New Transmitters Added to FCX Series

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1. Introduction

The new generation electronic transmitters FCX series are based on the unheard of development concept of high-accuracy of ±0.1% on all ranges and smart ↔ analog convertible and appeared at the '89 International Measuring Instrument Industry Show (JEMIMA) and INTERKAMA '89 and attracted the attention of world users and engineering manufacturers and measuring equipment manufacturers. The FCX Series, shipment of which started at the beginning of 1990, has accumulated a record of 40,000 units sold over two years.

A differential transmitter for high-temperature and high-vacuum and a double coating type transmitter have now been developed in the FCS series, which has gained high praise and trust of world users in such a very short time. An outline of these transmitters is introduced here.

2. Differential Pressure Transmitter for High-Temperature and High-Vacuum

2.1 Main specifications

The main specifications of the differential pressure transmitter for high-temperature and high-vacuum are shown in **Table 1**.

Table 1 Specifications of differential pressure transmitter for high-temperature and high-vacuum

Type	Remote seal		Level
	Press	Differential press	
Range	0to0.5MPa	0 to 32kPa 0 to 64kPa 0 to 130kPa	0 to 32kPa 0 to 64kPa 0 to 130kPa
Accuracy	±0.2% (Linearity including hysteresis)		
Flange	JIS 10K/30K, 80A/100A ANSI/JPI 150LB/300LB, 3B/4B		
Material of seal diaphragm	SUS316L		
Length of extension diaphragm	0, 50, 100, 150, 200mm		
Lower static pressure limit	266Pa {2 torr} (200°C)		
Process temperature	–15 to 200°C		

2.2 Composition and operation principle

The remote seal type differential pressure transmitter is shown in **Fig. 1**. Its principle is shown in **Fig. 2**.

The remote seal type differential pressure transmitter consists of a body with a built-in silicon sensor that detects differential pressure as a capacitance change and a flange with a seal diaphragm and a capillary tube (filled with silicon oil) that connects these. The sensor is a capacitance type sensor with a single crystal silicon diaphragm as the measuring diaphragm (moving electrode), and is common to

Fig. 1 Outline of differential pressure transmitter with remote seal diaphragm for high-temperature and high-vacuum

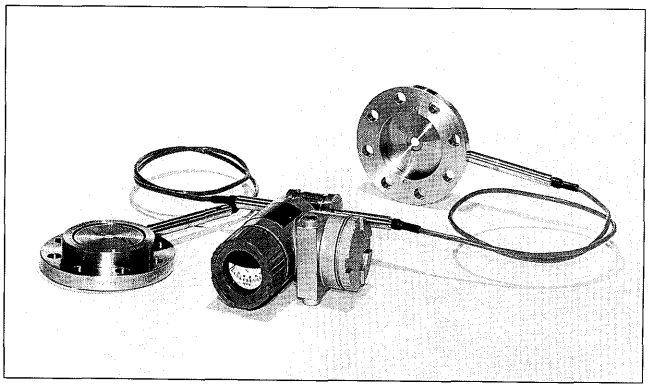
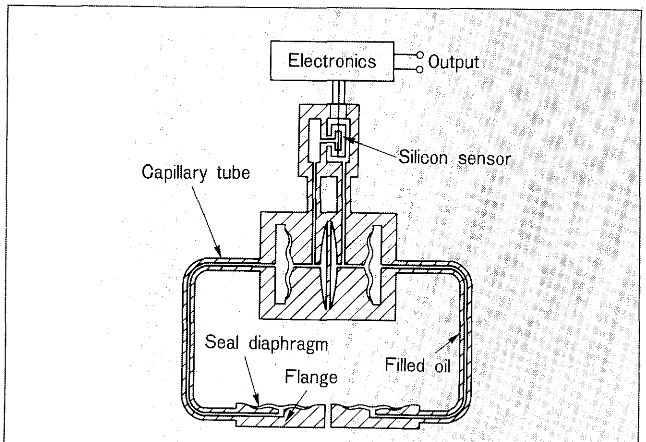


Fig. 2 Principle diagram of differential pressure transmitter with seal diaphragm



the FCX series. The measurement pressure acts on the measuring diaphragm of the silicon sensor through the remote seal diaphragm and the filled oil.

