LPG APPLIED TECHNOLOGY FOR SEISMIC HAZARD

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Abstracts

This report describes technologies that can utilize the characteristics of LP gas to provide a decentralized energy source in response to seismic hazards. In this paper, we describe two of these highly advanced product security technologies. One is an example of preventive technology designed to prevent large-scale damage in the event of an earthquake, and the other is an example of recovery technology designed for the quick restoration of gas supply after an earthquake.

First, we will discuss product technology designed to prevent large-scale damage in the event of an earthquake. In Japan, because of the earthquake risk it is mandatory to stop the gas supply whenever an earthquake occurs in order to prevent secondary disasters due to LP gas leaks. Since most LP gas suppliers in Japan sell LP gas by volume, LP gas is usually sold in containers and supplied through regulators to combustors via gas meters installed in every household. The earthquake-proof automatic gas shut-off device developed by ITO KOKI is operated by the pressure of the supplied gas itself, without using electricity or needing an operational engine to cut off the gas supply in the event of an earthquake. This device is appreciated because its operation does not require the use of electricity in the LP gas supply bases (hazardous areas) and because it is easy to operate, without the need for other operational gases such as nitrogen or compressed gas.

Next, we will discuss product technology designed to quickly restore the gas supply after an earthquake. A large-scale earthquake will damage city gas pipeline also. If the damaged equipment used for town gas supply can still be operated safely, LP gas can substitute for town gas in order to facilitate cooking and bathing. However, since gas combustors are designed around the calorific value of natural gas, some modification is needed to make this possible. Accordingly, ITO KOKI has developed a propane air mixer which does not need any electricity supply or power source, facilitating the "adoption of a portable device allowing the safe use of gas with combustors designed around the calorific value of natural gas". By mixing propane gas with air to attenuate propane gas to the same calorific value as natural gas, it then becomes possible to resume town gas supply in seismic hazard areas without the need to convert the combustors.

The earthquake-proof automatic gas shut-off device was installed in 90% or more of all large-scale LP gas supply equipment in Japan and the propane air mixer that can operate without the need for electricity has received a Japan Gas Association Technology Award in recognition of its contribution to large-scale earthquakes involving LP gas damage in the past. Nowadays not only town gas entrepreneurs but also the public facilities such as evacuation centers and hospitals are also adopting the device for seismic hazard prevention and recovery purposes.

ITO KOKI's earthquake-proof automatic gas shut-off device provides a safe, convenient, easy and effective seismic countermeasure for use with large-scale LPG supply equipment. Moreover, since our propane air mixer does not need electricity or a power source it can contribute to the prompt restoration of gas supplies in stricken areas by allowing the use of propane gas instead of town gas. This product, in particular, can therefore be of immense help in the utilization of LP gas as a decentralized energy source.

Introduction

Japan is one of the most quake-prone countries in the world, and before the recent Great East Japan Earthquake, a number of big earthquakes have already claimed many lives and properties in various parts of the country. We cannot control earthquake because it is a natural phenomenon, but it is necessary to minimize secondary damage and take prompt recovery measures.

This paper describes 1) an earthquake-proof automatic gas shut-off device designed for LP gas supplied by a relatively large amount, and 2) a device intended to be used for the quick restoration of town gas supply.

1. Earthquake-proof automatic gas shut-off device

1.1. Earthquake-proof automatic gas shut-off device used by community gas utility businesses for housing complex

1.1.1 This device is intended to be used for LP gas supply for domestic use ranging from a few dozen to around 500 houses. In Japan, LP gas is generally supplied to detached houses and apartments which are provided with gas cylinders, a pressure regulator, and a gas meter. LP gas is also supplied for much larger areas, like small-scale town gas supply.

1.1.2 Installation location

In the event of a great earthquake which may break or damage gas pipework and destroy buildings, there is a risk of releasing a large volume of LP gas from gas containers and causing large-scale fires and explosions. In case of such an earthquake, seismic sensors and seismic shut-off valves are provided for an LP gas container shed connected with gas supply equipment, in order to urgently shut off gas supply and prevent the disaster from spreading further.

1.2 Features and mechanism of the earthquake-proof automatic gas shut-off device

1.2.1 When an earthquake occurs, the device will shut off gas supply in the following steps:

Detecting an earthquake → Sending a shut-off signal → Shutting off gas supply

In general, it may be assumed that this kind of shut-off system consists of an electrical sensor and electrically-controlled shut-off operation. However, such a system is difficult for community gas utility businesses for housing complex. The first problem is electric power sources: in most cases, LP gas container sheds are not equipped with a power source. Second, an electric power source, if any, needs to be explosion-proof electric equipment in order to prevent gas explosion, which means the system is extremely expensive.

Our earthquake-proof automatic gas shut-off device is activated by gravity and the pressure of supplied gas, independent of electric energy. The device is highly valued in the market for its simple structure, user-friendliness, and easy installation, inspection and maintenance, and low cost.

