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【Customer Solutions Special】

Greetings

Thank you for your continuing interest in our magazine.

Amid the rapidly changing global environment, 2017 marks the final year of the Valqua Group's 7th medium-term management plan, NV・S7. We also reached a major milestone toward the 8th medium-term management plan. Under our corporate philosophy The Valqua Way, we offer "H & S" (H [hardware = products] " and "S [sealing-engineering service]) " in order to maximize customer value and satisfaction. We are also laying the foundation for our growth to prepare for the coming 100th anniversary year through creative ideas, nimble action, and enhanced global risk management.

Valqua Technology News, our technical journal, celebrates its 60th anniversary year since the first issue of Valqua Review in 1957. This issue is the 33rd since *Valqua Review* was rejuvenated and became *VALQUA Technology News* in 2001.

Like the 31st and 32nd issues, this issue examines how we solve problems for customers. Especially, this issue features solution services to prevent troubles caused by corrosion and leaking from the perspective of "security and safety".

Regarding gaskets, we introduce case examples of problems and countermeasures against them, and as for elastomer sealing, this issue introduces our sealant-selection service "Seal Quick Searcher™ - Elastomer Ver." We also provide an introduction of Seal Training Center (STC) , which offers on-the-job training for sealing work.

The contents of this issue consist of our technical knowledge and evaluation & analysis results, which we have accumulated over the decades. We believe they are quite useful information for you to take countermeasures in order to prevent problems.

Valqua will continue to develop new products, unique technologies, and new services to meet your needs, and hope this issue provides useful information for understanding our technology development efforts. We appreciate our valued customers for their continued support of our products and services, and look forward to continuing to serve you.

Senior Excutive Officer Director of Corporate Research and Development Group **Mutsuo Aoki**

Unsuitable Usage Conditions of Gaskets and Countermeasures

1. Introduction

The term "gasket corrosion resistance" means the ability of a gasket to resist corrosive fluids including acidic and alkaline fluids. It also sometimes refers to countermeasures for events that could occur with given fluids. To address such events, not only seal materials themselves, but also proper selection and application of seal materials are important. This report introduces examples of such events and countermeasures.

2. Examples of Troubles and Countermeasures

2-1) Blooming phenomenon of resin-type gaskets caused by polymerizable monomers

The phenomenon of blooming occasionally occurs in the fluororesin jacketed gasket: No. N 7030 series and the filler-added fluororesin gaskets: No. 7020, No. 7026, and No. GF300 series. Chemical reaction between the constituent materials and fluid is not considered to cause this phenomenon. In addition, the results of analyzing affected gaskets, which revealed the involvement of a material not contained in the gaskets, and the morphology of affected gaskets, suggest that the phenomenon might be caused through the following mechanism: monomeric fluid permeates the inside of a gasket; the permeating fluid causes polymerization inside the gasket; the polymerization results in volume expansion; and the expansion causes the gasket to break.

Figure1　Blooming phenomena of a resin-type gasket

To address these problems, it is recommended to change to a spiral wound gasket (No. 7596V), which does not break when fluid permeates and polymerizes, and to use gaskets made of PTFE only which are less likely to cause permeation. Also, inadequate tightening is possible o cause permeation, so proper tightening can be a countermeasure in some cases.

2-2) Chemical degradation of a core joint sheet caused by permeation of strong acids into the PTFE jacket of the N 7030 series

Because of PTFE jackets, PTFE jacket gaskets are superior in chemical resistance to joint sheets. However, PTFE could permeate some chemicals when a PTFE jacket gasket is used for a long period. The PTFE may occasionally allow fluid, especially hydrochloride, to permeate the gasket's core and affect the core. If that happens, the following events may occur: fluids accumulate into the inside of the PTFE jacket and the inner core; traces of permeation including discoloration are observed; and fluid contents are detected by analyzing the inside of the core. As countermeasures, it is recommended to increase the thickness of the PTFE jacket and to change the gasket material (for example, to use the PTFE blended gasket No. MF300 and the spiral wound gasket containing PTFE filler) .

2-3) Decomposition of expanded graphite caused by oxidation using the gasket above the recommended temperature

As a seal material, expanded graphite has ideal properties including excellent chemical resistance and low creep relaxation, but when the temperature is 450°C or higher, its oxidation reaction with oxygen in the air usually causes gasification, which transforms the content into carbon monoxide, carbon dioxide, etc., resulting in fade-out. Therefore, recommended ranges of temperature are maximum 400°C for the graphite sheet gaskets: No. VF-30 and No. VF-35E, which are comprised of carbon only and are significantly affected by temperature, and maximum 450°C even for the spiral wound gasket containing expanded graphite filler of the No. 6590 series because of the structural advantage. When those gaskets are used at temperatures above the recommended range, leakage occurs due to loss of the constituent material in a relatively short time. In the case of spiral wound gaskets, placing non-asbestos filler or mica filler along the inner and outer periphery blocks oxygen contact, inhibits oxidation decomposition, and maintains sealing functions at 450°C or higher. Although non-asbestos filler loses organic constituents at high temperatures, usually, inorganic constituents will not change. Therefore, during non-asbestos filler remains within hoops, it prevent expanded graphite from oxidation because of oxygen shielding effects.

Figure2 Oxidation loss of expanded graphite from a spiral wound gasket

2-4) Leakage of heat transfer oil through gasket

Oils and fats used as heat media are generally designed to have a low viscosity so as to flow smoothly and efficiently. It means they are easy to permeate into gaskets. In general, expanded graphite itself shows lower coefficient of thermal expansion and thermal stability, and could be highly suitable material for seal. However, expanded graphite shows relatively poor resistance in permeation and sometimes it results in leakage through the sheet gaskets.

In general, permeation through materials could be decreased with increasing density by compression, so it could be a countermeasure to generate tightening load to suitable for sealing. For trustworthy sealing, changing to spiral wound gaskets containing expanded graphite filler such as the No. 6590 series is recommended.

2-5) Chemical degradation of a joint sheet gasket in applying to solvent (acid/alkaline) process line

When a gasket is used for a fluid for which it does not have enough resistance, the resulting fade-out or dissolution of some constituent materials make the gasket more fragile and softer, leading to reduce tightening stress and other phenomena. These events can readily be determined by analyzing used products. In these problems, it is especially dangerous that a gasket breaks so markedly that it does not keep its original shape.

As a countermeasure, it is recommended to change to gaskets, such as No. UF300, which have more resistant to fluid.

2-6) Erosion of soft gaskets caused by slurry fluid

When a gasket looks severely broken in appearance but has no tightening problems, and an analysis of a used product shows no chemical deterioration caused by fluid and heat, even if it is very rare case, physical fracture by erosion from fast-moving powder crashing against the gasket could be considered. Although the fluid's properties and the channel's design influence the erosion, erosion usually occurs in slurry fluids which contain fine particles.

As a countermeasure, it is effective to place constituent materials that have adequate resistance against erosion inner side of gasket such as spiral wound gasket with inner ring or sheet gasket with grommet.

Figure3　Erosion of a soft gasket

3. Conclusion

We introduced a part of cases of gasket corrosion troubles and countermeasures. We hope this report will help you to select and determine seal products to solve leakage problems and achieve the required sealing.

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Evaluation of Basic Sealing Properties of the Pipe Flange Connection with Metallic Flat Gasket

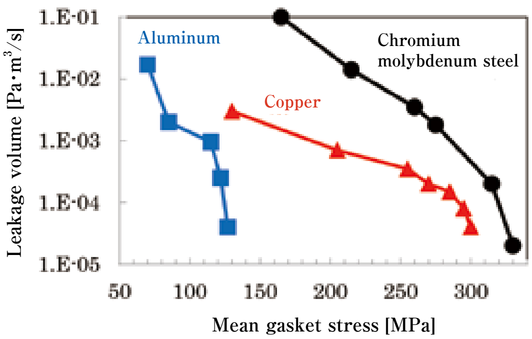
1. Introduction

It is known that the metallic gaskets such as metal flat gaskets and ring joint gaskets are widely used within the flange connection under high temperature and high internal pressure conditions in petroleum refining, petrochemical, and power plants. However, the some leakage accidents occur in the connections. The main reasons of those are considered that the mechanical characteristics and tightening method of the gasketed connection have not been clarified. Many previous studies for soft gasket such as the compressed fiber sheet gaskets, PTFE gaskets, and spiral wound gaskets have been performed in American Society of Mechanical Engineers (ASME), High Pressure Institute of Japan (HPI), universities, and manufacturers. However, there have been few studies on a flanged connection with the metallic gasket, so their behaviors remain unknown[1), 2)].

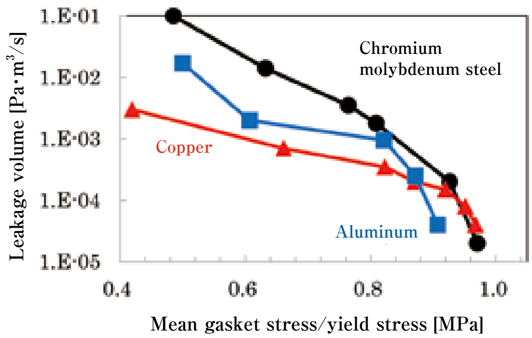
Kondo et al. reported the plastic strain on the gasket face made the sealing performance in metallic flat gasket improved[3)-7)].

The relationship between the leak rate of metallic flat gaskets made by chromium-molybdenum-steel, copper and aluminum and the mean contact gasket stress were shown in Figure1 (a). It was found the sealing performances were improved as Young's modulus and surface hardness of material decrease. In addition, when the ratio of mean contact gasket stress for the yield stress was related with leak rate, the leak rate decreased exponentially at the value of ratio is near 1.0 as shown in Figure1 (b). Those data indicated that the sealing performance of metallic gasket was influenced so much by the yield stress. However, most of prior studies have been discussed around the leakage of 1×10^{-4} Pa·m^3/s level due to the limitations of the measuring functions of evaluation equipment.

The objective of this paper is to discuss the leak rate of $1\times10^{-4}\sim10^{-7}$ Pa·m^3/s for metallic gaskets. The sealing performance of the gaskets under compression was measured for two types of gasket materials (aluminum and copper) and three types of gasket width using platen by the experiments and the FEM calculations. In addition, the mechanical characteristics of pipe flange connection with metallic gasket were evaluated using the ASME/ANSI class 300 2-inch flange.



