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Development of the Next Generation Gas Leak Tester

Main author

Shota Mine
Tokyo Gas Co., Ltd.
JAPAN

Co-authors

Kazunari Haino
Kazuhiko Isoyama
Yoshihiro Atarashiya
Tokyo Gas Co., Ltd.
JAPAN

Shinichiro Arima
Masami Ochiai
Yu Sasaki
Aim Tech Co., Ltd.
JAPAN

Takeshi Abe
Tokyo Gas Engineering Co., Ltd.
JAPAN

Katsunori Sekiya
Toyo Keiki Co., Ltd.
JAPAN

1. Abstract

We have developed *SAVER PRO Smart* (SPS), a novel gas leak tester with a temperature compensation function. The tester consists of two separate units: a pressure sensor unit and a tablet for memory and control functions. The two units can transfer data and commands using Bluetooth technology. This product has three attractive features. The first feature is the temperature compensation function, for which we received a technology award from The Japan Gas Association in 2012. The state of the art compensation algorithm effectively eliminates the influence of ambient temperature changes when making sensitive pressure measurements. It is important to note that pressure drifts due to subtle ambient temperature change may obscure pressure changes caused by a leak if no compensation is considered. For instance, leak inspections carried out in late afternoon are often accompanied by a drop in ambient temperature, and the temperature changes may result in faulty inspection results. In this situation, for instance, the quality of leak inspection reliability can be significantly improved with SPS. The second feature is ease of use. The seven-inch tablet employed in the tester provides a handy and usable human-machine interface for users. Moreover, software updates have become easier because of the tablet. Until now, it has been necessary to send such products to the manufacturer for software updates. This product can perform updates by accessing a specified URL from a tablet as well as a personal computer. The third feature is multiple sensor operation, in which one tablet can communicate with up to five sensor units. This is especially effective for leak inspections in newly constructed apartments, because this function makes it possible to perform gas leak testing of other rooms during the measurement time when gas leak testing of one room is being performed, thus shortening the total working hours. With the above-mentioned novel features, SPS has greatly changed the image of gas leak testers in Japan. We are convinced that this product will enable us to make a significant contribution to improving security and making work more efficient.

C O N T E N T S

2. Body of Paper

2-1 Introduction

Gas leak tests are among the most important tasks in order to ensure the integrity of gas pipes. Gas leak testers commonly used in Japan include water column manometers, chamber pressure gauges, and electrical diaphragm pressure gauges. Gas leak testers are categorized into several groups depending on their testing durations and pipe capacities.

In addition to high reliability and high detection capabilities, a leak tester should have excellent usability and durability for everyday usage in the field. SPS employs a separate configuration (a measurement unit and a tablet as a control unit) for superior usability, whereas previous models have sensors and small displays in a single unit.

2-2 Conventional products

Conventional products, SAVER PRO I (SPI) and SAVER PRO II (SPII), are shown in Figs. 1 and 2, respectively. SPI is the world's first leak tester with a temperature compensation function. SPII is the successor of SPI, and has a printer and fewer control buttons. These products can be used not only for city gas applications, but also LP gas applications.

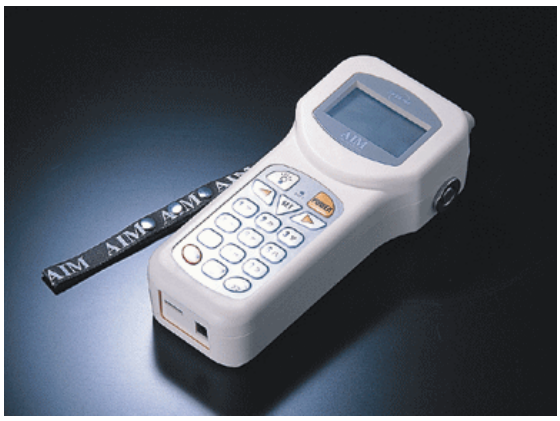


Fig. 1 SPI Fig. 2 SPII

Table 1 Specifications of SPI and SPII

	SPI	SPII
Dimensions (mm)	W 100 × H 220 × D 60	W 185 × H 153 × D 40
Weight (g)	730	770

2-3 Product structure

The appearance and specifications of SPS are shown in Fig. 3 and Table 2, respectively. SPS consists of two separate units: a pressure sensor unit, and a tablet for memory and control functions, which is the major design change that has been made from its predecessors for better usability. The appearance of these units is shown in Fig. 3.

