Valqua Technology News

Winter 2021

No.40

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

Greetings

Valqua, Ltd.
Representative Director,
Chairman & CEO
Toshikazu Takisawa

I would like to wish everyone a Happy New Year for 2021.
We sincerely thank our valued readers for your continuing interests in our magazine.

Looking back on last year, many manufacturers and service providers were significantly restricted in their activities due to the global spread of COVID-19. The global economy has recorded a downturn in activity on par with the Great Depression approximately 90 years ago. However, on the other hand, there has been an explosive increase in amount of data used for social activities through 5G and the evolution of AI technology, and with the effect of increased demand due to the sudden increase in teleworking in the industrial field, the situation in industrial areas related to semiconductors is quite bright. In addition to this market environment with a mixture of favorable and tough winds, the global situation is increasingly complex geopolitically, starting with the results of the US presidential election this year and the beginning of retransitioning from "Unilateralism" to "Multilateralism". Now is the time for businesses to review the actual state of change in their situation from a different perspective and provide new values to customers and the market, as this is important from now onward.

Our group has worked towards goals in a variety of areas such as developing products, expanding business projects, and advancing into the overseas market since its founding to create "VALUE" and "QUALITY," which are also the origins of our company name, VALQUA, and contributed to developing society and realizing a better life for people. Considering this historical path and the situation that our company is placed in today and in the future, we think that it is important to be determined to act now and go back to this revolutionary spirit to open new horizons. To actualize this determination, last year, we have designated and announced various management targets that clearly aim to contribute to improving mankind and the global environment as a "company of challenges that tackle the future and the unknown" as a long-term management plan toward the 100th anniversary of our founding in 2027. With this background, our group will continue progressing with the strategies for recovery and growth in the future along the three-year mid-term management plan, “New Frontier 2022” (NF2022) that started from this term.

In this mid-term plan, we are determined to provide revolutionary solutions that will contribute to maximizing the performance of our customer’s products and processes by improving technology development in our entire group through strengthening open innovation to realize H&S concepts. In realizing this, we position 2021 as the year of transformation, and will evolve our company culture into a company that strives to boldly attempt new ideas without being bound by previous successes and fearing failure, and wish to achieve healthy and sustainable growth with our customers.

In closing, for this New Year’s greeting, I would like to wish for your continued support and prosperity. Thank you.

Introduction to Valqua Technology News No. 40 Winter 2021

We wish you a Happy New Year of 2021.
I would like to express my sincere gratitude to all for reading Valqua Technology News.

Since the beginning of 2020, the business environment surrounding the entire world has undergone a major change due to the spread of the COVID-19. In particular, the emphasis on social distancing has promoted the development and introduction of ICT-related technologies for working remotely and labor-saving business activities. However, in retrospect, this direction has already been thought out in various ways from the perspective of improving efficiency, and even when the COVID-19 problem has been solved, its value will not be inherently lost. The changes currently occurring should be viewed as irreversible and we believe that these changes will continue in the future.

The major changes in the environment that we are experiencing will also affect the perspectives and action plans of businesses in the future, and it is expected that the demand for further labor-saving and efficiency improvement will increase. Also, in order to respond to such demands, we have further strengthened our recognition that it is extremely important to break away from the business model of simply providing hardware products to the market and shift to a business model that strives to provide services that contribute to the "value creation (koto-zukuri)" for our customers.

In order to respond to such business demands, all divisions related to technology development in our company will further focus on the transformation into a H&S (Hardware & Service) company, which we have been promoting since the mid-term plan two years ago, and on activities to develop high value-added technology solutions especially from the S (Service) perspective. Specifically, as stated in the three-year mid-term management plan, "New Frontier 2022" (NF2022), which was launched in the current fiscal year, we will "further invest management resources in R&D," "accelerate the development process by utilizing open innovation," and "prepare next-generation R&D infrastructure". With these three strategies at the core of our NF2022 plan, we will strengthen our core businesses from an H&S perspective and ambitiously expand into new business fields. We will work toward the growth objectives set out in NF2022 and toward the 100th anniversary of our founding in 2027, and continue to strive to become a "company of challenges that tackle the future and the unknown".

In relation to our background of the above, the current issue of Technology News, written with the cooperation by our customers, includes articles on our activities in flange tightening, technological development using external technologies, introduction of H&S-related products and our company's products, as well as application examples. In order to provide our customers with safety and security at their production sites, we are determined to work together with our customers to develop technologies. We hope that you will read this article as an example of our R&D activities that lead to the development of solutions that are not limited to our core competence of seal engineering, but also consider the market needs associated with DX.

We hope you will continue to enjoy VALQUA Technology News as well as our products and services.

Senior Executive Officer, Director of Corporate Research and Development Group Mutsuo Aoki

Our engagement with improvement of quality in workmanship within a common certification system for flange fastening

1. Introduction

For a stable supply of safe and high-quality product

As part of local community through the operation of petroleum and petrochemical factories, it is essential to appropriately control maintenance of facilities.

The fluids we deal with are diverse, which can be either gas, liquid or solid. Some of them are combustible, flammable or explosive, or toxic to human bodies and environment. Therefore, we must definitely avoid any leakage coming from defects of the flange fastener component.

Meanwhile, there are hundreds of thousands of flange fastener components in the factory. We aim at early detection of defects in our daily check, and we must prevent a leakage disaster in the future with the right control of tightening at flange fastening.

However, in reality, there is a tendency that the number of disasters and accidents "caused by flange fastening" within Japan is increasing. As shown in Table1 and Figure1, the total number of disasters and accidents due to the failure of management control of facilities has been increasing every year. Part of this are disasters and accidents "caused by flange fastening," which count 30% and more of those. They are increasing by number and proportion, and remain high in recent years.

We can suggest that "qualification system" and "industry structure" are the cause of an increase of troubles arising from flange fastening.

Regarding the former, the problem is that there is no official qualification system for flange fastening and we are dependent on technical tradition among operators. For example, all dangerous and important work in the factories including welding, non-destructive checking, crane, scaffolding, and oxygen-deficient operations have official qualification systems and structures in which knowledge and skills are gained systematically including classroom education and practical lectures. On the other hand, flange fastening operation is important, but has no official qualification system. In the current situation, it can be practiced by anyone regardless of their knowledge or skill.

Table1 Number of disasters due to the defects of maintenance control of facilities

year	Poor corrosion management	Caused by flange fastening	Poor inspection management	Poor inspection	Poor vessel management	total
2018	121	95	18	34	13	281
2017	113	93	29	30	7	272
2016	109	102	20	41	10	282
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

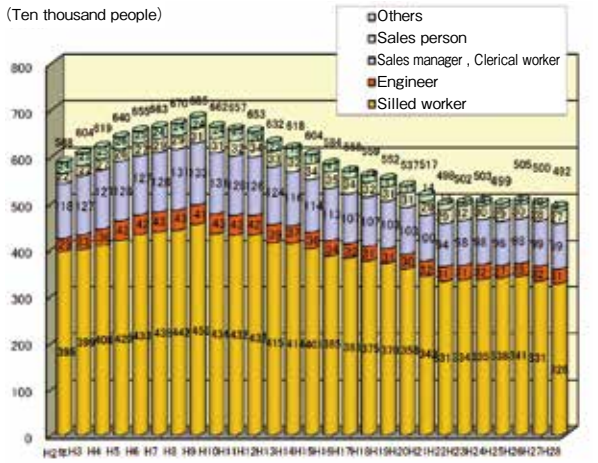
Source : "Summary of accidents related with high pressure gas" by the Ministry of Economy, Trade and Industry

Source : "Summary of accidents related with high pressure gas" by the Ministry of Economy, Trade and Industry

Figure1 Number and proportion of disasters attributed to flange fastening

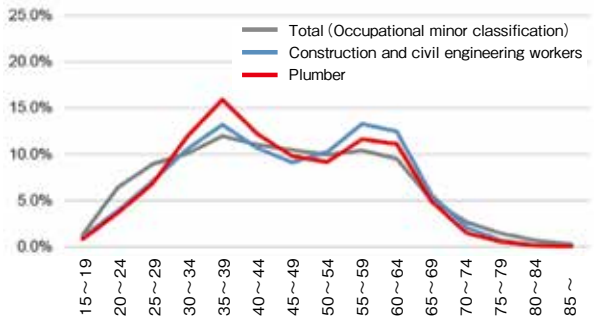
Regarding the latter, the problem is that domestic construction workers are decreasing and aging yearly. As you can see in Figure2, the number of construction workers has decreased by around 30% within the last 20 years. Also, as seen in Figure3, 30% of plumbers are 55 years and older, therefore it is inevitable that those with more experience who we have depended upon for their knowledge and experience will decrease drastically in near future.

With all these situations, it is an urgent necessity to build an education system for flange fastening to secure safety especially for young workers, foreign operators and those working on the spot and to improve operational quality.



