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**ПРИМЕНЕНИЕ УСТРОЙСТВА ЗАПИСИ ДАННЫХ В ПРОЦЕССЕ
ТЕСТИРОВАНИЯ И КАЛИБРОВКИ ИЗМЕРИТЕЛЬНЫХ ПРИБОРОВ
USING A DATA LOGGER WHEN TESTING AND CALIBRATING
MEASURING INSTRUMENTS**

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*Ключевые слова: устройство записи данных; калибровка; измерение; датчик давления;
переменный ток; абсолютная погрешность*

*Key words: data logger; calibration; measurement; pressure transmitter; measurement;
DC current; full scale error*

Nowadays accuracy of measuring units is one of the most important industrial goals. In this case a proper testing and calibration plays a vital role. Pressure transmitters of different types are commonly used in production as well as treatment, transportation, storage, processing and distribution of oil and gas. These instruments convert the pressure sensed into proportional electrical signals like DC current, DC voltage etc. To facilitate and bring uniformity among wide-ranging industrial applications, currently such electrical outputs are standardized to certain fixed values like (4 to 20) mA, (0 to 10) V

etc. which can be configured to the required upper and lower limits of pressure within the transmitter's specified operating range.

Calibration of transmitter is done by applying known pressure using a pressure standard and the output electrical parameter is measured using a precision multimeter.

In this paper an application of a datalogger to a pressure calibration process is presented. The advantages facilitates faster and efficient recording of calibration data is presented.

Experiment

An experiment was conducted at Fluid Control Research Institute, Kerala, India during a course of flow measurement and calibration for international students under ITEC program.

The purpose of this experiment was to define a difference in testing results in case of using data logger comparing to regular testing. The unit under testing was an absolute pressure transmitter with a range of measured pressure from 800 to 1200 mbar and range of output from 4 to 20 mA. All the process was carried out according to the standard DKD-R 6-1.

For the first experiment, following instruments were used:

- Multifunction Pressure Indicator;
- Digital Multimeter.

Instruments were connected as shown in figure 1.

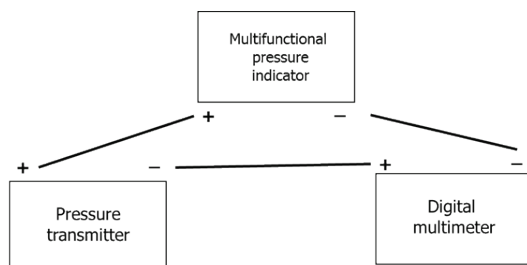


Figure 1. Connection of instruments

In this assembly, a multifunction pressure indicator not only indicates pressure, but also provides power to pressure transmitter and digital multimeter, while digital multimeter takes an output reading from a pressure transmitter, which is in units of current. A pressure was produced by a hand pump.

According to the standard, measurements were conducted using a step of 50 mbar. Each value was measured 3 times, among which 2 direct and 1 reverse process (figure 2).

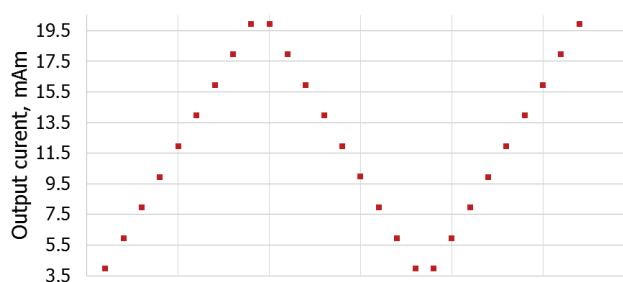


Figure 2. First experiment. 3 cycles of readings

For the second experiment, digital multimeter was replaced by data logger, so that list of instruments looked as following:

- Multifunction Pressure Indicator;
- Data logger.

For the experiment HYDRA Series III Data Acquisition Unit by Fluke was used as a data logger. It has a 67 analog channel, and able to measures and records dc volts, ac volts, dc current, ac current, resistance, frequency, and temperature. It is with a digital 8-bit transistor-transistor logic (TTL) port that can sense and output.

