Development of a leak-preventing cover for low-temperature flanges

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1. ABSTRACT

The flange joints of piping used in plant equipment have gaskets in them. Over long periods of use, the sealing performance of these gaskets decreases, resulting in the need for repairs such as replacing the gasket.

However, when it is difficult to stop the equipment, it is also difficult to perform a complete repair by replacing the gasket. A solution to this problem is even harder with the extremely low-temperature liquids found in LNG plants.

We have developed a leak-preventing cover that can be installed in the event of a leak of an extremely low temperature (approx. -160℃) fluid su ch as LNG (liquefied natural gas) without shutting off the flow of liquid or gas.

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2. BODY OF PAPER

2.1 Introduction

It has been 30 years since the first receiving facilities for the acquisition of liquefied natural gas (LNG) were built. These facilities have low-temperature systems for receiving, storing, and sending LNG to and from LNG tanks, and these systems have low-temperature valves and piping flange joints that often have seat gaskets. Over long periods of use, these seat gaskets are known to lose their sealing performance, and thus must be checked for leaks periodically. When a leak is found, the seat gasket must be replaced.

Equipment for handling LNG is operated under environments with extreme low temperatures (approx. -160℃), so even when a section of the equ ipment is purged for maintenance, it takes time to separate the section and to let it come to room temperature.

Thus when a seat gasket needs to be replaced, this can affect operations at these facilities significantly, and the situation sometimes cannot be addressed as quickly as possible in some cases.

It is for this reason that we started on the development of a leak-preventing cover that can be easily installed in the event of a leak while the equipment is in operation. Some progress has been made in this initiative, and it is described below.

2.2 Outline

2.2.1 Purpose of development

As a permanent repair, it must be able to completely seal the joint “seal area” of the low-temperature valves and piping flanges that are used at extremely low temperatures and high pressures.

2.2.2 What it is for

(1) For the bonnet flange joints of low-temperature valves

(2) For piping flange joints

⇒The bonnet flanges for low-temperature valves come in additional shapes such as squares and ovals depending on the model and opening size, but this project focused on regular round flanges as the initial target.

2.2.3 Conditions under which it is used

(1) Internal pressure

:It shall be able to completely seal pressures of 2.0 MPa

⇒The initial target specified compatibility with systems used to receive and send LNG to/from LNG tanks.

(2) Surface temperature

:It shall be possible to secure it in place under low-temperature conditions (approx. -100℃).

⇒Because of the need to install it under low-temperature conditions, it will have to be made of a material that can take sudden changes in temperature during installation.

2.3 Characteristics of the cover

2.3.1 Structure of the cover

This cover comprises a cover, packing fittings, and packing. (See Fig. 1)

The body of the cover had to be given a split structure so that it can be installed on round low-temperature valve bonnet flanges and piping flanges.

During the tests at the development stage, the sealing performance of this split surface became an issue, and a two-part split structure was adopted in order to minimize the number of split surfaces.

2.3.2 Cover material

The material requires safe and reliable mechanical characteristics under the chemical and physical effects that it is subjected to at the maximum and minimum service temperatures. Because of its use under extremely low-temperature conditions, an aluminum alloy was chosen.

This material has a large coefficient of linear expansion compared to the stainless steel that is used for low-temperature valves and piping flanges, allowing its large shrinkage in response to temperature changes to be utilized effectively to provide sealing performance.

Specifically, when this cover is installed on a low-temperature valve or a piping flange that is at an extremely low temperature (surface temperature: approx. -100℃), the temperature of the cover, which is initially at room temperature, will gradually decrease, causing it to tighten against the joint of the low-temperature valve or piping flange with a “self effect” that resulted in better sealing than when a stainless steel cover is used.

Also, it is 30% lighter than an equivalent stainless steel cover, making it easier and safer to install on site, resulting in shortened installation time.

2.3.3 Structure of seal

The interface between the cover and the low-temperature valve or piping flange joint is built up with the square packing that is often used as gland packing in valves in order to utilize their elasticity in this seal assembly.

This seal assembly has a structure in which the square packing is pressed inward evenly across its entire surface using the force of the bolts. (See Fig. 2)

Because of this, even if the surface pressure of the packing decreases (i.e. it relaxes) over time, retightening the bolts allows the original surface pressure to be regained.

The degree of tightening can be quantitatively controlled (standardized) with the tightening torque of the bolts so that sealing performance can be maintained over long periods.

2.3.4 Seal packing

The seal packing comprises a stack of two types of Teflon packing with different hardnesses.