The measuring diaphragm is displayed in proportion to the pressure difference (differential pressure) that is applied to the two seal diaphragms and the capacitance (differential capacitance) generated between two fixed electrodes at both ends is changed.

2.3 Manufacturing technology

When a transmitter is used in a high-temperature and high-vacuum plant, the transmitter output drifts and when this drift is severe, the output will change in a very short time and overshoot may occur.

The four main causes of this are:

(1) Thermal decomposition of the oil filled in the transmitter

(2) Gasification of the humidity, air, etc. dissolved in the interior liquid

(3) Gas generated by decomposition of the dirt and fat adhering to the constructing material

(4) Redesorption of the gas dissolved in or adhering to the constructing material

To settle these problems the next measures were performed.

Fig. 3 Linearity

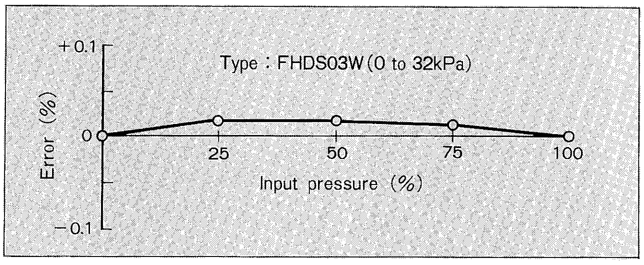


Fig. 4 Temperature effect

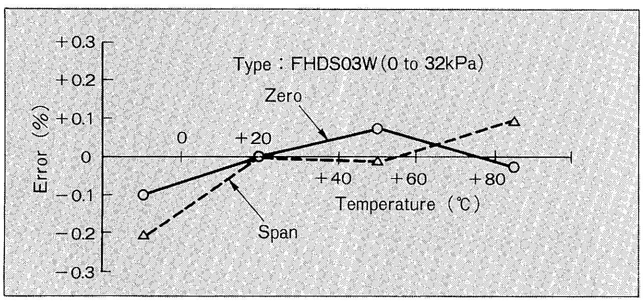
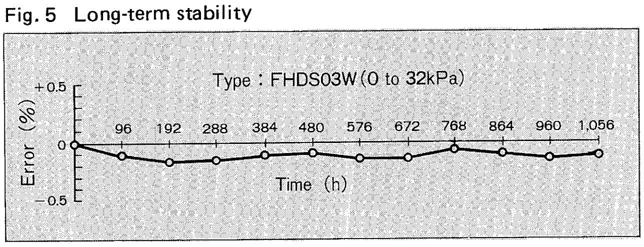


Fig. 5 Long-term stability



(1) Selection of filling liquid

Excellent heat resistance methyl-phenyl-siloxane silicon oil is selected as the filling liquid.

(2) Dehydration and outgassing of filling liquid

The filling liquid is heated at a high temperature and is amply churned in a high vacuum and the water and gas in the liquid are removed.

(3) Surface treatment of parts

After each part is ultrasonically cleaned, the parts are baked for a long time in the high-temperature and high-vacuum state. Then, after assembly and immediately before filling with liquid, the inside of the transmitter is cleaned by baking in a high-temperature and high-vacuum state that exceeds the working conditions.

2.4 Characteristics

The results of evaluation testing of the remote seal type differential pressure transmitter are shown in **Figs. 3** to **5**.

Figure 3 shows the linearity, **Fig. 4** shows the temperature effect, and **Fig. 5** shows the results of testing of the zero drift when both seal flanges were left in the 200°C, 133Pa {1 torr} state.

The linearity and temperature effect show excellent characteristics without a loss of the high accuracy that is a special feature of FCX series transmitters. The long-term stability shows a very good stability of zero drift change of 0.25 or less after 1,000 hours.

3. Gold and Ceramics Coated Seal Diaphragm Type Transmitter

The FCX series transmitter placed on sale in 1989 were a line of products using hastelloy C, monel, and tantalum as the special material of the seal diaphragm and process cover. These materials have been known for a long time as corrosion-resistant material and the special features of each are taken advantages of and they are used in many corrosive processes, etc.

