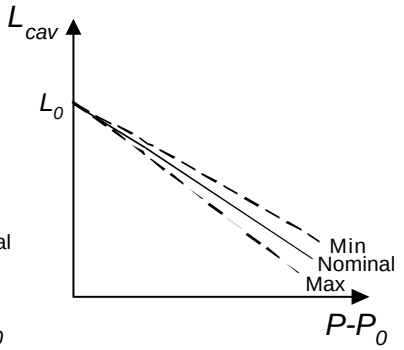
The accuracy of the transducer depends of the precision (0.1 % of FS), the thermal shift of the zero, (% FS/°C) and the thermal shift of the sensitivity (% Reading/°C). The total error is a function of these three separate errors, the worst case being the algebraic sum of their maximum or minimum values. The following figures illustrate the effect of these errors on the transducer response.



Nominal response of the pressure transducer



Thermal shift of the zero



Thermal shift of the sensitivity

4.0 UNITS OF PRESSURE

Some useful units of pressure						
atm	**kPa**	**bar**	**kgf/cm^2**	**psi**	**inH_2O**	**torr (mmHg)**
1.0000	101.325	1.01325	1.0332	14.7	33.93	759.94
0.9869	**100.00**	**1.000**	1.0197	14.504	33.49	750.00
0.9678	98.0665	0.98067	**1.000**	14.22	32.84	735.50
0.06806	6.8964	0.06896	0.0703	**1**	2.31	51.72
0.02946	2.9855	0.02985	0.0304	0.433	**1**	22.39