

AB ORLEN LIETUVA

APPROVED BY

Deputy General Director for Operations

_____ 2025

Order No TV1(1.2-1)-

PROCEDURE BM-11 FOR ASSEMBLY AND REPAIRS OF FLANGED JOINTS IN PRESSURE EQUIPMENT

I. GENERAL PROVISIONS

1. AB Lietuva (hereinafter – the Company) Procedure BM-11 for Assembly and Repairs of Flanged Joints in Pressure Equipment (hereinafter – the Procedure) defines requirements for the assembly and repairs of flanged connections in pressure equipment operated by the Company.

2. This Procedure applies to Company employees and contractors (in accordance with relevant contracts concluded with the Company) engaged in the organization, planning, and execution of flanged joint installations and repairs.

II. REFERENCES

3. This Procedure has been prepared based on the following standards:

3.1. ASME PCC-1:2019 - Guidelines for Pressure Boundary Bolted Flange Joint Assembly.

3.2. ASME PCC-2:2022 - Repair of Pressure Equipment and Piping.

3.3. LST EN 1591-4:2013 - Flanges and their joints. Qualification of personnel competency in the assembly of the bolted connections of critical service pressurized systems.

III. REQUIREMENTS FOR ASSEMBLY OF FLANGED JOINTS FOR PRESSURE EQUIPMENT

Requirements for personnel competency, assembly procedures and quality inspection

4. Contractor employees responsible for the assembly and repair of flanged joints shall be trained and certified in accordance with the LST EN 1591-4 standard, and shall comply with the requirements set forth in this Procedure. These employees shall be authorized to carry out all flanged joint assembly and repair activities defined within the scope of work specified in the contract concluded with the Company.

5. Company employees responsible for the assembly and repair of flanged joints shall adhere to the requirements outlined in this Procedure. Company employees (e.g., operators of process units and loading facilities, compressor operators) are authorized to perform the following joint assembly and repair works:

a) Installation and removal of blinds in pipelines carrying group 1 fluids (excluding substances that self-ignite upon contact with air), with a nominal diameter of $D_s \leq 50$ mm, an operating pressure of $P_d \leq 40$ bar, and an operating temperature of $T_d \leq 250^\circ\text{C}$.

b) Elimination of leaks in flanged joints (tightening of flanged joints) in pipelines carrying group 2 fluids, with a nominal diameter (D_s) of ≤ 50 mm, an operating pressure (P_d) of ≤ 40 bar, and an operating temperature (T_d) of $\leq 100^\circ\text{C}$.

6. Fluids are categorized into two groups.

Group 1 includes hazardous fluids classified as:

- a) Explosive;
- b) Extremely flammable;
- c) Highly flammable;
- d) Flammable (where the maximum allowable temperature is above the flash point);
- e) Very toxic;
- f) Toxic;
- g) Oxidizing.

Group 2 includes all other fluids that are not classified as hazardous.

7. Following the installation of new pipelines or the repair or reconstruction of existing joints, the Contractor shall perform a quality inspection of the assembled flanged joints in compliance with the requirements of this Procedure. All inspection data shall be documented in the Flanged Joint Assembly Quality Certificate (Attachment 4), and the results shall be confirmed by the signatures of the responsible individuals listed in the certificate. The certificate shall include a diagram showing the specific flanged joints along with their corresponding identification numbers.

In the case of positive inspection results, the original certificate shall be added to the technical documentation file for installation, repair, or reconstruction works. A copy of the certificate, serving as confirmation that the flanged joints may be finally assembled (tightened), shall be handed over to the employee responsible for performing these works.

In the case of negative inspection results, the supervisor of the works and the ordering party (customer) shall be notified immediately to address the identified nonconformities and arrange a repeat quality inspection of the respective flanged joints.

Cleaning and examination of flange and fastener contact surfaces

8. Before commencing the assembly of flanged joints, the flange and fastener contact surfaces must be thoroughly cleaned and visually inspected.