Source : "Current situation of construction industry, construction and building workers" by the Ministry of Land, Infrastructure, Transport and Tourism

Figure2　Transition of the number of construction workers



Source : "Detailed sample tabulation of the National Census" by Statistics Bureau of Japan, Ministry of Internal Affairs and Communications

Figure3　Age group distribution of plumbers

Mizushima Refinery of ENEOS Holdings has launched "Mizushima Flange Fastening Committee" together with nearby refineries on April 1, 2019 and built a common certification system for flange fastening in the area, which has been operating with efficiency and effectiveness. Following the education and certifying system of Mizushima, Kawasaki and Negishi Refineries also launched an association of flange fastening in the Keihin Area together with Raiznext Corporation and Valqua, Ltd., to introduce a common certifying system. They have rolled out the common certifying system on a trial basis at the regular repair work (hereinafter, "Regular repair") in the accounting year of 2020 and are advancing its formulation.

Table2　Business establishments composing Mizushima Flange Fastening Committee

・Mizushima Manufacturing Site, Production Control Division, Asahi Kasei Corporation
・Mizushima Factory, Zeon Corporation
・Mizushima Factory, Mitsubishi Gas Chemical Company, Inc. (MGC)
・Okayama Office, Mitsubishi Chemical Corporation (MCC)
・Mizushima Refinery, ENEOS Holdings

In this report, we describe the summary, results and validation of the effect of the certification system for flange fastening introduced on a trial basis at the regular repair conducted in March 2020 at Kawasaki Refinery.

2. Summary of certification system for flange fastening

To improve the quality of flange fastening, what is important are operators' skills who fasten flanges and the knowledge of supervisors who instruct this operation. Therefore, the certification system for flange fastening we created has two educational parts, "practical education (practical skills)" and "knowledge education (classroom learning)," , with unified educational contents, and we realized a system in which we can educate with efficiency by standardizing the level of education.

Also, we issue certificates to approved supervisors and

operators, which allow them to operate flange fastening in other business establishments just by showing them. Overlapped education is not necessary which promotes efficiency.

2-1) Practical education (practical skills)

Practical education aims at learning the behavior of flanges when fastening them and understanding the operators' own abilities. Until now, education was acquiring senses through instructions of supervisors based on their experience. Now we can quantitatively confirm the skill level by having the operators have a real physical experience with the bolting simulator (Figure4). With this simulator, it is possible to evaluate skills quantitatively which used to be evaluated qualitatively. This simulator uses criteria including "enough fastening is given to the gasket," "strength to the fastening shaft of each bolt is even," and "no sign of uneven crush on gaskets."

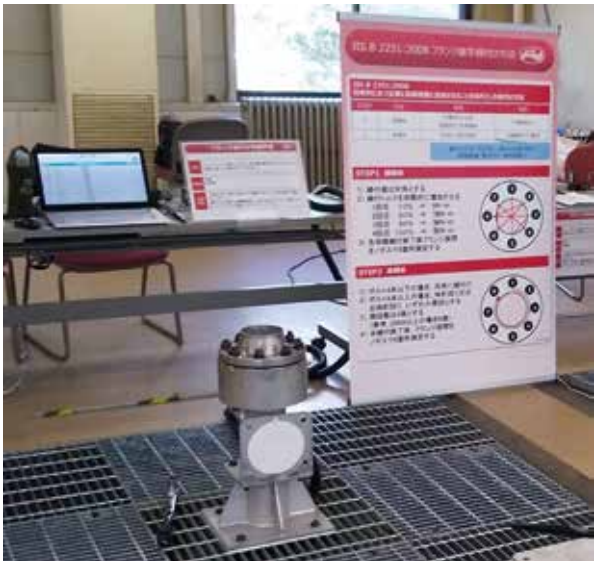


Figure4 Bolting simulator

2-2) Knowledge education (classroom learning)

For knowledge education, we used educational materials created by the Mizushima Flange Fastening Committee, based on HPITR Z110 (Guideline for Flange Fastening Operation Training) issued in September 2018. In addition, we have set up 4 educational levels (Table3) as this committee did, to create an efficient educational system by clarifying the educational contents and participants of education for each level.

Table3 Levels for knowledge education in the certification system for flange fastening

Education level	Target position	Education item	Education time
Level Ⅳ	Education lecturer	HPI TR Z110 "Manager"compliance	4hr
Level Ⅲ		HPI TR Z110 "Worker"compliance	2hr
Level Ⅱ	Manager	ENEOS standard (classroom lecture + practice training)	1hr
Level Ⅰ	Worker	ENEOS standard (classroom lecture)	5-20min

3. Effect of our engagement

3-1) Summary of system operation

In November 2019, we have conducted education for level III at Kawasaki Refinery (number of participants: 17). Education for Level III is given to be approved as lecturers. We gave classroom education with education content was based on HPI TR Z110 (education time: 2 hours).

Contents of education include "control of fastening gaskets and bolts as fastener parts," "setting up and procedure of fastening load and target torque," "pressure-resistant airtightness test," "opening of fastener part," and "trouble examples."

As practical education (practical skills), we conducted "training on fastening procedure" in accordance with JIS B 2251, using the bolting simulator, following a lecture in advance of practical education regarding interactions of elasticity, causes of uneven fastening and countermeasures for it as warnings on flange fastening, and then evaluated each person's skill (pass/fail).

After this, we launched operation of this system on a trial basis at a regular repair (March 2020) in Kawasaki Refinery. We gave education for level I to all supervisors and operators engaged in flange operations for works on quiet devices (number of participants：411). This education was carried out according to the flow as follows by the lecturers who acquired approval of level III as given above.

The flow of this education starts with collective education (10 to 20 minutes) which explains "behaviors of flanges at diagonal/circling fastening," "importance of

setting up," and "description of interactions of elasticity and uneven fastening". Following this, the skill of each participant was evaluated by using the bolting simulator and judged as pass or fail. We issued certificates to those who passed, which will allow them to do flange fastening operations on sites.

3-2) Findings from hearing of the participants

We received good feedback overall from participants of level III education, including 90% of them replying that it raised their awareness of flange fastening and 80% saying they can apply the contents of lectures at operations on sites. Also, 60% say they found out something new from the contents given to lecturers. Therefore, it was also found effective as an opportunity to learn again.

Seventy percent of participants of level I said that contents of collective education were clear, and 80% replied that the certification method of practical skills was good. We had comments such as, "It was good because changes of axial tension of each bolt at the time of flange fastening were easy to comprehend which made it possible to operate in a short amount of time."

3-3) Findings from analysis of operators' skills

We have analyzed operators' skills, using the bolting simulator. This simulator maintains a log of fastening process which makes it possible to confirm characteristics of operators with fastening (too much fastening, lack of fastening or uneven fastening). For this, we can give appropriate advice on that which leads to improve skills with efficiency.

The result of analysis of operators' skills this time shows that the ratio of too much fastening is higher, about twice, than that of lack of fastening. Furthermore, what we found from analyzing too much fastening, there was a higher proportion of operators that fastened some of the bolts too much rather than generally fastening of bolts too much. We think this is because of difference of axial tensions rising among bolts with operators' postures. Regarding uneven fastening (there is a great variety among surfaces of flanges), we think the set up at the initial stage is important and it is necessary to conduct a proper fastening procedure.

3-4) Review of effect of education on comprehensive airtightness test

At the very final phase of a regular repair, we conduct a comprehensive airtightness test by bringing in nitrogen within the system for the purpose of confirming soundness of open parts including devices and plumbing flanges, and the whole equipment. To be precise, we conduct a soap bubble test to check leakage of nitrogen at the open parts including each flange after bringing in nitrogen and pressure rising. If leakage is detected, more flange fastening is carried out. If leakage cannot be halted despite of that, we decrease the pressure of nitrogen in the system and conduct the pressure rising test again upon re-opening flanges, maintaining surfaces of gaskets and exchanging gaskets.

To validate the effect of education, we inspect "number of re-rising pressure system caused by flange fastening" and compare it with the results of re-rising pressure at the last regular repair in 2016. As shown in Table4, we halved the number of re-rising pressure system compared to the last results and lowered the risk of increase of the number of operations and extension of the procedure, and a certain level of educational effect was recognized.

Table4 Survey on number of re-rising pressure system caused by flange fastening

Comprehensive airtightness test number of strains	Number of re-boosting systems		2020 regular maintenance Number of points (Reference value)
	2020 regular maintenance	2016 regular maintenance (Same scale as last time)	
307	6	11	4520

Next, regarding leaked flanges (14 flanges within 6 systems) which were the main cause of re-rising pressure, we show in Table5 the findings from our survey on the specifications of flanges and gaskets, reasons of leakage and layout of the scene. We found out the main reasons of leakage as the following two:

- Cleaning of surfaces of gaskets failed as the plumbing layout did not allow secure clearance between flanges when they were open.
- Fastening layout was not good as there were obstacles, which led to uneven fastening.