With regard to measuring DC current it has following specifications:

Input Protection. — 0.15 A / 600 V resettable PTC

Table 1

DC current input characteristics

Range	Resolution	Resolution			Reference Resistance (Ohms)	Burden Voltage
		Fast 4½ Digits	Medium 5 ½ Digits	Slow 6 ½ Digits		
100 µA	100.0000 µA	10 nA	1 nA	0.1 nA	1k Ω	< 1 mV
1 mA	1.000000 mA	100 nA	10 nA	1 nA	1k Ω	< 1 mV
10 mA	10.00000 mA	1 µA	100 nA	10 nA	10 Ω	< 1 mV
100 mA	100.0000 mA	10 µA	1 µA	100 nA	10 Ω	< 1 mV

Table 2

DC current accuracy

Range	24 Hour (23 ± 1 °C)	90 Days (23 ± 5 °C)	1 Year (23 ± 5 °C)	T.C./ °C Outside 18 °C to 28 °C
100 µA	0.005 % + 0.003 %	0.015 % + 0.0035 %	0.015 % + 0.0035 %	0.002 % + 0.001 %
1 mA	0.005 % + 0.001 %	0.015 % + 0.0011 %	0.015 % + 0.0011 %	0.002 % + 0.001 %
10 mA	0.005 % + 0.003 %	0.015 % + 0.0035 %	0.015 % + 0.0035 %	0.002 % + 0.001 %
100 mA	0.005 % + 0.001 %	0.015 % + 0.0035 %	0.015 % + 0.0035 %	0.002 % + 0.001 %

The sequence of testing was the same, but for each value of pressure not only one output was measured, but 10 readings (figure 3).

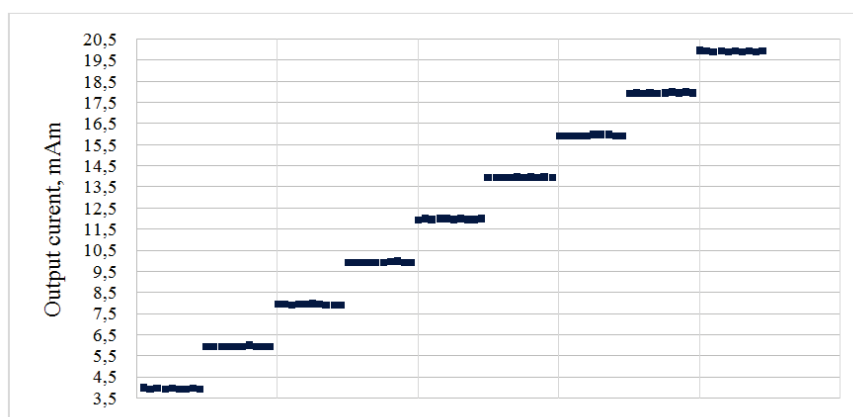


Figure 3. Second experiment. 1 cycle of readings

You can thoroughly see fluctuations among one reading on figure 4.

These fluctuations are caused by small pressure changes. After fine adjustment pressure can not remain constant, that's why manual taking of an output reading is under risk of containing some error.

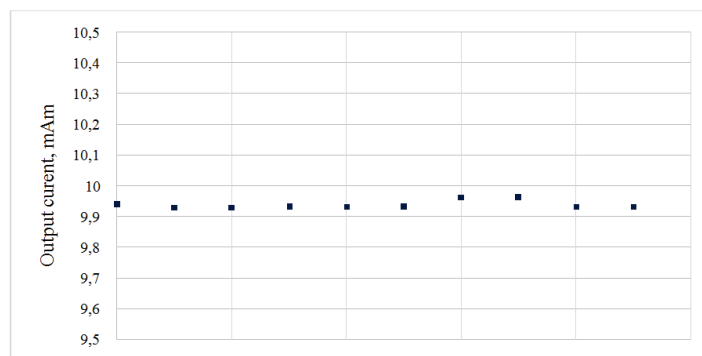


Figure 4. Second experiment. Fluctuations of current among one reading

By this particular reason using a data logger becomes necessary. It gives an opportunity to set a number of points to log among one reading. After that, according to requirements, mean value, minimum value, maximum value are taken. In our case, a mean value is considered as the most accurate. Moreover, with this instrument, there is no need to handwrite results, all results are saved as excel file.

