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DEVELOPMENT OF THE "ADVANCED LIVE JOINT SEAL CONSTRUCTION METHOD"

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ABSTRUCT

This paper details the “Advanced Live Joint Seal Construction Method” which has been developed to prevent leaks from old-model joints (in which yarn is used as a sealing material), in ductile cast iron gas pipelines.

This construction method aims to increase the air-tightness of the joint by sealant, under the condition of trenchless and live pipe. At the location of the joint, acrylic emulsion-based sealant is pressurized and injected from a special jig called a “packer” which has been inserted into the pipeline. The sealant is infiltrated into the yarn inside the joint, and intensifies seal performance of it.

In the development work, we contrived some ideas for advancement of this construction method. The “sponge seal cover” obtains the optimum adhesion to the contact between the inner surface of pipe and the surface of packer. The “three holes drilling” enables to extend the maximum length of construction per pit. A clamp reinforces the strength of the pipe with the “three holes drilling”. A CCD camera mounted to the packer body ensures safety and quality of work execution.

This construction method was applied to actual work execution on sites in July 2009, and four devices are deployed at present. The total length of the application of this method In Osaka Gas is 12km as of March 2011.

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1. INTRODUCTION

In ductile cast iron gas pipelines, gas leaks sometimes occur from the old-model joints (bell-and-spigot joint) in which yarn is used as a sealing material. The yarn drying up is one of the factors of leak. A conventional construction method to prevent this leak is the "Outer Face Sealing Construction Method," by which a sealant is applied to the outer surface at a joint. However, this construction method required an excavation for a joint, resulting in the costs equivalent to that for replacing the pipes; as a result, a construction method that would be less expensive and more effective in preventing leaks was desired.

To solve this problem, the "Live Joint Seal Construction Method" was developed by Osaka Bousui Construction Co., Ltd., Toho Gas Co., Ltd., and Osaka Gas Co., Ltd. in 1992. And following the basic specification of this construction method, Osaka Gas Co., Ltd recently made various improvements and added new functions to this method to allow a leak prevention effect to be clearly displayed.

2. OVERVIEW OF THE CONSTRUCTION METHOD

This construction method is put into practice as follows. As shown in Fig 1, a special jig that is both expandable and contractible (hereinafter referred to as a "packer") is inserted into a gas pipe, and as the packer is expanded at the location of the joint (where a round gap is observed, referring to Fig 5) to be worked on, the sealant is pressurized and injected to be infiltrated into the yarn inside the joint. This increases the air-tightness of the joint, preventing leaks for a long period of time. Fig 2 shows the overall construction of the device.

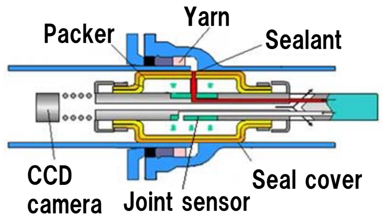

Fig 1: How the sealant is injected

The packer is connected to a composite tube covered with high density polyethylene, and the packer can be moved freely by pushing and pulling this tube by the pusher. The pushing force has a maximum value of 100 kg. The location of the joint can be detected by the joint sensor inside the packer. To expand the packer, gas in the pipeline is used. The gas is taken into the drive unit and pressurized by the pump to allow the packer to expand. A spindle of the packer is hollow and gas is allowed to flow even when the packer is inflated; this allows the work to be executed without interrupting a flow of gas. The packer shrinks when the vacuum pump is driven. In this process, the gas drawn from the packer is returned into the pipeline.

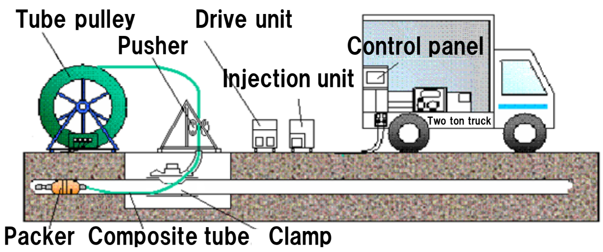

Fig 2: Overall construction of the device

The sealant stores in the tank attached to the injection unit. And it feed into the packer by a gear pump (driven by a servo motor). Quantity of sealant and injection time is previously fixed according to the dimension of pipe. These operations are carried out in a series on the control panel by an operator.

