Valqua Technology News

Winter 2022

No.42

VALQUA, LTD. HARD&SERVICE COMPANY H&S
https://www.valqua.co.jp

New Year's Message

VALQUA, LTD.
Chairman & CEO
Toshikazu Takisawa

I would like to start by wishing all of you the best in 2022 and thanking our regular readers for all their support.

Last year, the COVID-19 pandemic continued to have a serious impact on economic and social activities. Vaccines were developed and rolled out to combat the virus, but as evidenced by the emergence of variants and the need for booster vaccines, this New Normal that we are navigating requires new modes of action. Meanwhile, as noteworthy global trends, this year witnessed an unprecedented boom in demand for semiconductors, as well as diverse environmental movements and a growing interest in issues of economic security. I imagine that these matters were of deep interest to our readers. As for environmental issues, Valqua has expressed our support for the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD), and we plan to implement a variety of related activities and to improve our reporting from this perspective.

As symbolized by the idea of the Great Reset, virtually all values are undergoing rapid and significant changes. The Valqua Group will continue to develop our business activities in a way that meets our stakeholders' expectations by refining our sensitivity to the surrounding environment and continuing to transform into a company that can enact a quick response to changes in that environment. Against this backdrop, our group's technology development activities are not bound by past practices or experiences of success; rather, they focus on communication with the outside world and incorporate ideas from outside of the group. Last year, this resulted in our announcing capital and business alliances related to multiple technology developments. I hope that this new framework will produce technological development results that will serve as new pillars for the group in the near future.

I stated in my message in last year's issue that we would position 2021 as the first year of transformation. Over the last year, we have indeed implemented several initiatives in the aim of corporate transformation (CX), including those mentioned above. This year, we will build on this foundation to accelerate our further transformation by promoting DX (Digital transformation), and we will undertake company-wide activities to create value that can contribute to the development of today's society, where digitalization is accelerating.

Valqua has elected to participate in the Prime Market, which is slated to begin in April 2022 as part of the Tokyo Stock Exchange's new market reorganization.

Under this new framework, we will further evolve our management philosophy based on The Valqua Way, and we will move forward toward our centennial in 2027 to further increase the value that we offer our stakeholders by becoming a company of challengers that takes on the future and the unknown.

To conclude this message, I would like extend to you my best wishes for this new year, ask for your continued support, and express my hopes for the continued development of our readers.

On the Publication of the Winter Issue of Valqua Technology News

I would like to thank all of you for following Valqua Technology News, and I offer you my best wishes for 2022.

Last year, the global COVID-19 pandemic continued unabated, causing significant impacts on global industry. But amid all this, the pandemic resulted in progress in the construction of a service infrastructure using IT technology and in the development of communication tools, and new business and project processes have become standardized as well. Meanwhile, the business environment around us reflects a growing interest in sustainability, and I am aware that there are a variety of technical discussions around the achievement of carbon neutrality. Also, with networks creating connections between all conceivable things, the management of the information obtained through these networks has become an important business issue. The supply and demand of semiconductors and related components also came to be discussed from the BCP perspective, a new phenomenon this year.

Amid such a business environment, for the last year we have been promoting a variety of initiatives under the concept of Corporate Transformation (CX) in order to achieve the major goals we have set for the 100th anniversary of our founding in 2027. In the area of technology development, we will focus more closely on the open innovation activities that we have already begun in order to successfully evolve into an H&S company. In an era where technology is developing at an extremely fast pace, it is essential that we implement agile, high-quality technology development so that we can continuously deliver new technology solutions to customers. That's why Valqua believes that it is essential to consider collaboration with research institutions, academia, and companies that possess excellent technologies, both in Japan and overseas, with no restrictions on the format. This is also the foundation for the system of collaboration with technology venture companies that we have already announced.

We have accumulated technologies in the fields of seal engineering and material design through our many years of technical activities. Our CX activities in technology development in the future will be based on these technologies, and we will use the open innovation described above to evolve further. Specifically, we intend to use techniques such as materials informatics to create materials with new functions and fuse them with digital information to lead to the construction of new services. One example of this, as mentioned in our previous issue, is developing technology for predictive maintenance using the IoT. Development has already reached the stage where the technology is ready to be introduced to the public, and we hope you look forward to seeing these solutions put to use in actual production sites in the near future.

Under such circumstance, this issue of Technology News will cover application technologies for seal engineering—which was the starting point for Valqua's technology—and sensing technology using new materials as well as methods to consider the appropriate direction for future technology development from the IP perspective. I hope you all find these articles helpful, and I appreciate your continued support of our products and services and for Valqua Technology News.

Director, Managing Executive Officer CTO & CQO Mutsuo Aoki

Results of airtightness test after flange tightening training

1. Introduction

We are a facility that conducts plant maintenance of which there are not many within Nippon Express Co., Ltd., and working hard as the main contractor of daily maintenance tasks and periodic repair work (SDM work) to ensure the safety and stable operation in chemical plants.

In a chemical plant, there are many flange connections (hereinafter, abbreviated as "flange") to connect the main parts of equipment (heat exchanger, reaction vessel, tanks, pumps, valves, etc.) and piping.

Tasks to open and tighten flanges account for a substantial proportion of daily maintenance tasks and periodic repair work, and as a long-term issue, the goal has been to eliminate leaking at airtightness tests. However, on-site confirmation (such as hammering) after implementation of work requires time and effort. There have been many times that we inconvenienced our clients because it took many days to successfully pass the airtightness test.

Figure1　Outside view of the VALQUA Seal Training Center™ (Nara)

Figure2　Inside view (1) of VALQUA Seal Training Center™

Figure3　Inside view (2) of VALQUA Seal Training Center™

In addition, since it is a chemical plant, it is necessary to make the various operators aware about the importance of flange tightening because some inner fluids may be harmful and there is a possibility of a major disaster if there is a leak during plant operation. When we were starting to investigate measures for improvement, we were introduced by Toyo Sangyo, Co. Ltd. that VALQUA has training equipment. We visited VALQUA's Seal Training Center™ (STC) in Nara and experienced the training. Then, we considered the introduction of this training equipment hoping that it could be used to resolve our issues.

We handle a diverse range of gaskets, but we specified the one that is used the most, No. GF300 to be implemented.

This report is about the utilization status of "Flange tightening training" and its results.

2. Utilization of flange tightening training equipment (Settings for JIS10K 100A No.GF300)

2-1) Settings for evaluation criteria

Firstly, to utilize the flange tightening training equipment, proficiency was ranked into 3 levels using stars to clarify the proficiency judged by training results.

"☆☆☆" Pass……Can conduct flange tightening
"☆☆" Level 2……Can conduct tightening under the advice of a team leader
"☆" Level 3……Cannot conduct flange tightening

Criteria for each rank were as follows:

"☆☆☆"……Torque value of bolts ① to ⑧ is within 90±5N·m, and no tendency of uneven tightening according to the line graph.
"☆☆"……Torque value of bolts ① to ⑧ is between 90±5N·m and 90±10N·m, and no tendency of uneven tightening according to the line graph.
"☆"……Torque value of bolts ① to ⑧ is under 80N·m or over 100N·m.

