EMERGENCY SERVICES AND TECHNOLOGY DEVELOPMENT TO RESPOND TO GAS LEAKS ON CUSTOMERS' PREMISES

Sosuke Yahata, Hajime Kojima, Hiroki Kikuchi
Tokyo Gas Co., Ltd.

Keywords: emergency service, technology development, premises, lining methods

1. Background

1.1 Characteristics of emergency service work in Japan

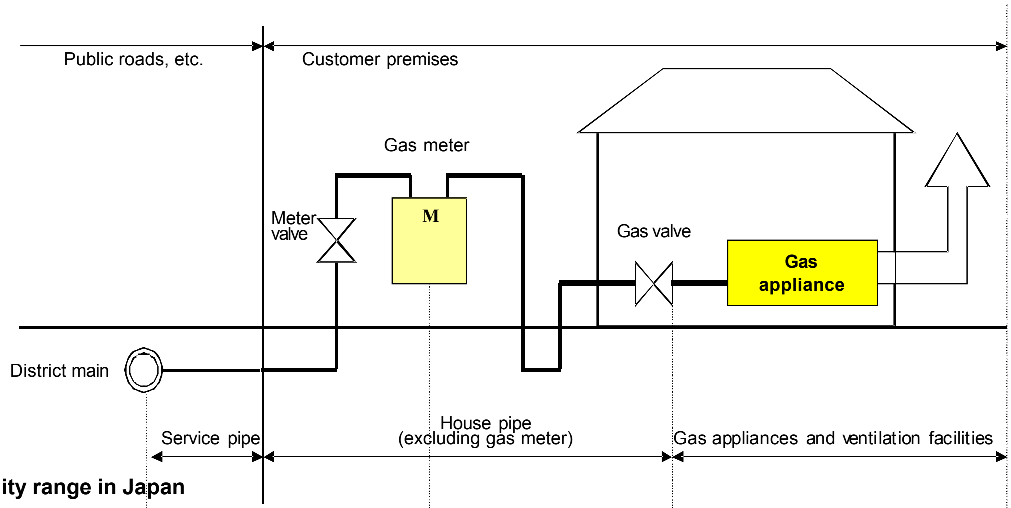
Tokyo Gas began to supply gas in Tokyo metropolitan area of Japan in 1885, and has continued to supply gas there for more than a century. Although Tokyo Gas has appropriately renewed its equipment during this past period, leakage caused by aging of equipment still occurs. A system (emergency security system) has been established in Japan, so that when it has been confirmed that a gas leak has occurred, the gas utility supplying the area can be informed of the leak, and the gas utility can dispatch workers to repair leaks on all emergency calls regardless of its property division, from leaks on public roads and customers' premises at any time, 24 hours a day 365 days a year. Incidentally, most leak repairs are done to equipment on customer premises; equipment which is each customer's property.

As shown in Figure 1, it is a characteristic of Japanese law that requires gas utilities to repair leaks regardless of the property division of the leaking equipment owing to the boundaries between security responsibility divisions and property divisions are different. (In the United States for the example, the property, construction, and responsibility divisions are all separated by each customer's gas meter.). Under Japanese law, the gas utility's property division extends to the boundary of each customer's premises, the work division ends at the gas meter, and the security responsibility division extends to some of the gas appliances. Therefore, a gas utility is legally obligated to take responsibility for security by providing emergency service in response to a leak, in addition to inspecting for leaks on pipes in customer premises, which are not its own property, surveying gas appliances, and providing notifications to customers.

There are reasons why, in addition to its legal responsibilities, this emergency security system has been established. Japan's gas utilities operate in a business environment in which they compete with companies supplying other kinds of energy. Therefore, a gas utility's system which promptly ensures the safety of its customers is counted on to improve the reliability and the convenience of gas and to encourage the continued use and expansion of gas. As a result of such conditions within Japan, systems established to deploy workers in emergencies play important roles for gas utilities.

