

# 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

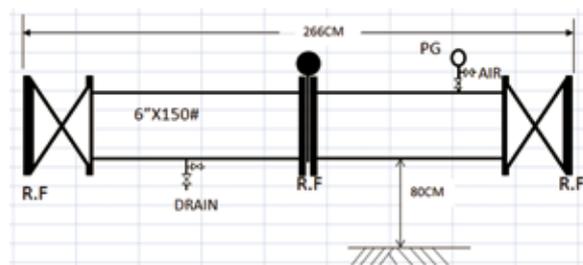


Figure2 Practical test pipe joint

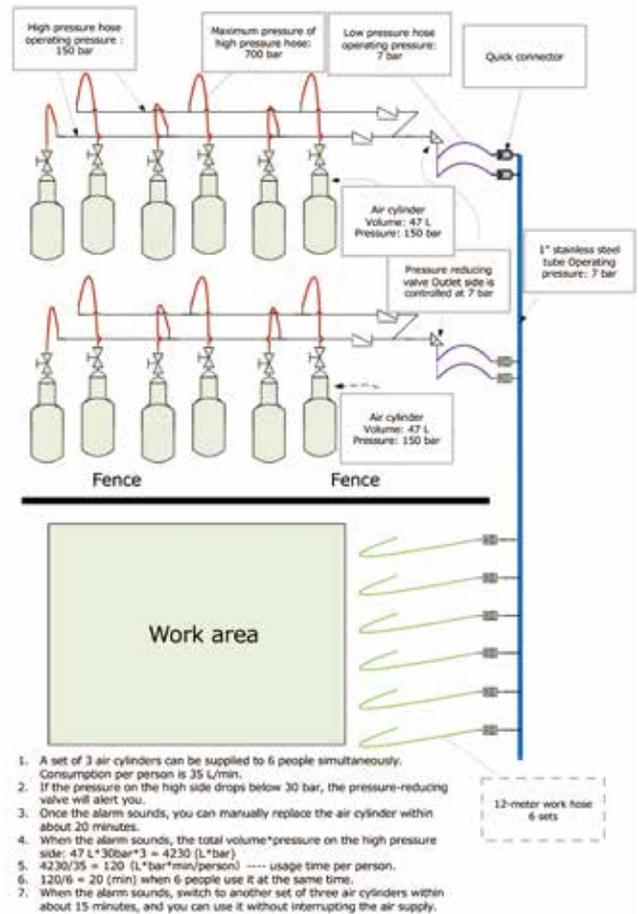
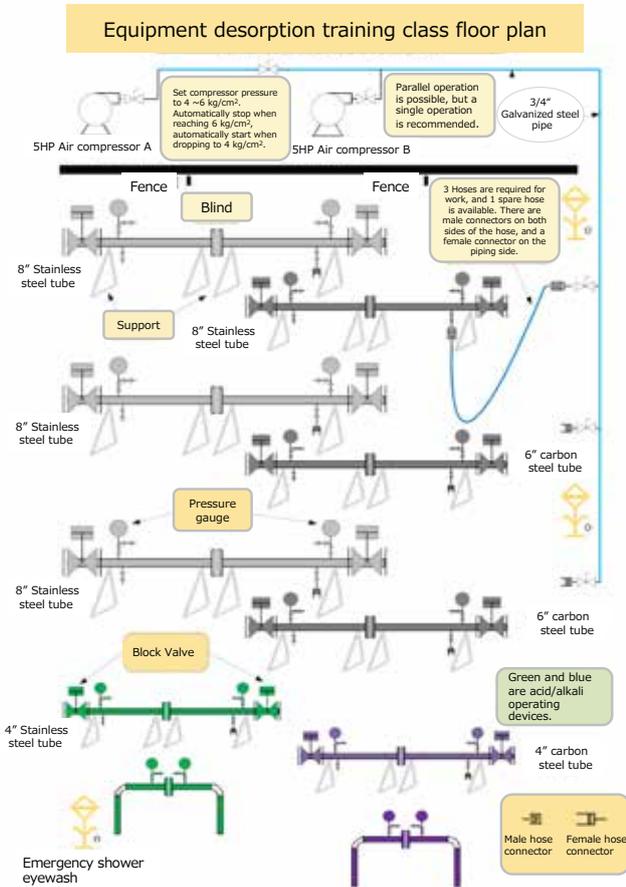


Figure3 Material room design plan

Winter 2021

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### 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 room ① : 3 sets of 30L air cylinders, 3 spare cylinders  
The air header is attached to these air cylinders (Figure3).
4. Material room ② : 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

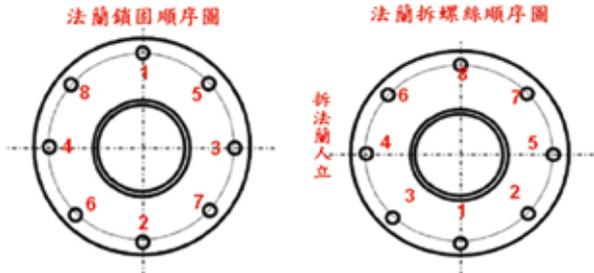


Figure4 Order of flange tightening

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/cm<sup>2</sup> 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 (2019/03/29 Document No. 12015-001)



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