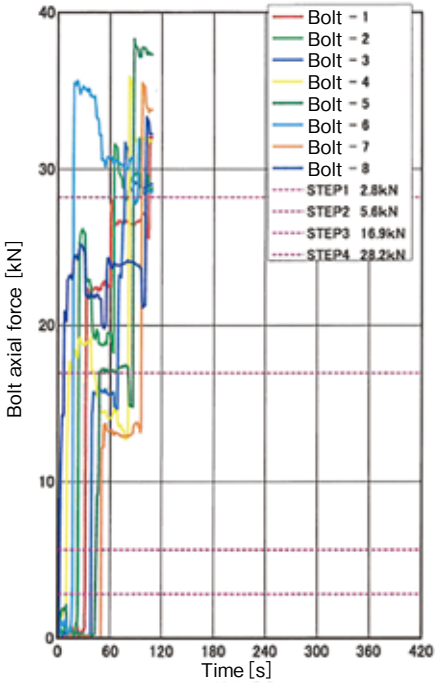

Figure4 Sheet gasket (No.GF300) tightening axial force over time

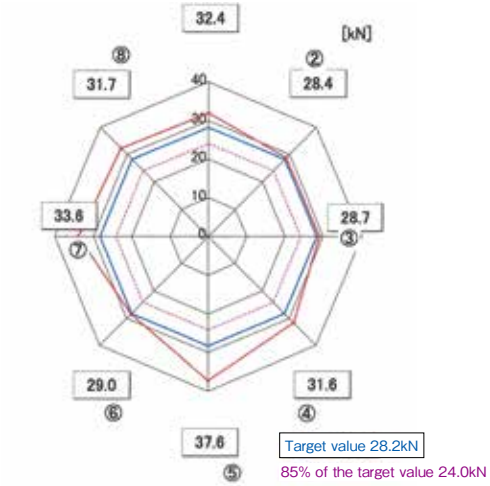

Figure5 Tightening axial force distribution of sheet gasket (No.GF300)

2-2) Training method

①Explanation of tightening method
Explain the method of tightening in a diagonal pattern and increasing the torque in 3 steps.

②Explanation of evaluation criteria
Explain 2-1, and explain why under 80N·m is considered as a failure.

③Training procedure
After each trainee acquires the sense of torque values using the torque-sensor training device (See photograph), they are tested on the flange-tightening training device (Photograph attached) and when this is completed, the results are printed out on the spot for evaluation.

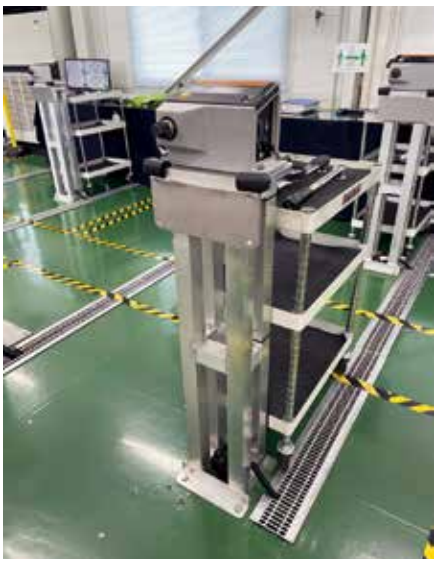

Figure6 Torque-sensor training device

Figure7　Flange-tightening training device

Figure8　Scene from training (1)

Figure9　Scene from training (2)

Figure10　Scene from training (3)

Figure11　Scene from training (4)

3. Results of flange-tightening training

3-1) Situation of the operators' skill level

Table1　Training pass rate

Year	No. of trainees	No. of successful trainees	Pass rate
2017	568	224	39.5%
2018	559	240	43.0%
2019	562	264	47.0%
2020	557	267	48.0%
2021	563	284	50.5%

Five years have passed since we implemented flange-tightening training. It started with a test format as shown in Table1, but in the beginning, rather than find operators that passed, we looked for those that

didn't and restricted them from conducting flange tightening. This led to a significant drop in the number of leakage sites.

Prior to implementation, we asked operators to work on flange tightening based on their years of experience or an estimation based on how the flange looked, but being able to "visualize" with the training was one of the outcomes that were achieved immediately after implementing the training.

This will continue to be part of the education program before the start of periodic repair works.

3-2) Transition in number of leakage sites at periodic repair works

Table2 shows how the number of leakage sites at periodic repair works changed from before training implementation until now.

Table2 Transition of number of faulty airtightness sites

Year	No. of tightening sites	No. of faulty airtightness sites	Pass rate
2017	8500	400	95.0%
2018	8500	400	95.0%
2019	8500	280	96.7%
2020	8500	240	97.2%
2021	8500	180	97.9%

4. Conclusion

Further issues for the future would be that while the test for the training is conducted under good conditions for conducting tightening tasks regarding the site and position, in the actual field, tightening tasks at such good conditions would be less than half the total. There is an advantage that flange leaks at bad conditions stand out and places that require caution become clear, but to reduce the number of leakage sites, we feel that it is necessary to create an environment similar to the actual field for the training equipment and build up the skills of each operator.

In addition, we would like to focus on the status of the flanges (rusted, surface corrosion, distorted flanges, etc.) and of the bolts and nuts (the screw of the bolt is rusted, etc.) and consult with the client to aim to improve the quality of our work and increase customer satisfaction.

The target number of people receiving training is about 300 each for the spring periodic repair works and autumn periodic repair works, respectively. This requires more discussion on how to secure the days and times.

In closing, I would like to thank VALQUA, Ltd. for manufacturing this equipment and conducting maintenance every year, and offering us an opportunity to report, along with the staff in connection with distributor Toyo Sangyo Co., Ltd. We wish for continued cooperation in solving issues in the future as well.

Shinya Kiriyama
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Shunan Branch, Heavy Machinery & Construction Section

Appropriate Tightening Method of Gaskets

1. Introduction

Appropriate maintenance of high pressure vessels is indispensable for safe operation of the plant. The fluids handled may have flammable, flammable, explosive, toxic, and other properties so leaks can lead to disasters and accidents. Therefore, plant operators are conducting daily management to ensure appropriate tightening of the numerous flange tightening sites within the plant.

However, the current situation is that the number of harmful accidents caused by flange tightening has not decreased. Table1 and Figure1 show the analysis of high-pressure gas accidents in Japan. As these statistics indicate, the total number of accidents due to poor maintenance of facilities is not showing a decreasing trend, and about 30% of that constituent factor is due to "flange tightening causes". Therefore, appropriate flange tightening is one of the major issues for the safe operation of a plant.

To increase the skills and knowledge related to flange tightening, establishing standards regarding gasket fitting represented by ASME PCC-1[1] and training programs for gasket tightening tasks like the Seal Training Center are gathering attention.

This report will introduce a summary of items that require careful attention for gasket tightening based on trouble caused by flange tightening.

Table1 No. of cases of accidents due to poor maintenance of facilities

Year	Insufficient corrosion control	Flange tightening causes	Test control failure	Inspection failure	Vessel control failure	Total
2020	104	72	22	37	14	249
2019	155	84	13	35	10	297
2018	124	99	19	35	13	290
2017	113	97	29	30	8	277
2016	109	109	20	42	10	290
2015	93	60	31	17	21	222
2014	78	55	19	11	16	179
2013	80	56	28	16	20	200
2012	65	59	65	8	11	208
2011	67	66	66	8	20	227

Source: METI "Summary of High Pressure Related Accidents"

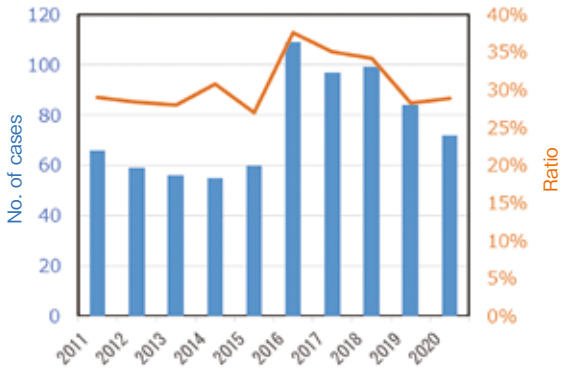

Figure1 No. of cases and ratio of flange tightening related accidents

2. Troubles related to gasket tightening

Analysis of the cause of trouble that occurred in actual gasket work cases found that the major causes were insufficient tightening, excessive tightening, and uneven tightening.

Insufficient tightening is the state where the appropriate surface pressure is not on the entire gasket. It is common in flat face flanges or when flange or bolt strength is insufficient. In addition, a decrease in gasket surface pressure due to stress relaxation may lead to leakage and damage due to the gasket being unable to resist internal pressure and being pushed out by the fluid (blow out). Figure2 shows the external appearance of a blowout gasket.