When there are many customers, on the other hand, the number of personnel and the expense required to maintain the emergency security system both raise. For example, as shown by Figure 2, there are 28.8 million customers for gas in Japan, and 94.3% of these are residential customers. Tokyo Gas, with 10.3 million customers, supplies greatest number of customers in Japan, and similarly, most of its customers are residential users. In this business environment characterised by such a large number of customers mostly are residential users, 680 personnel, who account for about 1/3 of the staff of the Supply

Division, are required to continuously maintain the emergency system which deploys personnel to perform repairs.



Responsibility range in Japan

	Service pipe	House pipe (excluding gas meter)	Gas appliances and ventilation facilities
Property division	**Gas utility**	Customer	
Construction division	**Gas utility**		Customer (installer)
Responsibility division	**Gas utility**		**Gas utility (in part)**

Responsibility range in US

Property division	Gas utility	Customer
Construction division	Gas utility	Customer (installer)
Responsibility division	Gas utility	Customer (installer)

Figure 1. Comparison of Gas Equipment Divisions*1

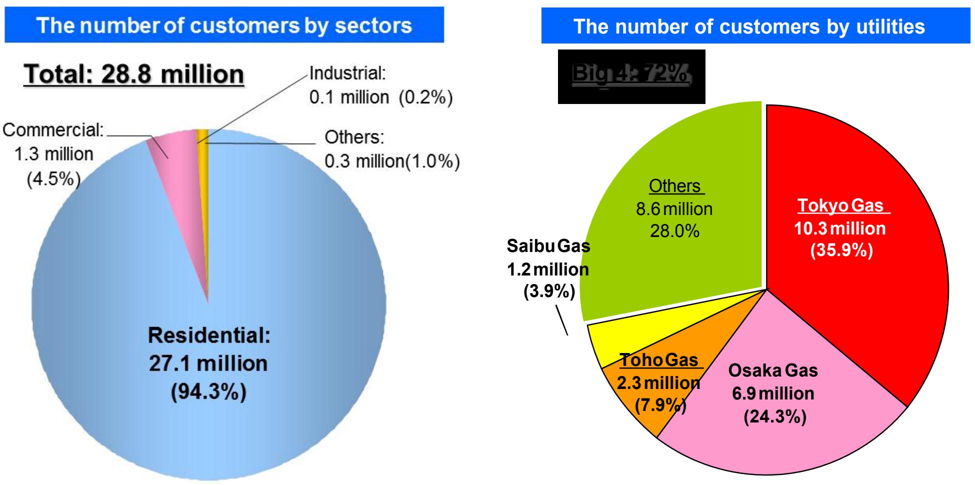


Figure 2. Numbers of Gas Customers in Japan *1

1.2 Changing emergency service work

The load of this emergency work performed in response to leaks is counted on to decline as the frequency of leaks fall as a result of renewal of equipment. But as Figure 3 shows, the number of leaks which Tokyo Gas repairs has remained almost unchanged for the past six years, with over 90% of the leaks caused by equipment on its customer premises. It is hypothesized that, as shown in Figure 1, gas pipelines and other equipment which are assets of the customers and are located on their premises still include many gas pipes and equipment which have deteriorated over time as a result of the fact that the times when it is renewed are decided by the customers. And because, for the same reason, gas utilities cannot actively do renewal work to prevent leaks on customer premises, and without any effective methods of reducing their frequency, it is predicted that the number of such leaks will continue at the same level. More efficient ways of repairing leaks are in demand so that Tokyo Gas can fulfil its legal responsibilities and perform this vast quantity of repair work while ensuring the trust of its customers.

And in addition, as a result of the recent fluctuation in the number of people hired caused by economic trends, the numbers of workers by age cohort are scattered (See Figure 4.), so that a shortage of workers resulting from an abrupt decline of veteran workers is supplemented by using new recruits. In response to the decline in the skill level predicted to occur as the percentage of inexperienced workers increases in this way, organised personnel training is carried out to pass on skills to newcomers and strengthen skills training, in order to minimize the impact of this decline and to ensure the trust of our customers. Turning to the technological (tools) approach to the problem, we wish to maintain the quality of emergency work and to perform it more efficiently.

As explained above, in the emergency work field, expectations of technology development which can improve work efficiency and maintain work quality are rising.