9. All traces of the previous gasket installation must be removed from the gasket contact surfaces. To prevent damage to the surface finish, cleaning shall be performed using approved solvents and/or soft-wire. Cleaning stainless steel flanges with brushes containing carbon steel bristles is prohibited, as it may lead to corrosion caused by metal interaction.

10. Gasket contact surfaces of both mating joint flanges shall be examined for any damage to the surface finish, including as scratches, nicks, gouges or burrs.

11. Any questionable imperfections shall be reported to the facility's mechanical engineer for evaluation and corrective action, if necessary.

12. When working with large-diameter flanges that have a history of leaks, the gasket contact surfaces of both joint flanges shall be inspected for flatness in both radial and circumferential directions. This may be accomplished using straight-edge gauges and feeler gauges. A securely mounted run-out/flatness gage or field machining equipment capable of providing accurate total

indicator readings may be also used. The facility's mechanical engineer shall be responsible for conducting this inspection.

13. The faces and threads of studs, bolts, and nuts shall be examined for damage, including rust, corrosion, or burrs. Any damaged components shall be replaced. Bolt/nut combinations for which the nuts do not turn freely by hand past their final tightened position shall be replaced.

14. Recommendations for previously used studs, bolts and nuts:

a) For fasteners of common grade (e.g., SA-193 B-7 studs with SA-194 2H nuts or SA-193 B16 studs with SA-194 7 nuts) with diameters up to M30, it is recommended to replace them with new fasteners prior to each assembly;

b) For fasteners exceeding M30 in diameter, it is advisable to assess their condition, compare reconditioning costs with the price of new fasteners, and consider the operating conditions of the joint;

c) When using coated bolts and studs, the remaining corrosion protection and self-lubricating functions shall be considered with the respect to continued use or replacement.

d) Studs and nuts of any diameter shall be replaced if found to have been abused or nonlubricated during previous assemblies.

e) Thread dies generally do not produce a smooth reconditioned surface; therefore, turning bolt threads in a lathe is the recommended method for reconditioning costly fasteners. Since this process removes thread material, it is essential to ensure that the tolerance limits for the original class of fit are not exceeded. Any fastener with thread dimensions below the minimum major diameter or minimum pitch diameter shall be replaced.

f) Nuts are generally replaced rather than reconditioned;

g) The facility's mechanical engineer shall determine whether studs, bolts, and nuts are suitable for reuse.

15. It is advisable to replace all fasteners that have been affected by operational fatigue, difficult disassembly or joint leakage.

16. If one bolt or stud in a joint is replaced, it is recommended to replace all bolts or studs. If all bolts or studs cannot be replaced or if more than one bolt or stud is replaced, they shall be spaced symmetrically around the bolt circle and surrounded by old fasteners.

17. Nut-bearing or washer-bearing surfaces of flanges shall be examined for scores, burrs, visual evidence of out-of-squareness (indicated by uneven wear), etc. Roughness, gouges, and protrusions should be removed from these surfaces. On severely damaged flanges, machining of the affected area shall be required. In this case, the resulting residual flange thickness shall meet the minimum acceptable value as specified in applicable technical requirements or manufacturer specifications.

Alignment of flanged joints

18. Proper alignment of all joint members results in maximum sealing surface contact, uniform and design-level gasket loading, and reduced friction between the nut and the flange.

19. Out-of-tolerance conditions should be corrected before the gasket is installed to avoid damaging it. Only minimum or reasonable adjustments are allowed after the gasket is installed.

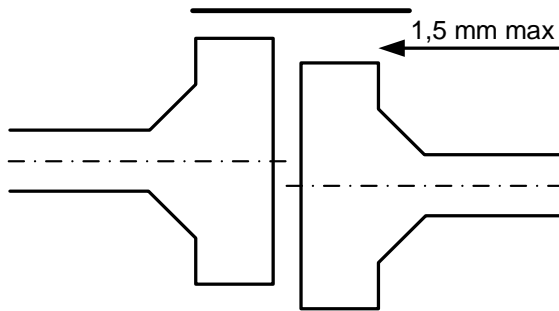
20. When aligning requires more force than can be exerted by hand or common hand and hammer alignment tools such as spud wrenches and alignment pins, a separate decision shall

be made. If alignment is proper, this will result in the bolts passing through the flanges at right angles and the nuts resting flat against the flanges prior to tightening.