Conversely, gasket destruction may occur if gaskets are tightened excessively. This is especially common in fluorocarbon resin envelope gaskets. As shown in

Figure3, many circumferential cracks are generated and destroyed, leading to leakage.

Uneven t tightening refers to a state in which the gasket surface pressure becomes uneven. If sections of the gasket are insufficiently tightened or excessively tightened, this causes partial leakage, ruptures, and deformities. Figure4 shows uneven tightening. In this case, tightening strength was low in some sections, and friction between the flange and gasket decreased, causing leakage by being pushed out with internal pressure.

These failures are all caused by Inappropriate tightening and highlight the importance of tightening management. Therefore, we will introduce basic tightening procedures and control methods to conduct appropriate tightening tasks.

Figure2　Case of gasket blowout due to insufficient tightening

Figure3　Case of compression failure due to excessive tightening

Figure4　Case of deformity due to uneven tightening (insufficient tightening in a section)

3. Standards for the tightening procedures

In general, multiple bolts of pipe flanges are tightened, but the tightening task is normally conducted one-by-one. The axial force of a bolt of the tightened flanges changes upon the tightening of other bolts, and the axial force decreases in many cases. This phenomenon is called elastic interaction. The effect of elastic interaction is minimized by repeated multiple tightening to adjust the target bolt tightening load.

ASME PCC-1[1] and JIS B 2251[2] are introduced as standards that show multiple tightening procedures. ASME PCC-1[1] and JIS B 2251[2] standards perform diagonal tightening after circular tightening. Diagonal tightening effectively prevents uneven tightening of the gasket by increasing the tightening torque in stages. Tightening in a circular pattern reduces the inconsistent tightening load due to elastic interactions in adjacent bolts.

Table2 compares ASME PCC-1[1] and JIS B 2251[2]. JIS B 2251 is a standard that enables even more efficient and accurate tightening than the ASME PCC-1[1] established earlier. In ASME, all bolts are tightened during diagonal tightening, but in JIS, only 4 to 8 bolts are tightened. It is more efficient when the number of bolts is large. Regarding the circular tightening at the target torque, ASME is until the nut stops rotating, but JIS sets an upper limit on the number of times. Furthermore, setting in JIS the target torque to 110% when the number of bolts is 12 or more is also a technique for quickly achieving the target bolt axial force. The JIS B 2251's applicable range is joint sheet gaskets and spiral

Table2　Tightening procedures in JIS B 2251 and ASME PCC-1

JIS B 2251		ASME PCC-1	
Stages	**Procedures**	**Stages**	**Procedures**
Preliminary tightening	Only 4 or 8 target bolts Stage-wise, diagonal tightening	Preliminary tightening	All bolts Snag torque (≤20%)
Main tightening	All bolts tightened in a circular pattern 100% Target torque is 110% for over 12 bolts No. of times going around: 4 to 6 cycles	Rounds 1 to 3	All bolts are tightened in a step-wise diagonal pattern
		Round 4	All bolts tightened in a circular pattern 100% (Until the nut does not rotate)
Additional tightening	After 4 hours passes, same of tightening as the main tightening No. of times going around: 1 to 2 cycles	Round 5	After 4 hours passes, same tightening as Round 4

Snag torque: Necessary torque to firmly attach the bolt seating surface

wound gaskets. However, our in-house experimental results confirmed that this is also applicable for High Performance Non-asbestos Sheet by No.GF300 and fluorocarbon resin sheet gaskets.

4. Tightening control method

Quantitative tightening management methods for gaskets include a torque method, a rotation angle method, a torque gradient method, an axial force management method using an ultrasonic axial force meter, and a bolt tensioner. Each method has advantages and disadvantages, and it is necessary to select a method by comprehensively determining the balance among workability, construction accuracy, etc. Table3 shows a comparison of various control methods.

JIS B 1083 Rules for Bolt Tightening[3] proposes the torque method, rotation angle method, and torque gradient method. The torque method only controls tightening torque using a torque wrench. It is used widely as a simple and conventional control method. However, about 90% of tightening torque is consumed by the friction of the bolt face and seating, and therefore, variation is likely to occur depending on the frictional properties of each material.

The rotation angle method is a method that controls the rotation angle of the bolt by tightening. When tightening at the elastic region of bolts, the variation becomes more significant if the rigidity of the bolts is high. Conversely, when tightening at the plastic region, it is less likely to be affected by rotation angle error. Still, there is an issue that bolts become plastically deformed and cannot be reused.

The torque gradient method uses the tightening rotation angle and tightening torque gradient as tightening indicators, and the yield load of bolts is the target value. It is used to keep the variation in initial tightening small and maximally utilize the elastic region of the bolt. As with the rotation angle method of the plastic region, it is necessary to take care not to exceed the yield point and proof load.

Axial force control of the bolt is possible with high-precision tightening control because it is not affected by friction with the seating, and axial force of the bolt is controlled using devices such as ultrasonic axial force meters and bolt tensioners.

Ultrasonic axial force meters are a method that measures the length of the bolt and obtains the axial force from the difference in bolt length before and after tightening. It is applicable only in the elastic region where the axial force and bolt elongation are in a proportional relationship. The method has high precision, and the measurement itself is simple, but it is necessary to keep the surfaces of both ends of the bolt smooth.

Bolt tensioners are a method that pulls the bolt with hydraulic pressure until the pre-designated target axial force. The nut is tightened, and the hydraulic pressure is released to give the designated axial force. Extra bolt length and space are required for attaching the bolt tensioner. Both ultrasonic axial force meter and bolt tensioner have high precision but require time and cost. They are often used in important sections such as high-pressure pipes and large diameter flanges.

For non-quantitative tightening, hand wrenches are used for small diameter flanges, and impact wrenches are used for large diameter flanges. However, experience is required for even tightening because variation is high, and it isn't easy to control tightening strength.

As a sealing manufacturer, we recommend the quantitative tightening control methods shown in Table3.

Table3 Quantitative tightening control method

Tightening control method	Tightening indicator	Tightening region
Torque method	Tightening torque	Elastic region
Angle rotation method	Tightening rotation angle	Elastic region Plastic region
Torque gradient method	Tightening torque gradient of tightening rotation angle	Elastic limit
Ultrasonic axial force meter	Bolt elongation	Elastic region
Bolt tensioner	Bolt axial force	Elastic region

5. Effect of tightening procedure on bolt axial force

We will introduce the results evaluating bolt axial force and gap between the flange faces with the tightening methods of ASME PCC-1 and JIS B 2251[4]. Tables4 and

5 show the test methods, Figure5 shows the measurement results of bolt axial force, and Figure6 shows the measurement results between flange faces. Gaskets were spiral wound gaskets (No.6596V) with expanded graphite filler and joint sheet gaskets (No.6500) , dimensions are JPI Class 300 24 inch.

Figure5 shows that for No.6596V, the mean value was higher in bolt axial force and the variation was lower. for JIS B 2251 than ASME PCC-1. This is because in JIS B 2251 stipulates that "for spiral wound gasket, perform circular tightening with a tightening torque of 50% after the preliminary tightening," and set the target torque as110%. The gasket width of spiral wound gaskets is narrow, and there is a tendency toward uneven tightening because the compression amount is high. In ASME PCC-1, circular tightening is until the nut does not rotate and as shown in Table5, the number of times of going around is higher for JIS B 2251.

Next, Figure6 shows the gap between flange faces, and as shown in the results for bolt axial force, for No.6596V, the tightening procedures for JIS B 2251 had a smaller gap between faces. In addition, regarding the variation of the gap between flange faces, the tightening procedures for ASME PCC-1 did not show a variation as large as that for bolt axial force.