(See Photo 1)

One link of the harder packing is positioned so that it is in contact with the flange joint (at the center) to prevent the packing from consolidating and entering (deforming into) the gap between the flanges. Each side of the harder packing has layers of softer packing with excellent flexibility to achieve the required sealing performance.

2.3.5 Structure of nuts

It is possible to obtain the required sealing performance at the joints of low-temperature valves and piping flanges using this cover. However, bolts and nuts are used to fasten together the bonnet flanges of low-temperature valves and piping flanges, and the threads of these bolts and nuts, as well as the seats of these nuts have mechanical tolerances (gaps), necessitating the use of a seal assembly.

Because of this, the existing hex nuts were replaced with cap nuts during installation; these nuts have a gasket added to the nut seat in order to obtain reliable sealing performance. (See Photo 2)

2.4 Effects of development

(1) Improved safety level

Preventing leaks and a fast response to the initial stages of leaks is now possible for an increased safety level.

(2) Implementation in other plants

The basic structure of this newly developed cover is that it can also be used on piping flanges, allowing it to be used just in plants with needs related to extremely low temperatures and high pressure, but in a wide variety of plants such as those handling dangerous materials.

(3) Reduced costs

Because the cover can be installed while the equipment is running, it does not affect the operation of the plant and does not require the fluids inside the pipes to be purged, resulting in cost savings.

2.5 Current issues

The 2.0 MPa specification cover (300LB-6B) has excellent sealing performance and ease of installation at low temperatures, and is currently being used in actual plants. (Patent obtained in April 2009)

In order to increase the pressure, the 5.0MPa specification cover (600LB-4B) is our next target, and this cover is currently being field-tested. In addition, a low-pressure large-opening specification cover (150LB-28B) under development is currently undergoing laboratory tests.

2.6 Conclusion

The technology developed in this initiative allows pre-emptive measures to be taken on seat gaskets for which deterioration due to age is a concern, resulting in improved safety.

This initiative was a joint R&D initiative with Hirata Valve Industry Co., Ltd.

3. LIST TABLES

Table 1 **Installation procedure**
(It is desirable to reduce the pressure as much as possible)

(1) Replacing the bolts and nuts on the flange	(2) Installing the cover
	
(1) Remove the bolts and nuts one by one (2) Confirm the surface condition of the seats of the nuts (Repair any scratches) (3) Attach the cap nuts to the prescribed torque.	(1) Install the two-part split cover in the proper location (2) Insert the packing (3) Tighten the bolts on the packing fittings to the prescribed torque (After the assembly has stabilized at its low-temperature condition, recheck the torque)