In 1991, a line of products using titanium and zirconium at the seal diaphragm of the level transmitter and

Fig. 6 Gold and ceramics coated seal diaphragm type transmitter

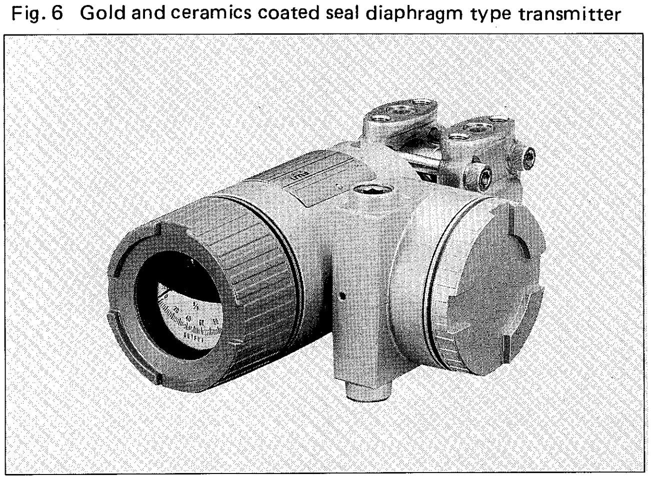
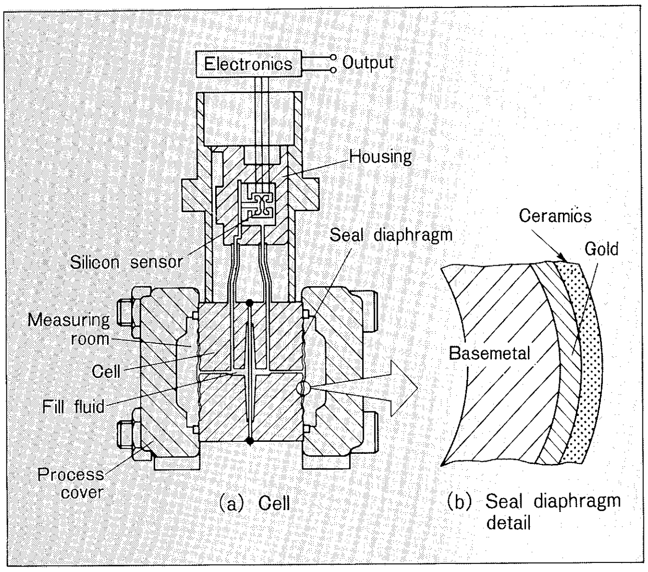


Fig. 7 Cross section of the cell and seal diaphragm



remote seal type transmitter were added to the line up.

This year, a transmitter using a seal diaphragm with a new construction (gold and ceramics coated seal diaphragm type transmitter) was added to the line up of FCX series transmitters. An outline of this new seal diaphragm type transmitter is introduced here.

3.1 Construction of gold and ceramic coated seal diaphragm type transmitter

3.1.1 Construction and action of transmitter

The gold and ceramics coated seal diaphragm type transmitter is shown in **Fig. 6**. Externally, it is the same as the standard differential transmitter. A cross section of the cell of the transmitter is shown in **Fig. 7 (a)**. The process pressure guided to the measuring room between the process cover and cell acts on the silicon sensor through the seal diaphragm and filled liquid and is converted into differential capacitance. The differential capacitance is converted to a signal proportional to the differential pressure by the electronics section mounting a microprocessor. This signal is then converted to a 4 to 20mA DC output signal. The electronics section is the same as that used with the FCX series.