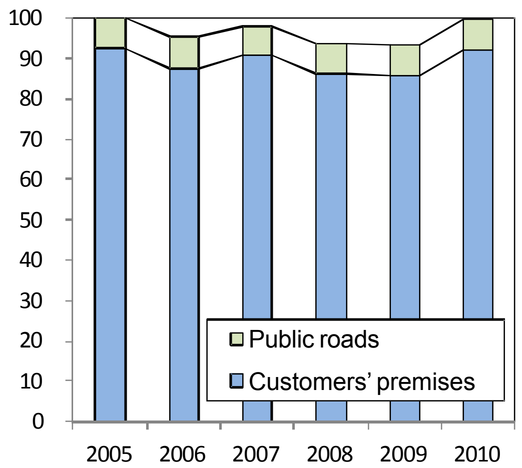


Figure 3. Changing Numbers of Leak Repairs in Recent Years
(When 2005 is considered to equal 100)

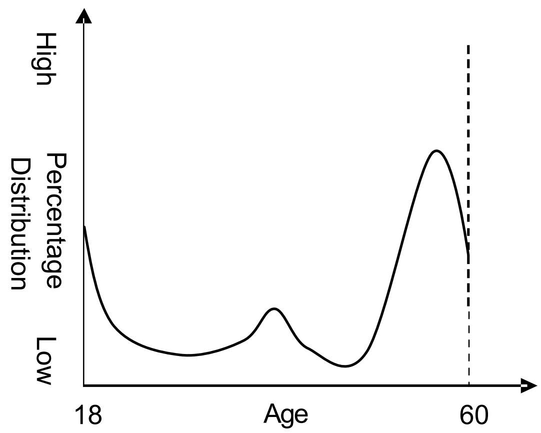


Figure 4. Ages of Personnel
(As a recent model)

2. Aims

In light of the above background circumstances, this paper focusses on leaks on customer premises, which account for a large percentage of all leaks, and on repair methods, to analyse trends in emergency leak repair works. And it also considers the present state and future prospects of the development of technologies to perform emergency work more efficiently or to maintain the quality of the work.

3. Methods

3.1 Trends in leaks on customer premises

In order to clarify points which must be noted in order to perform emergency work more efficiently, records of customer premise leaks from 2005 to 2010 were aggregated by type of equipment using a database of leakage report cases to analyse leak trends.

3.2 Form of and repair of leaks

The present state of and problems related to the forms of leaks by type of equipment and restoration methods for customer premises are analysed. The lining (interior repair) method which we now apply to leaks requiring complex repairs is briefly described.

3.3 Development of technology to repair leaks

Recent development of the lining interior repair method as one effort to deal with the challenge of the leak repair work in the preceding paragraph is described.

3.4 Future technology development

The question of what kinds of technology should be developed in order to achieve future efficiency improvements and maintain quality is considered.

4. Results

4.1 Trends in leaks on customer premises

To clarify trends in leaks on customer premises, Figure 5 shows changes in the percentages of leakage type of equipment among leaks on customer premises from 2005 to 2010. And Figure 6 shows percentages of leaks on customer premises in 2010 by type of equipment as numerical values. The leaks on customer premises considered here are all low pressure leaks (0.1MPa or lower), and almost all are leaks in residential systems. These figures reveal trends during these years: no change in the percentages of leaks by equipment, with about 60% occurring in valves, about 35% in pipes, and about 5% in other types of equipment. Therefore, to consider the repair of leaks on customer premises, the study focused on leaks in valves and pipes, which leak most frequently.