21. The best practice is to repair the misaligned component by replacing it correctly, removing and reinstalling it in the properly aligned position

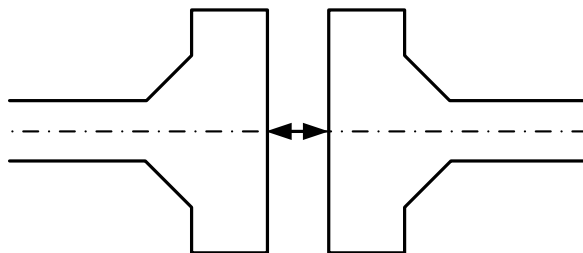
22. The axial gap at any measured point in a flanged joint shall not exceed 1.5 mm (see Fig.1). Measurement shall be done at four points around the flange, approximately 90 degrees from each other.

Fig. 1. Centerline High/Low



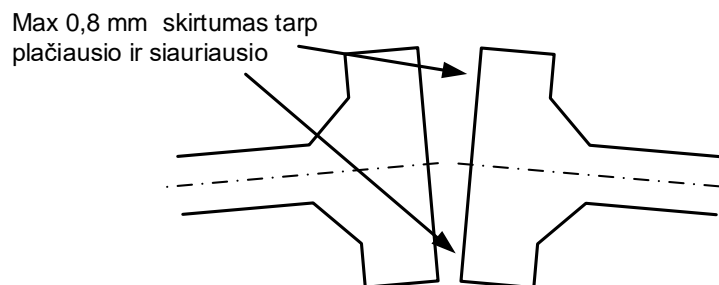
23. The distance between two flanges at rest shall not be greater than twice the thickness of the gasket (see Fig. 2).

Fig. 2. Excessive spacing or gap



24. Piping or vessel flanges shall be aligned so that the distance between flange faces is equal at all points around the circumference of the joint, ensuring the flange faces remain parallel to each other. The tolerance is usually determined by measuring the closest and farthest distances between the flanges and comparing them. An acceptable practice is to maintain a difference of no greater than 0.8 mm at the outer diameter of the sealing surface, achieved using a force of no greater than 10% of the maximum torque for any bolt (see Fig. 3).

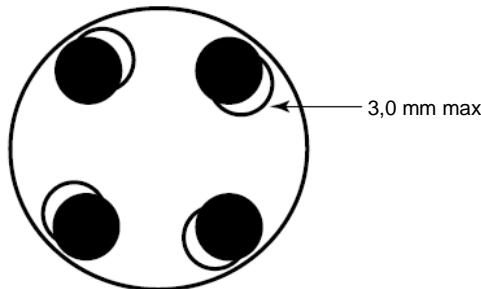
Fig. 3. Parallelism



25. Piping or vessel flanges shall be aligned so that the bolt holes are properly matched,

allowing fasteners to pass through perpendicular to the flanges without obstruction or induced stress. The tolerance is measured by observing a 90-degree angle where the fastener passes through the holes. It must be within 3 mm of perfect alignment (see Fig. 4).

Fig. 4. Alignment of holes



26. When no external alignment devices are used, the flanges should be brought into contact with the uncompressed gasket uniformly across the sealing surface, applying less than 10% of the total target assembly bolt load. During flange alignment, bolts shall not be tightened beyond 20% of their specified maximum torque.

27. When external alignment devices are used, the flanges should be brought to the compressed gasket thickness uniformly across the sealing surface, applying an external load of less than 20% of the total target assembly bolt load.

Installation of gasket

28. Gaskets shall be installed after verifying that they meet the required dimensional (outer diameter, inner diameter, thickness) and material specifications. The gasket type shall be determined by the process fluid properties and operating parameters specified in Attachment 1. The facility's mechanical engineer is responsible for selecting gaskets for operated equipment.