3.1.2 Construction of seal diaphragm

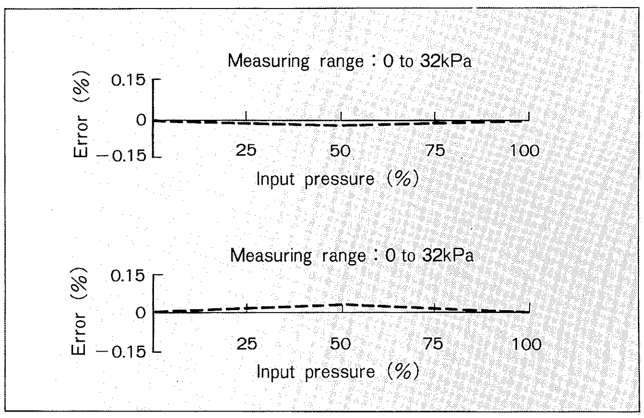
A magnified cross section of the seal diaphragm is shown in **Fig. 7 (b)**. The construction is a two layer construction with the base metal of the seal diaphragm sequentially coated with gold and a ceramic. The ceramic part has an electrical isolation property and decreases combination of the position ions of the measuring fluid (for example, H+) and the electrons inside the base metal. Its corrosion resistance and wear resistor are also excellent. As is well known, gold is a noble metal with stable properties. Gold is also known as a material that dissolves hydrogen with difficulty.

Table 2 Main specifications

Item			Diff. Pressure	Flow	Pressure
Type	Analog		FHC	FHF	FHG
	Smart		FKC		FKG
Measuring range		(1)	0...32kPa	0..32kPa	0...0.5MPa
		(2)	0...64kPa	0...64kPa	0...3MPa
		(3)	0...130kPa	0...130kPa	0...9.8MPa
Accuracy (at reference condition)			0.15%	0.375%*	0.15%
Linearity			0.1%	–	0.1%
Temp. effect (at max. span)	Zero		0.5%/55°C	1.5%/55°C*	0.5%/55°C
	Total		0.8%/55°C		0.8%/55°C
Static pressure effect	Zero (at max. span)		0.5%/16MPa	1.3%/16MPa*	–
	Span		0.4%/10MPa	0.4%/10MPa	
Over pressure effect (at max. span)	Zero	(1)	1%/16MPa	2.5%/16MPa*	–
		(2)	0.6%/16MPa	1.5/16MPa*	
Turn down ratio			10 : 1		
Temperature limits	Cell		–20 to 120°C		
	Amp.		–20 to 85°C		
Pressure limits			16		–

*: at 20% of flow

Fig. 8 Linearity of gold and ceramic coated seal diaphragm type transmitter



3.2 Main specifications

The main specifications are summarized in **Table 2**.

3.3 Basic characteristics

The linearity of a differential transmitter with a maximum measuring span of 32kPa is shown in **Fig. 8**. The linearity is within the accuracy standard (0.15%) even when the range is changed up to 1/10.

The typical temperature effect is shown in **Fig. 9**. Since accurate calculation for compensation is performed by microprocessor, the zero and span error due to temperature is small.

Fig. 9 Temperature effect of gold and ceramic coated seal diaphragm type transmitter

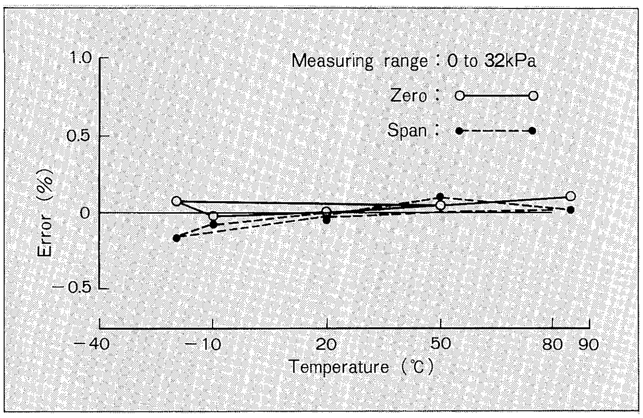
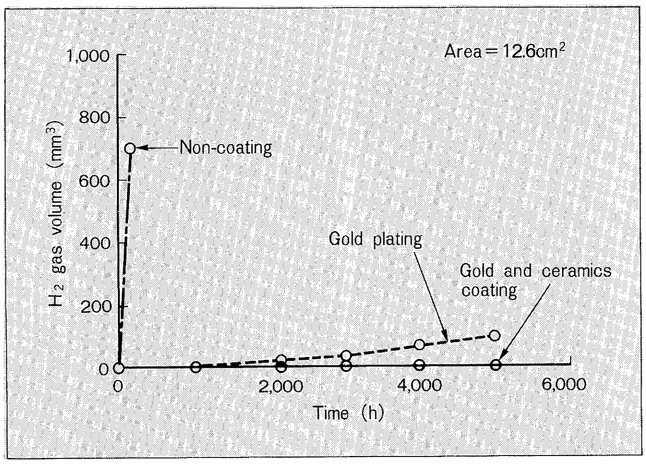