Table5 Detailed investigation of the flange responsible for re-pressurization

System No.	Size (B)	Class (pound)	Working pressure (MPa)	Cause of flange leakage	Flange orientation	Tightening layout	Clearance between flanges
1	11/2	300	3.35	One-sided tightening	Vertical	Defective	Have clearance
	18	–	3.35	Improper cleaning of the gasket surface	Beside	Defective	Have clearance
	11/2	300	3.35	One-sided tightening	Vertical	Defective	Have clearance
	18	–	3.35	Improper cleaning of the gasket surface	Beside	Defective	Have clearance
	6	600	3.35	RJT poor rubbing	Beside	Good	No clearance
2	18	–	2.3	Deterioration due to aging of the gasket surface	Vertical	Good	Have clearance
3	6	300	1.48	Improper cleaning of the gasket surface	Beside	Good	No clearance
	6	300	1.48	Improper cleaning of the gasket surface	Beside	Good	No clearance
	8	300	1.48	Improper cleaning of the gasket surface	Beside	Good	No clearance
4	6	150	0.42	Improper cleaning of the gasket surface	Vertical	Good	No clearance
	12	150	0.42	Improper cleaning of the gasket surface	Vertical	Defective	No clearance
	11/2	150	0.42	One-sided tightening	Vertical	Defective	No clearance
5	18	150	1.08	Improper cleaning of the gasket surface	Vertical	Defective	No clearance
6	1	300	0.35	One-sided tightening	Beside	Defective	Have clearance

As measures for these, we will continue engagement towards eliminating re-rising pressure tests by reviewing the operation manuals and education contents so that we can carry out the right operation.

4. Summary and overview for the future

4-1) Summary

- Certification system for flange fastening allows us to standardize education and we do not need overlapped education for users and operators.
- We can evaluate skills quantitatively by using the bolting simulator, and with logs of fastening process, we can give right instructions to operators.
- We had good feedback from the participants through a hearing regarding system operation (level III, level I). They say "contents of lecture were clear," "awareness with flange fastening was raised," and "(what we learned) are applicable at operation scenes."
- We decreased the number of re-rising pressure systems at the comprehensive airtightness test, compared to the previous (2016) regular repair.

4-2) Overview for the future

ENEOS Holdings is planning to systematize education by introducing the certification for flange fastening as well as bolting simulator in all its refineries from now on. Although it is possible to establish a certification system that is shared within the country and not just for a single company alone and can operate effectively for the convenience of operators, there are many agendas including unified maintenance of skill data of operators and controllers.

We will continue collaborating on this to completely eliminate troubles caused by flange fastening in the future in Japan.

Yosuke Koga
Regular Repair Planning Group
Kawasaki Refinery,
ENEOS Holdings

Shigeo Sakai
H&S Sales Division,
Valqua, Ltd.

Effectiveness of Flange Tightening Training and Expectations for VALQUA H&S at the Petrochemical Plant in Linyuan, Taiwan

1. Introduction

Since our founding, we have worked hard to stabilize the national energy supply for 74 years. As the number one annual sales in the Taiwan petrochemical industry, the public is paying close attention to our occupational safety and environmental protection. The business environment faces severe challenges due to the aging employees and the personnel shortage. We are proactively grasping this situation, improving operational performance, and proposing human resources technical training as a root countermeasure. To improve operational performance, we have introduced a process safety management (PSM) system, smart industrial security, and promoting following four systems in industrial safety management practice.

1. Build a complete process safety information system.
2. The work permit shall be combined with the investigation record of the pre-work tripartite joint investigation and the graded supervisor.
3. Create an employee's job performance passport.
4. Investigate the root cause of accidents or equipment failures.

Strengthen basic training in core technology and personnel (including contractors). Flange tightening training is one of the primary tasks to reduce security accidents and equipment leakages.

2. Flange Tightening and Removal related accident

In recent years, the causes of accidents that occurred during the disassembly of flange joints in the petrochemical industry in Taiwan are as follows.

1. The target of the operation is not clear.
2. Wrong gasket or material.
3. Flange disassembly residues are not properly disposed.
4. No hazard analysis/notification for flange disassembly operations.
5. No protective equipment when removing the flange.
6. There is no operational standard for flange removal and tightening.
7. Lack of or no training for flange disassembly.
8. Old-fashioned tools are used to remove the flange.
9. Others.

If an accident occurs due to the above factors cause death, injury, shutdown orders, fires due to leaks, unplanned shutdowns, or environmental protests will severely damage the company's management and reputation. Furthermore, employee fatalities and injuries can cause families to be displaced, especially affecting contractors, a vulnerable segment of society. Flange removal work in the petrochemical industry involves many people and a wide range of operations, from tightening and removing an individual flange to tightening and removing piping and heat exchangers, maintenance of rotary machinery, and cleaning instrumentation and storage tanks. Therefore, an urgent need is to implement effective management and provide

flange tightening and removal training.

3. Overview of our training implementation

To ensure the safety of the disassembly and assembly work of oil refining and chemical plant contractors, our company established the "CPC Corporation Contractor Equipment Tightening and Removal Training System Implementation Guidelines" (C5731SHM10) in 2019. In addition, the training content of flange tightening was created by referring to JIS B 2251 Flange Joint Tightening Method, a Japanese industrial standard introduced by VALQUA, and through VALQUA's training, the relevant knowledge and skills of the trainees in removing and installing bolts have improved.

This training includes the following:

1. Selection of bolt and gasket specifications (e.g., materials, dimensions, and tightening force) and others (e.g., anti-sticking/anti-seizing agents).
2. Use of bolts and torque wrenches and torque calculation.
3. Understand the difference between cold bolting and hot bolting through the Valqua technical book HANDBOOK (50% of the bolt tightening force is consumed at the contact surface between the nut and flange, and 40% is consumed at the nut and bolt thread. , The remaining 10% is effective axial force, etc.).

One particular point that can mention is that with the VALQUA flange tightening training device, the participants can check whether the bolts are properly tightened based on strain gauges and computer calculations. In addition, verifying the presence of diagonal and circular tightening is possible, enabling the participants to grasp the points they have not understood so far and understand the standard tightening concept.

At our company, to acquire good tightening techniques of bolt tightening and removal, we have introduced Valqua's flange tightening training equipment. We also train our employees and contractors to use these devices to verify the skills of the installers and to help them understand the effectiveness of standard procedures and the reasons for implementing them so that they are convinced to follow the standard tightening procedures. We purchase HANDBOOK from Valqua and distribute and utilize it as a reference book for our repair department. In addition, as of September 2020, a total of 34 training sessions have been conducted for a total of 848 people. In July 2020, we received an endorsement and public commendation from the Kaohsiung City Government's Labor Bureau, and were asked to promote this activity downstream to petrochemical plants in the petrochemical industry. The first step has already taken place on September 25, 2020, and we will continue to cooperate with the Kaohsiung City Labor Bureau to implement this training.

3-1) Training equipment and planning, Equipment location

The plan and location for conducting the simple practical training are as follows:

Figure1 Practical test venue

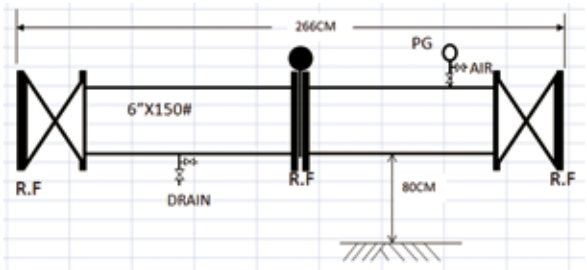


Figure2 Practical test pipe joint

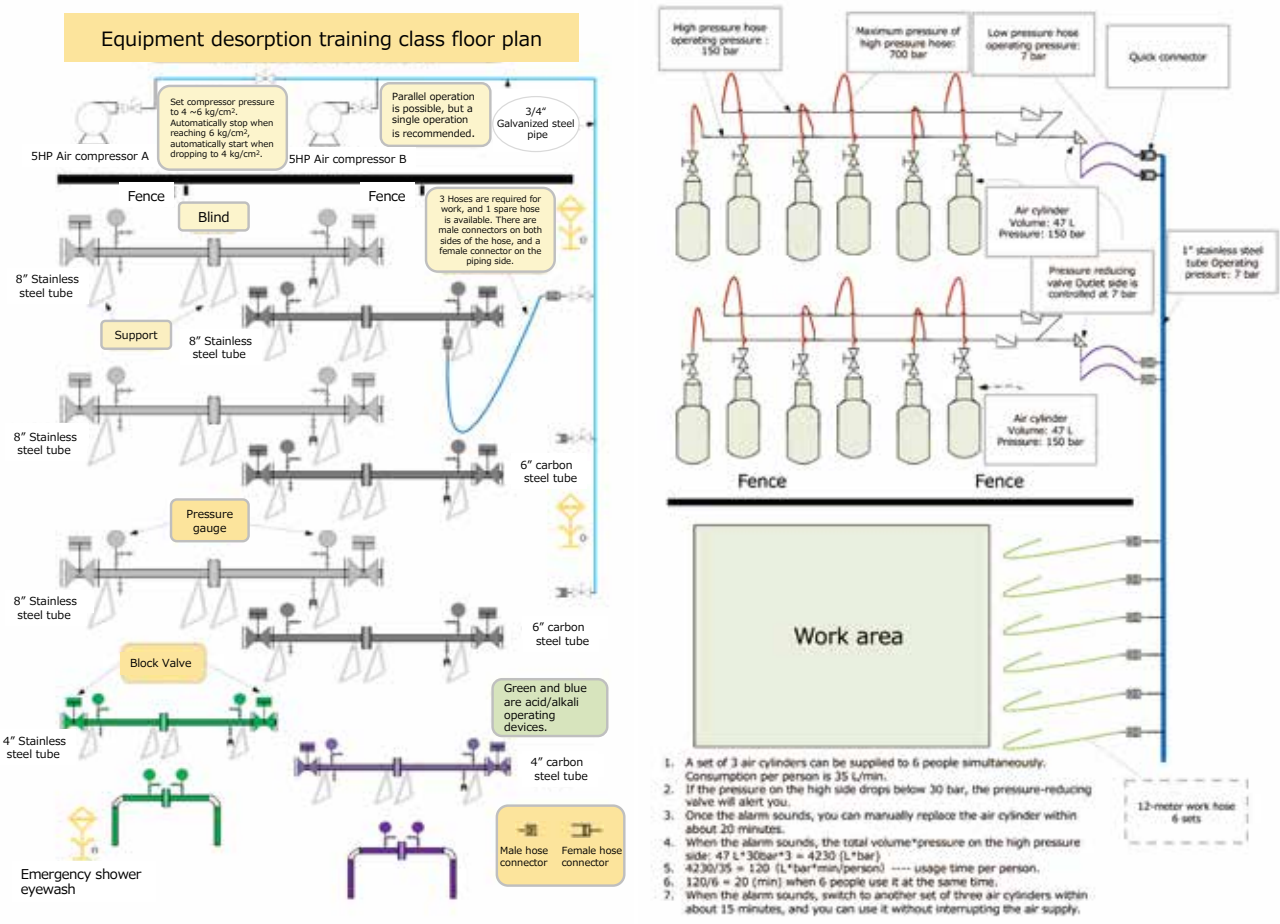


Figure3　Material room design plan

3-1-1) The location of the tightening and removal flanges are as follows.

1. Area：Approximately 5m×10m (Figure1).
   ※ The room is fully air-conditioned.
2. 3 sets of 150lb×6B flange joint (Figure2).
3. Material room①：3 sets of 30L air cylinders, 3 spare cylinders
   The air header is attached to these air cylinders (Figure3).
4. Material room②：3 sets of air compressor, air header and hose.
5. 6 air breathing masks and 3 sets of hoses.
6. Tool set：12 of 3/4B ratchet wrenches.
7. Accessories：6B×150lb×1/8B 3 thin blind flanges, consumables 6B×150lb non-asbestos gasket and spiral gasket consumables.
8. Other accessories：scraper, cleaning and lubrication unit, foam leak detection unit, 3/4 B Yatoi tube, 3 sets each of large and small F wrenches, hanging sign, steel ruler, steel brush, tool basket, bolt storage pan, etc.
9. Others：6 helmets, gloves, fire extinguisher, safety markers installation, first aid kit, lockers, etc.

3-1-2) Flange tightening experience area and flange tightening hands-on installation

VALQUA is the main planner (Figure8).

3-2) Training Courses

As a reference in all fields, we introduce our training courses. The one-day training course is divided into

Figure4 Order of flange tightening

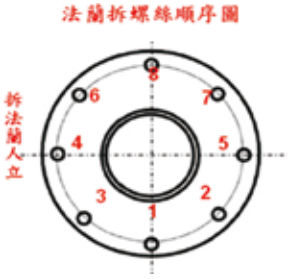


Figure5 Order of bolt removal

classroom lectures and practical exams. The content of the classroom lectures includes explanation of relevant accident cases, hazard recognition of the working environment, use of respiratory protection equipment, safety of flange tightening and removal, general knowledge (gasket selection, piping material and specification, bolts, tools, etc.), and introduction of process flow chart (P&ID) for employees. JIS B 2251 introduced by Valqua is adopted for the flange attachment/detachment training. The flange tightening procedure is to temporarily tighten diagonally (Figure4) with four levels of tightening force of 10%, 20%, 60%, and 100%, and then tighten four times with 100% tightening force (clockwise, Or counterclockwise tightening). The order of bolt removal is followed by our specifications, starting at the bottom of the flange and working from the bottom up (Figure5). The "pause inspection point" is placed at the bottom from where three bolts are removed to protect the operator.

■Practical test program :

I. Before starting work, check the following.
   1. Check the target work (installation of white construction sign).
   2. Check the measurement value of pipe residues (select protective equipment).
   3. Check the processing status of the pipe contents (rechecking safety before installation).
   4. Check the target dimensions, specifications, materials, etc.

II. While working wear respiratory protection/check discharge/remove flange/install blinds (yellow construction signs)/check discharge/remove closure plate/conduct restoration.

III. Check for pressure test leaks above 3kgf/cm² and (clean) organize the location.

4. Training effect

The flange tightening and removal training are similar to the implementation of factory work, but both focus on pre-work precautions. Next, each member will sign and gain the approval (work will start after confirmation of the construction site, construction details, environmental treatment of the construction surroundings, audit of the treatment status with blind flanges drawings of the construction piping or equipment, hazard precautions, construction methods, etc., and the issuance of a construction permit on the same day). The contractor's pre-work hazard notification and safeguard preparation are more important than the actual work; a lack of environmental awareness can lead to the threat of death as soon as disassembling the flange. For example, an accident may occur during hydrogen sulfide and other

Figure6 Three-party joint questionnaire form before construction

toxicological work. However, steps such as three-party joint investigation and pre-work training before the actual work are generally not emphasized. In addition, because they are considered unprofitable man-hours and do not recognize the danger they pose to the workers, the flange tightening and removal training involves much effort and the necessary steps to master the practical skills. In some cases, they become unsuccessful. Until now, there has been no standardized training course for flange tightening and removal, and veteran employees with long service years have guided workers based on their experience. The work procedures are also described in our "Piping Construction Standards (a document of the Ministry of Transportation of Taiwan, equivalent to the Ministry of Land, Infrastructure, Transport and Tourism of Japan)" (CS-102-0006-5) SOP and the related contract work agreements. However, in the case of flange tightening, for example, it was difficult to determine what was correct on-site, such as how many times to tighten temporarily or how many times to tighten fully, and standard work procedures were lacking especially in the case of flange removal. For example, the order of removing bolts is from bottom to top, from a distant place to the neighborhood, and whether to disassemble diagonally, etc. We solved the problem with the newly established "CPC Corporation Contractor Equipment Tightening and Removal Training System Implementation Guidelines" (C5731SHM10). For tightening, we adopted the strongly supporting JIS B 2251 standard and purchased a VALQUA flange tightening training equipment. By doing so, we can compare the previous tightening method with the new method, JIS B 2251 standard, in real-time from the radar image on the screen, allowing reliable and effective verification. On the other hand, when disassembling the flanges, a group discussion method was adopted by experts to specify the order of detachment. In the case of vertical flanges, three bolts should be removed from the bottom to the top and then stopped for inspection. Work should continue after safety is confirmed, and in the case of horizontal flanges, the order of removal was determined to be from the bolt farthest away from the person.

These regulations and measures are significant for the petrochemical refining industry. We aspire to become an industry leader in industrial safety. We have already taken a big step, but in the future, we are working to enable mutual recognition, learning, and dissemination of training within the industry.

Linyuan Petrochemical Plant revised the labor procurement SOP from the root and applied it to new procurement projects from July 1, 2019, and actively promoted and participated in processing old projects with additional methods. Within six months, the establishment of "equipment flange tightening and removal training" was planned and completed, and also the number of successful candidates for contractor dispatch training by September 2020 reached 331 (Figure7).

At the Lin Yuan Petrochemical Plant, training began as follows:

- May 7, 2020
  Conducted training for new employees.
- May 21, 2020 and June 5, 2020
  Conducted training for engineers and next executive candidates (Figure8).
- August 20, 2020 and September 4, 2020
  In the other divisions, "equipment flange attachment/detachment and tightening/fixing" tour training was conducted in two stages, with a total of 46 participants.
- August 2020
  No.3 Aromatics Unit Group (name of a CPC Corporation work group) / A total of 50 people participated in the re-measuring training for HEPCO repair contractors of flange tightening and removal operators.

The actual effect of the project appeared as a great benefit during the shutdown maintenance of No.4 Naphtha Cracker group (name of a CPC Corporation work group) at the end of 2019 and the New No.3 Naphtha Cracker group (name of a CPC Corporation work group) at the beginning of 2020. The quality of the contractor's equipment, the flange tightening and removal was greatly improved. In addition to reducing

Figure7　Contractor flange tightening and removal training.

Figure8　Flange tightening training

industrial safety incidents, flange tightening training can reduce the uncertainty of downtime due to leaks and reduce the rate of flange leakage of volatile organic compounds (VOCs). Since the training has been conducted for a short period, it is impossible to quantify the training effect on reducing flange leakage rate at this stage. But we are confident that it will be effective and hope to be able to prove it with quantitative data in the future.

5. Conclusion

We would like to thank VALQUA for their cooperation in providing flange tightening and removal standards and training. We hope that more workers and contractors will receive the training to maximize their bolt removal and tightening skills and enhance tightening safety. We would like to maximize the bolt removal and tightening technology and improve the safety of tightening by training more workers and contractors.