29. Gaskets shall be positioned concentrically with the joint's inner diameter, taking suitable measures to ensure that it is adequately supported during the positioning process and maintain its stability within the sealing area. No portion of the gasket should project into the flow path preventing flow disruption and avoiding potential damage to the gasket.

30. It is important to ensure that the gasket will remain in place during the joint assembly process. A very light dusting of spray adhesive on the gasket (not the flange surface) may be used if necessary. Particular care should be taken to avoid adhesive chemistry that is incompatible with the process fluid or could contribute to stress corrosion cracking or pitting of the flange surfaces.

31. Gaskets shall not be reused, except for metallic gaskets. The substrates of metal gaskets with facing layers may be reused after having been reconditioned and refaced in a manner consistent with the original product specification.

Lubrication of working surfaces

32. Lubrication shall be applied to the working surfaces of studs, bolts, and nuts to achieve the required tension in the flanged joint and to improve the consistency of the resulting load.

33. The lubricant must be chemically compatible with the bolt/nut/washer materials and the process fluid. The use of lubricant chemistry that may cause corrosion cracking, galvanic corrosion, oxygen auto-ignition, or similar adverse effects is strictly prohibited. The facility's mechanical engineer is responsible for selecting proper lubricants.

34. The selected lubricant must be suitable for the expected range of application temperatures.

35. Before lubricant is applied to the bolt and nut threads, the nuts shall move freely by hand past where they will come to rest after tightening. This ensures that threads are clean, undamaged and suitable for proper engagement.

36. Lubricant shall be applied liberally and completely to the nut contact faces and to the threads on both ends of the bolts past where the nuts will come to rest after tightening. Lubricant shall be applied or sprayed only after bolts have been fully inserted through the joint holes to prevent contamination by solid particles, which may lead to unpredictable torque response.

37. Lubricant shall not be applied to the gasket or gasket-contact surfaces. These surfaces shall be protected against inadvertent application of lubricant, which could compromise seal tightness or result in gasket damage.

Installation of studs, bolts and nuts

38. Before installation, it is essential to verify that studs, bolts and nuts comply with established specifications (materials, diameter, length of bolts, thread pitch, and nut thickness equal to the nominal bolt diameter). The selection criteria for studs and nuts are detailed in Attachment 2. The facility's mechanical engineer is responsible for selecting studs and nuts for operated equipment.

39. Stud length selection shall consider the presence of washers, nut height and required thread protrusion. Threads of studs and nuts shall fully engage for the entire depth of the nut. Excess thread protrusion beyond the nut can hinder joint disassembly due to corrosion or damage.

Tightening of studs and bolts

40. Several tightening methods are available such as hand wrench, slug/hand wrench, impact wrench, torque tools, and tension tools.

41. Tightening tool selection shall be based on the required tightening force, accuracy of torque control, joint type, and other relevant technical specifications.

42. Hand wrenches are practical only for bolts approximately 25 mm in diameter and smaller.

43. Hand-operated torque wrenches are practical only for bolts and studs with assembly torque less than 700 N·m.

44. Torque increments for flanged joints:

a) Installation: hand tighten, then snug up to 15 – 30 N·m (not to exceed 20% of target torque). Check flange gap around circumference for uniformity. If the gap around the circumference is not uniform, make the appropriate adjustments by selective tightening before proceeding. Target torques are indicated in Attachment 3.

b) Round 1: tighten to 20% – 30% of target torque. Check flange gap around circumference for uniformity. If the gap around the circumference is not uniform, make the appropriate adjustments by selective tightening before proceeding.

c) Round 2: tighten to 50% – 70% of target torque. Check flange gap around circumference for uniformity. If the gap around the circumference is not uniform, make the appropriate adjustments by selective tightening before proceeding.

d) Round 3: tighten to 100% of target torque. Check flange gap around circumference for uniformity. If the gap around the circumference is not uniform, make the appropriate adjustments by selective tightening before proceeding.

e) Round 4: continue tightening the bolts and studs, but on a circular clockwise pattern until no further nut rotation occurs at the Round 3 target torque value. This ensures even load distribution and final joint stability.