3. SCOPE

The scope of this construction method is the following

Pressure: Low pressure (up to 3.0kPa)
Dimension of pipe: 100A, 150A and 200A (as of July 2011)
Kind of pipe: Ductile cast iron pipes
Construction length: 100m max (on one side of a pit)
Allowable number of bends: up to 4 bends (45˚ or less)

4. IMPORTANT POINTS IN THE DEVELOPMENT WORK

(1) Solution to sediments in the pipe

For the sealant to be effective in preventing leaks, it must be injected onto the entire circumference of a joint securely. The important point in achieving the secure injection is the adhesion of the contact between the inner surface of pipe and the surface of packer. Sediments of foreign bodies such as sand and chippings in the pipeline reduce the adhesion on the contact surfaces at the bottom of the pipe, allowing a large amount of sealant to flow from the gap between the contact surfaces. This does not allow the injection pressure to rise, preventing the sealant from sufficiently infiltrating inside the joint.

On the other hand, too much adhesion between the contact surfaces causes the gas pressure inside the joint to rise concurrently with the injection of the sealant, and the subsequent balance between the sealant injection pressure and the gas pressure causes the "trapped gas" to appear at the top of the pipe as shown in Fig 3, preventing the sealant from infiltrating. Consequently, when the execution of a work in the pipeline with sediments is assumed, two conflicting functions must be provided: it is necessary to increase the adhesion between the contact surfaces at the pipe bottom to prevent the sealant from flowing out, while the adhesion between the contact surfaces at the upper side of the pipe should be lowered to secure the path for the gas pressure to escape.

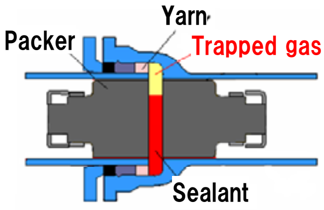

Fig 3: Trapped gas

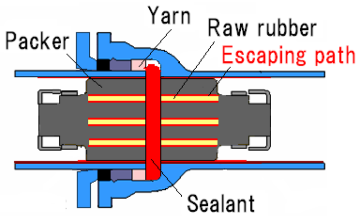

Fig 4: Escaping paths

As a means of solving this problem, we noted the seal cover to be mounted on the packer. To be more specific, a spongy material with good adhesive performance (3 – 5 mm thick) is used as the seal cover, being formed into a cylindrical shape. Rectangular slices of raw rubber (1 mm thick) are also sewn at regular intervals on the circumference of the cylindrical object to secure slight gaps between the seal cover and the raw rubber edges as escaping paths for the gas pressure (as shown in Fig 4); this yields an optimum adhesion. Photo 1 is the sponge seal cover as mounted on the packer.


Photo1: Sponge seal cover

(2) Extension of the maximum length of construction

Extending the maximum length of construction per pit, it is possible not only to increase the length of construction per day but also to bring a great advantage in enabling flexible selection of the location of the pit in a planned section of the construction, according to the situation of the work site.

The insertion angle of the tube plays an important role for it. It is because minimizing the insertion angle of the tube to the gas pipe makes it possible to decrease the resistance to the tube at the insertion point. Consequently we can prevent the tube from being buckled and increase the hardness of the tube material. In this construction method, the drilling at the section where the packer was to be inserted was arranged so as to enable "three holes drilling," that is, long sideways drilling relative to the pipe axis direction, namely a range of three holes; this arrangement allowed the insertion angle to be set at 52.5˚ (compared to 70˚ in the conventional method). In addition, high density polyethylene was adopted as tube coating material to suppress the attenuation of the pushing force; this allowed the maximum length of construction to reach 100 m.