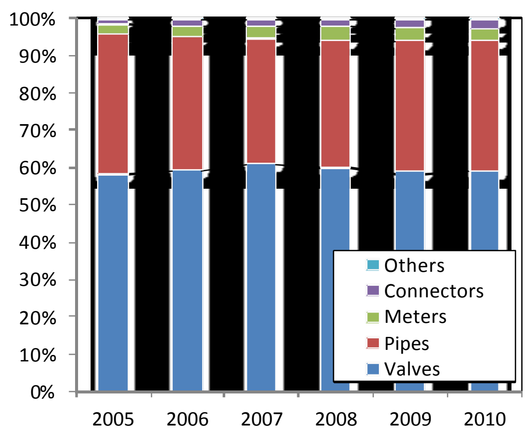


Figure 5. Changing Percentages of Leaks by Category of Equipment

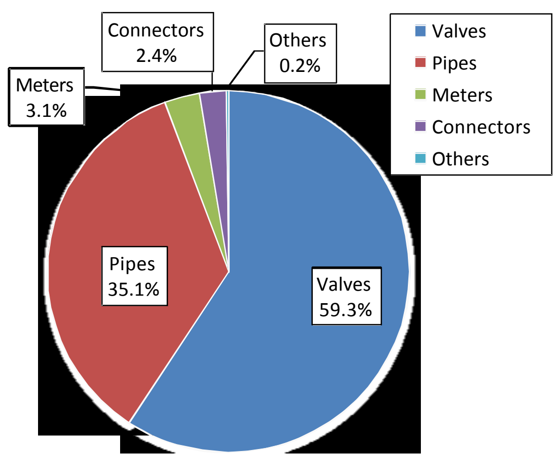


Figure 6. Percentages of Leaks by Category of Equipment (total for 2010)

(total for the years 2005 to 2010)

4.2 Forms of leaks and their repair

The following are the forms of leaks and repair method for each type of equipment. To hypothesize the operation or maintenance of leaks of valves which account for about 60% of leaks on customer premises, and of meters, connectors and other parts other than pipes, which are about 5% of these leaks, the leak can often be confirmed visually. Also, these are caused by looseness of connectors, or extremely small gaps in moving parts, so leaks are generally small, at only a few cc/min. In the case of valves for example, it is, of course, possible to visually examine them to permit operation, and these can often be repaired simply by performing greasing. So they are repaired quickly and easily with few problems related to work efficiency.

Leaks in gas pipes, which account for the remaining 35% of leaks, are usually caused by pipe body corrosion resulting from deterioration of galvanized gas pipes over years, and in some cases, the leaking quantity is high. If the location of these leaks can be checked visually, in most cases, the leaks can be repaired by wrapping the location in tape, which is a repair method that can be completed quickly. But at hidden parts on pipes on customer premises where the location of a leak cannot be specified (places which cannot be seen), it is necessary to excavate under concrete or break a wall, so this repair is particularly time-consuming and work efficiency is lowered. Or when an inspection shows that work space cannot be obtained, preventing repair work, it is necessary to ensure safety to prevent a more serious accident, requiring that the customer's supply of gas be cut off, which is inconvenient for customers and lowers their confidence in gas. In addition, in such cases, considerable experience (skill) is necessary to quickly specify and reliably repair the leak, which is one reason why strengthening personnel development is viewed as a priority. (See Table 1)

Table 1 Difference Between Repair Works

Leak Environment	Leakage Level	Repair Works	Required Time	Difficulty
Exposed (Valves, Meters, Others)	Low	Greasing Taping Renewal	Short	Easy
Underground (Pipes, Pipe-Joints)	High	Excavation Breaking Taping Renewal	Long	Difficult

The interior repair method has been established as a method of performing the emergency repair of such time-consuming locations or of locations not normally repairable to ensure safety and to quickly restore the supply of gas. The interior repair method now used is a lining method executed by creating an air flow with a blower to force liquid epoxy resin through the pipe to repair the leak by applying a resin membrane as shown in Figure 7 and Figure 8.

This method can ensure a specified quality by execution for a specified time, because if the range of the leak can be narrowed to a certain degree of pipe system and resin appropriate to this can be selected, it is possible to perform leak repair work by the same execution procedure regardless of the environment at the repair location.

If this lining method is used, there is no need to consider problems such as specifying leak point, excavation, or wall demolition mentioned above, so it is used mainly to repair pipes at hidden locations. During the more than 20 years since the beginning in about 1990 of the brisk development of this kind of method, it has been used very effectively at hidden locations. Although it is a method used for a long time and whose effectiveness has been proven, a number of problems with the method remain unresolved as explained in the following paragraph.