(a) The relationship between leak rate and mean contact gasket stress



(b) The relationship between the leak rate and the ration of the mean contact gasket stress for yield stress

Figure1 The sealing performance of metallic flat gaskets

2. Experimental Method

Figure2 showed the experimental setup of platen device in which metallic flat gasket was compressed for measuring an amount of leakage. The experimental setup was consisted of the compression tester (AUTO GRAPH 500KND; made by Shimadzu Corporation) consisted of the platen made of SUS304, a helium gas cylinder, a pressure gauge, a flow meter for amount of leakage and the displacement gages. The device for measuring leak rate could be alternately switched functions between a soap-film flowmeter and helium leak detector (made by ULVAC). When the leak rate was 1×10^{-4} Pa·m^3/s or lower, the measurement was performed using the helium leak detector. The materials of flat metallic gasket were aluminum (A1050) and copper (C1020). The sizes of gasket were $\phi25\times\phi20$ (outside×inside diameter), $\phi30\times\phi20$, $\phi40\times\phi20$, $\phi65\times\phi$ 55mm, and the gasket thickness was chosen as 3.0mm. The helium gas was applied to 4MPa after the platen with gasket is compressed, and then, the leak rate and displacements of gasket were measured. In a test sequence of compression and recompression, the contact gasket stress was changed in the following stepwise: 0 → 180 → 0 MPa for aluminum, and 0 → 450 → 0 MPa for copper.

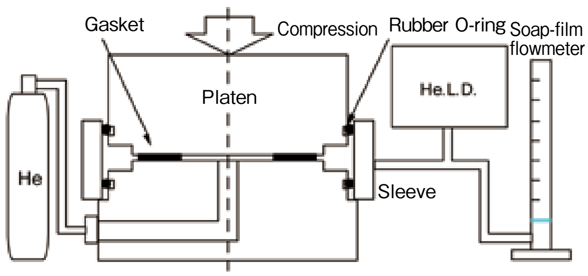


Figure2 Illustration of platen test equipment

3. FEM Calculations Method

The FEM calculations were performed for the platen test shown in section 2, using the numerical code ABAQUS. Figure3 showed the 3-D FE model of the platen test equipment with metallic flat gasket. Originally, an effective evaluation can be calculated with the axi-symmetric model, however, the 3-D model was employed to compare with one for the pipe flange connection. The gasket was modeled as elastoplastic element, and the Platens were modeled as elastic element. The platen was under compression, then the gasket stress, compression displacement and corresponding plastic strain were calculated. Here, the corresponding plastic strain is defined as:

$$\overline{\varepsilon^p} = \int\sqrt{\frac{2}{3}\left\{\left(d\varepsilon^p_{xx}\right)^2+\left(d\varepsilon^p_{yy}\right)^2+\left(d\varepsilon^p_{zz}\right)^2\right\}+\frac{1}{3}\left\{\left(d\gamma^p_{xy}\right)^2+\left(d\gamma^p_{yz}\right)^2+\left(d\gamma^p_{zx}\right)^2\right\}}$$

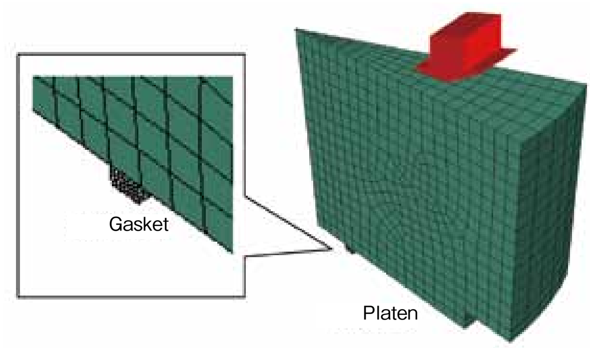


Figure3 FE model for platen testing

4. Results of Experiments and FEM calculations

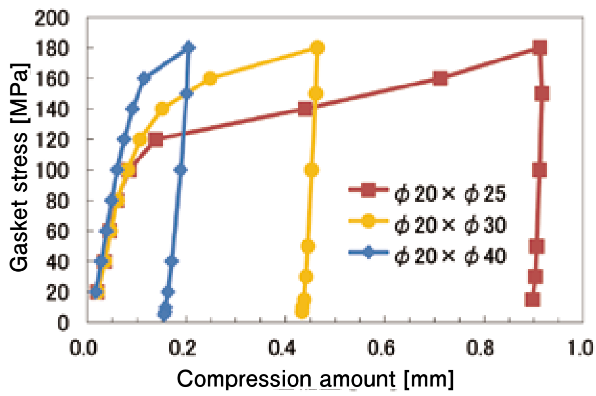
Figure4 showed the results of platen test for aluminum and copper gaskets. It was found that the deformation increased as the outer diameter of gasket decreased (as the gasket width decreased) in both materials. This was resulted in the influence of shape of gasket.

Figure5 showed the surface conditions of the aluminum flat gasket with a diameter of $\phi20\times\phi40$ and the platen after the compression test. It seemed that there were white discolorations at inner and outer side positions of gasket on both the gasket face and the platen faces. Those imply that the compressed aluminum gasket would have been deformed to inner and outer diameter and be sharpened by the friction with the platen faces because of remained small aluminum particles on the surface.

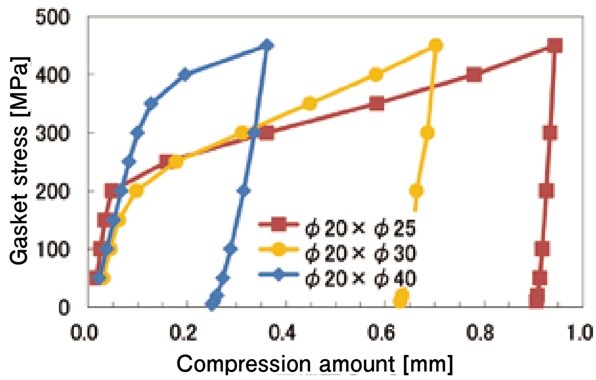
The relationship between leakage volume obtained from the platen test and the mean gasket stress was shown in Figure6. Use of a helium leak detector allowed the measurement of very small leakage volume of approx. 1×10^{-7} Pa·m^3/s. The measurement results for both aluminum and copper gaskets showed that application of a higher average gasket stress reduced the leakage volume and that a reduction of the mean gasket stress increased the leakage volume. Also, the reduction rate of leakage volume became more moderate at around 120 MPa for aluminum and at around 250 MPa for copper.

In general, the relationship between leakage volume and mean gasket stress is known unchanged even when the gasket width is changed. Therefore, the sealing properties of metal flat gaskets can be organized according to the mean gasket stress. During the unloading process, the leakage volume rapidly increased at approximately 30 MPa for aluminum gaskets and at approximately 50 MPa for copper gaskets. This was considered to have been caused by the loss of conformability of initial step of loading between the flange and gasket surfaces.

Figure7 showed the results of a Finite Element Analysis which replicated the platen test. The figure showed the distribution contours of gasket stress and corresponding plastic strain when the gasket material is aluminum and the gasket dimensions are $\phi20\times\phi25$. The figure indicated that the corresponding plastic strain rapidly increased when the mean gasket stress increased from 100 MPa to 120 MPa. At that time, the gasket might have undergone a marked plastic deformation to fill the very small roughness on the flange surface to improve sealing properties. This result indicates that plastic strain of a gasket surface is necessary for metal gaskets to exert their excellent sealing properties.



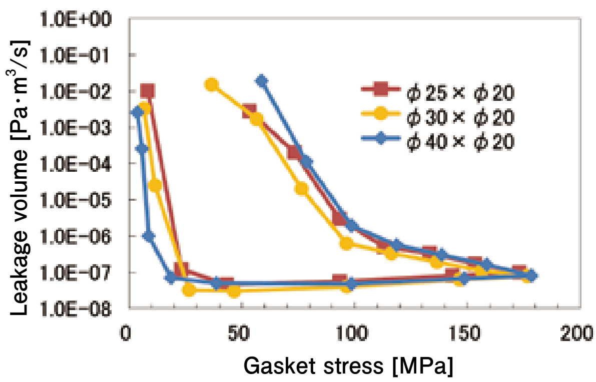
(a) Compression properties of aluminum flat gaskets



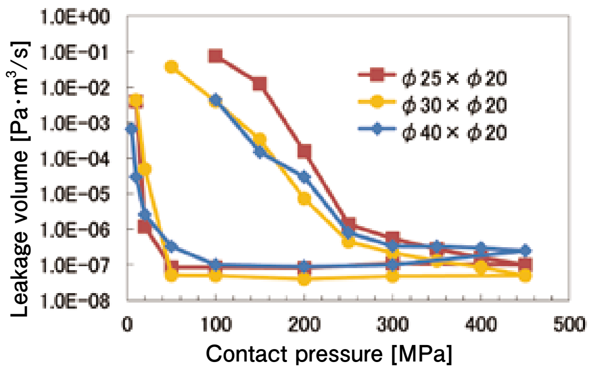
(b) Compression properties of copper flat gaskets

Figure4　Compression properties of copper flat gaskets

Figure5　Surfaces of gasket and flanges after compression test

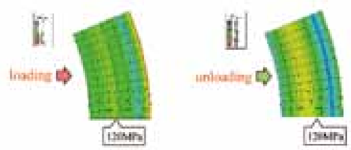


(a) Relationship between leak rate and contact gasket stress for aluminum flat gaskets

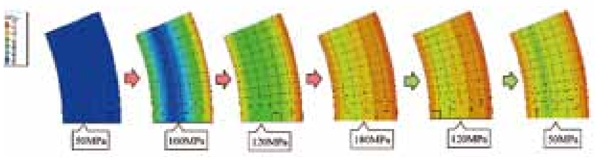


(b) Relationship between leak rate and contact gasket stress for copper flat gaskets

Figure6 Relationship between leak rate and contact gasket stress



(a) Contact gasket stress distributions



(b) Corresponding plastic strain distributions

Figure7 Distributions of contact gasket stress and corresponding plastic strain at each step obtained from FEM calculations

5. Evaluations of pipe flanged connection with the metal gasket

The previous sections described the evaluation using a platen, which enabled ideal homogeneous compression. In this section, the evaluation of characteristics using actual pipe flange connection was discussed.