Table4 Test conditions

Gasket	Spiral wound gasket No.6596V	Joint sheet gasket No.6500
Dimensions	JPI Class300 24inch t4.5	JPI Class300 24inch t3.0
Diameter of flange seat	ϕ692.2	ϕ692.2
Bolt	M39, 24 bolts	M39, 24 bolts
Target gasket face pressure	40MPa	40MPa

Table5 Tightening procedures

	JIS B 2251	ASME PCC-1
Tightening stages until target value	4 stages	3 stages
Tightening procedures	At preliminary tightening: Diagonal tightening At main tightening: Circular tightening	Diagonal tightening Circular tightening
Target bolts	At preliminary tightening: 4 bolts At main tightening: All bolts	All bolts
Total number of stages until completion of tightening	11 stages	8 stages
Notes	Tightening at 110% of target torque	At circular tightening, tightening until nuts do not rotate

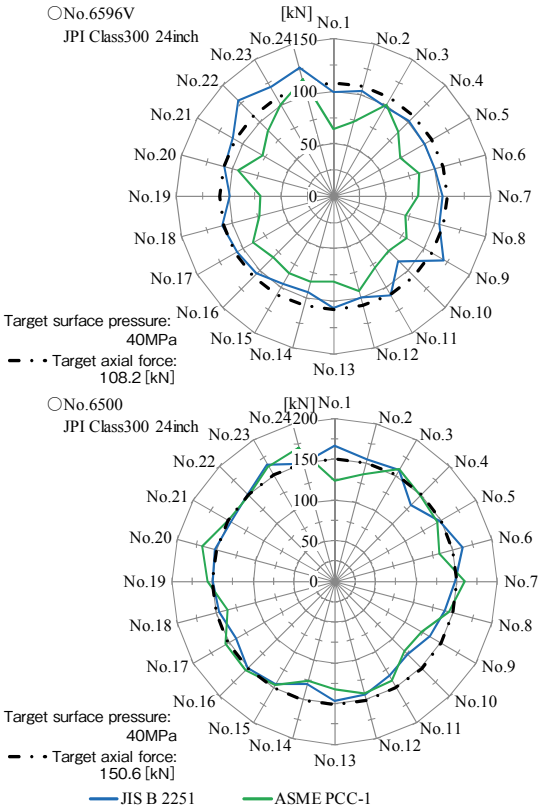

Figure5 Distribution of bolt axial force

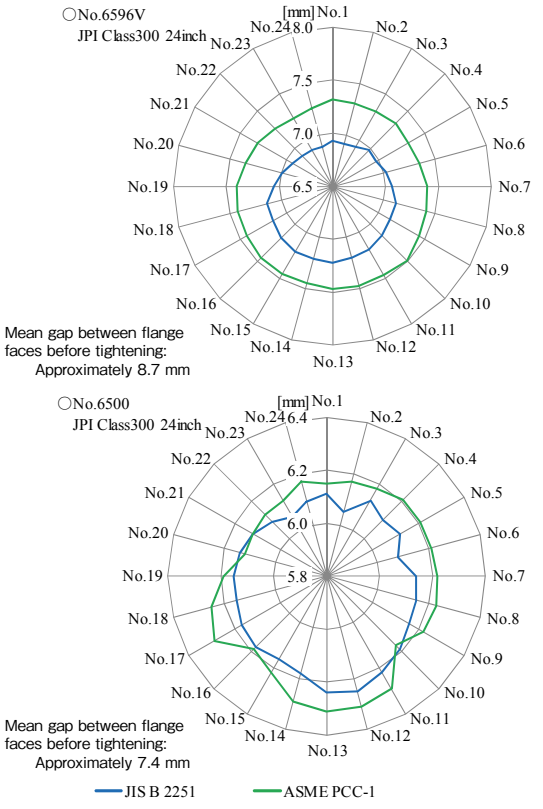

Figure6 Gap between flange faces

6. Conclusions

The equipment of domestic plants is aging, and by 2025, most of the equipment will be in operation for more than 40 years. Therefore, an "increased risk for accident occurrence" and "decreased profitability due to decreased operating rate" is anticipated. This report introduced several cases of gasket trouble, basic procedures for tightening, and methods to control tightening. Our company will continue to provide seal engineering services as a sealing manufacturer and contribute to eradicating accidents due to leakage.

7. Reference

1) ASME PCC-1, Guidelines for pressure boundary bolted flange joint assembly (2010)
2) Japanese Industrial Standards. JIS B 2251 "Flange connection tightening method" (2008)
3) JIS B 1083, Rules for Bolt Tightening (2008)
4) Takahiro Fujiwara, "Effect of tightening procedures on sealing properties", Valqua Technology News Vol. 37 (2019)

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IP Landscape Initiatives

1. Introduction

IP landscape is becoming widely recognized as an offensive intellectual property strategy. The main entity in this initiative is the intellectual property division within the company, but close coordination with the management, R&D division and business division is essential. As the degree of recognition of IP landscape rises, services that provide external consultation and analysis software to support companies are seizing this business opportunity and starting to increase.

Looking back on intellectual property strategies at the national level, first of all, the declaration by the Cabinet of Junichi Koizumi on Japan as a "Nation Built on Intellectual Property" in 2002 to increase the creation, protection and exploitation of intellectual property (IP) such as patents and contents that have traditionally been strong areas for Japan, to compete against the US who have increased their competitiveness by using IT (information technology) such as the Internet as a weapon, and the rapid growth of Korea and China regarding manufacturing can be mentioned1) . At that time, the Intellectual Property Promotion Plan was established as a national strategy, and the founding of the IP High Court, and revision of the patent law related to inventions by employees were promoted at the national level.

In June 2018, the government further announced "Aiming for a "value design society", Intellectual Property Strategy Vision"[2]. This summarized a vision to direct the long-term developments and measures for thirty years onwards from 2025 that utilize technology such as AI and blockchain against the backdrop of a transition from paying for physical goods to paying for experiences. In these times when the societal image of the future is drastically changing, it is important to continuously consider and disseminate new values and have these values felt by the people throughout the world, and it was anticipated that intellectual property such as "service", "solution" and "information data" would drive the future.

In June 2021, the Financial Services Agency and Tokyo Stock Exchange revised the Corporate Governance Code to include the description, "In view of the importance of investment into human resources and IP, effective directions should be taken to help sustainable growth of companies by distribution of these and other management resources and strategic implementation of business portfolios"[3]. With this, Intellectual Property Strategy Headquarters at the Prime Minister's Office and METI collaboratively established a "Study group on effective disclosure and governance of IP investment and utilization strategy" from August 2021. At this study group, it was recognized that in a time where the management environment of companies is significantly changing with the recent advances in digitalization and going green, IP and intangible assets that are indispensable for a company's management are considered to be also drastically changing. Therefore, it is further required to accurately recognize how IP and intangible assets can be utilized for sustainable management of a company's future" and "validate their business model based on the importance of IP and intangible assets for management and it is unavoidable to construct a strategy to maintain and strengthen IP and intangible assets that support competitiveness and investigate a sustainable business model that utilizes the IP and intangible assets that are a strength upon firmly

understanding and analyzing why IP and intangible assets are necessary for the company's management and what IP and intangible assets are the source of competitiveness and differentiation as a strength of the company and how this leads to value creation and the creation of cash flow". This is the current situation where companies are even more expected to understand their own company and other companies' strengths and weaknesses from the prospective of IP and investigate sustainable business models.

2. What is IP landscape?

Among these formulation and promotion of IP strategies at the national level, there is a growing movement to directly utilize IP analysis in management and business. Although many companies are now considering IP landscape, since the target of IP landscape in each company is analysis handling confidential items such as business strategy and R&D strategy of each company, no company completely discloses its analysis process and results, and many companies only disclose a summary.

The definition of IP landscape differs widely and the content of each company's measures is varied because there is no set definition. Some major companies have established a specialist team to actively handle this in an organized manner, and there are some examples of public announcements regarding the results, but it is extremely rare for a company to disclose detailed content such as introducing development cases of specific products and services.