Results

Based on measurements, mean values of output were calculated for every pressure step for both experiments (figure 5).

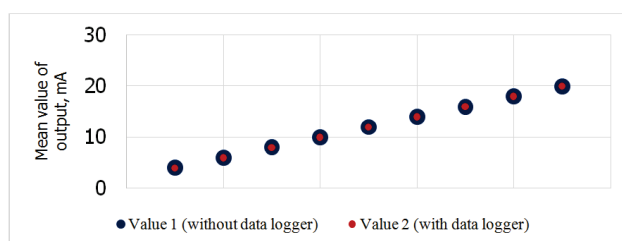


Figure 5. Results of two experiments

As you can see on the graph, there is almost no difference between measurements conducted with or without using data logger. However, if we proceed calculations and calculate full scale error (one of the most important parameters for calibration) according to the formula (1), we can see a completely different situation (figure 6).

$$FS\ error = \frac{(test\ current - ideal\ current)}{maximum\ current}. \quad (1)$$

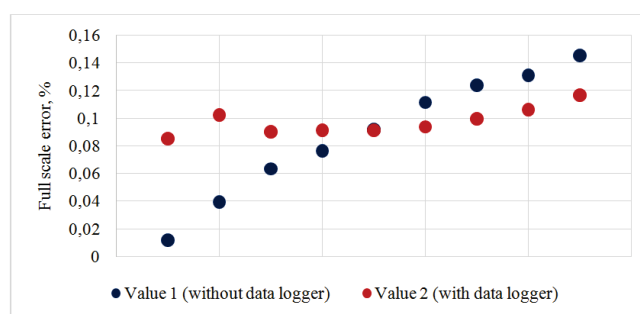


Figure 6. Full scale error

According to the first test, FS error continuously increases, while second test shows the same parameter as a constant range between 0.08 and 0.12 %. Although minimal value of FS error doesn't matter so much, a maximum value can cause a rejection of a testing unit of a customer, if it exceeds required level.

Conclusion

In terms of increasing requirements in different scopes of industry, the accuracy of calibration becomes more and more important procedure. Although not all of up-to-date technologies are prescribed by calibration standards, it is definitely necessary to improve a process for fulfilling customers' requirements. Using a data logger is one of a variety of modern facilities, which can increase a quality of calibration and simplify the process.

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ИССЛЕДОВАНИЕ ТЕМПЕРАТУРНЫХ ПОЛЕЙ В СКВАЖИНЕ В ПРОЦЕССЕ ЗАКАЧКИ ЖИДКОСТИ НА ОСНОВЕ ЧИСЛЕННОЙ ИНВЕРСИИ ИЗЕГЕРА

**RESEARCH OF TEMPERATURE PROFILES IN THE WELL IN THE COURSE
OF PUMPING LIQUID ON THE BASIS OF NUMERICAL INVERSION OF ISEGER**

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*Ключевые слова: температурное поле; скважина; преобразование Лапласа — Карсона;
численная инверсия; алгоритм Изегера*

*Key words: temperature field; well; Laplace — Carson transforms; numerical inversion;
Iseger's algorithm*

Исследования температурных полей актуальны и широко применяются на нефтепромыслах [1, 2]. Ранее в работе [3] установлено, что метод Изегера может инвертировать преобразования Лапласа функций с неоднородностями и особенностями, и результаты численного обращения имеют более высокую точность, чем при использовании других методов инверсии. Применение метода численной инверсии к задаче о температурном поле в скважине [4, 5] имеет особую значимость,