Fig. 10 Hydrogen volume penetrated some seal diaphragms



3.4 Example of application of gold and ceramic coated seal diaphragm type transmitter

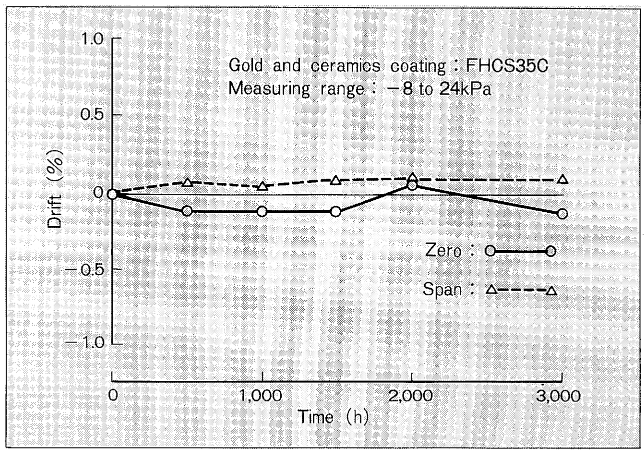
When a transmitter is used to measure medium including hydrogen in a petrochemical plant, oil refinery, or similar plant, hydrogen gas collects in the filled fluid and zero and span drift, etc. occur. This mechanism is considered as described below. The hydrogen included in the measuring medium is absorbed at seal diaphragm surface as atomic hydrogen (H) and some of it is moved by the diffusion effect and is returned to hydrogen molecules at the seal diaphragm surface and is collected inside the fill fluid as hydrogen gas.

Thereupon, from the following principle, the gold and ceramic coated seal diaphragm type transmitter was judged to be able to solve this problem and was field tested in our company.

(1) Since the isolation property of ceramics acts to decrease the combination of the hydrogen ions in the measuring medium and the electrons in the diaphragm, the hydrogen atom number of the seal diaphragm surface is reduced.

(2) Since gold dissolves hydrogen with difficult, diffusion

Fig. 11 Zero and span drift in long-term stability test



of the hydrogen atoms in the gold and ceramic coated seal diaphragm type transmitter can be suppressed.

3.4.1 Restriction effects of hydrogen penetration of seal diaphragm

The result of measurement of the hydrogen gas volume (at room temperature) that penetrate the gold and ceramic coating seal diaphragm type transmitter under the following test conditions are shown in **Fig. 10**.

Test conditions

- Temperature: 80°C
- Pressure: 9.81MPa {100kgf/cm²}
- Measuring medium: Water solution containing hydrogen

An uncoated sample is penetrated by a plenty of hydrogen gas in a short time. Penetration of a sample coated with only gold by a small amount of hydrogen was recognized. Penetration of the gold and ceramic coated sealed diaphragm by hydrogen was not recognized (within measuring error). As a result, the excellent hydrogen penetration prevention effect of the gold and ceramic coated seal diaphragm was confirmed.

3.4.2 Long-term stability

The long-term stability under the conditions given below is shown in **Fig. 11**. Satisfactory results were obtained.

- Temperature: 100°C
- Pressure: 11.8MPa {120kgf/cm²}
- Measuring medium: Hydrogen gas

4. Conclusion

The new type of transmitters added to the electronic transmitter FCX series line up was introduced above. Products matched to user needs will be added and deveopment of more appealing products will be promoted in the future.