Tightening sequence

45. Figure 5 and 6 illustrate the cross-pattern tightening sequence and bolt-numbering system, using a single tightening tool.

46. Table 1 outlines the cross-pattern tightening sequence and bolt numbering system when using a single tightening tool.

Fig. 5. 12-bolt flange numbering sequence

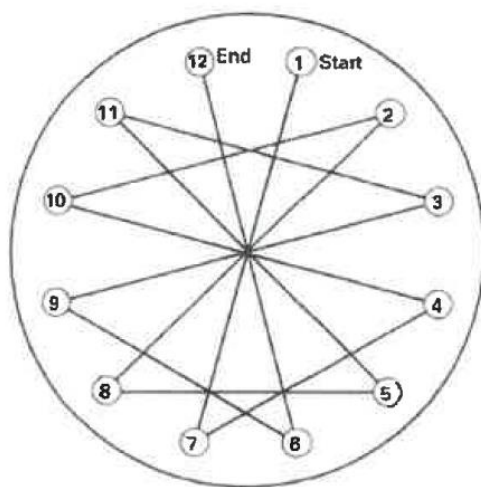
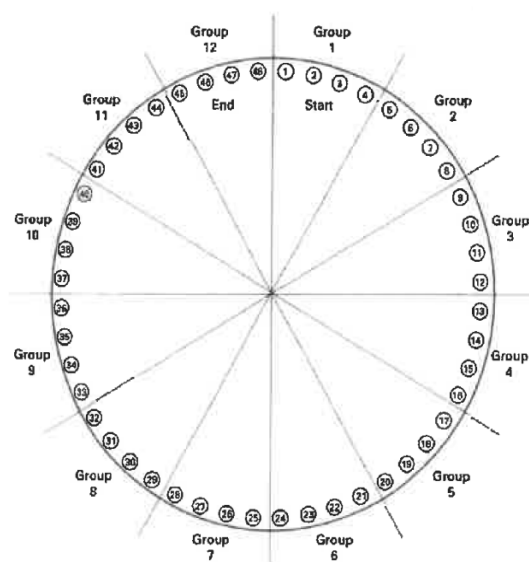


Fig. 6. 48-bolt flange bolt grouping



Grupė	Varžtai
1	1-2-3-4
2	5-6-7-8
3	9-10-11-12
4	13-14-15-16
5	17-18-19-20
6	21-22-23-24
7	25-26-27-28
8	29-30-31-32
9	33-34-35-36
10	37-38-39-40
11	41-42-43-44
12	45-46-47-48