In this report, we define IP landscape as "analysis of IP information within the global market, observing customer needs, technological trends and the situation of players in a multifaceted way to utilize it for searching new markets and uses for products and developing new businesses and products". At Valqua, we are already utilizing IP landscape for searching new uses and opening up new businesses and products, and promoting the development of value-added products and services to resolve unknown issues in discussion with the Development Division and Business Division.

3. Investigation tool

In this report, an example of an analysis method for IP landscape targeting PTFE is introduced.

Mapping was conducted to allow a visual understanding of which technical areas have the most PTFE-related patent applications (Figure1). This technical classification was prepared based on the international patent classification designated by a global IP association and the number of patent applications for PTFE is displayed by the shade of the color. Red is the technical area with the most patent applications and grey is the technical area with the least patent applications.

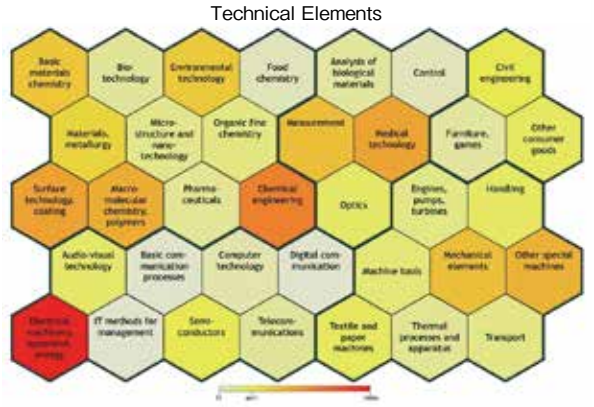

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Figure1　Patent application technical classification for PTFE

By using such figures, it is possible to visually and macroscopically understand the technical areas regarding PTFE that are being focused upon and those that are not. In addition, by focusing the analysis target on specific companies, it is also possible to understand the PTFE-related fields that each company are focusing upon. Figure2 indicates the technological concepts that

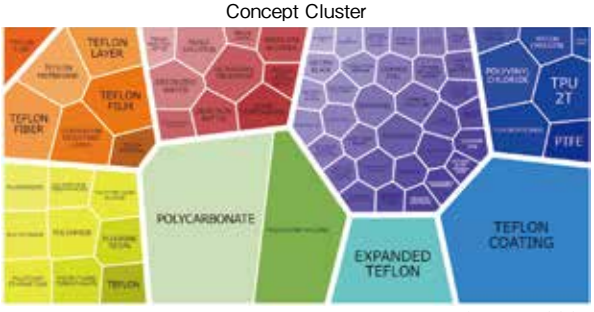

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Figure2　Technological concept mapping of PTFE

have patent applications and the target for PTFE related patent groups.

This concept map groups the PTFE-related patent applications by concept and each group's area is correlated with the number of patent applications. Utilizing such concept maps, it is possible to understand the details of individual patent contents such as the concepts that are receiving high attention or low attention and unexpected concepts, and it is thought that this may lead to clues for searching new uses and developments.

Figure2 is a visualization of PTFE technology in general and by focusing on specific companies, it could also be helpful in understanding the strengths and weaknesses of those companies.

Figure3 shows a different analysis of PTFE patent applications. This is color-coded by technology clusters and the number of patent applications is indicated by contour lines. The larger the number of patent applications, the higher the contour lines. This figure also allows a macroscopic visualization of areas that have many patent applications. By preparing this type of mapping for each year, it is also possible to understand technical trends by time by seeing the sections that recently increased in height.

Landscape by technology cluster

Figure3　Landscape of PTFE

4. Activities

4-1) CX

Valqua has positioned 2021 as the starting year for corporate transformation (CX), and promoted various initiatives. Not limiting ourselves to providing hardware, but placing the evolution into a H&S company that delivers value-added service to customers as our basic principle, we are promoting development activities for our service technology products, that incorporate digital solutions, to be a trigger for innovative digital transformation for our customers' total business.

4-2) IP activities

We are placing an emphasis on IP landscape as part of corporate transformation from the IP aspect. Patent application activities are conducted in new areas as a result of searching for new value-added services and new product candidates through active utilization of the IP landscape.

IP landscape study tools have many features and the analysis tools are evolving daily. While enhancing the training of staff to enable analysis according to their aim, we work towards actively implementing the most recent tools.

In May 2019, as part of open innovation, we announced the establishment of the Cooperative Research Laboratory for Advanced Functional Materials with National Institute of Advanced Industrial Science and Technology (AIST)[4]. Valqua is conducting advanced functional material development with AIST and we are currently applying for patent applications regarding the technical results. Valqua is implementing IP landscape for searching for uses of such materials and also promoting ways to search for uses that would be a target. Such initiatives will continue to be used actively as a method to search for uses of seeds.

In addition, regarding the development of services that consider digital transformation (DX), conducting IP landscape should allow us to strengthen and promote our main activities in the future by providing high value-added services that combine the areas that are Valqua's strength together with IT technology.

5. Conclusions

In this article, we introduced Valqua's activities related to IP landscape, but the content is limited because of the need for confidentiality. Valqua intends to work on solutions that can provide ways to solve our customer's issues by implementing value creation from a new viewpoint, IP, in addition to technical development based on our customer needs and on seeds that we have always provided.

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Usui Nobuta
INTELLECTUAL PROPERTY DIVISION

Applications of PTFE nanofibers for flexible devices

1. Introduction

Valqua has considered various application utilizing PTFE nanofibers.

In this project, we worked with CONNECTEC JAPAN and started from the stage of brainstorming for ideas on utilizing PTFE nanofibers. CONNECTEC JAPAN has their proprietary low-temperature application technology and is experienced in producing flexible devices.

Among several of the candidates, we focused on the air permeability and flexibility of PTFE nanofibers and also the insulating and water-repellent properties of PTFE material to consider the possibilities of PTFE as a flexible device.

As flexible devices, we assumed uses in healthcare and wearables. Here we introduce a concept model for flexible devices that was produced by conducting technological development that included direct wiring formation on PTFE nanofibers.

2. Characteristics of PTFE nanofibers

First, we will have a general overview of PTFE nanofibers[1]. As a material, PTFE nanofibers have a nonwoven fabric structure and are an aggregate of PTFE fibers with a diameter of approximately 600 to 700 nanometers (Figure1). The fibers consist of 100% PTFE and are produced from PTFE dispersion using a special electrospinning method.

PTFE nanofibers have the following features through its characteristics as PTFE material and having nanofiber structure.

- Chemical -resistant, climate-resistant, heat-resistant (260℃), fire-resistant
- Safe for humans (non-invasive, clean)
- Water-repellent
- High electric resistance, low dielectric constant
- Flexible material
- Good air permeability
- Resistant to thermal deformation

Table1 shows the general properties of PTFE nanofiber nonwoven fabric. It is a material with porosity of 80 to 90 % and repels water but has permeability. Expanded PTFE is a material with similar structure and characteristics, but it shrinks significantly when exposed

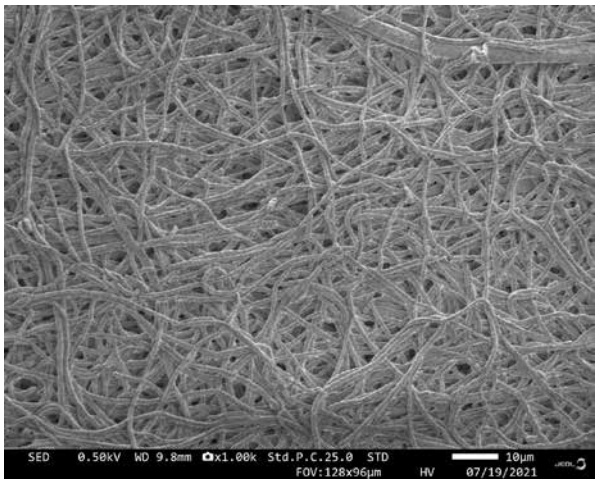

Figure1 Structure of PTFE nanofibers

Table1 PTFE nanofiber properties (representative values)

Properties	Value
Basis weight [g/cm^2]	16.7
Thickness [um]	56
Volume resistance [Ω・cm]	10^{13}
Dielectric constant (@6 GHz)	1.14
Water contact angle [°]	140
Air permeability [L/min/cm^2/psi]	4.3

to 260℃, whereas PTFE nanofiber nonwoven fabric barely shows any thermal shrinking (Figure2).