Figure8 showed the test equipment for pipe flange connection, and figure9 showed the FEA model of the pipe flange connection with gasket. The connection sizes were chosen as ASME/ANSI class 300 2 inch and bolts were eight M16. Taking into account the symmetry of the connection, a one-thirty two part of connection was analyzed. In the FEM model, it was assumed that the nut was connected with a bolt and the screw thread of the bolt was not taken into account. In addition, for simplicity, the hexagonal nuts were replaced with a circle shape. The uniform bolt stress was applied to the cross sectional area in the bolt at initial tightening, while the displacements of the symmetrical plane were fixed in the axial direction. In the experiments, each axial bolt force was measured using the strain gauge attached to the shank of each bolt and the outputs are recorded in a data logger. The helium gas 4MPa was applied from cylinder and the leak rate is measured by pressure drop method.

Figure10 showed the leak rate from aluminum flat gasket with dimensions of φ65×φ55 for the bolted flange connection (2inch) with metallic flat gasket which was described in dotted line and the measured result in the platen tests was described in line. Although the value of lower leak rate from pipe flange connection could not be measured by the pressure drop method, it was found that the leak rate of bolted flange connection behaved similar with that in the platen test because it was due to the flange rotation in the bolted flange connection and the plastic deformation occurred in lower average gasket stress region. The leak rate decreased substantially when the contact gasket stress was applied 100MPa. Figure11 showed the corresponding plastic strain distributions at that timing using FEM calculations. It indicated that the corresponding plastic strain was small when the contact gasket stress was 90MPa, however rapidly increased at contact gasket stress 100MPa. It was considered that the sealing performance increased so much under un-uniform stress compression in pipe flange connection because of increasing of the corresponding plastic strain.

The method of determining bolt preload for achieving allowable leak rate (less than 1×10^{-4} [$Pa\cdot m^3/s$]) was proposed in reference [8]. This equation is described in Eq. (1) .

$$F_{fmin} = b \times \sigma_{yield} \times \frac{\pi}{4}\left(d_2^{\ 2} - d_1^{\ 2}\right)/(N \times 1000) \quad (1)$$

where, d_2 is the outside diameter and d_1 the inside diameter of the gasket, N is the bolt number and b is the coefficient which indicates the initiation of the plastic deformation in the metallic gasket.

Figure12 showed the leak rate of 2" bolted flange connection, the abscissa was bolt preload from average gasket stress in Figure9 The triangle marks (○,△,□) showed the bolt preload calculated by Eq. (1) . The compressive yield strength of aluminum and copper gaskets were 120 and 250MPa, respectively. In addition, the factor of better sealing used was 0.8 in the previous paper [6]. The leak rate less than 1×10^{-4} [Pa·m^3/s] can be obtained by the bolt preloads calculated by Eq. (1) . Thus, Eq. (1) was verified for determining the bolt preload to satisfy the allowable leak rate in bolted flange connection with flat metallic gasket.

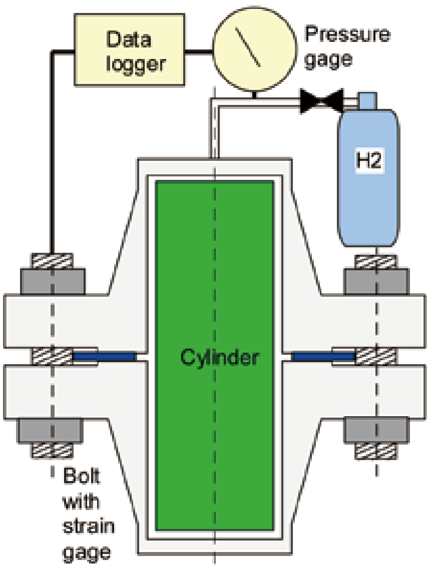


Figure8 Illustration of pipe flanged connection

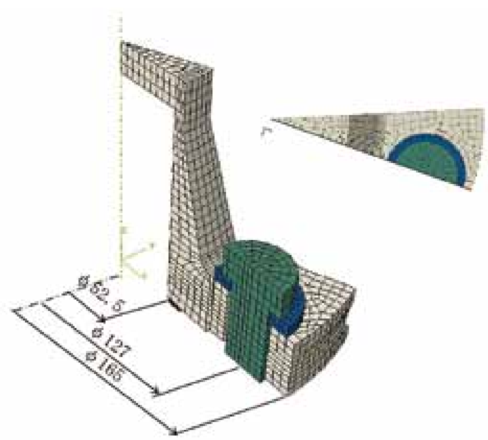


Figure9 FEA model of pipe flange connection with metal flat gasket

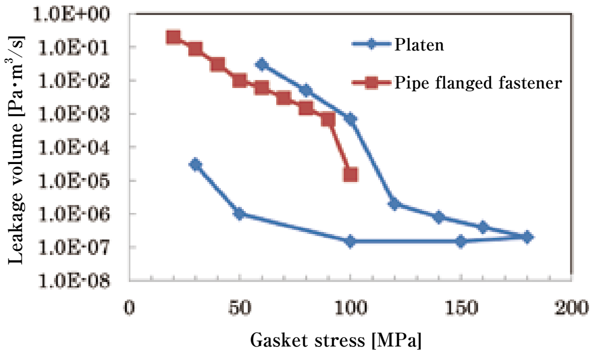


Figure10 Comparison of leak rate from platen test and pipe flange connection

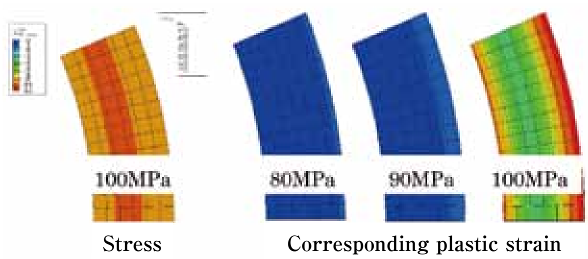
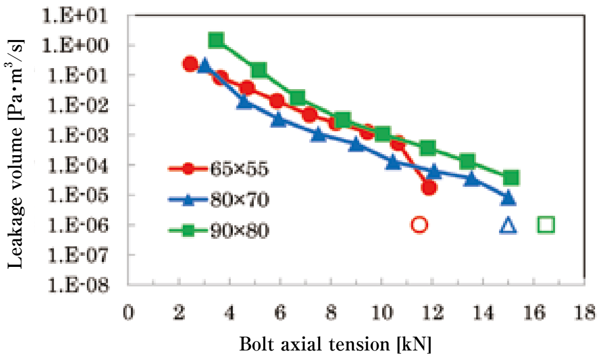
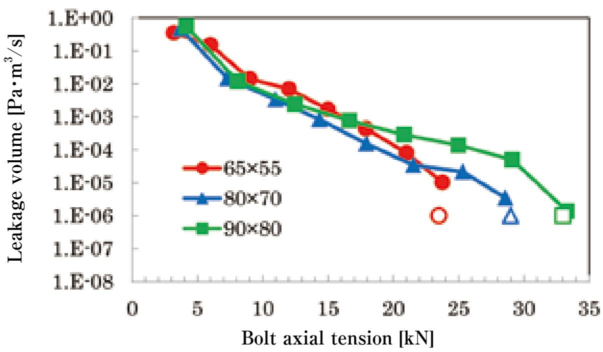


Figure11 The corresponding plastic strain distributions of aluminum flat gasket in pipe flange connection



(a) Aluminum flat gasket



(b) Copper flat gasket

Figure12 Measurement results and estimated results of leak rate for pipe flanged connection

6. Conclusion

In the present paper, the leak rate of 10^{-7} level for flat metallic gaskets which were compressed using the platen devise testing machine was measured. In addition, the leak rate in the bolted flange connection with flat metallic gaskets was also measured. The contact gasket stress distributions in both platen test and bolted flange connection with flat metallic gasket were analyzed using FEA calculations. The results obtained are as follows.

(1) The leak rate of the metallic gaskets which were compressed in the platen devices was measured in the 1×10^{-7} [Pa·m^3/s]) level using both methods of a soap film flow meter and a helium leak detector.

(2) In the platen device tests, it was found that the leak rate was independent of the dimensions of gaskets. In addition, the leak rate decreased with an increase of the gasket stress linearly to the leak rate level of 10^{-6} which corresponded to the gasket yield strength.

(3) In an ASME/ANSI class 300 2-inch pipe flange connection, sealing properties were also found to have been markedly improved when part of the gasket's contact surface had yielded.

(4) It was provided a method for calculating the axial tension required for initial bolt fastening of a fastener under a basic leakage volume of 1×10^{-6} Pa·m^3/s and compared calculated values with experimental results to verify the method.

7. References

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Troubles While Mounting Gaskets and Countermeasures

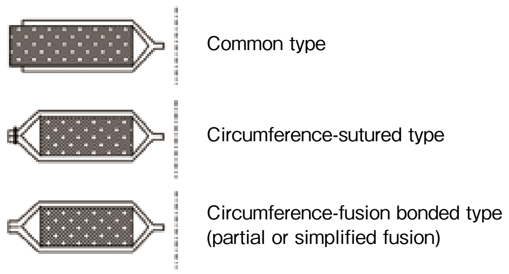
1. Introduction

The term *seal* means to prevent a fluid from leaking from inside to outside or from outside to inside in piping, devices, and equipment at various plants and the members for such purposes. To achieve sealing as intended, not only the seals themselves but also the proper selection and application of seals are important. Among sealing-related information, we previously introduced gasket-tightening troubles and countermeasures[1]. This report introduces additional troubles that may occur while mounting gaskets and countermeasures.

2. Examples of Mounting Troubles and Countermeasures

2-1) Jacket's fold-over in fluorocarbon resin envelope gaskets

The fluorocarbon resin envelope gaskets, No.N7030 series, have the jacket sideways V- or U--shaped cross section, all of which have openings on the side of outside diameter. Due to such jacket's structure, when a gasket is mounted, especially when it is mounted into a narrow space inside a flange, the gasket's fluorocarbon resin jacket sometimes folds over and is tightened while the jacket is left bent toward the inside. This bent part causes a level difference which becomes a channel for leakage, resulting in poor sealing. Therefore, care should be taken not to cause a fluorocarbon resin jacket to fold over when mounting. Fold-over can be prevented by using the following countermeasure products whose outer sides are adhered and closed. In such products, the whole circumference does not need to be welded completely; partial side spot welding or simple welding is sufficient.