Table 1. Tightening sequence for cross-pattern passes when using a single tool

Varžtų skaičius	Veržimo seka
4	1-3-2-4
8	1-5-3-7 → 2-6-4-8
12	1-7-4-10 → 2-8-5-11 → 3-9-6-12
16	1-9-5-13 → 3-11-7-15 → 2-10-6-14 → 4-12-8-16
20	1-11-6-16 → 3-13-8-18 → 5-15-10-20 → 2-12-7-17 → 4-14-9-19
24	1-13-7-19 → 4-16-10-22 → 2-14-8-20 → 5-17-11-23 → 3-15-9-21 → 6-18-12-24
28	1-15-8-22 → 4-18-11-25 → 6-20-13-27 → 2-16-9-23 → 5-19-12-26 → 7-21-14-28 → 3-17-10-24
32	1-17-9-25 → 5-21-13-29 → 3-19-11-27 → 7-23-15-31 → 2-18-10-26 → 6-22-14-30 → 4-20-12-28 → 8-24-16-32
36	1-2-3 → 19-20-21 → 10-11-12 → 28-29-30 → 4-5-6 → 22-23-24 → 13-14-15 → 31-32-33 → 7-8-9 → 25-26-27 → 16-17-18 → 34-35-36
40	1-2-3-4 → 21-22-23-24 → 13-14-15-16 → 33-34-35-36 → 5-6-7-8 → 25-26-27-28 → 17-18-19-20 → 37-38-39-40 → 9-10-11-12 ↓ 29-30-31-32
44	1-2-3-4 → 25-26-27-28 → 13-14-15-16 → 37-38-39-40 → 5-6-7-8 → 29-30-31-32 → 17-18-19-20 → 41-42-43-44 → 9-10-11-12 ↓ 33-34-35-36 → 21-22-23-24
48	1-2-3-4 → 25-26-27-28 → 13-14-15-16 → 37-38-39-40 → 5-6-7-8 → 29-30-31-32 → 17-18-19-20 → 41-42-43-44 → 9-10-11-12 ↓ 33-34-35-36 → 21-22-23-24 → 45-46-47-48
52	1-2-3-4 → 29-30-31-32 → 13-14-15-16 → 41-42-43-44 → 5-6-7-8 → 33-34-35-36 → 17-18-19-20 → 45-46-47-48 → 21-22-23-24 ↓ 49-50-51-52 → 25-26-27-28 → 9-10-11-12 → 37-38-39-40
56	1-2-3-4 → 29-30-31-32 → 13-14-15-16 → 41-42-43-44 → 21-22-23-24 → 49-50-51-52 → 9-10-11-12 → 37-38-39-40 ↓ 25-26-27-28 → 53-54-55-56 → 17-18-19-20 → 45-46-47-48 → 5-6-7-8 → 33-34-35-36
60	1-2-3-4 → 29-30-31-32 → 45-46-47-48 → 13-14-15-16 → 5-6-7-8 → 37-38-39-40 → 21-22-23-24 → 53-54-55-56 → 9-10-11-12 ↓ 33-34-35-36 → 49-50-51-52 → 17-18-19-20 → 41-42-43-44 → 57-58-59-60 → 25-26-27-28
64	1-2-3-4 → 33-34-35-36 → 17-18-19-20 → 49-50-51-52 → 9-10-11-12 → 41-42-43-44 → 25-26-27-28 → 57-58-59-60 → 5-6-7-8 ↓ 37-38-39-40 → 21-22-23-24 → 53-54-55-56 → 13-14-15-16 → 45-46-47-48 → 29-30-31-32 → 61-62-63-64
68	1-2-3-4 → 37-38-39-40 → 21-22-23-24 → 53-54-55-56 → 9-10-11-12 → 45-46-47-48 → 29-30-31-32 → 61-62-63-64 ↓ 17-18-19-20 → 57-58-59-60 → 33-34-35-36 → 5-6-7-8 → 41-42-43-44 → 13-14-15-16 → 49-50-51-52 → 25-26-27-28 ↓ 65-66-67-68

Tightness testing

47. Testing shall be performed to verify the tightness of flanged joints, ensuring their operational suitability and compliance with design sealing specifications.

48. Acceptable test fluids include inert gas, water or service fluid.

49. Testing shall be conducted at the operating pressure of the respective equipment. If achieving the operating pressure with inert gas is technically impossible, the test shall be performed in two stages:

a) Stage I – a tightness test using inert gas at the maximum inert gas equipment pressure. All depressurized joints shall be inspected using a special leak detector or soap solution.

b) Stage II – a tightness test using service fluid at the operating pressure. All depressurized joints shall be visually inspected.

50. The use of substitute gaskets during testing instead of those designed as the final seal for the joint is prohibited. Gaskets shall conform to design specifications and be identical to those intended for operational use.

IV. REQUIREMENTS FOR FLANGED JOINT REPAIRS

Replacement of studs and bolts in operating equipment

51. Corroded or otherwise damaged studs and bolts in flanged joints may only be

replaced during pressure equipment operation if the following conditions are met:

- a) The operating pressure of the system must be reduced to at least 50% of the relative pressure of the components;
- b) If necessary, the flanges of the affected joint shall be adequately supported or locked to prevent vibration, pulsation, or other external loads that may affect the tightness or stability of the joint;
- c) There must be no visible signs of leakage of process fluid in the gasket area;
- d) The flanged joint must contain at least eight bolts or studs.