In response to the government's urgent demand for industrial safety measures throughout the petrochemical industry, we will actively introduce leading-edge technical systems and equipment to fulfill our responsibility. We will then spread the use of these to provide substitute training to industry personnel to ensure that the petrochemical industry can be managed sustainably as a safe industry.

6. References

1) CPC Corporation Contractor Safety and Health Management Act (2020/10/20　5731-SHM-01)
2) Taiwan National Oil Corporation Piping Installation Standard (2018/04/12 CS-102-0006-5)
3) Ring joint gasket flange installation for Taiwan Chinese-Oil Corp. Standard (2018/02/23 CS-102-0003-1)
4) Taiwan PetroChina Contractor Equipment Removal Training Program Implementation Guidelines (2020/07/10 5731-SHM-10)
5) VALQUA STC Training Materials (2019/03/29Document No. 12015-001)

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Effects of carbon black on compression set with peroxide cross-linking elastomer

1. Introduction

One of the important parameters showing heat resistance of elastomer sealing materials is compression set (CS). CS is an indicator for the permanent distortion in case of loading at a certain temperature for a certain amount of time to the elastomer material in compression, and it is calculated as Figure1. For example, CS100% indicates that it is completely distortion and highly likely to end up in leakage. It is an effective measure to check durability of sealing materials.

Usually, carbon black (Carbon) is contained in elastomer materials as a reinforcing filler, and we can adjust their mechanical properties including tensile strength and stretch by changing the primary particle-size or the amount of Carbon added. However, it has become an issue in the product development scenes that there were often trade-offs between the mechanical properties and CS gained from blending Carbon.

It is well known that CS is correlated with effective cross-link density of elastomer in non-Carbon filled system. Therefore, it is possible that this trade-off is also related with effective cross-link density. However, we cannot properly evaluate properly the cross-link density in Carbon filled system with calculations of a general swelling test due to an effect of reinforcement of Carbon, and it was an issue that we could not analyze the correlation with CS.

Based on this, in this report, we analyzed the relationship between effective cross-link density of Carbon-filled systems and CS, using mainly dynamic viscoelasticity measurements. We also examined the causes of changes in CS of elastomer material with different types of Carbon fillers. We think that with this analysis, we can contribute to controlling trade-offs between mechanical properties and CS, and to establish guidelines for selection of Carbon in accordance with demanded characteristics.

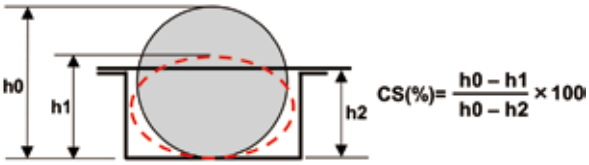

Figure1 Calculation of CS

2. Experiment

2-1) Preparation of samples

Composition of Carbon mixture in each sample is shown in Table1. We chose FKM (VDF-HFP-TFE copolymer) and EPDM (ethylene-propylene-diene copolymer) from among peroxide cross-linked systems, which are especially suitable to be used in high temperature environments, as the elastomer base materials. We prepared samples that were each blended with 3 different particle-sizes of Carbon (HAF: primary particle size is about 28 nm, MAF : primary particle size is about 38 nm, MT : primary particle size about 450 nm) for both polymers, and also made non-Carbon filled system as the control system. As for blended materials other than Carbon, we used 2, 5-Dimethyl-2, 5-di (tert-butyl peroxy) hexane as peroxide for both FKM and EPDM systems, and used triallyl isocyanurate as a cross-linking coagent. The same blending amount was set for each polymer system. In addition, with EPDM system, as other blended materials, the same blending amount of anti-aging substance, zinc oxide and processing aid were added to each sample.

Table1 Carbon blend compositions and physical properties

Sample	F-Control	F-A20	F-B20	F-C20	E-Control	E-A50	E-B50	E-C50
Polymer species	FKM				EPDM			
Carbon black species	—	MT	MAF	HAF	—	MT	MAF	HAF
Primary particle size (nm)	—	450	38	28	—	450	38	28
N_2 absorption specific surface area (m^2/g)	—	7	49	79	—	7	49	79
Amount of carbon black (phr)	0	20	20	20	0	50	50	50
Hardness (JIS A)	57	72	84	86	48	65	70	70
Tensil strength (MPa)	5.2	14.9	21.6	22.5	1.7	9.7	16.6	16.8
Elongation at break (%)	330	245	220	230	185	190	215	230
100% Modulus (MPa)	1.2	2.6	5.9	5.4	1.2	2.6	5.3	3.4
CS (%) at 200℃×72hr	N.D	14.8	17.6	21.2	9.1	13.4	21.4	31.6

Polymers and each blended material were kneaded by 8-inch rolls. Afterwards, 2 mm-wide sheets and CS disc pieces (Φ29×12.5t) were created by compression pressure molding.

2-2) Evaluation methods

We have measured hardness, tensile strength, tensile breaking extension, 100% modulus and CS of each sample at 25℃ according to JIS K6253, K6251 and K6262. We conducted swelling test by soaking EPDM sample for 72 hours, using toluene as solvent and calculated effective cross-linking density (vs) using a modified Flory-Rehner equation[1].

We carried out dynamic viscoelasticity measurements using DMS6100 (Seiko Instruments) under tension mode, rate of rising temperature at 2 ℃/min, frequency at 10 Hz, applied distortion at 0.05 % and temperature range between -50℃ and 150℃.

3. Results and discussion

3-1) Relationship between mechanical properties and CS

Table1 shows mechanical properties and CS of each sample. These are the results from blending 20phr of each Carbon in FKM system and 50phr in EPDM system.

With both FKM and EPDM systems, the smaller the particle-size of Carbon used, which is said to be better in reinforcement in general, the higher the increase in hardness and tensile strength. Although 100% modulus also showed similar tendencies, it decreased with HAF filled substance with the smallest particle size.

While with EPDM system, the smaller the particle size of Carbon used, the higher the increase in breaking elongation, FKM system showed a different tendency and F-Control, which is non-Carbon filled substance, showed the largest value.

With both FKM and EPDM systems, the smaller the particle size of Carbon used, the more CS increased and heat resistance was lowered. In addition, from the results of mechanical properties mentioned earlier, it was confirmed that there is a trade-off relationship between changes in CS dependent on the blended Carbon type, and hardness, tensile strength and 100% modulus . It should also be mentioned that it was not possible to measure CS of F-Control because the sample was broken by compression at measurement.

3-2) Correlation between effective cross-linking density and CS

Although it is well known that CS is correlated with effective cross-linking density measured by swelling test in non-Carbon filled system, the situation is different with Carbon-filled system. Figure2 shows the relationship between effective cross-linking density and CS measured by swelling test of EPDM system samples produced in this experiment.

It cannot be said that there is a correlation between effective cross-linking density and CS from these results. We consider this is due to the reinforcement effect of Carbon.

Cross-linking density is calculated in swelling tests according to the degree of swelling of the sample soaked in good solvent. Therefore, we consider that it would be difficult to calculate accurate effective cross-

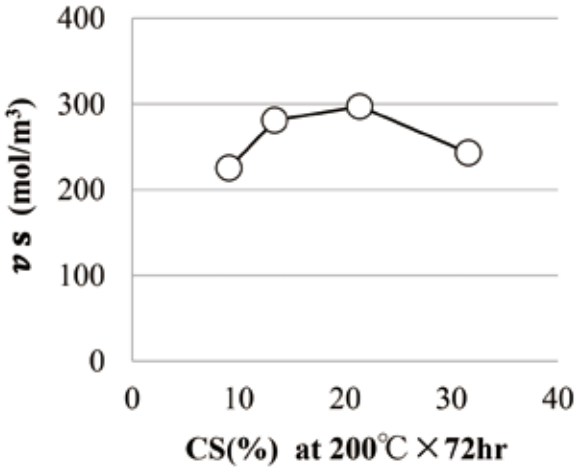

Figure2 Relationship between effective cross-lining density and CS from swelling test

linking density if natural swelling is disturbed by reinforcement property of Carbon.

3-3) Relationship between dynamic viscoelasticity properties and CS

Since the past, there is loss tangent, (tanδ) , as another indicator to show cross-linking density in non-Carbon filled system, which can be acquired by dynamic viscoelastic measurements. For example, Imoto and coworkers[2] reported the higher the cross-linking density, the lower tanδ on the higher temperature side becomes. They said that the lower the cross-linking density is, the more terminal molecular chains which easily flow increase, and the larger tanδ becomes, which reflects energy loss due to forced vibration.

Iwabuki and coworkers[3] report a good correlation between tanδ within the high temperature range and the cross-linked component amount (or uncross-linked component amount) obtained by pulsed NMR despite any type of filler. The tanδ within a high temperature range reflects relaxation due to the movement of terminal molecular chains even in Carbon-filled systems, and this can be an effective measure when analyzing the correlation between effective cross-linking density and CS.