Figure2 Difference in thermal shrinking of PTFE nanofiber nonwoven fabric (left) and ePTFE (Right)

3. Formation of wiring on PTFE nanofibers

3-1) Wiring formation

To use as a flexible device, we considered using PTFE nanofibers itself as a circuit board.

Wiring formation on PTFE nanofiber was conducted by the printing method. In general, as wiring formation methods for electric circuits, there are several methods: photolithography method, inkjet printing method, screen printing method and gravure offset printing method. This project used the screen-printing method and jet dispenser method.

Control parameters include conductive ink type (conductive particle type and diameter, solvent, viscosity), printing speed, and discharge pressure in the case of jet dispenser. Optimization of these parameters made it possible to conduct wiring formation on PTFE nanofibers.

Figure3 and 4 show examples of printing of circuits using screen printing and jet dispenser. Both methods were able to form wiring without any bleeding of conductive ink when printed under optimal conditions.

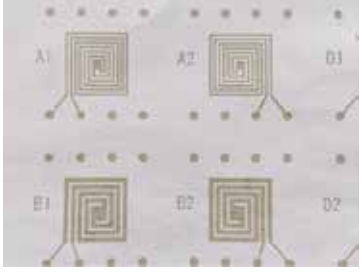

Figure3 Example of wiring by screen printing

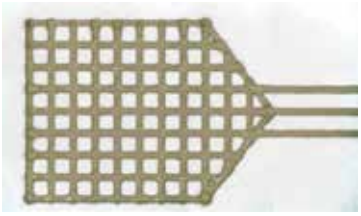

Figure4 Example of wiring by jet dispenser

3-2) Microstructure

Figure5 and 6 show a cross-section photograph of circuit boards formed by the jet dispenser method. Generally, the PTFE surface is water-repellent and oil-repellent, and it is a material that is difficult to be printed on as designed by conductive ink. However, as the figure shows, wiring material is formed and attached at the designated line widths on the PTFE nanofibers. Additionally, it can be seen in the enlarged figure, that a portion of the conductive ink component has entered the micropores of PTFE nanofibers, thus maintaining adhesion with PTFE nanofibers, and no bleeding of conductive ink is confirmed.

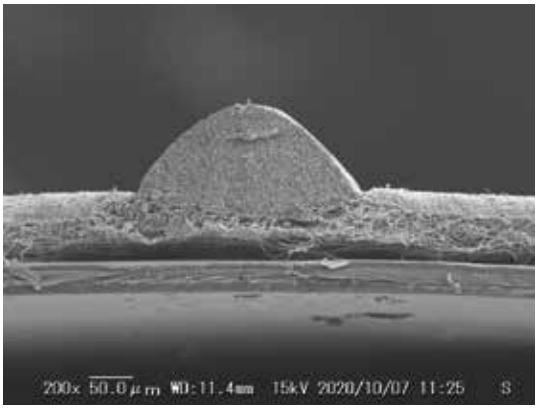

Figure5 Surface of PTFE nanofibers and wiring

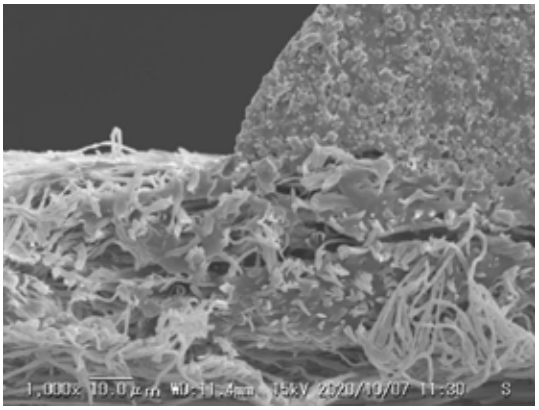

Figure6 Enlarged view

3-3) Durability tests

In this project, we confirmed the adhesion of conductive ink with PTFE nanofibers and the change in electric resistance value using MIT tests.

The sample used this time was an electromyography sensor that will be mentioned later, and it was used after circuit formation with line width of 0.5mm, followed by covering the circuit with insulation material.

The MIT test was conducted using a tester as shown in Figure7. Table2 shows the test conditions (refer to JIS P8115. However, considering the strength of PTFE nanofibers, no load as designated). Circuit properties were measured as electric resistance between the two edges of the electric circuit before and after the test.

Table2 MIT testing conditions

Parameter	Testing conditions
Test rate	90 cpm
Bending angle	135°
Radius of curvature	0.38 mm
Test repeats	3,000 repeats
Load	—

Figure7 MIT tester

As a result of the test, Figure8 shows no sign of disconnection at the bending section (red dotted line). In addition, Figure9 shows no significant change in electric resistance value, and this means good electric conductivity was maintained even after the test.

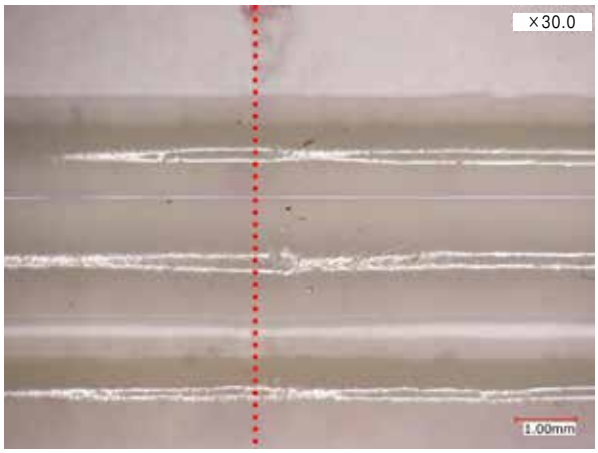

Figure8 Photograph of the bending section (After 3,000 repeats)

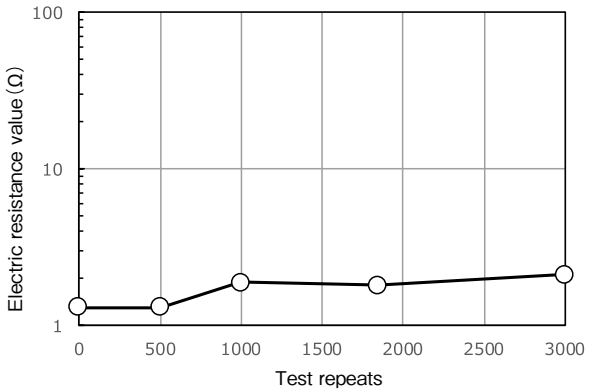

Figure9 Relationship of conductivity change due to MIT test

4. Application to flexible devices

Figure10 shows a photograph of PTFE nanofibers with various wiring patterns. By using printing methods, it is possible to form various wiring patterns.

Figure10 PTFE nanofibers forming various wiring patterns

As an example of a flexible device using PTFE nanofibers with wiring patterns, we tried electromyography sensors and touch sensors.

Generally, electromyography sensors are made of patch-type electrodes and assumed to be unsuited for continuous use because they do not have air permeability. In contrast, sensors that use PTFE nanofibers would have the characteristics of PTFE itself and be safe for medical use, non-invasive, and water-repellent, as well as air permeability that nanofiber structures have. Therefore, it would be unlikely that they have an adverse effect on the body even if continuously used, and they would be appropriate for wearable devices. In addition, it is difficult to convey over words, but the material has a gentle texture when next to the skin, and this is another point that makes it ideal for continuous use.