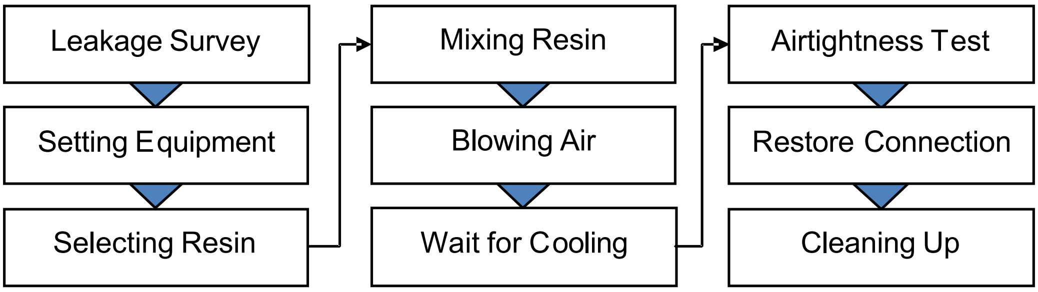


Figure 7. Interior Repair Method Procedure

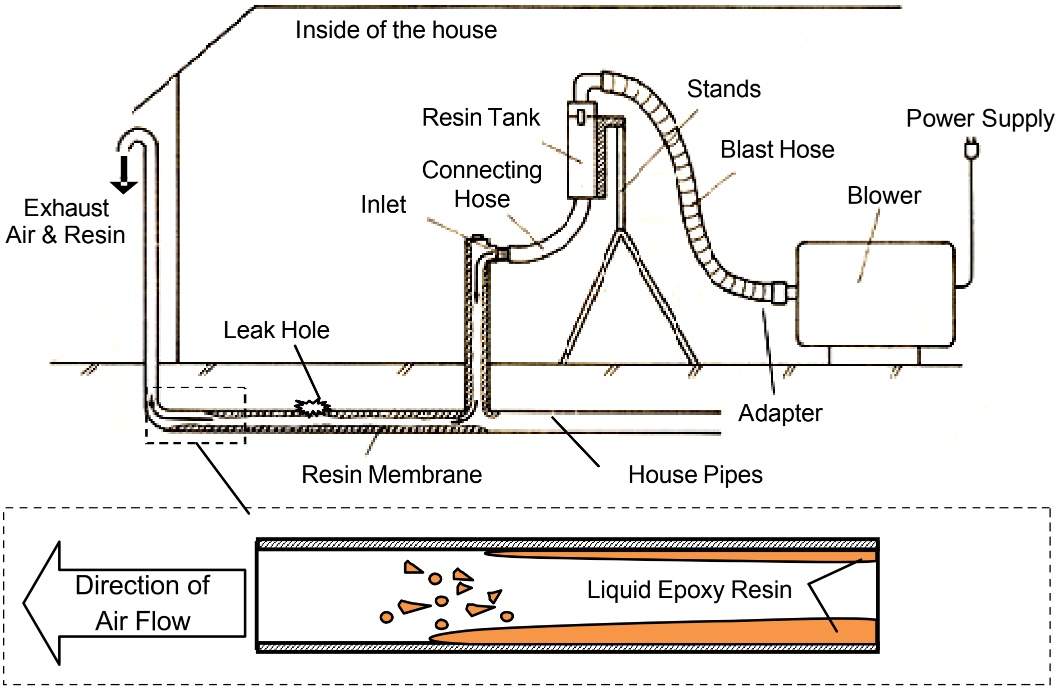


Figure 8. Airflow-Lining Interior Repair Method

4.3 Development of leak repair technologies

The interior repair method is useful under specified conditions, but it is executed using a variety of types of resin according to the environment (exposed or buried?) and the temperature (winter or other season?) at the location of the leak. Its use has also been restricted in many other ways, for example, by the fact that resin emits an extremely strong odour and the range (diameter, length) of its use is narrow. These conditions are satisfied by less than 1/3 of all pipe repairs, so it has only been applied in limited cases. In contrast, workers who desire greater efficiency, demand the development of further improvements.