※) Note: The circumference-sutured type can be used only in gaskets with diameters of ϕ400 or narrower. When circumference-sutured types are not applicable, circumference-fusion bonded types can be used.

Figure1　Jackets of fluorocarbon resin envelope gaskets

2-2) Wetting of a felt sheet of a fluorocarbon resin envelope gasket

Some No.N7030-series fluorocarbon resin envelope gaskets use felt sheets as their cores; however, a felt sheet is vulnerable to compression fracture when it is wet. Therefore, they should not be mounted and tightened in rainy weather.

2-3) Scratching on the surface of expanded graphite gaskets

Expanded graphite material has ideal properties as a seal material including excellent chemical resistance and minimal creep relaxation; on the other hand, it has handling disadvantages including vulnerability and fragility. If expanded graphite gaskets are roughly handled during transportation or mounting, it could be easily to develop leakage channels on the surface and the risk of poor sealing.

Therefore, the following products should be stored and transported in the packaged condition to prevent surface scratching: the expanded graphite sheet gasket; No.VF-35E, the expanded graphite spiral wound gasket; No.6590 series, the serrated metal gasket with expanded graphite sheet: No.6540H, the metallic flat gasket with expanded graphite attached: No.6560, and the metal jacketed gasket with expanded graphite attached: No.N6520. Also, care should be taken when mounting them, such as avoiding scratching the gaskets with sharp objects including nails and tools and not placing them directly on the ground.

2-4) Breakage of large-diameter spiral wound gaskets in pre-utilization conditions including transportation

Small-diameter spiral wound gaskets do not break easily, but large-diameter spiral wound gaskets with or without inner / outer rings have a risk of breakage (so-called loosening) when excessive force is applied during storage, unpacking, transportation, and mounting. Especially, spiral wound gaskets with a diameter of over 2000 mm have higher risks. If the gaskets break, they cannot be used anymore.

Therefore, take care not to apply excessive force including twisting and strain to these products.

- Avoid placing a gasket in the standing position; the horizontal position is desirable.
- Do not forcibly dismount fixtures when unpacking (a written unpacking procedure is enclosed with a large-diameter spiral wound gasket; read and follow the dismounting steps).
- The number of staff required for transportation and mounting varies depending on the product's size. The following table shows the ideal number of staff for the operation.

Table1 Approximate number of staff required to handle gaskets of a given size

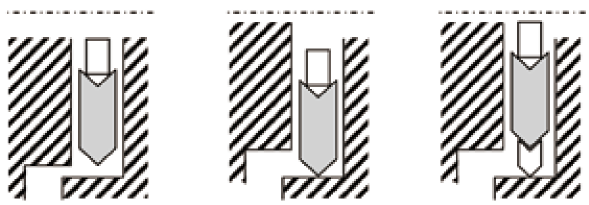
Gasket's inner diameter	Number of handling staff
1000 ～ 1500 mm	2 or 3
1500 ～ 2000 mm	3 or 4
2000 ～ 3000 mm	4 to 6
3000 ～ 4000 mm	6 to 8

2-5) Misaligned mounting of large-diameter spiral wound gaskets

In a male-female flange and groove flange which have a large roughness clearance, especially in a vertically placed spiral wound gasket, the main body of the gasket is dislocated from the flange face, and the flange face edge sometimes contacts the inside area of seal body. In this case, a spiral wound gasket might protrude beyond the gap, resulting in breakage or leaking.

Therefore, for a spiral wound gasket used in a heat exchanger, the number of the inner metal strip without filler and the number of spot welding applied to each winding are increased; in addition, the gasket's outer diameter is manufactured to ensure over-tolerance . These approaches reduce the risk of protrusion, breakage, and leakage even when the main body is dislocated from the flange face.

When such problems occur despite these approaches, additional metal strip without filler for a 3.2-mm main body can be applied to the outside and inside of the regular 4.5-mm main body. This process can prevent the main body from becoming dislocated from the flange face. Also, for the same purpose, a metallic round bar can be placed inside.



Ideal configuration

An example in which the main body is dislocated from the flange buckling

An example in which a 3.2-mm hoop is added to keep the main body within the flange buckling

Figure2 Positional relation of spiral wound gaskets to flange face

Other than the above-mentioned approaches, the following mounting method can be used: for tentative holding, a retainer plate and bolts specialized for the retainer plate are used to hold the gasket in an appropriate position; guide bolts are used to appropriately adjust the flange; the gasket is tentatively held with bolts which are used in actual equipment; then, the retainer plate is removed and final tightening is applied to the gasket.

2-6) Mounting a metal jacketed gasket in the wrong direction

When a metal jacketed gasket is used in a male-female flange or groove flange and the metal jacket is mounted in such a direction that the folded part of the metal jacket contacts with the convex part of the flange, the flange's convex edge sometimes breaks the folded part of the metal jacket during tightening.
Therefore, a metal jacketed gasket needs to be mounted in such a manner that the folded part becomes the groove bottom. In addition, since the gasket has an inside and an outside, in the case of non-symmetrical branching gaskets, mounting instructions clarifying the direction of the metal folded part must be included on the drawing.

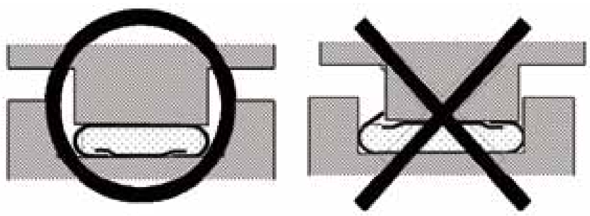


Figure3　Mounting direction of a metal jacketed gasket

2-7) Incomplete contact of a metal ring joint gasket to a flange

When both a flange and a gasket are new, no contact problems would occur; however, when a ring joint gasket is used in a flange that has been used for a long time, incomplete contact between the flange and gasket sometimes results in inadequate sealing.
Therefore, firstly it is necessary to confirm whether the whole circumference of the gasket contacts with the flange (hereafter, contact). To confirm this, pigments including red lead primer are applied to the gasket, the gasket is tightened to approximately 20% of the target torque, and then it is opened to check how the pigments remain on the surfaces. Confirmation can be conducted either on the outside or inside contact (when the pressure is high, the outside is desirable), to check whether contact is present on the whole circumference (line contact is acceptable). After whole-circumference contact is confirmed, the gasket is appropriately tightened, and then the gasket can be used.
When contact is not confirmed on the whole circumference, grinding is needed. Also, grinding is used to remove scratches and corrosion of a flange's groove. In the grinding process, polishing powders are applied to the gasket and then the gasket is rotated in the flange's groove. Red lead primer or other pigments are used to confirm whether whole-circumference contact is achieved. In the case of an octagonal type, grinding can be performed by using an octagonal gasket itself which is to be mounted. However, in the case of an oval type, grinding using an oval gasket itself reduces the excellent sealing properties attained through line contact, so, an octagonal gasket or tool specialized for grinding is used for the process.
In addition, in the case of gas seal and in case of using hard materials such as stainless steel, the gasket paste should be thinly applied.
When sealing functions are inadequate despite applying gasket paste, the following other countermeasures can be taken: replacing the gasket with a ring joint gasket loaded with a cover made of a soft material including expanded graphite or copper, or arranging a gasket in a special dimension fitted for a flange.

2-8) Common checks for all gaskets

Common checks for all gaskets while mounting are as follows:

- Whether a flange has rust, scratches, or dents which adversely affect the flange's sealing properties
- Whether part of a gasket which was previously used adheres to the flange
- Whether the gasket's surface has scratches or adhesion of foreign substances
  (Especially, if a bolt hole has foreign substances inside while an upper bolt is being inserted in a horizontal pipe, the substance can fall off and adhere to a gasket.)
- Whether the gasket's dimensions are correct
  (Even when a gasket has the same outside

diameter as the specifications, sometimes, the inner diameter is different from the specifications. In such cases, smaller inner diameters can cause leakage into a channel.)

・Whether the gasket type is correct

3. Conclusion

This report introduced troubles occurring while mounting gaskets and countermeasures against them, for various types of gasket. Since customers conduct sealing themselves, we hope this report will help them to avoid leakage troubles and achieve sealing as intended.

4. Reference

1) Takahiro Fujihara, *VALQUA Technology News* No. 31, pp. 8–11; 2016

Satoshi Akiyama
Sales Group　Technical Solution Division

An Introduction and How to Use Seal Quick Searcher™ (SQS) —Elastomer Version—

1. Introduction

We started our gasket version of Seal Quick Searcher™ (SQS) in April 2014 under the following concept: the user can freely select search keywords to obtain product information and specifications more easily and quickly through SQS, which can process a much wider vocabulary.

This SQS can not only retrieve product information such as Web catalogs but also includes Valqua's unique system of employing temperature- and pressure-selection figures and graphs in the output displays for assisting product selection (patent pending for "A system to select recommended sealing materials") .

This report introduces the elastomer version of SQS, which we started in October 2014.

2. Characteristics of Seal Quick Searcher™

Seal Quick Searcher™ is designed to support diverse customers ranging from those who usually use our products to those who do not know what products to use under given conditions or whether their intended product is suitable for their objectives. This report introduces these features for assisting product selection.

2-1) Various approaches

The elastomer version of SQS enables a search to be made based on shape, application, and rubber material. This search mechanism was designed for product search assuming: that the customer has already determined the shape, but does not know the part numbers of optimal products; that the customer has already determined a material based on performance, but does not know available options regarding the shape, or that the customer has already determined a usage condition, but does not know the optimal shape and material.

2-2) Selection of optimal material

Ten to 15 types of elastomer material can be used as sealants. However, even just one material has different physical, oil-resistance, and chemical-resistance characteristics depending on how it is used. One example of a marked difference in characteristics is as follows. Even for O-rings having the same shape, the material should be chosen depending on the purpose. For O-rings used under static conditions in which long-term reliability is a priority, materials offering good anti-compression set (settling resistance) are optimal; for O-rings used under dynamic conditions, not only anti-compression set but also resistance to damage caused by sliding, such as abrasion resistance, should be prioritized when selecting a material.