Figure3 shows the relationship between tanδ and temperature in EPDM system samples. The smaller the particle size of Carbon used , the lower the peak value of

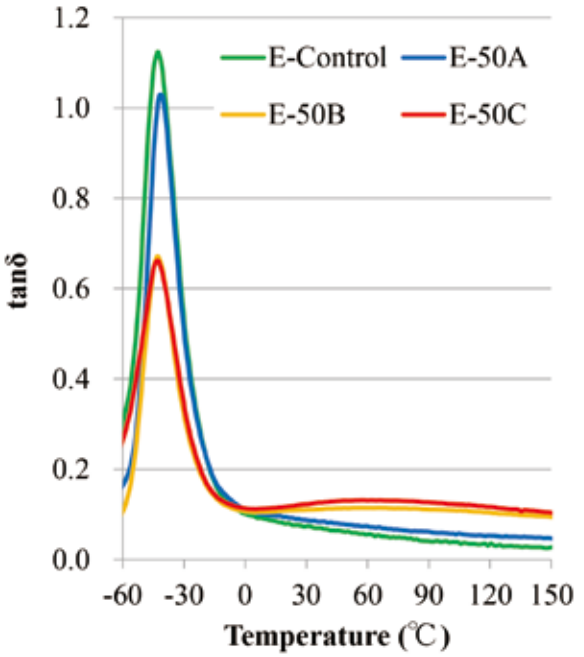

Figure3 Relationship between tanδ and temperature in EPDM systems

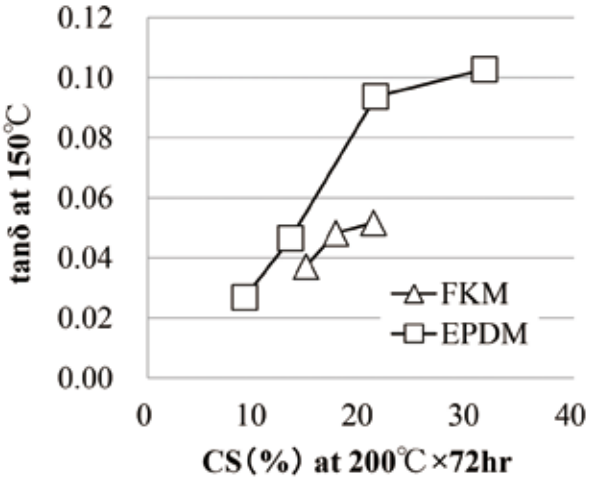

Figure4 Relationship between tanδ at 150℃ and CS

tanδ becomes, which we consider is exhibiting the reinforcement property of Carbon. On the contrary to the peak value, the smaller the particle size of Carbon added, the higher the value of tanδ on the high temperature side, which is regarded as reflecting relaxation due to the movement of terminal molecular chains.

Figure4 shows the relationship between tanδ and CS at 150℃ in FKM and EPDM systems respectively. Unlike

the results of Figure2, tanδ increases according to the increase of CS both in FKM and EPDM systems, which tells us there is a correlation. If we assume tanδ at 150℃ reflects the amount of relaxation due to the movement of terminal molecular chains, we consider that increase of tanδ means decrease of effective cross-linking density led to increase of CS. In addition, it suggests a possible effectiveness of tanδ within the high temperature range as an indicator of cross-linking density in Carbon-filled system.

3-4) Relationship between the total surface area of Carbon and tanδ

Figure5 shows a relation between the total surface area of Carbon filler in each sample and tanδ at 150℃. The total surface area of Carbon was calculated by multiplying the nitrogen absorption specific surface area (m^2/g) for each Carbon shown in Table1, by the compound amount (g).

As a result, we found that tanδ increased according to the increase of the total surface area of Carbon filler for both FKM and EPDM systems and had a good correlation.

The basic structure of Carbon is a graphite structure, however on the surface, it possesses defective areas including oxygen, hydroxyl groups and structures in which graphite has undergone ring cleavage by hydrogenation, which are reported to become receptors for free radicals[4]. This means that increase of tanδ in accordance with increase of the total surface area of Carbon which was confirmed in Figure5 could have occurred because peroxide radicals, which was an initiator for cross-linking, was trapped due to the increase of defect areas on the surface of Carbon in elastomer and effective cross-linking density has decreased.

Together with the results of Figure4, this leads us to conclude that increase of the total surface area of Carbon in elastomer inhibits cross-linking reaction with peroxide, and increases CS by decreasing the effective cross-linking density.

Thus, when we design the recipe, since adding too much Carbon or small particle-sized Carbon increases CS, it is necessary to consider and determine appropriate Carbon type and blending amount while considering the balance with mechanical properties.

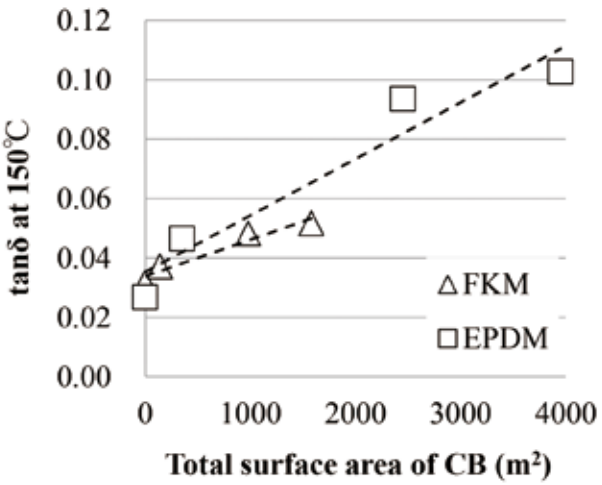

Figure5 Relationship between the total surface area of filled Carbon and tanδ at 150℃

4. Conclusions

We found the following through analysis of the relationship between CS of peroxide cross-linked FKM and EPDM in Carbon-filled systems and effective cross-linking density using dynamic viscoelasticity.

(1) The results of dynamic viscoelasticity measurements suggest the smaller the particle size of Carbon filler in both FKM and EPDM systems, the higher tanδ(150℃) increased and the larger the relaxation due to the movement of terminal molecular chains.

(2) tanδ(150℃) has a good correlation with CS in both FKM and EPDM systems, and CS increased as tanδ increased, suggesting the possibility of an increase of CS in not only in non-Carbon filled but also in Carbon filled system with decrease of effective cross-linking density.

(3) With increase of the total surface area of Carbon filler, tanδ (150℃) increased. This brings us to the conclusion that increase of the total surface area of Carbon in elastomer inhibits cross-linking reaction of peroxide and that decrease of effective cross-linking density would bring increase of CS.

5. Acknowledgment

This report analyzed a limited number of Carbon types. For planning better guidelines of Carbon selection, we think it is necessary to conduct a more multifaceted analysis that analyzes more varieties of Carbon and uses other analysis methods, which we plan to carry out in the future.

Finally, to proceed in this study, we were given a lot of support and advice from Junji Mizukado, Group Leader of the Chemical Materials Evaluation Group, Research Institute for Sustainable Chemistry, National Institute of Advanced Industrial Science and Technology. We thank him very much.

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2) Minoru Imoto et al.: Nippon Gomu Kyokaishi, 41, 1103 (1968)
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High heat resistant non-silicone adhesive tape

(Manufactured by Korea Taconic, AGC Group, P-KT:6323)

1. Introduction

The performance required of masking tapes is higher than ever before due to the higher integration of electronic circuit boards caused by the recent trend toward smaller and larger capacity information terminals and the adoption of lead-free solder alloy to reduce substances of environmental concern. Generally, silicone adhesives are used for high-temperature adhesive tapes, but since silicone adhesives are usually not recommended for temperatures above 200℃ and silicone volatile components are noted as a cause of contamination of semiconductor chips, there is a need for masking tapes with non-silicone adhesives and improved heat resistance.

Our company has been selling masking tapes using non-silicone adhesives, and we have started handling a grade with further improved heat resistance, which is introduced in this report.

Figure1 Product photo of high heat-resistant non-silicone adhesive tape

2. Background

Due to the increased adoption of lead-free solder alloy in recent years, the temperature of the mounting process is said to be 230℃, and masking tape that can withstand this temperature is essential. Generally, polyimide tape coated with silicone adhesive is used for masking tape (confirmation required), but the normal grade is 200℃, and even the heat-resistant grade is 260℃. However, since a silicone adhesive (polysiloxane) is used, low-molecular-weight siloxane decomposes when used at high temperatures, and this causes problems such as contamination of the wafer surface and contact failure in electronic circuits.

Non-silicone masking tapes have traditionally had problems such as low heat resistance of the adhesive, residue after use, and foaming due to decomposition gas, but since they do not generate siloxane, they are expected to contribute to ensuring reliability in the mounting process (SMT; Surface Mount Technology) of circuit boards, which will become increasingly dense in the future.

3. Product specifications

The adhesive tapes introduced here are all made of a polyimide base material that is coated with a non-silicone adhesive (Table1).

Table1 Types of heat-resistant adhesive tapes

			Type A	Type B	Type C	conventional product
Thickness	Substrate (polyimide)	μm	25	25	25	25
	Adhesive	μm	38	38	38	39
Peel Strength (SUS)		gf / 25mm	Min 200	Min 300	Min 200	Min 350
Max. working temperature		℃	200	200	260	160

※ This is a product under development and specifications are subject to change.