In response to this need, we developed the ES (Emergency Seal) method shown in Table 2 and Figure 9 in 2012, and have begun to introduce it following several hundred field tests. The basic principle of this method is, as shown in Figure 10, blocking leak holes by forming a lining membrane in the pipe using epoxy resin injected by an air flow just as with the existing lining method. But the epoxy resin used is varied, sharply improving the method so it can be applied more easily. For example, at places where resins were selectively used according to the environment (exposed or buried) in the past, the same resin can be used to repair leaks under any environment as shown in Figure 11 and Figure 12. And because low odour resin constituents are adopted considering the odour, the unpleasant impact on customers is mitigated. The execution range is expanded, permitting its use to repair almost all ordinary leaks on customer premises. In this way, the method which was developed is intended to make it easier to execute, mitigate bad odours, and expand its applicable range (See Table 3). In addition, because its basic principles are identical to those of the existing method, it can be executed using past skills, materials and manual, simplifying its introduction, relocation and diffusion.

This development is counted on to permit the use of the interior repair method in many situations in the future, cutting the repair work time from the formerly long required time, and providing improved work quality.

Table 2 Specifications of ES method

Name of Method		Emergency Seal Method
Type of Pipes		Galvanized White Gas Pipes
Type of Resin		Two component, thermosetting epoxy resin
Nominal Diameter		15 – 50 mm
Span of Execution		Max 30 m
Repairable Leak Hole	Exposed	Max. φ0.8mm
	Underground	Max. φ10mm

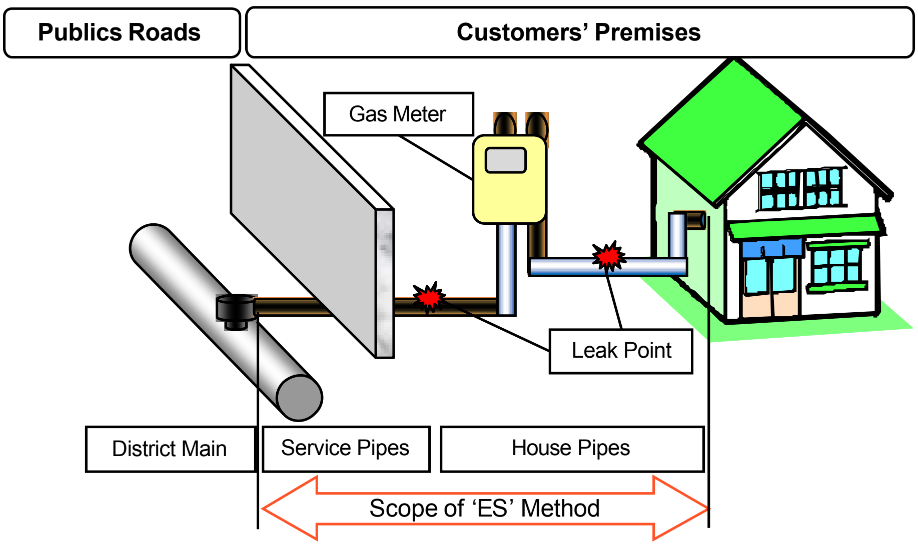


Figure 9 Scope of ES Method

Resin of ES Method

Test conditions

Pipe: ϕ 20mm Clear PVC pipe
Length: 20 meters
Temperature: 5 ° centigrade
Ventilator: 1
Amount of Resin: 1,000g