The elastomer version of SQS employs our expertise in material selection. In SQS, customers can select a product application and usage conditions, and then SQS automatically suggests the optimal material.

2-3) Links to technical information

As Figure1 shows, SQS displays associated information as a search result on product characteristics and service conditions (the range of applicable conditions) . SQS also shows links to technical and dimensional data of *VALQUA Handbook* to facilitate understanding of more detailed product information and dimensional lineups.

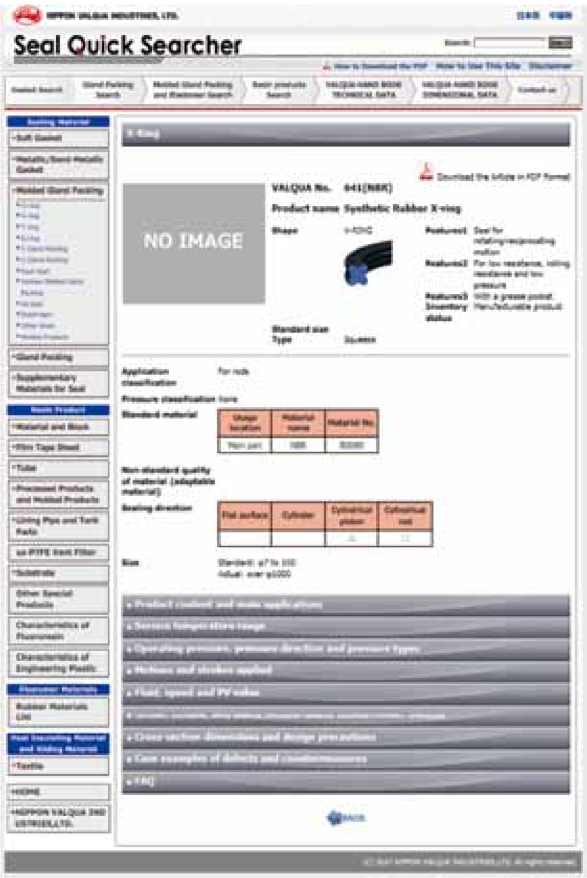


Figure1　An example of SQS search result

3. An Example of Searching Using SQS

Although most customers have already used SQS, this section introduces practical examples of using the elastomer version of SQS for searching, which was introduced in the above section, focusing on its main characteristics.

3-1) Searching approach

As Figure2 shows, the elastomer version of SQS enables searching based on the following variables: ① shape, ② product application and industrial field, ③ rubber material.

① Regarding the approach based on shape, customers choose one of the shapes shown in Figure3, and enter usage conditions. SQS then displays the primary output as shown in Figure6.

② Regarding the approach based on product application and industrial field, customers enter a field and then usage conditions. SQS then displays the primary output as shown in Figure4.

③ Regarding the approach based on rubber material, customers select the material/material No. as shown in Figure5, then SQS displays the primary output as shown in Figure6.

Figure2　Search approach

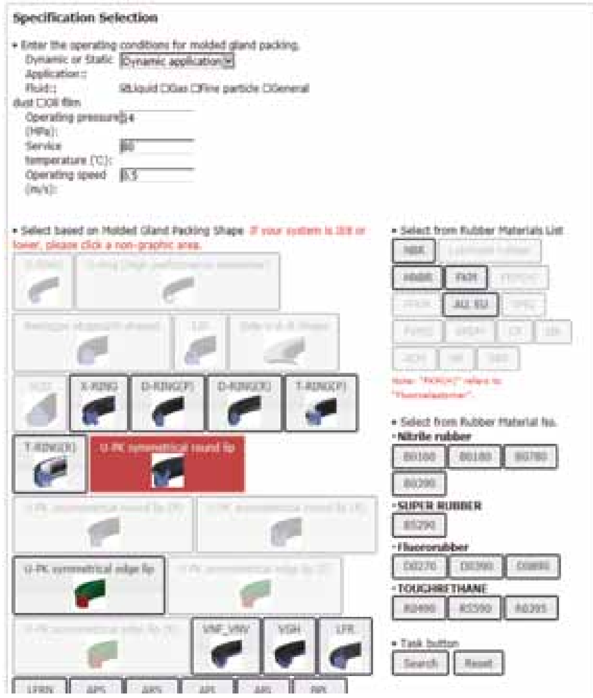


Figure3 ①　Input for searching based on shape

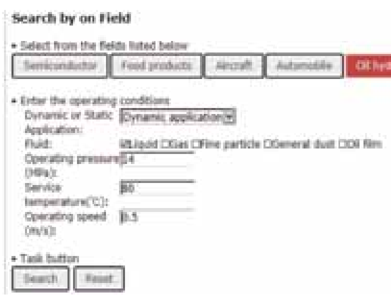


Figure4 ②　Input for searching based on field

Figure5 ③ Input for searching based on material

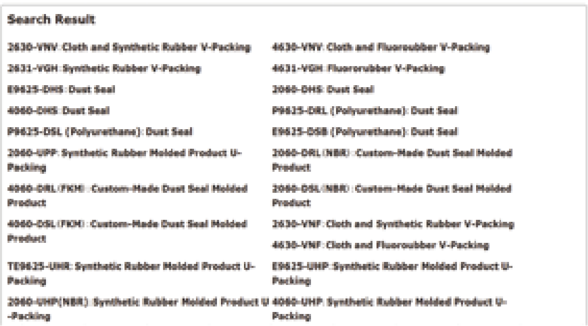


Figure6 Primary output

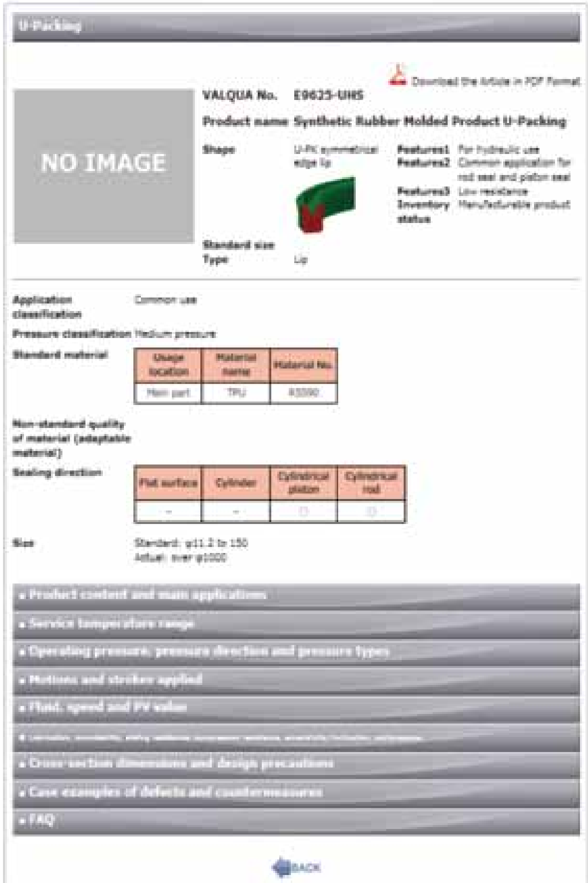


Figure7 Secondary output

3-2) Search Results

Part numbers and products shown as the primary output are a list of applicable products which correspond to the input variables. When a given part number or product is selected, detailed product information is shown as the secondary output as shown in Figure7. After selecting a given variable from the secondary output (tabs on the bottom section of the display), more detailed information including the information shown in Figures8 and 9 (product information and operating-pressure information) is provided (the information shown is an example).

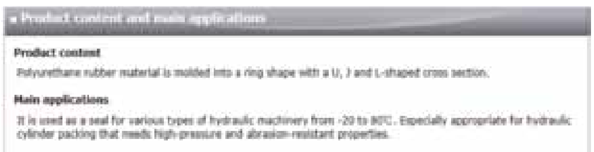


Figure8 Tertiary output: product contents and main applications

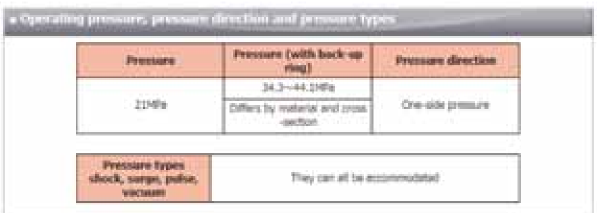


Figure9 Tertiary output: operating pressure, pressure direction, and pressure type

4. Conclusion

The elastomer version of Seal Quick Searcher™ is a search system programmed to use information which customers select from a Web product catalog, to suggest seal options which meet the customer's usage conditions and equipment, more quickly and robustly, without making mistakes in product selection. Please use SQS, which will help you to find the ideal sealant for your needs.

Looking ahead, we will make SQS even more user-friendly, easier to understand the output, and more technologically informative, thus supporting customers further.

Akira Ueda
Corporate Research and Development Group
Development Division

Seal Training Center (STC) – Interactive Training for Sealing Operation

1. Introduction

In recent years, technology succession issues in plant maintenance skills have gained attention in Japan due to the retirement of the baby-boomer generation and the deterioration of plant equipment. Therefore, maintenance management is becoming more important. However, as extension of continuous running periods, there are fewer opportunities for younger operators to experience on-site periodical repair, and making it difficult to maintain and improve plant-maintenance skills. Especially, it is said that plant managers who are educated with only basic knowledge of flange operation including specifications and procedures without enough on-site experience have increased. In spite of that, they need to face on-site troubles and field operators tend to follow their experience and intuition for troubleshooting. In general, finding root causes of troubles by knowledge only from education is not easy. It is considered that some serious seal-related accidents have occurred by luck of on-sight experience. According to the Fire and Disaster Management Agency, the number of accidents including fires and leakage (except for those caused by earthquakes) occurring at major petrochemical complexes around Japan has been increasing rapidly since 2006.

Also, in developing nations, where many projects for the new construction and expansion of facilities and equipment are planned, manpower shortages cause leakage troubles due to inappropriate selection of seal product and unstable operation. To address such problems, these countries are urgently demanded to develop and secure operators.