Figure11 shows a trial electromyography sensor. In this figure, the 3 electrodes are made to be worn separately, but it is also possible to combine them as shown in Figure12, and it could be considered to be used as a wristband type device.

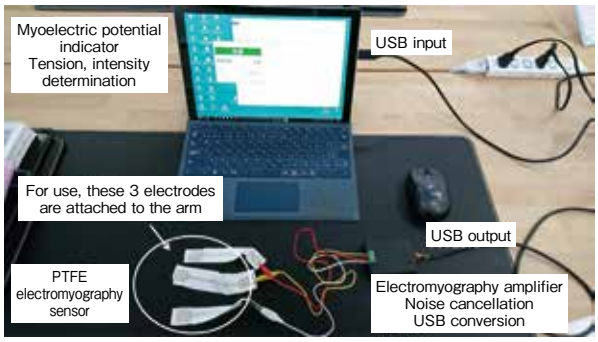

Figure11　Trial electromyography sensors
(Electromyography amplifier and display software are products from Tokyo Devices Inc.)

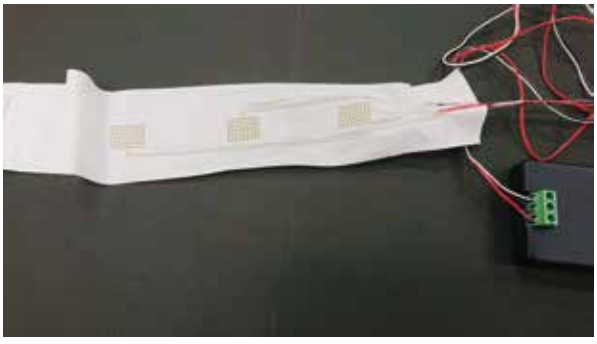

Figure12　Electromyography sensor, integrated type

Figure13 shows a trial touch sensor. A capacitance change type touch sensor was manufactured as a trial. The sample shown in the figure had variability in the detection sensitivity per matrix, but was confirmed to have the basic functionality of a capacitance change type touch sensor.

PTFE nanofibers themselves do not have stretchability, but they have the ability to follow free-form surfaces of a certain degree of size, and applications to various input user interfaces including wearables can be considered.

Figure13　Trial touch sensor
(Microcomputer board and display software from Renesas Electronics Corp.)

5. Future developments

This time, we investigated the utilization of PTFE nanofibers in flexible devices. By forming wiring on PTFE nanofibers, we think that we have shown possibilities as to their application that go beyond their utilization as only a material. In the future, with the progressively ageing society in Japan, we think that the use of wearable devices in the healthcare field will increase. In addition, there are types of devices such as foldable smartphones that have not been seen before, and it is predicted that various user interfaces will be further required in the future.

To be able to follow this drastic changing society in a flexible way like nanofibers, we will continue our efforts on further expanding the examples we have shown here and also produce products that benefit society.

6. Conclusions

Through a collaborative effort with CONNECTEC JAPAN, we were able to show new possibilities for utilizing PTFE nanofibers. We think that the utilization cases that we introduced in this report are only a portion. We consider that the development of novel devices could be possible using Valqua's unique material, PTFE nanofiber, and CONNECTEC JAPAN's proprietary low temperature technology. With this, we hope that we can help realize our readers' ideas.

7. References

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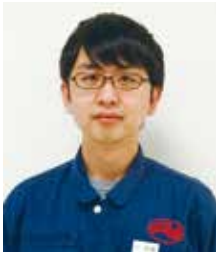

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VALFLON™ lined steel pipes Gasketless mechanism

1. Introduction

VALFLON™ (PTFE) has anti-corrosive properties and does not elute of metal ions. VALFLON™ lined steel pipes are used for the transport of chemical solutions (strong acid, alkali, solvents, etc.) manufactured at chemical plants and in piping that handles high-purity items for the semiconductor industry. Other than VALFLON™ piping materials, lines with corrosive fluid that cannot be carried by metal tubes use glass lining pipes and karbates. However, these have low mechanical strength, and are easily damaged if used as scaffolding or receives impact during piping work. In addition, if there is a concentration of stress due to land subsidence or earthquakes, it has the disadvantage of possibly causing unanticipated accidents. VALFLON™ piping material, utilizing the superior flexibility of VALFLON™, is appropriate for these uses. Recently, in the semiconductor industry, VALFLON™ piping material is used for handling high purity chemical solutions.

As the connecting structure of such VALFLON™ piping material, flanges are installed at the connecting pipe ends and a gasket is placed between the flanges at the pipe connection to be tightened. In this report, we will introduce a "gasketless mechanism" that does not place a gasket in between the flanges.

2. Outline of gasketless mechanism

2-1) Problem to be solved

1. There is no specific installation position for gaskets or seat for fixation
2. Misalignment of gasket may lead to decrease in sealability
3. Misalignment of gasket may lead to gasket protruding into the inner pipe and may adversely affect inner environment due to fluid accumulation
4. High-level skill (techniques) to precisely align gasket and transfer of those skills (techniques)

For connection of pipe components, to avoid misalignment within the flow route, the center axes of the connecting flanges need to be placed facing each other to allow flow, and also the center axis of the gasket that is the containment section must also be placed in alignment with the central axis of the flange. However, there is a problem that high skill (technique) is required for connecting the pipes with high precision alignment of flange and gasket. First, the flange that is formed as one with the piping component or fixed at the open end of the piping component, gaskets are a different material from pipe components and second, there is no gasket seat to fix the position or determine the alignment of gaskets on the flange flare surface.

For pipe installation devices, even if the pipe routes are connected through a central axis, if the gasket is installed misaligned, part of the open ends of the gasket bore would protrude into the tube. There is an issue that protrusions of the gasket would increase the flow resistance of the liquid within the pipet and substances that flow with the liquid may accumulate at the protrusions and lead to worsening of the inner environment. Other than this, piping connections that use conventional gaskets close the connecting section by placing each flange surface in contact with the opposite side of the gasket, and crushing the two gaskets from both sides by tightening the flanges. In other words, the two flange surfaces have a structure that do not come in

contact because of the gasket in between. Such connecting devices have issues because they may decrease in pipeline sealing properties due to reasons such as a gasket that is not installed in the appropriate position leading to uneven flange tightening.
Figure1 and 2 show a photograph and diagram of the pipe junction.

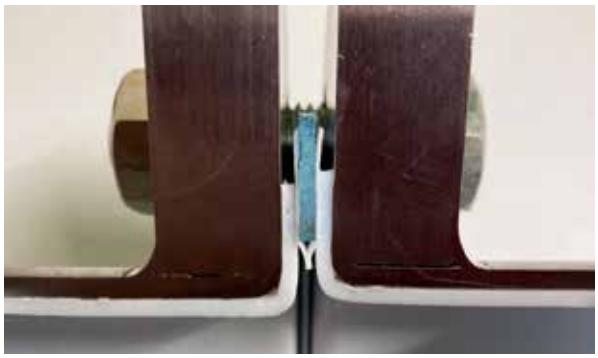

Figure1　Photograph of the pipe junction

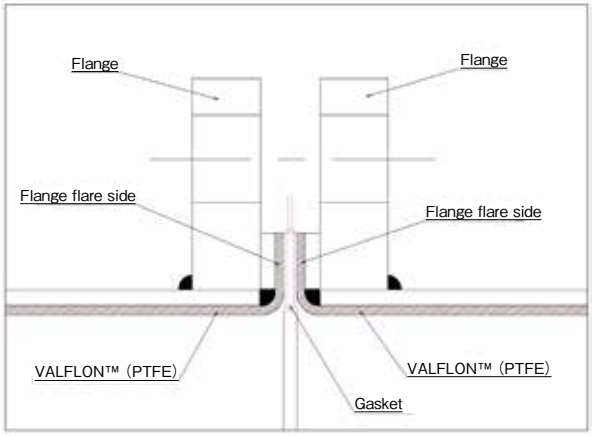

Figure2　Diagram of pipe junction

2-2) Measures to solve the issues

To solve the above issues, VALFLON™ (PTFE) that is used in sections of the flange No. 1 formed at the opening of the tube No. 1 and flange No. 2 formed at the opening of tube No. is pressure bonded together and this has a metal touch junction that connects the metal of the flange flare that seals the surrounding area of the pipeline junction and the flange section that does not have VALFLON™ (PTFE) lining.
In the above piping device, the metal section of flange No. 1 and flange No. 2 have a concave-convex shape that is a structure that relieves misalignment of the pipes at the tightening section. Figure3 shows the junction.