4. LIST OFF FIGURES

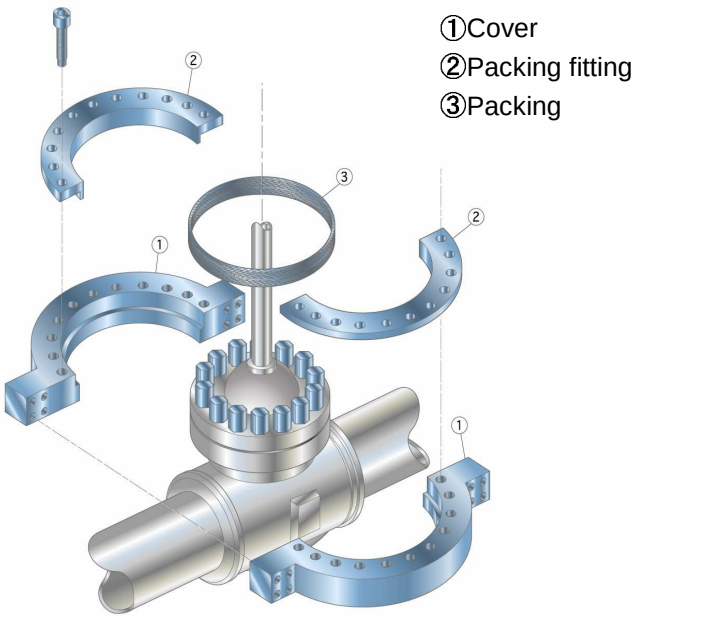

Fig. 1: Drawing of cover

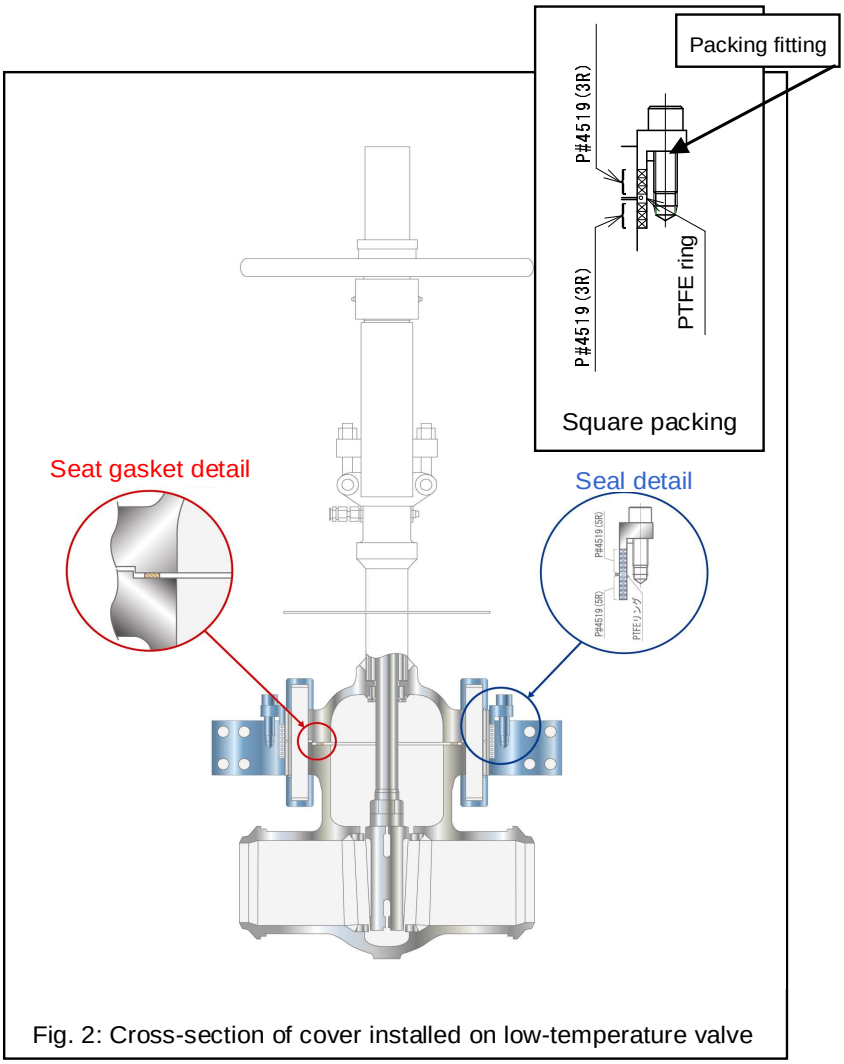

Fig. 2: Cross-section of cover installed on low-temperature valve

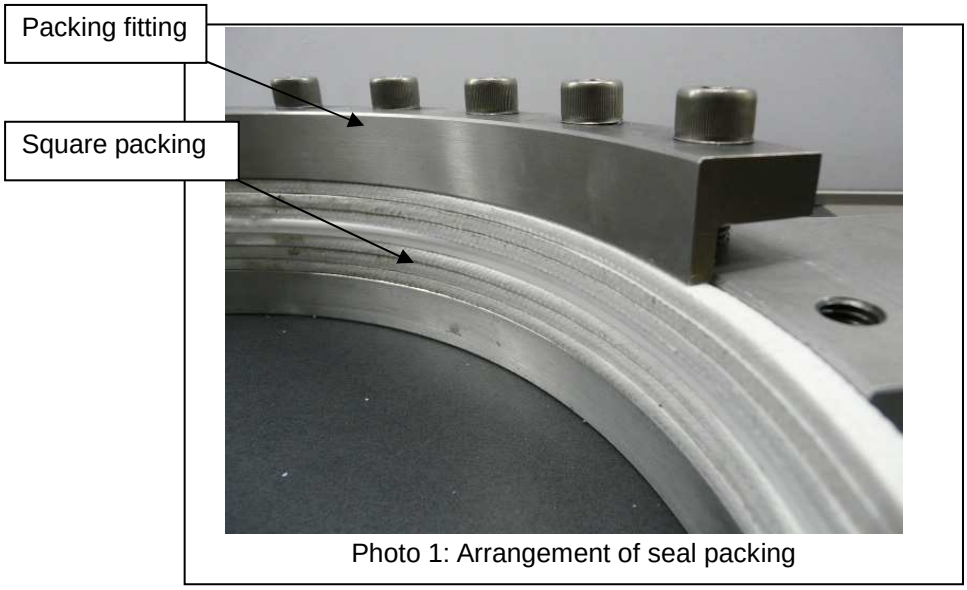

Photo 1: Arrangement of seal packing

Photo 2: Cap nut (gasket on seats)