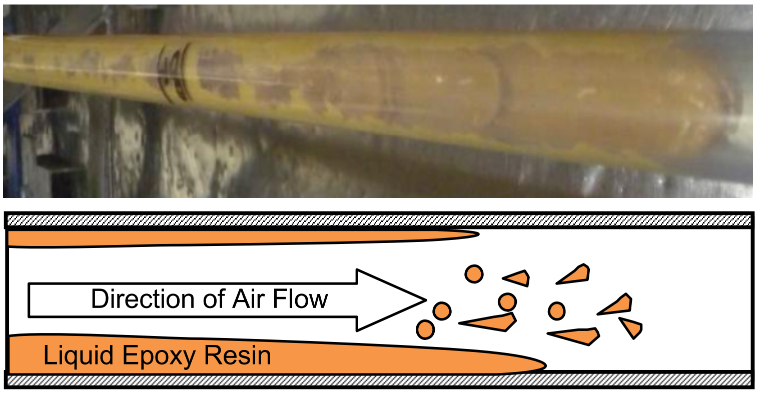


Figure 10. Photo of Experimentation

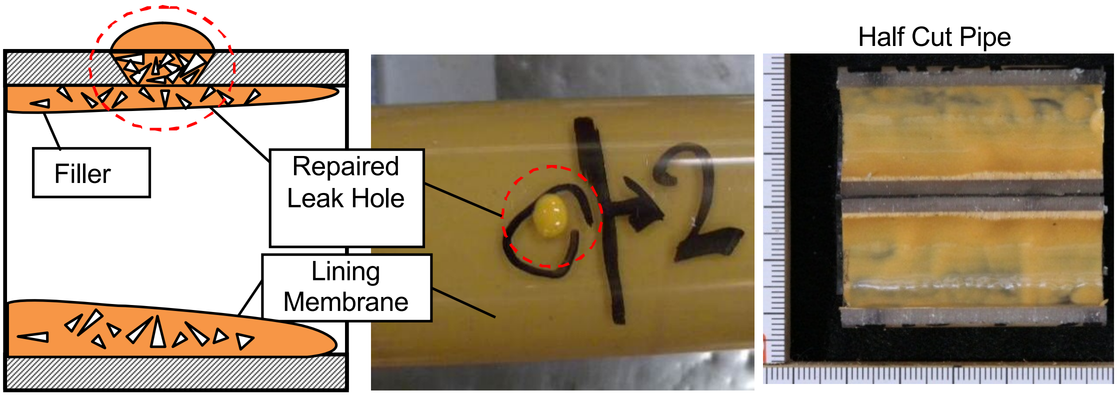


Figure 11. Exposed Pipe Repair Method Model (Left), Photo (Right)

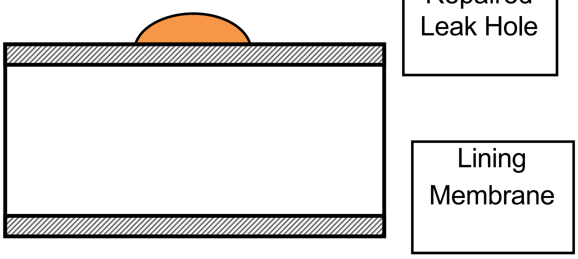


Figure 12. Underground Pipe Repair Method Model (Left) Photo (Right)

Table 3 Comparison Between Repair Methods

Item	Former Lining Method	Emergency Seal
Temperature	Resin must be selected: Winter or Others	One type of resin usable for every cases
Environment	Resin must be selected: Exposed or Underground	One type of resin usable for every cases
Nominal Diameter	Exposed : 15 ~ 32 mm Underground : 15 ~ 50 mm	15 ~ 50mm(Without distinction of exposed or underground)
Resin Odour	Very High (Underground)	Low
Execution	Hard and Difficult to mix	Soft and Easy to mix

4.4 Future technology development

Technologies to improve the efficiency and to maintain the quality of leak repair work are developed to achieve the following three goals.

One is longer durability of the interior repair method (lining method) explained above. The top priority of the present lining method used to repair leaks is to quickly stop leaking, so it was not expected to provide long-term durability of several decades after repair work, and in some cases, a second deployment is necessary. Future improvement of the durability of the resin used by this method, which is now an emergency repair method, is counted on to reduce worry about redeployments to deal with a leak recurring, further improving work efficiency.

The second is the further expansion of its application range. The present lining method is applied only to old galvanized gas pipes, and its application to flexible pipes or other gas pipes with sharply different materials or structure is not anticipated. Many kinds of lining-use resin materials such as epoxy resin are used, so it is impossible to describe them all. In contrast, as one type of research on resins, we have started to research the behaviour of liquid epoxy resin applying CAE as shown in Figure 13, and we aim to use liquid resin more widely in the future.