Fig. 3 SPS

Table 2 Specifications of SPS

	Tablet	Pressure sensor unit
Dimensions (mm)	W 199 × H 118.8 × D 10.4	W 74 × H 146 × D 38
Weight (g)	330	420

2-3-1 Tablet for memory and control functions

The menu screen on the tablet and description of the measurement menu are shown in Fig. 4 and Table 3, respectively. Greatly improved usability was achieved with the seven-inch color display and touch screen. There are three inspection modes in the device: the chart paper mode, the digital mode, and the special measurement mode. The temperature compensation mode, multiple sensor operation, and the long-time measurement mode are under the special measurement mode sub-menu. Users should choose an appropriate mode depending on their leak testing tasks in the field. The chart paper mode and the digital mode are in the top screen as they are frequently used modes. Up to 400 measurement data sets can be browsed in the data list mode.

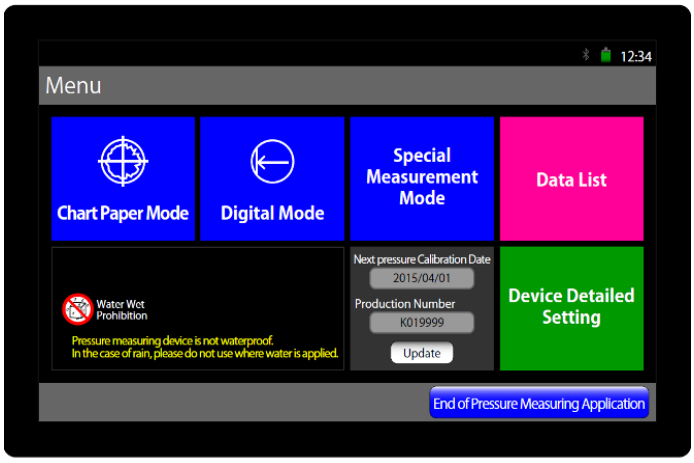


Fig. 4 Menu screen on the tablet

Table 3 Features of each measurement mode

Measurement Mode		Description
Chart Paper Mode		On-screen simulated chart paper manometer.
Digital Mode		Displays pressure readings from the pressure sensor.
Special Measurement Mode	Temperature Compensation Mode	Digital pressure mode with temperature compensation.
	Multiple Sensor Control	Multiple pressure sensors can be controlled with single tablet.
	Long-time Measurement	Prolonged pressure survey up to seven days.

2-3-2 Pressure sensor unit

The specifications of the pressure sensor are shown in Table 4. Maximum measurement pressure is 20 kPa, whereas the maximum pressure was 10 kPa for the previous products. Moreover, continuous use for 200 hours (about eight days) has been achieved by employing a lithium ion polymer rechargeable battery.

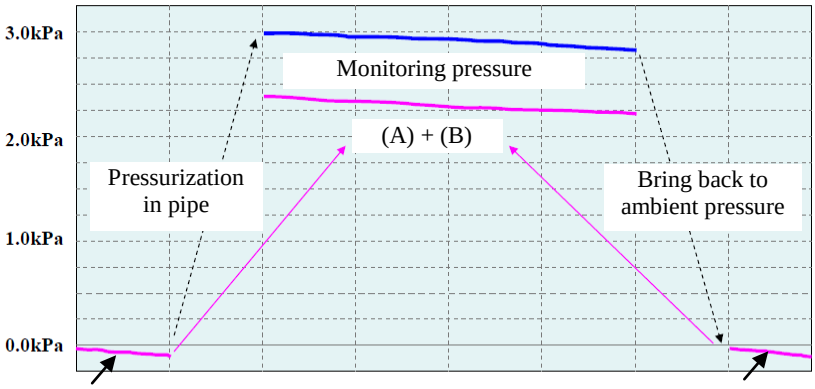
Table 4 Specifications of pressure sensor