To meet those needs and to provide training opportunities regarding various on-site sealing operations, Valqua started to produce skill-training curriculums. The first Seal Training Center (STC) was established in our R&D center in Nara, Japan in 2014 to train specialized trainers. It offers interactive training of sealing operation curriculum with organizing hardware-side educational accommodation.

2. Market Development

As Figure1 shows, starting from STC in our Nara R&D center, we opened other STCs including in Machida, Tokyo, Japan and also in China, Taiwan, Vietnam, Thailand, and South Korea to provide training on sealing operations for Japanese and oversea customers. This training program has become widely known and been rated high.

Especially, in Vietnam, Petrovietnam Manpower Training College (PVMTC), a technical-education school under the control of Petrovietnam, the largest nation energy company, adopted our training system for their technical training on handling industrial-use seal products. PVMTC is Vietnam's only vocational training school for processing plants, where over 15,000 field workers from various industries study.

We dispatched several Vietnamese specialists as a trainer to PVMTC, and lent main equipment of STC and transferred it to PVMTC. We also provide our technologies through essential training-associated knowledge, textbooks and other materials, thus offering practical training on sealing skills to contribute the heavy chemical industry of Vietnam. We also expect to promote the Valqua brand through those activites.

Furthermore, in China, we have co-held “Valqua Training Session” with China Petroleum and Chemical Industry Federation which have been sponsored by the China Friction & Sealing Material Association for seals and fluororesin products since 2003. At “Valqua Training Session” in 2016, our new on-site service of conducting STC training at users' sites was introduced with user’s great interest.

Figure1 Locations of STC

3. Concept

STC, which has attracted great interest from the market, was developed through our accumulated sealing skills, especially engineering skills obtained by analyzing and solving troubles.

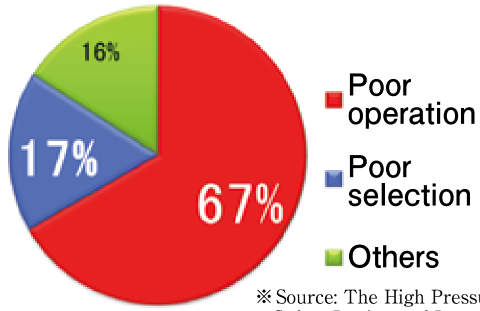
The High Pressure Gas Safety Institute of Japan has analyzed the causes of high-pressure-gas accidents and disclosed the results as shown in Table 1. The colored cells in the table show the number of accidents caused by seals, which account for 20 to 25% of all accidents.

Table 1 Cause-specific analysis of high-pressure-gas accidents

Classification / Year	Poor design and manufacturing of equipment				Poor maintenance and administration of equipment							Poor organization				Human factors			Total
	Poor design	Poor manufacturing	Poor operational management	Total	Poor corrosion management	Poor testing management	Poor inspection	Poor fastening management	Poor sealing management	Poor vessel management	Total	Poor organizational management	Insufficient operational standard and others	Insufficient communication	Total	Errors in operation and judgment	Malpractice	Total	
2015	54	9	24	87	85	30	13	28	26	21	203	2	6	1	9	40	6	46	345
2014	53	14	19	86	72	19	11	29	26	17	174	0	15	6	21	33	6	39	320
2013	38	14	23	75	77	28	18	23	33	19	198	0	15	1	16	50	4	54	343
2012	35	11	10	56	65	65	8	28	31	11	208	0	13	1	14	69	13	82	360
2011	22	17	11	50	67	66	8	38	28	20	227	0	8	1	9	45	4	49	335

The High Pressure Gas Safety Institute of Japan, *Summary Report of Accidents Associated with High-Pressure Gas* (as of December 2015)

Among accidents caused by seals, over 80% were due to inappropriate selection of seal product and unstable operation, as shown in Figure2.



※Source: The High Pressure Gas Safety Institute of Japan

Figure2 Causes of leakage

Therefore, as Figure3 shows, we extracted on-site problems, analyzed seal-related troubles, introduced countermeasures against the problems and applied the knowledge into our STC training curriculums. In short, the STC training covers the processes from the basics of seal product selection to the management of sealing-associated components. Based on "Know-Why"; to know the causes of leakage and why selection and operation are important, we have developed training which integrates classroom-lecture theories and operational training to teach our Know-How including what operations are required and how to solve problems.

4. Training Program

We analyzed mistakes in seal-product selection and operation which are the major causes of accidents stemming from sealing and then devised countermeasures. STC offers training focusing on such countermeasures. In selection training of seal product, trainees study the basic selection guidelines to learn how to select optimal gaskets based on fluid type, pressure, and temperature specified by the customer. Then, they learn about the dynamic behavior of

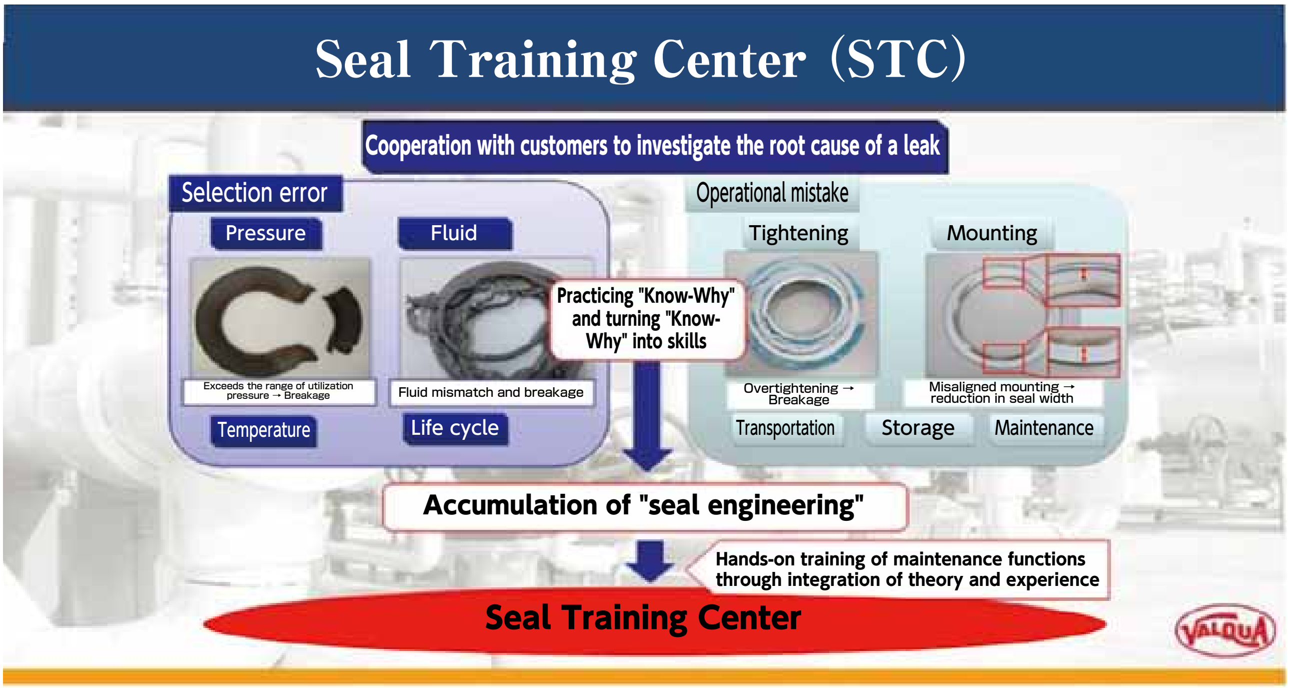


Figure3　Concept of STC

gaskets under special environments to understand the malfunctions and troubles caused by inappropriate selection.

In addition, trainees learn the effects of management conditions regarding not only gaskets but also sealing-associated components including flanges and bolts, which are used in flanged fasteners, to acquire key aspects of on-site management/supervising operations.

In operational training, trainees use the flange training device shown in Figure4 to confirm their own bolt-tightening skills. In the confirmation process, the device uses special sensor bolts to compare the trainee's tightening force with the target force and then shows how a particular trainee can conduct a tightening operation. In the process, the special sensor bolts output the axial bolt force applied during flange tightening as an electronic signal, then the data logger transforms the signal into axial bolt force, which is shown on the PC display. The display can compare the trainee's results with the predetermined target axial bolt force.

Trainees then use the torque-sensor training device, shown in Figure5, to confirm their own tightening characteristics and power-adjustment skills, and

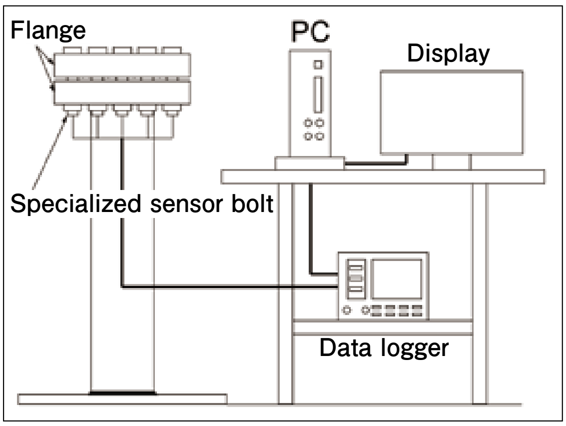


Figure4　Flange-tightening training device

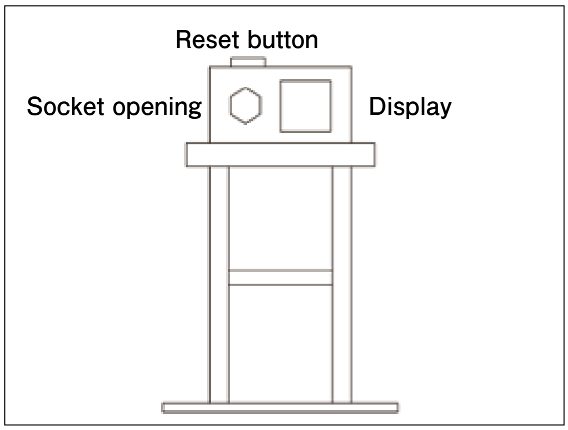


Figure5　Torque-sensor training device

practice repeatedly until there is no deviation in bolt-tightening. The torque-sensor training device inserts a tightening tool in the socket opening and the display shows the tightening torque under the trainee's posture and power adjustment.