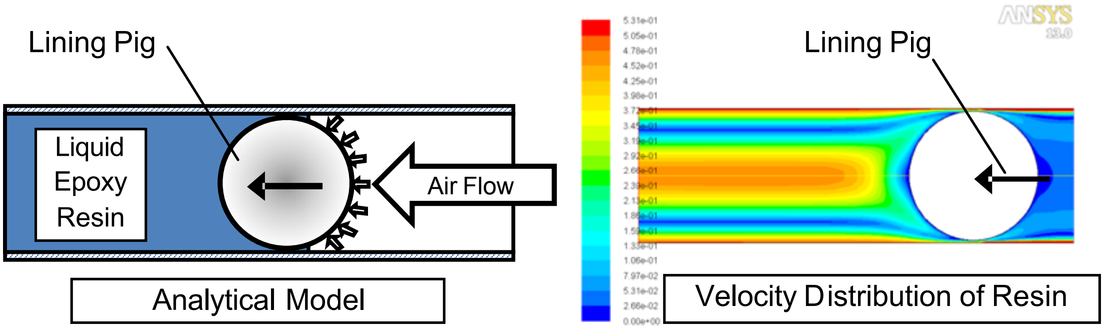


Figure 13. Research on Behaviour of Liquid Resin

The third is the development of technology to improve overall efficiency of emergency work. This paper has discussed the repair of leaks, the lining method (interior repair) in particular, but as shown by the chart of the time spent performing standard pipe body repair work in figure 14, leakage survey accounts for a great deal of the time spent performing actual emergency work. And reducing the time required for this step in the work depends to a great deal on the skill of each worker. There is a strong demand to specify the locations of leaks more efficiently and more quickly. As a technology development theme, it requires the ability to respond under all possible circumstances, so hurdles to its achievement are extremely high, but the benefits gained through success are also extremely great.

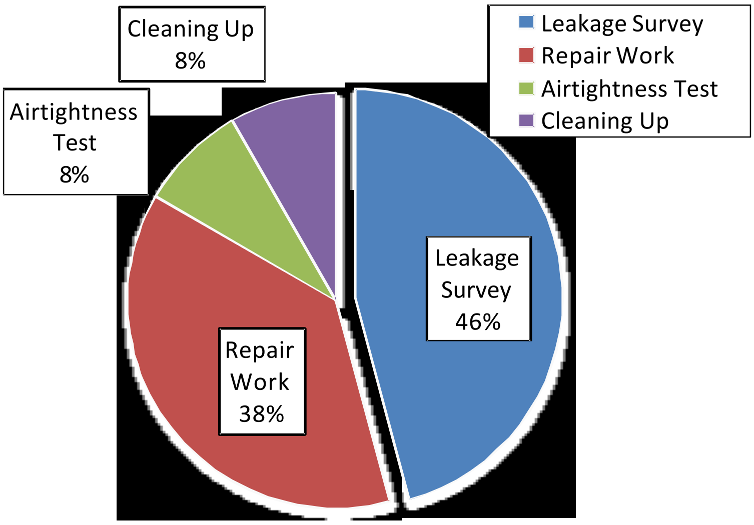


Figure 14. Allocation of time in Repair Work

5. Summary

Leak repair service work on customer premises, which is part of emergency work by Tokyo Gas, is an important work and service, and also imposes a heavy load. There are no prospects of soon improving the situation concerning leaks on customer premises, so it is predicted that the load of this work will continue to be heavy in the future. In addition, as the number of veterans has fallen in recent years, the number of newcomers has climbed. Our policy is to strengthen personal development in order to prevent a fall of the skill level caused by this change in the age distribution of personnel.

Under these circumstances, we have considered the development of technologies needed to more reliably ensure customers' satisfaction. The following are the conclusions of this paper.

(1) In the emergency work field, we expect to improve work efficiency and maintain work quality by technological development.

(2) Recent trends in leaks on customer premises show little fluctuation, with about 60% occurring on valves, about 35% on gas pipes, and about 5% occurring on other parts.

(3) One method of increasing efficiency is the use of the interior lining method which permits the repair of hidden parts of pipelines; a time-consuming type of work.

(4) As a consequence of the many restrictions on the use of the conventional interior repair method, it has been improved to use liquid epoxy resin, establishing a new method (ES method), allowing the lining method to be executed more efficiently and extensively.

(5) In order that emergency work is performed more efficiently and more reliably in the future, three approaches to technology development will be considered.

・Improvements of durability of the resin used by interior lining repair method

・Searching for new uses through research on liquid resins

・Shortening the time required to specify the locations of leaks

References

*1 The Gas Industry in Japan, 2011.4.1, Japan Gas Association