Type	Electric formula diaphragm type pressure gauge
Pressure measurement range (kPa)	-0.5 to 20
Continuous pressure measurement time (hours)	200
Gas types	Air, city gas, propane gas

2-4 Product features

2-4-1 Temperature compensation function

The temperature compensation algorithm is shown in Fig. 5. The measurement process of the temperature compensation mode consists of the following three steps: (1) monitoring pressure changes in pipes at ambient pressure to asses temperature influences; (2) main leak testing by monitoring pressure changes with an applied pressure in the pipes; and (3) repeating (1) again in order to ensure that the temperature influence has not changed before and after the leak test. The net pressure drop caused by leaks can be obtained by calculating (2) minus (1). An example of measurement results from the temperature compensation mode is shown in Fig. 6. The state-of-the-art compensation algorithm effectively eliminates the influence of ambient temperature changes. It is important to note that pressure drifts due to subtle ambient temperature changes may obscure pressure changes caused by a leak if no compensation is considered. For instance, leak inspections carried out in late afternoon are often accompanied by a drop in ambient temperature, and the temperature changes may result in faulty inspection results. In this situation, for example, the quality of leak inspection reliability can be significantly improved with SPS. The temperature compensation algorithm received a technology award from the Japan Gas Association in 2012.



(A) Monitoring pressure without pressurization (B) Monitoring pressure without pressurization

Fig. 5 Temperature compensation algorithm

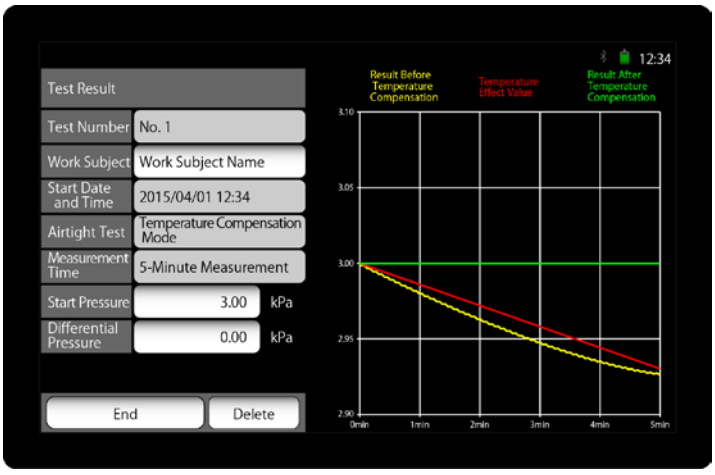


Fig. 6 An example of the temperature compensation mode

2-4-2 User-friendly human-machine interface

The seven-inch tablet employed in the tester provides a handy and usable human-machine interface for users. Moreover, software updates have become easier because of the tablet. Software updates can easily be performed simply by accessing the manufacturer's website, whereas it used to be necessary to send the tester back to them.

2-4-3 Multiple sensor control

As shown in Fig. 7, SPS has a multiple sensor control mode in which one tablet can communicate with up to five sensor units. This is especially useful for leak inspections in newly constructed apartments, because this makes it possible to perform leak testing in many apartment rooms at once, which contributes to shortening the total working hours.

2-4-4 Security countermeasures with password authentication and data encryption

In order to prevent data tampering and unauthorized use of the tester, security countermeasures with password authentication and data encryption are employed. It is virtually impossible to tamper with the data due to the use of a password having eight or more digits when logging in and encryption using the Advanced Encryption Standard (AES) with a key length of 128 bits.