In addition, trainees receive training on recognizing malfunctions which occur due to over-tightening and under-tightening. The training proceeds as follows. First, the trainee fastens flanges loaded on the sealing-property training device, as shown in Figure6, to make the contact pressure lower than the contact gasket stress necessary for sealing. Then, the pressure gauge adjusts the pressure to replicate air leaking, so the trainee experiences the leakage to understand the necessity of selecting the optimal fastening conditions. Next, the trainee uses the compression-fracture training device shown in Figure7 to experience and understand problems which occur due to over-tightening.

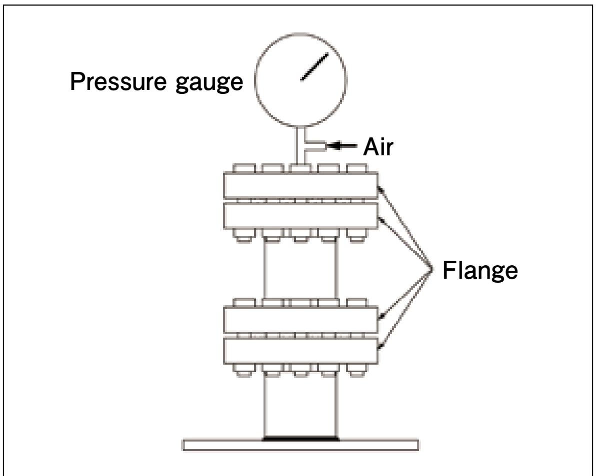


Figure6 Sealing-property training device

In addition, we established a curriculum in which trainees can learn other important points. For example, some devices, which are replicated device and piping alignments, are used to make trainees understand the phenomenon of creep, which is dependent on the gasket's temperature, so they can experience and understand the resulting problems and countermeasures.

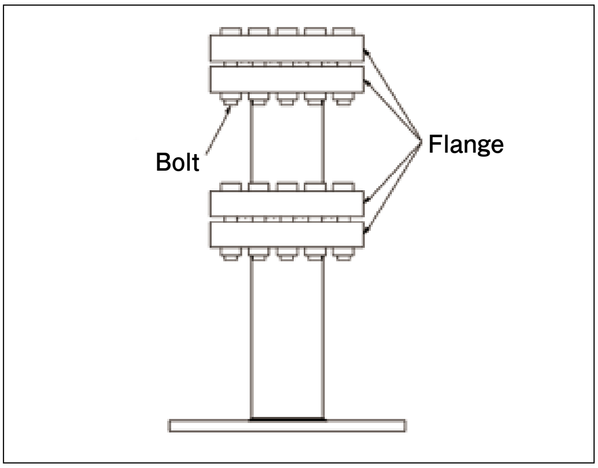


Figure7 Compression-fracture training device

At the end of the training, the on-site tightening-simulation training device shown in Figure8 replicates the following situations to confirm the effectiveness of the training and whether the trainees have acquired tightening skills and whether they can operate properly: a) a work environment with a narrow footing, assuming that the trainee works at a high place; and b) a work environment which replicates a narrow work space due to the presence of piping which is not subject to tightening.

These efforts of ours are highly evaluated by many customers including plant owners and companies associated with plant engineering.

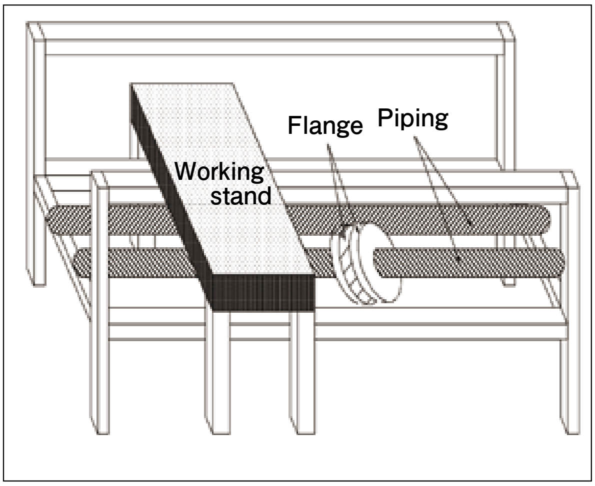


Figure8 On-site tightening-simulation training device

5. Conclusion

To date, STC users have given us feedback that they want to continue with such training programs. They have also requested additional training on trouble-prone devices including heat exchangers, so we will continue to develop new curriculums. We have also received inquiries for training all operators engaging in flange operations at periodical-repair sites, and are now studying ways to improve on-site services.

Overseas, we are planning to expand collaboration with public institutions, such as we have already done in Vietnam and China, in other countries.

Furthermore, we are establishing service package systems which include IT-based maintenance supports and abnormality diagnoses as a "Hardware & Seal-engineering service" business, which integrates products and services to meet needs obtained at skill trainings.

Akira Muramatsu
H&S BUSINESS GROUP

Management of Tightening of Flanged Fasteners at Plants

1. Introduction

Let me express my congratulations on the 90th anniversary of the establishment of Nippon Valqua Industries, Ltd. and on the publication of the 90th anniversary issue. I greatly respect everyone who has supported the sealing industry.

Skills to prevent the fluid within flanged fasteners from leaking are very important for stable and safe plant operation. In addition, high reliability is required in response to the lengthening period of continuous plant operation, environmental problems, and emission regulations regarding leakage. To ensure reliability, it is necessary steadily to build skills and techniques, as shown in Figure1. Especially, regarding sheet gaskets, restrictions on asbestos led to greater use of non-asbestos materials, and so fluororesin sheet gaskets became the norm. So, we needed to take into account the operational behavior of fluororesin sheet gaskets to set the tightening force for them. Robust tightening operation and management for such settings also became important.

This report describes the evaluation of alternative gaskets to asbestos, the results of collaborative studies to clarify the behavior of fluororesin gaskets during operation, and Mitsubishi Chemical Corporation's certification system to ensure proper tightening management.

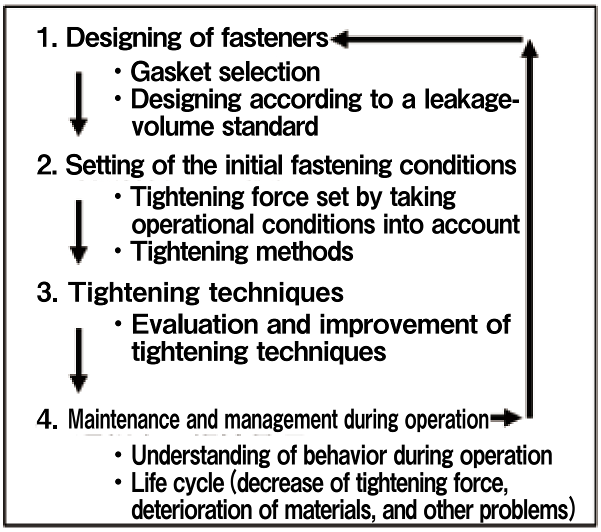


Figure1　Concept of fastener management

2. Gasket Selection

Regarding sheet gaskets, asbestos fiber joint-sheet gaskets have mainly been used for their excellent heat resistance, sealing properties, ease of handling, and cost performance.

In 2006, an ordinance amending the Industrial Safety and Health Law Enforcement Ordinance was issued. The ordinance banned the manufacture and use of asbestos and other substances, with an exception for some products. Therefore, asbestos gaskets needed to be replaced with non-asbestos gaskets. As substitutes for asbestos joint sheets, non-asbestos joint sheets, which contain organic fibers including aramid fibers and inorganic fibers, were considered the primary candidate. However, non-asbestos joint sheets contain non-asbestos fibers, which are stronger than asbestos fibers and have weaker fiber-to-fiber interwinding power than asbestos fibers. In asbestos fiber joint-sheet gaskets, thin and long asbestos fibers themselves were the strength members of a gasket, whereas in a non-asbestos joint sheet, rubber as a binder served as the strength member. Therefore, functional decline due to hardening of the rubber was a concern for gaskets used at temperatures above the heatproof temperature of rubber. To address this concern, we decided to conduct evaluation tests regarding the temperatures of non-asbestos joint sheets.

Figure2 illustrates the test line. We set up test piping in a plant steamline with an inner pressure of 1.3 MPa and a temperature of 190°C and then conducted a 6-month loading test. During the course of the study, no macroscopic external leakage was found. However, in an opening process after the test, cracks developed when a non-asbestos joint-sheet gasket was removed from the surface of a flange sheet as shown in

Figure3. This result showed that non-asbestos joint-sheet gaskets cannot be used for a long time at high temperatures and that additional tightening cannot be applied to those gaskets. So, we concluded that non-asbestos joint-sheet gaskets cannot be a substitute. Also, in this test, other types of gaskets were assembled simultaneously. Foamed-carbon gaskets stuck to the surface of a flange sheet and were not easy to handle, and so we concluded that foamed-carbon gaskets could not be a substitute either. On the other hand, no major macroscopic problems occurred with fluororesin gaskets, making these gaskets the primary candidate.

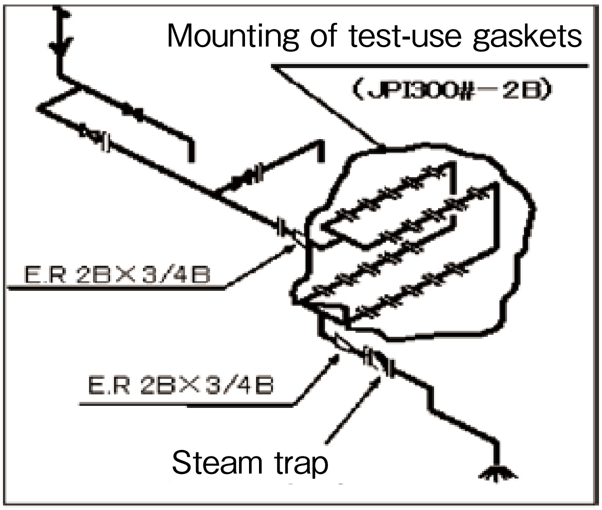


Figure2　Outline of the test line

Figure3　Removed gasket

3. Tests to confirm the behavior of fluororesin gaskets

Fluororesin sheet gaskets had been used as gaskets with excellent chemical resistance before the non-asbestos trend caught on. When fluororesin-specific flow causes a reduction of tightening force, we have applied additional tightening to solve the problem. However, the possibility and timing of additional tightening depend on empirical rules. For proper maintenance and management, we needed to understand the behavior of gaskets and devise proper countermeasures. Therefore, we conducted various tests to understand their behavior.