4. Features

In the following, we will examine the heat resistance of Type C, which has the highest heat resistance.
After standing in an oven at 260℃ for 2 hours, as shown in Table2, residue due to deterioration of the adhesive can be seen in the conventional product, but no residue can be seen in "Type C" with improved heat resistance (Table2).

Table2 Residue check of heat-resistant adhesive tape after heat test at 260℃ for 2 hours

	After heating	Enlarged pictures
conventional product		
Type C		

In addition, no residue was observed in the actual test in a solder bath (285℃, 10 minutes) (Table3, Figure2).

Table3 Residue check of heat-resistant adhesive tape after solder bath test

After heating		Enlarged pictures	
			

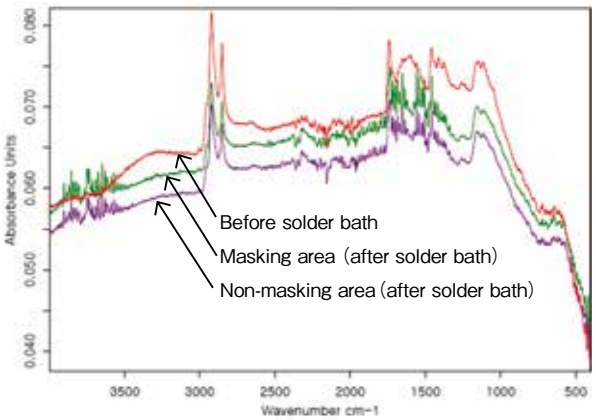

Figure2 IR absorption spectroscopy before and after solder bath test

5. Conclusions

This product was designed as a masking tape for the solder reflow process of surface mounting (SMT) of rigid and flexible boards, but as stated, no residue was observed under 260℃, and the product has sufficient capability for masking applications.
By all means, it has been confirmed that since a non-silicone adhesive is used, no siloxane is detected in the decomposition gas and we believe that this product will be useful in other applications where contamination by siloxane is a problem. In addition to the solder reflow process described in this article, we can also expect to see the product used in wire bonding, thermosetting mounting processes, dicing, and packaging processes.
Furthermore, the adhesive tape is introduced as a masking tape made of polyimide in this article, but it could also be coated for other base materials such as fluoroplastic tape, therefore it is possible to consider non-silicone release tapes for the heat-sealing process.

※ All data and values in this document are representative values under a certain environment. It is necessary to confirm the suitability of the product when using it.

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Introduction of Flange Gap Gauge

Figure1　Photo of product appearance

Figure2　Photo of product storage

1. Introduction

For the safe operation of various plants, periodic inspections, reliable repair work, and record management are essential. However, in recent years, the problem of technology inheritance due to the retirement of veteran workers and the decrease in practical opportunities due to the extension of regular repair intervals have occurred. Under such circumstances, there is a growing trend to use digital technology to maintain and manage plants facing ageing.

This paper introduces the "Flange Gap Gauge," a digital caliper with a measurement data transfer function useful for dimensional measurement.

2. Production dimensions and main specifications

2-1) Production dimensions

Figure3 shows the production dimensions.

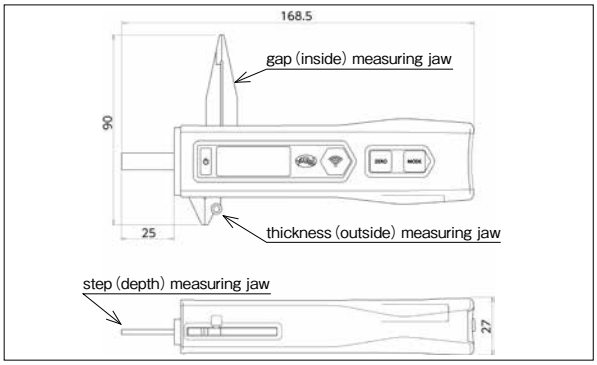

Figure3　Product dimensions (unit: mm)

2-2) Main specifications

Table1 shows the main specifications.

Table1　Main specifications

product name	Flange Gap Gauge
part number	No. FGG-01
size	168.5mm×90mm×27mm
weight	200g
range	0～25mm [Minimum gap (inside) is about 2mm]
accuracy	±0.1mm
Minimum display unit	0.1mm
Operating environment temperature	0～40℃
Battery	Continuous use time about 10 hours
charging time	about 70 minutes

3. Main functions and features of the product

3-1) Easy measurement and digital recording

Using the same measurement methods as ordinary calipers, data can be sent to a device by pressing the data transmission button.

A large display and backlight are used to make it easier to read measured values and a fixed value mode is equipped, which records values held for 0.5 seconds or longer during measurement. (Figure4)

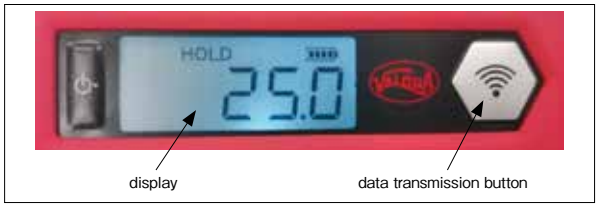

Figure4　Display and data transmission button

3-2) Data display and output

Measurement data can be displayed on a smartphone, tablet, or other device installed with the free dedicated application※, using the Bluetooth® function to show the results of measurement values or output as a CSV file. The file can then be transferred to a PC to support the creation of reports (Figures5, 6 and Table2) .

※ The dedicated free application is "TRASAS Admin," provided by KYOTO TOOL CO., LTD.

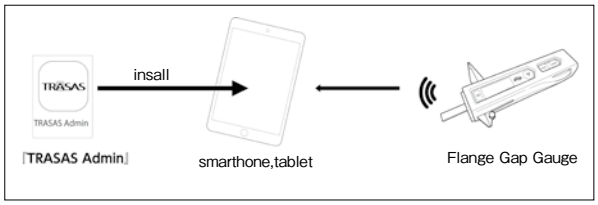

Figure5　Linkage with terminal

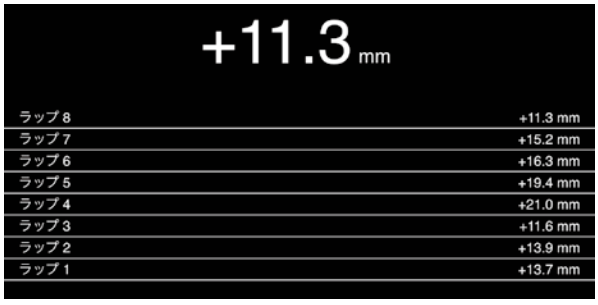

Figure6　Example of result display of measurement data

Table2　Example of data output of measured values

タイムスタンプ	計測値	単位
2020/10/06 14:17:28	+13.7	mm
2020/10/06 14:18:11	+13.9	mm
2020/10/06 14:18:26	+11.6	mm
2020/10/06 14:18:38	+21.0	mm
2020/10/06 14:19:19	+19.4	mm
2020/10/06 14:19:44	+16.3	mm
2020/10/06 14:20:04	+15.2	mm
2020/10/06 14:20:13	+11.3	mm

3-3) Three measuring points

There are three measuring points, flange gap (inside) measuring jaw, thickness (outside) measuring jaw and step (depth) measuring bar, that enable measurement according to the application (Figure3) .

3-4) Portability

The product is equipped with a strap that prevents falling during measurements and a rubber jacket to improve the grip for stable measurements.

Please refer to the instruction manual for other details and measurement methods. It can be viewed and downloaded from the catalog download page on our website.

4. Usage opportunities

4-1) Flange fastening management

Gap measurement between flanges may be performed as a completion inspection of flange fastening work. As awareness of safe plant operation has increased in recent years, plant owners have been requesting contractors to perform gap measurements, and contractors have been adopting this method to differentiate themselves from their competitors.

However, the current measurement methods often use ordinary calipers and taper gauges, and there are problems such as reading error of measured value, erroneous recording, and troublesome report preparation.

The digital caliper "Flange Gap Gauge" is a measurement

tool that can solve these problems.

4-2) Various product inspections

It can also be used to manage data on the measurement results of gaps (inside), thicknesses (outside), and steps (depth) in various other measuring opportunities.

5. Effects

The following effects can be expected from the use of a Flange Gap Gauge.

5-1) Prevention of human error

①Elimination of value reading errors and recording errors during measurements

②Elimination of mistakes when entering records into a PC

5-2) Shortening the work time from measurement to report creation

①Simplification of recording and inputting measurement results leads to shorter work time

6. Conclusions

We believe that the Flange Gap Gauge introduced in this article is a helpful measurement tool for managing flange fastening that leads to safe and secure plant operation. We will continue our efforts to provide products that can contribute even more.

7. References

1) KYOTO TOOL CO., LTD.: TRASAS Admin User's Manual

※Bluetooth® is a registered trademark of Bluetooth SIG, Inc. (USA).