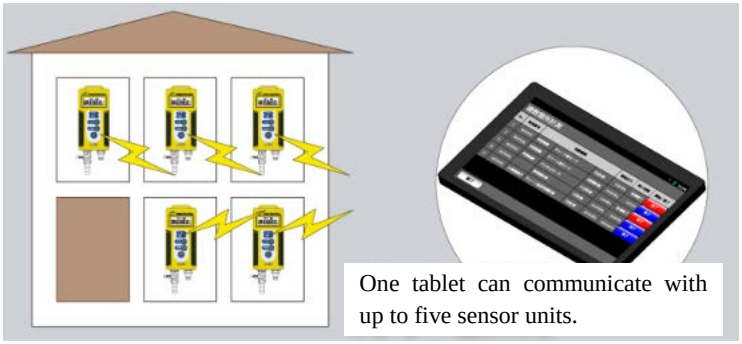


Fig. 7 Multiple sensor control mode

2-4-5 Simulated chart paper mode

The simulated conventional chart paper mode is shown in Fig. 8. It is easy for workers accustomed to conventional manometers to judge the testing results. The measurement pressure range is 5 to 20 kPa and the measurement time can be selected from 2 minutes to seven days.

Fig. 8 Simulated conventional chart paper mode

2-4-6 Data management system

The measurement data saved in the tablet can be transmitted to a personal computer using Bluetooth technology and the Mail Sending function. In addition, SD cards can also be used to transfer data. The transferred data can be rearranged by supervisors, and selected data can be printed from the computer. Complex data management such as the tabulation of multiple inspection results for a single household is possible with the software, as shown in Fig. 9.

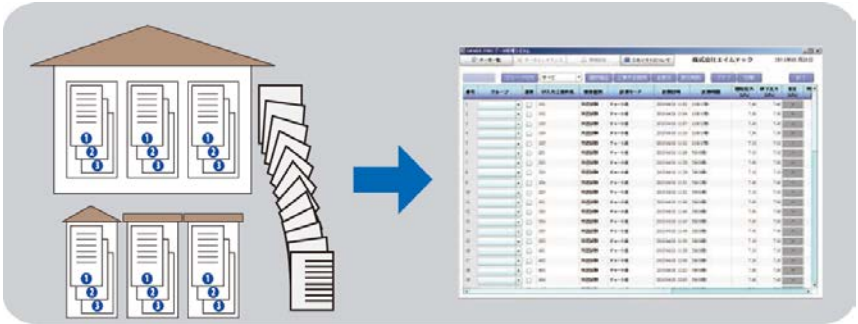


Fig. 9 Data management system

2-5 Performance evaluation test

2-5-1 Basic performance

The performance of SPS has been tested. The test procedure, which was also applied to the previous models, includes the dust resistance, drip resistance, and impact resistance of the tester. It has been confirmed that the tester complies with IP 4 2 of JIS C 0920 for dust and drip resistance. The tester was not damaged by falling to a concrete surface from a height of 0.5 m.

1) Protection grade IP 4 2: Protection of an enclosure against penetration by a solid 1.0 mm or more in diameter. Protection of an enclosure against the infiltration of dripping water falling vertically even if the enclosure is tilted at an angle within 15 degrees.

2-5-2 Temperature compensation function

The testing conditions are shown in Table 5. Extreme temperature increase/decrease conditions of 0.3°C/min, which could occur in exposed pipes, were chosen in order to evaluate the temperature compensation function. Six temperature patterns with/without leaks were tested, and the validity of the algorithm up to a pipe volume of 50 L was confirmed.

Table 5 Testing conditions

Test gas	Air
Piping capacity (L)	27, 50
Test pressure (kPa)	3.0, 16.5
Test time (min.)	5

Table 6 Evaluation patterns

No	**Leak**	**Temperature change conditions**			
		Condition	**Before test**	**Gas leak test**	**After test**
1	Not present	No change	→	→	→
2		Constant increase	↑	↑	↑
3		Constant decrease	↓	↓	↓
4	Present	No change	→	→	→
5		Constant increase	↑	↑	↑
6		Constant decrease	↓	↓	↓

2-6 Summary

A novel gas leak tester having excellent usability and performance has been developed. SPS has been marketed in the Japanese city gas field since August 2013, and it has been contributing to better safety and efficiency in gas fitting work.

3. List of Tables

4. List of Figures