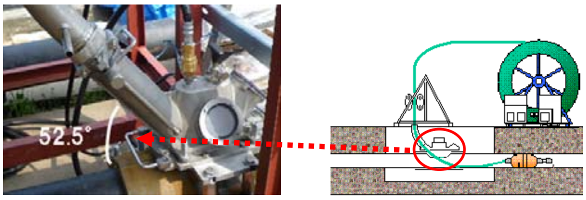

Fig 5: Tube insertion angle

(3) Clamp and temporary stopper

The reinforcing clamp installed in the drilling section was developed, with the aim of meeting the requirements of the "three holes drilling". A shutter plate is installed in the flange section of the clamp. In consideration of the operability in opening and closing a shutter, however, the flange is provided with an edge to decrease the deflection of the shutter plate; these are the features of the new clamp. When a drilled hole is plugged temporarily, a special temporary rubber stopper is used with a function to prevent the stopper from coming off because of gas pressure, and from falling


Photo 2: Clamp

into the pipe through the holes.

(4) Observation and record of work execution

It is possible that circumstances affecting the execution of work, such as sedimentation of foreign bodies, the location of branch stub, for instance service pipe and joints not on a plan, occur in the existing pipes. The surest way to grasp such condition of pipeline is to use images for confirmation. An intra-pipe camera can be inserted into the pipe before the work execution starts, but this method poses problems such as loss of work execution time and a shortening of the distance into which a camera can be inserted.

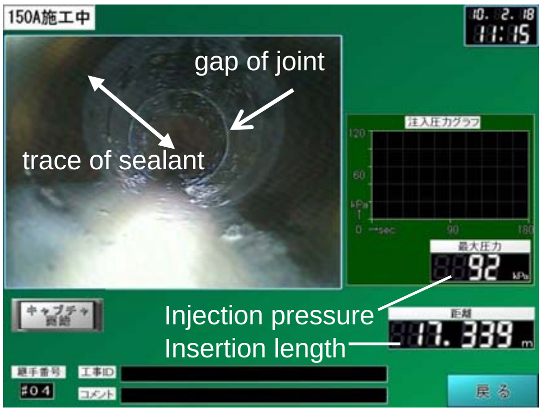

Fig 6: Image of work record

To deal with these problems, an underwater CCD camera was mounted to the packer body to obtain image outputs on the monitor of the control panel in this construction method. Since images can be stored in electronic files, images of joints after work execution can be retained as execution records.

(5) Sealant

An acrylic emulsion-based sealant is used. The water content in the sealant disappears due to natural evaporation, and the remaining sealing content inside the joint performs the sealing action. In the current development work, several acrylic emulsion-based sealants were selected, and from among them, the sealant that promised a sealing effect for the longest time was selected on the basis of a preliminary experiment. After this sealant was injected in the joints which had been gathered from construction site, a test of repeated bending equivalent to 40 years' use was conducted on them. The absence of leaks has been confirmed.

The test conditions are the following.
Deflection angle: 0.05°
Cycles: 3 – 5 cycles/s
Number of times of vibration: 1.9 million

5. TRACK RECORD

This construction method was applied to actual work execution on sites on a trial basis in July 2009. After making several improvements, two devices were deployed to introduce this construction method on a full scale from April 2010.

Table 1 shows the track record of the application of this method as of March 2011.

	150A	200A
Number of spans	184	38
Total length	10,570m	2,123m
Number of joints	1,808	374

Table 1: Track record of the work execution using this construction method (as of the end of March 2011)

The devices to be used with 300A pipes are under development, with the aim of introducing them in actual work execution from April 2012.

6. MANUFACTURERS

The manufacturers of this construction method are the following.
Devices: Osaka Bousui Construction Co., Ltd.
Clamp: Hitachi Metals, Ltd
Stopper: Nishiyama Corporation