1.2.2 Mechanism of the seismic sensor

The seismic sensor consists of a steel ball element on the stand and a heavy bob element attracted to a magnet. When an earthquake occurs, both of the elements leave their set positions due to the acceleration and frequency of oscillations, and they fall on the lever. As a result, the spindle coupled with the lever is pushed up to open the valve disc of the blow valve and release the filler gas.

Earthquake shaking intensity is generally expressed by oscillation acceleration level, and it is also related with oscillation frequency. The frequency is characterized to be limited within a relatively narrow range from 1.43 to 3.3 Hz in general. The oscillation range from 3.3 Hz to several tens of Hz is defined as daily-life oscillation range.

The upper portions of their respective operating characteristic curves of the steel ball element and the heavy bob element of the seismic sensor represent their operational ranges. If the oscillation frequency is lower than 5 Hz, both the elements fall from their set positions when the acceleration reaches 350 to 400 gal range. When the frequency exceeds 5 Hz, the operating acceleration of the steel ball element will increase with the increase of frequency. It means that the higher the frequency gets, the less the steel ball element becomes likely to fall.

In the specific range from 5 to 10 Hz, the steel ball element has the property of being inoperative while the heavy bob element has the property of being operative. The combination of the simple elements with different operational characteristics provides the sensor with operational stability.

1.2.3 Mechanism of the seismic shut-off valve

The seismic shut-off valve is installed between a separated automatic change over and a second stage regulator, where the flow of supplied gas ranging from 0.03 to 0.08 MPa is provided.

At the entry side of the seismic shut-off valve, a diaphragm case of the seismic shut-off valve and the seismic sensor is connected with a copper pipe by way of a reset valve. The pressure of gas introduced to the diaphragm case overcomes the force of the spring and pushes up the diaphragm and the valve disc connected with the diaphragm. In consequence, the seismic shut-off valve opens to allow the supplied gas to flow.

While the seismic sensor is in the “on” condition, the gas pressure in the diaphragm case and the blow valve of the seismic sensor remains the same as when the gas was filled and the seismic shut-off valve remains open.

When an earthquake with acceleration over a predetermined value (400 gal) occurs and the seismic sensor is activated, the spindle is pushed up to open the blow valve and release the filler gas to the atmosphere. As a result, the spring closes the valve to prevent the gas from flowing to the exit.

1.3. Past successful use and future use of our seismic sensors and seismic shut-off valves

Our company has been developing and marketing seismic sensors and seismic shut-off valves for nearly thirty years. We have been providing them for most of the community gas utility businesses for housing complex in Japan, and they play a major role in the prevention of a large amount of gas from being emitted. However, the shut-off device is not the only thing for preventive measures against gas emission. Still more countermeasures are demanded for various processes of gas supply. We, as a manufacturer, believe that our mission is to provide customers with comprehensive safety systems, considering operating energy and cost reduction.

2. Transportable propane air mixer

2.1 Introduction

Town gas is basically supplied through conduit pipes from a gas supplier to consumers. If the area is hit by an earthquake, the gas supplier is no longer able to supply gas until the soundness is confirmed, and it requires a large number of workers and days to restore the damaged pipeline.

Many facilities such as hospitals, nursing homes and emergency shelters should be given top priority in the restoration of disrupted lifeline utilities as soon as possible. Actually, it may not take so much time to make those facilities prepared for receiving gas again, but gas will not be supplied until the pipeline is restored.

If gas consuming facilities are sound, a temporary supply of LP gas, which is excellent in mobility, will enable them to provide meal, bath and other essential services without waiting for full-scale restoration of town gas (natural gas) supply.

About twenty years ago, our company started the development of our transportable propane air mixer, described hereinafter. The development and trial manufacture was carried out to make it usable as a construction tool and an emergency device in case of a disaster.

A very important feature of the device is the controllability with gas pressure without using any electric power source, thereby realizing simple components, lower costs and user-friendliness of the device.

2.2 Combustibility and compatibility with gas burning appliances

Table 1 shows physical property values of typical kinds of gas.

Gas Type	13A (Natural Gas)	LPG (C3H8-95%)	PA－13A
Specific Gravity	0.655	1.55	1.333～1.337
Gross Calorific Value MJ/m3N	46.1	101	61.9～62.6
Wobbe index (W.I)	56.96 (52.7～57.8)	82.47	53.6～54.1
Maximum Combustion Potential (MCP), Cm/S	46.0	39.0	40.9～41.0

Table 1

It is extremely important to know what combustion properties two different kinds of gas show to the same gas burning appliance. If they exhibit similarly good combustibility, it means that the two kinds of gas are compatible with each other for the gas appliance. The compatibility is determined by the Wobbe index (WI) and the Maximum Combustion Potential (MCP).