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Examples of Reciprocal Motion Applications of LFR SEAL™

1. Introduction

Since its development and launch as a low-torque seal for rotary applications, LFR SEAL™ has been used mainly in the circular tables of machine tools, and has received a good reputation with our customers. In order to further expand the application of LFR SEAL™, we have considered the application of LFR SEAL™ as a seal for reciprocating machinery. In this report, we introduce the results of evaluating LFR SEAL™ by air pressure under reciprocating motion test conditions.

2. Features of the LFR SEAL™ low-torque seal for rotary applications

2-1) Design concept

The design concept of the LFR SEAL™ is shown in (1)-(5). This concept solves the problem of conventional rotary seals, which has been a challenge. Figure 1 shows the structure of the LFR SEAL™. The base material is an elastomer with excellent elasticity, and the sliding surface is covered with a low-friction resin material, which is simultaneously molded into a single structure.

Design concept

(1)Small space
In consideration of versatility, the seal mounting groove is the same as the groove dimensions of the standard O-ring for motion (JIS B 2401-1 P series). It is smaller in space than conventional slipper seals.

(2)Low-torque
Low-torque was realized by placing a resin material with a low coefficient of friction on the sliding surface with the axis, and by designing a unique shape.

(3)Improvement of pressure resistance
In order to prevent the seal from protruding into the gap between the axis and the seal, the shape of the seal is designed to prevent protrusion, thereby improving pressure resistance.

(4)Longer life
(2) Low-torque and (3) improvement of pressure resistance achieved longer life.

(5)Improvement in ease of installation
The seal has a double pressure seal shape with no specific direction to prevent incorrect installation. By making it a single structure of elastomer and resin material, it has the equivalent ease of installation as an O-ring.
installation as for O-rings.

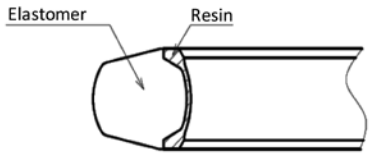

Figure1 Structure of LFR SEAL™

2-2) Comparison of rotational torque

The specifications of LFR SEAL™ and rotary torque comparison packing are shown in Table1. The packing is for axis diameter of ϕ30mm, and it was measured at a rotational speed of 100 rpm and air pressure of 0 to 0.5 MPa.

The results of rotational torque measurement are shown in Figure2. It can be confirmed that LFR SEAL™ has low-torque compared to O-rings and U-packings.

Table1　Specifications of comparison packing

No.	Comparison packing (Model)	Cross-sectional shape	Material
①	LFR SEAL (LFR30)		NBR + PTFE with filler
②	O-ring (P30)		NBR
③	U-packing (UPR30)		NBR
④	Σ-ring (For ϕ30)		NBR + PTFE with filler
⑤	X-ring (R30)		NBR

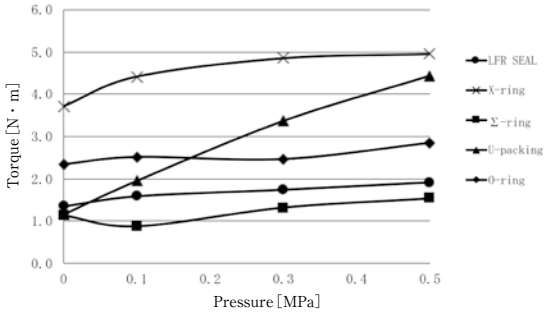

Figure2　Measurement results of rotational torque

3. Reciprocating motion test conditions

The specifications of LFR SEAL™ and comparison packings are shown in Table2. The packing was for axis diameter of ϕ30mm. The evaluation packings were the same type as the packings used in the rotational torque measurement in section 2-2). The evaluation test conditions are shown in Table3, and the schematics of the testing machine is shown in Figure3.

Table2　Specifications of comparison packing

No.	Comparison packing (Model)	Cross-sectional shape	Material
①	LFR SEAL (LFR30)		NBR + PTFE with filler
②	O-ring (P30)		NBR
③	U-packing (UPR30)		NBR
④	Σ-ring (For ϕ30) (Composite packing of O-ring and PTFE resin processed product)		NBR + PTFE with filler
⑤	X-ring (R30)		NBR

Table3　Evaluation test conditions

Item	Conditions
Shaft diametar	ϕ30mm
Stroke	200mm
Speed	150mm/s
Gas	Air
Pressure	0.5MPa
Motion	200mm stroke、4,500cycle
Lubrication condition	Apply grease to the packing and shaft. For your reference : Amount of grease 10cc/packing per 1pc Apply a thin layer of grease to the shaft.

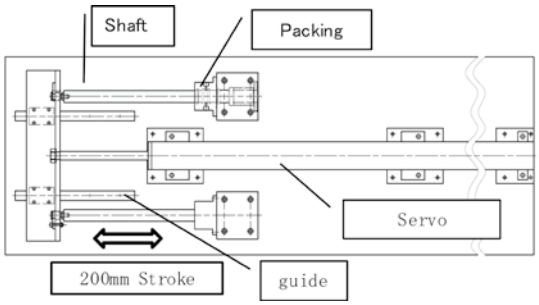

Figure3　Schematics of the testing machine

The sliding of the axis is designed to reciprocate with a servo cylinder (STP servo cylinder manufactured by Horiuchi Machinery). The groove size of each packing is designed to match the groove size of each evaluation packing.

4. Reciprocating motion evaluation test results

The results of the characterization are shown in Table4. The measurement results of leakage amount and sliding resistance are shown in Figures4 and 5.

The amount of leakage of LFR SEAL™ was small at less than 0.05 cc/min, and it was confirmed that it could be used under reciprocating conditions. In addition, at low air pressure, the sliding resistance of LFR SEAL™ was larger than that of U-packing and other comparable products.

Table4 Characterization results

No.	Comparison packing	Leakage (Standard leakage Compared with 3.4cc/min or less)	Sliding resistance (Compare with U-packing)	Presence of stick-slip	exothermic temperature [℃] ※1
①	LFR SEAL	Good	Large	None	25℃
②	O-ring	Good	Large	None	25℃
③	U-packing	Good	—	None	26℃
④	Σ-ring	Good	Large	None	26℃
⑤	X-ring	Good	Large	None	26℃

※1 Ambient temperature of testing machine : 23℃

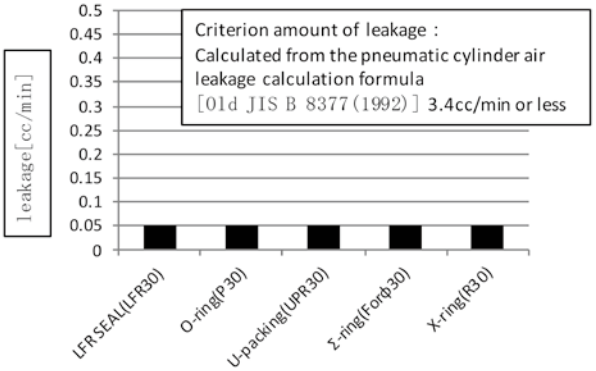

Figure4 Leakage measurement results

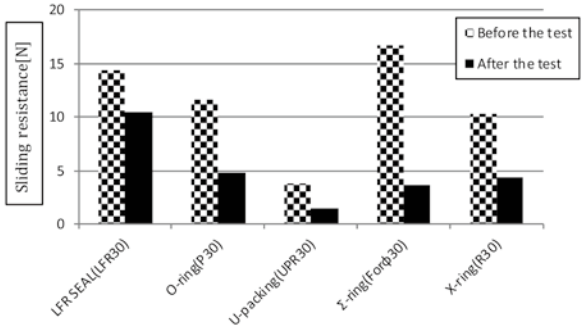

Figure5 Measurement results of sliding resistance

5. Summary

We believe that LFR SEAL™ can be used as a seal for reciprocating motion without any sealing problems. However, since the design concept of LFR SEAL™ is such that it can be used for hydraulic pressure at 14 MPa without protrusion, the sliding resistance value may be large when used for air pressure applications.

6. Conclusion

In this report, we introduced the evaluation results of LFR SEAL™ under air pressure and reciprocating conditions. We are also planning to do an evaluation test under hydraulic pressure and reciprocating conditions. In the future, we are planning to conduct evaluation under high-pressure hydraulic environment, which is LFR SEAL™'s specialty, and introduce examples of its use in reciprocating motion, so please look forward to it. If you are interested in LFR SEAL™ as a rotary seal, reciprocating seal, or "rotary & reciprocating" seal, please contact your nearest LFR SEAL™ sales representative.

7. References

1) Akihiro Nagano: VALQUA Technical Journal, No.30, 9-13 (2016)
2) Low Friction Seal for VALQUA Rotation, Catalog, LA08, (2017)

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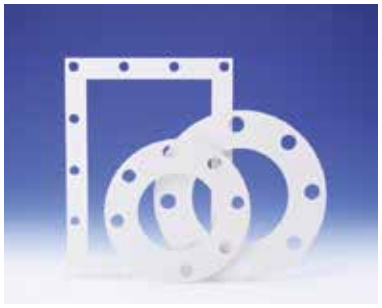

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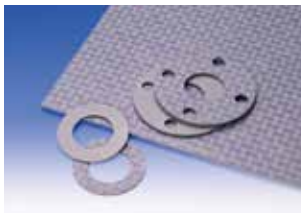

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