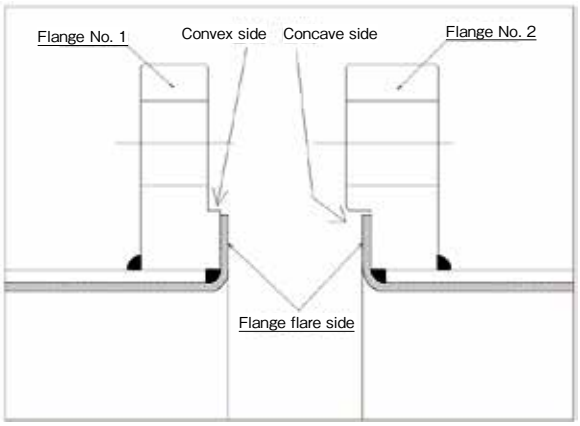

Figure3　Diagram of junction

After flange tightening, the lined junction is a structure that minimizes misalignment.
Figure4 and 5 show a photograph and diagram of the junction after tightening.

Figure4　Photograph of junction after tightening

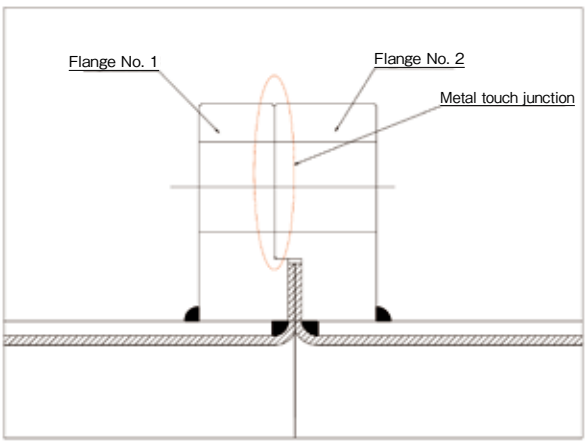

Figure5　Diagram of junction after tightening

3. Effect anticipated for gasketless steel pipes

(1) By connecting flange surfaces without a gasket in between the flanges, the occurrence of variability in the tightening state at the flange surface due to tightening tasks can be lowered and tightening precision can be improved.

(2) The housing section that was formed in a section of the flange houses the lining used for a section of the flange surface, and the lining that is pressure bonded due to the tightening of the flanges seals the area around the pipeline connecting section and realizes a piping device that has simple installation procedures while maintaining the sealability of flanges.

(3) Regarding the connection of pipes, by not having a separate component such as gaskets, it is unnecessary to determine the position of the gasket against the flange surface or maintain that state until tightening. Therefore, work efficiency improves and it is possible to improve the precision of tightening tasks without depending upon the assembly operator's skill (technique).

(4) Gasketless mechanism can prevent flow resistance within the pipeline by gaskets that were tightened in a misaligned position and prevent the accumulation of substances that are contained in the fluid.

(5) After connection of pipes, by not having a gasket in between, it is unnecessary to do retightening to maintain sealability.

(6) Metal touch mechanism can reduce the loosening of bolts due to vibration because there is no gasket in between.

4. Sealing performance

4-1) Pressure resistance and leakage tests

Standard tests and inspections for lined pipes were confirmed for gasketless mechanism. Table1 shows the pressure resistance and leakage test conditions and Figure6 shows a diagram of pressure resistance and leakage tests. It was confirmed that it is possible to maintain sealability with no problems without gaskets.

Table1 Pressure resistance/leakage test conditions

Pressure (MPa)	Retention time (min)	Fluid	Pinhole inspection
1.5	10	Water	AC15KV

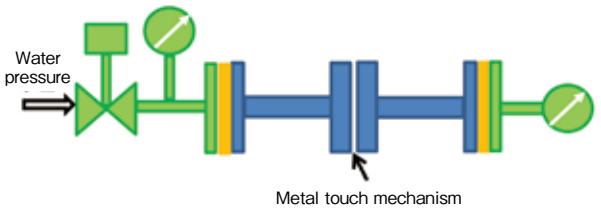

Figure6 Diagram of pressure resistance/leakage test

4-2) Heat cycle test

After connecting the pipes, the heat cycle was repeated to confirm whether leakage may occur due to stress relaxation of the sealing surface. Table2 shows the conditions for the heat cycle test and Figure7 is a diagram of the heat cycle test.

As a result of the heat cycle test, it was confirmed that sealability could be maintained without any problems.

Table2 Conditions for heat cycle test

	Pressure (MPa)	Retention time (min)	Fluid
①	0.6MPa	30	165℃ saturated steam
②	0.6MPa	15	Water at room temperature
※ Test is implemented by 100 repeats of ①→② as 1 SET			

Confirmation of sealability after test

Pressure (MPa)	Retention time (min)	Fluid	Pinhole inspection
1.5	10	Water	AC15KV

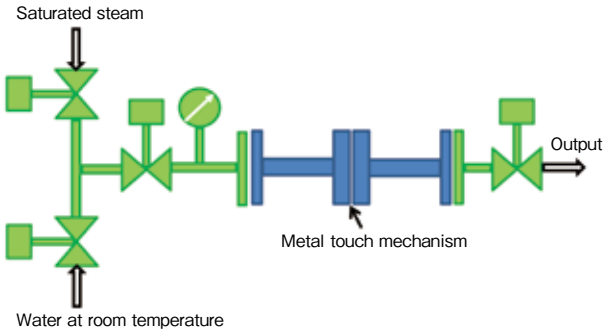

Figure7 Diagram of heat cycle test

5. Conclusions

VALFLON™ lined pipes with gasketless mechanism is a product that was produced with the customer's viewpoint, such as pipe installation and flange tightening control in consideration. In addition, it has the safety features because of its fire-safe property that would minimize the possibility of spreading fire. In the future, with further improvements, we aim to complete products that would be a mainstay of lined pipes and make products that our customers are satisfied with.

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Nobuyuki Kawai
VALQUA METAL TECHNOLOGY CO., LTD.
Production Division

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No.41 Summer 2021

● **Valqua Technology News Greetings** Director & CTO Mutsuo Aoki

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Winter 2022

No.40 Winter 2021

No.42

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● **Customer Solutions《Contribution》**

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Taiwan CNPC Corporation Lin-Yuan Petrochemical Plant, Petrochemical Division Lin Hsin-Cheng

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Elastomer Team, Product Development Department, Research and Development Division Ryosuke Nishi

● Product introduction

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No.39 Summer 2020

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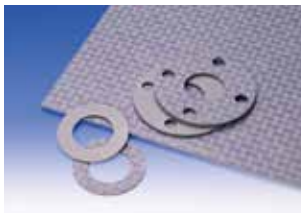
● Operating temperature range: -200 to 1200℃ ● Maximum pressure: 1.0MPa
*Please refer to our catalog for details.



UNIVERSAL HYPER™(UF300)

Sheet gasket that can be integrated in chemical lines.
In addition to stability at high temperatures and long-term use, chemical resistance has been improved, greatly expanding the range of applicable fluids.
It can be used for both strong acid and strong alkali lines.

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*Please refer to our catalog for details.

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VALQUA TECHNOLOGY NEWS
No.42 Winter 2022

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