52. Studs or bolts shall be replaced one at a time. Each newly installed element shall be fully tightened to 100% of the target torque before proceeding with the next replacement.

53. The replacement of studs and bolts in operating pressure equipment is permitted only with a permit issued in accordance with the Company's Occupational Health and Safety Procedure BDS-5 'Cold Repair Works';

Removal of studs and bolts during shutdowns of process equipment

54. During process equipment shutdowns, partial removal of studs and bolts from flanged joints in pressure equipment may be permitted to expedite repair preparation, provided the following conditions are met:

- a) The process fluid must be fully removed from the affected pressure equipment, and steam or nitrogen must be supplied to the system; If nitrogen is supplied, an additional safety assessment shall be conducted, particularly for confined spaces;
- b) No more than 50% of the studs or bolts in the flanged joint may be removed, and removal must follow an alternating pattern (every second stud or bolt); Stud removal is strictly prohibited if the flanged joint contains fewer than eight studs.

The removal of studs and bolts during process equipment shutdowns is permitted only with a permit issued in accordance with the Company's Occupational Health and Safety Procedure BDS-5 'Maintenance Works';

Troubleshooting of flanged joint leaks in operating process equipment

55. Approach to troubleshooting leaks in flanged joints depends on:

- a) Process fluid characteristics, i.e. the group of fluid;
- b) Type and intensity of leak.

56. Leaks in flanged joints can be classified as:

- a) Minor leaks – fluid dewing, dripping, or gas shimmering in the flanged joint area;
- b) Major leaks – a continuous jet flow of fluid or audible gas penetration through the flanged joint.

57. Minor leaks of Group 1 fluids and both minor and major leaks of Group 2 fluids through a flanged joint in operating pressure equipment may be mitigated by tightening the joint, provided the following conditions are met:

- a) The studs and bolts of the flanged joint must show no significant corrosion or cracking;
- b) The gasket must be free from visible damage;

c) There must be safe escape routes for personnel performing the tightening procedure;

d) If required, firefighters must be on standby near the work site, and a fire hose with water must be connected, following a risk assessment, as determined by the facility's manager.

58. The classification of the leak size – as minor or major – shall be determined by the facility's mechanical engineer in collaboration with the facility's manager, based on the evaluation of leak intensity, visual and acoustic indicators, and potential impact on operational safety.

59. Tightening of a flanged joint in operating pressure equipment shall be permitted only upon receipt of an official permit, issued in accordance with the Company's Occupational Health and Safety Procedures:

a) BDS-6/1 'Equipment Depressurization Works' – for minor leaks of Group 1 fluids;

b) BDS-5 'Cold Repair Works' – for minor and major leaks of Group 2 fluids.

60. To eliminate leak through retightening, the flanged joint's studs and bolts shall be tightened to 100–110% of the target torque specified in the design documentation or manufacturer's specification.

61. In the case of a major leak of Group 1 fluid through a flanged joint in pressurized operating equipment, tightening is prohibited. To ensure safety and prevent emergencies, a clamp shall be installed, or the equipment – or the entire facility, if necessary – shall be shut down.

V. FINAL PROVISIONS

62. Director of Maintenance shall be responsible for arranging periodic reviews of this Procedure and its update, if necessary.

VI. ANNEXES

Attachment 1. Selection of gaskets for flanged joints based on process fluid and its characteristics.

Attachment 2. Stud specifications.

Attachment 3. Tightening torques.

Attachment 4. Flanged Joint Assembly Quality Certificate

Full name	Position	Signature
Prepared by:		
Viktoras Fuks	Chief Engineer	
Agreed with:		
Audrius Daugnora	Deputy General Director for Operations	

Mantas Sutkus	Director of Maintenance	
Gražvidas Šakys	Deputy Director of Maintenance	
Rolandas Rupšys	Occupational Health and Safety Manager	
Kęstutis Šveliovas	Equipment Technical Supervision and Materials Analysis Manager	