The mixture of LPG and air at the ratio of 62% to 32% makes propane-air 13A (PA-13A) gas, which has similar combustibility as class 13A city gas.

2.3 Mechanism of the transportable propane air mixer

2.3.1 Production of the mixed gas by a venturi mixer

Figure 3 is a schematic view of a typical venturi mixer, and Figure 4 is a graph showing its characteristics.

Figure 4 shows the changes in LPG injection pressure Pn of the nozzle and calorific value Q of the mixed gas with the changes in back pressure Pb.

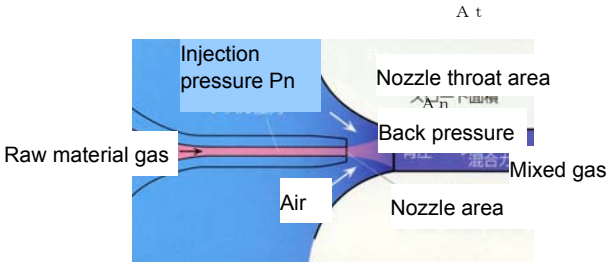


Fig.3

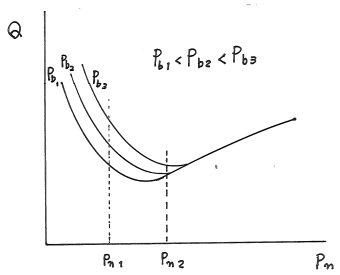
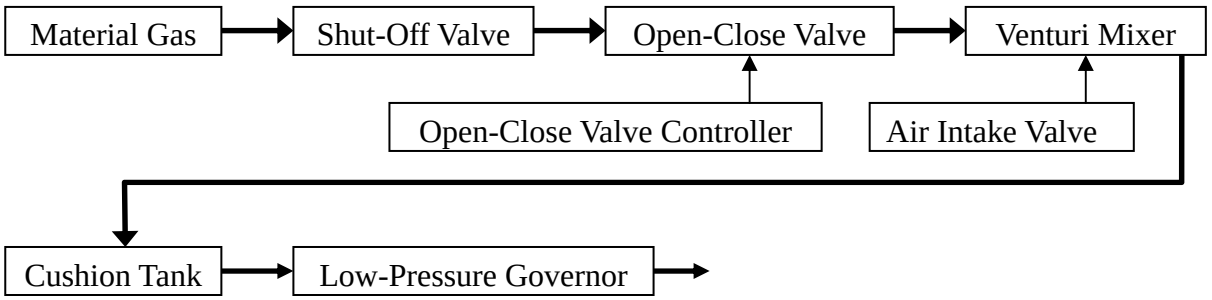


Fig.4

The transportable propane air mixer adopts 1) lower injection pressure and 2) a lower-capacity cushion tank. Although they may cause unstable calorific values owing to the characteristics of the venturi mixer, they are important factors for expanding the scope of application of this device. Regarding these opposite features, the present device detects changes in the back pressure and controls the gas injection and shutoff according to the changes in a very narrow range, thereby stabilizing calorific values.

2.3.2 Structure of the transportable propane air mixer

Main components and functions of the PA-13A producing device are as follows:



2.4 Past successful use of the transportable propane air mixer

The device has been successfully utilized for 1) lifeline restoration following earthquakes and other disasters, and 2) temporary supply of gas during gas conversion and daily construction work.

The following table shows major earthquakes where the transportable propane air mixer was utilized. Regarding the device model having a specification of 30 m^3/hour, in particular, several utility businesses are promoting efforts around the country to share their devices in the event of a disaster in order to speed up disaster recovery.

With the increasing recognition of the device, there are many reports on the application in various areas, such as small-scale works for preventing gas leak and pipe replacement works.

Earthquake	Date of occurrence
Great Hanshin Awaji Earthquake	Jan. 17, 1995
Niigata Chuetsu Earthquake	Oct. 23, 2004
Niigata Chuetsu-oki Earthquake	Jul. 16, 2007
Great East Japan Earthquake	Mar. 11, 2011

3. Superiority of LP gas as a decentralized energy source

In Japan, which is an earthquake-prone country, many public and private sectors are making various cooperative efforts to install earthquake-proof automatic gas shut-off devices and other devices, in order to prevent secondary disasters due to gas leaks. The transportable propane air mixer, which makes the most of the characteristics of LP gas as a decentralized energy source, makes a significant contribution to early disaster recovery in town gas service areas as well. After the recent Great East Japan Earthquake, the device has been used for the recovery of hospitals, nursing homes, emergency evacuation centers, and other top-priority facilities. As well as for these small-scale restoration works, it has been used for area-wide restoration by connecting several units with the main pipeline to supply gas for several hundreds of households.

The successful operation of those facilities by means of LP gas has definitely positioned LP gas as a decentralized energy source.

(End)