3-1) Test equipment

Figure4 illustrates the test procedures, and Table 1 shows the test conditions[1). A strain gauge attached to fastening bolts was used to measure bolt axial tension, and the contact pressure of the gasket was calculated from the contact area with the gasket. Tightening was conducted according to JIS B 2251 (2008) to achieve a gasket contact pressure of 25 MPa[2) (hereafter, bolt tightening was conducted according to the same standard) . No. GF300 gaskets were used.

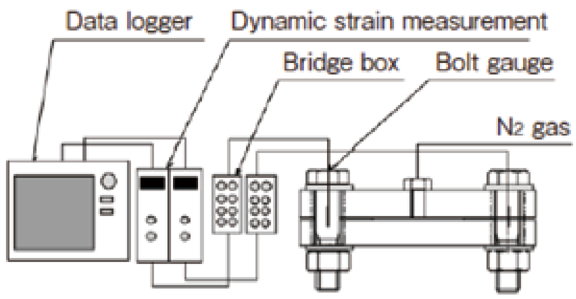


Figure4　Illustration of the stress-mitigation equipment

Table1　Conditions for the stress-mitigation test

Test-use dimension	JIS 10K 50A RF
Test-use temperature	200°C (24-hour cycle)
Gasket	V/NO.GF300
Flange	Material: SS400 Roughness of sealing surface: Rz = 14.4 μm (ave.)
Bolt (loaded with a strain gauge)	Dimensions: M16 × 4 bolts Material: SS400

3-2) Heat cycle-stress mitigation test

Gaskets were heated at 200°C in an electric furnace, and changes of the contact pressure of the gaskets were measured over time. Heating was conducted under the following three conditions: room temperature; continuous heating at a consistent temperature of 200°C; and application of a heat cycle alternating between 200°C and room temperature. In this test, one heat cycle was 24 hours with 2 hours of temperature rise and approximately 3 hours of temperature fall.

Figure5 shows the test results. The rate of contact pressure reduction with temperature load was more reduced than that at room temperature. In the heat-cycle case, a great reduction in contact pressure during the temperature-fall period was confirmed. Although the contact pressure of the gaskets increased during re-heating, it did not reach the contact pressure before temperature reduction. After periodic maintenance and before the start of operation, airtight tests are conducted. When the fall in temperature greatly reduces the contact pressure, countermeasures to restore the contact pressure should be taken to confirm the absence of leakage and then to prepare for the start of operation. Also, in areas where frequent heat cycles develop, the contact pressure of gaskets decreases gradually, so the same countermeasure to restore the contact pressure should be taken.

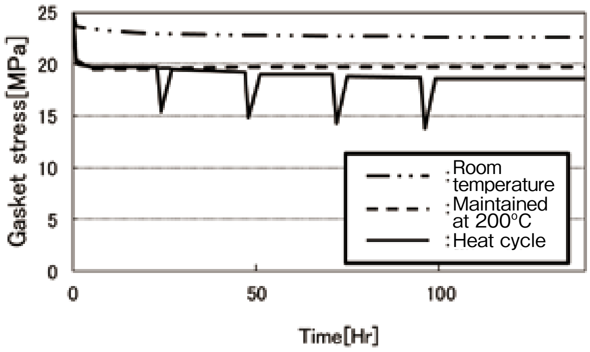


Figure5　Results from the heat cycle-stress mitigation test

3-3) Confirmation of the effects of additional tightening

Usually, as a countermeasure against reduced contact pressure, additional tightening is applied. Regarding the timing of performing this additional tightening, the following two conditions are taken: application at high temperatures after the start of operation; and application at room temperature during operational suspension for periodic maintenance and other reasons.

Figure6 shows the test results. Additional tightening increased the residual contact pressure, and the effects of contact-pressure retention were confirmed. Regarding the timing, additional tightening at higher temperatures resulted in greater residual contact pressure than at room temperature. Since the stiffness of gaskets decreased at high temperatures, tightening was conducted while flowing, which resulted in weaker flow after additional tightening. Such weakening was supposed to reduce stress mitigation. In the case of additional tightening under decreased stiffness, crushing strength is also expected to decrease, so the tightening force must be carefully considered. Although additional tightening at room temperature resulted in weaker effects than that at high temperatures, it is considered an adequate countermeasure in pre-operation airtight tests.

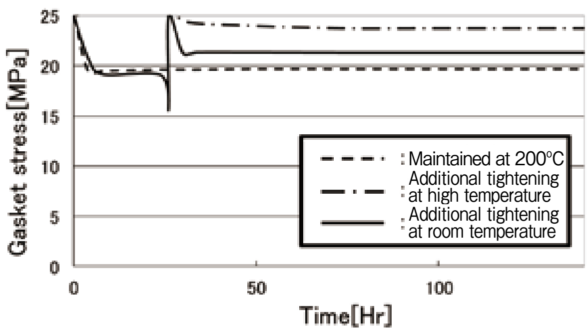


Figure6　Results of verification testing of additional tightening

4. In-house certification system

Ideally, a flanged fastener's behavior is clarified, tightening is quantitatively managed for all procedures, and tightening is performed in a controlled manner. However, due to limitations of managing tools, measurement cost, and limited work period, we select the target. So, most flanged fasteners are tightened based on the operator's skills and experience. In the past, assembling while misunderstanding a gasket's specifications, inadequate tightening, and uneven clamping caused malfunctions. To address these problems, Mitsubishi Chemical Corporation introduced and is utilizing a certification system for chief gasket operators. Table 2 shows the contents of the certification training. Chief gasket operators who have passed the test instruct, mentor, and supervise operators and conduct the final confirmation of assembling operations. In this way, they have responsibility for gasket assembling. Gasket-assembling cannot be conducted without the presence of a chief gasket operator. To date, approximately 3000 operators have been certified as chief gasket operators. This system appears to be effective for preventing malfunctions. All certification training sessions are provided in a classroom, which is expected to enhance knowledge, but skills are also acquired through on-site experience. Nonetheless, only on-site experience causes the problem that although operators understand differences in tightening conditions occurring when bolt axial tension is reduced by elastic interaction and when a different tightening attitude is applied, the timing and mechanism of the effects of bolt axial tension and torque cannot be visualized numerically and other measures remained as a problem. Therefore, part of our mobile training system was introduced in the Mizushima Plant and a practice training session was held for operators. Figure7 shows a picture of the practice training session. The training session includes the following four contents: evaluation of flange-tightening skills, torque-sensing training, understanding the importance of bolt maintenance, and recognition of crushing-prone gaskets. A total of 43 operators including new employees who had no on-site experience and skilled operators who had 30 years of experience participated in the training. Regarding their post-training impression, "understood very well" and "understood" accounted for over 90%. In addition, the training received good feedback including "visualization of changes in bolt axial tension made the training easy to understand". So, the training appeared to be very effective. We are now studying how to utilize the mobile training system and incorporate it into our certification system. In Mizushima's case, the number of trainees was 40. Therefore, we need to study the curriculum contents and training using multiple training devices to enable hundreds of trainees to participate during periodic maintenance.

Table2 Contents of the training session

1. Responsibilities of a gasket operator
2. Training to prevent mistakes in gasket mounting
   - Gasket types and their handling
   - Pressure rating and flange specifications
   - Bolt specifications at each plant
   - Points to confirm regarding core tightening and uneven clamping
   - Tightening methods (circling tightening)
   - Inspection and record submission
3. Handling of asbestos gaskets
4. Previous trouble cases
5. Verification testing

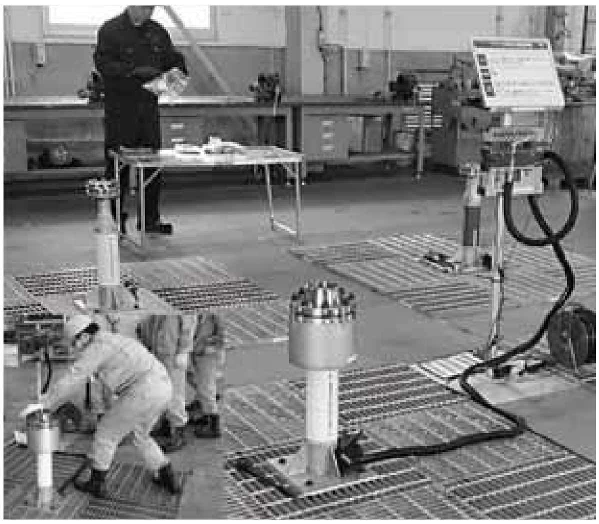


Figure7 Training session

5. Conclusion

Due to the retirement of old skilled operators and the trend of younger operators to leave work, there has been a declining number of operators specialized in flange-tightening operation and a decrease in the level of techniques and skills. A system for conducting proper tightening management without depending on skilled workers is necessary. For example, sealing-operation management systems enable automatic tightening tools to conduct tightening according to programmed procedures, enabling even novices to systematically apply tightening force at a predetermined torque value.

This report introduced our education and certification systems, as well as training sessions utilizing our mobile training system. Through such training media, we will strive to maintain the levels of our operators' skills. We will also introduce new systems in the pursuit of more reliable leakage-prevention technologies.

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2) JIS B 2251 "Flange Joint Assembly Guidelines", (2008)

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Earth-friendly, Human-friendly Manufacturing

New Gaskets and Gasketing Technology

Recent environmental regulations have led to a major transformation in the different types of gaskets and their materials. Likewise, we are also seeing major changes in the design standards for bolted flange connections.
In response to this technical situation, JISB0116 "Glossary of Terms for Packings and Gaskets" was completely revised for the first time in 37 years.
The recently published "New Gaskets and Gasketing Technology" is the first handbook that both covers the technical background leading up to this JIS terminology standards revision and explains the technical basics of gaskets and bolted flange connections in an easy to understand manner. As such, we feel it will serve as a reference for many of those involved in gaskets.

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