
Requirements

Classification: Internal

Status:  Relevant

Version: 7.03

TR1951 Piping Engineering

Project development

Requirements, TR1951, Version 7.03,

Document replaces version 7.02

Relevant versions:

- [7.01](#) (2016-11-15 07:31)
- [7.03](#) (2021-08-18 15:01)

1	Objective, target group and provision	5
1.1	Objective	5
1.2	Target group	5
1.3	Provision	5
2	TR2000 - Piping and valve material specification	5
2.1	General	5
2.2	Design codes	6
2.3	The European Pressure Equipment Directive (PED)	6
2.4	Line sizing and material selection	6
2.5	Piping specification in mechanical packages	6
2.6	Valve selection	6
2.7	Flanges and mechanical joints (Clamp connector)	7
2.7.1	ASME B16.5 flanges versus Compact flanges	7
2.7.2	Compact flanges	8
2.7.2.1	General requirements	8
2.7.2.2	Compact flanges installed upstream of ESDV (riser side for offshore)	8
3	Flange pressure rating and design pressure	9
3.1	Occasional variation of pressure and temperature	9
3.1.1	Example of application of deviation	9
3.1.2	PSV set pressure	9
3.1.3	Exposure time	9
3.1.4	Justification of piping overpressure	10
3.2	ASME B16.5 flange pressure rating including valves and equipment flanges	10
4	Equipment and system isolation for maintenance	10
4.1	General	10
4.2	Requirements to isolation barrier practice	11
4.3	Blinding and physical disconnection/ removal of spool piece	12
4.4	Single isolation barrier by use of valves	12
4.5	Double isolation and bleed (DI&B) by use of valves	12
4.6	Requirements for valves when used as isolation barriers	13
4.7	Simplified test for small bore valves	15
4.8	Use of stem backseat as isolation barrier	16
4.9	Use of other types of isolation barriers	16
5	Piping detail standard	17
6	Piping fabrication, installation, flushing and testing	17
6.1	General	17
6.2	Code hydro-test pressure	17
6.3	Bolt tensioning	17

6.4	Tubing as replacement for piping	17
6.5	Piping repair and cold installations methods	17
7	Acoustic fatigue in piping systems	18
7.1	Excitation from pressure reduction sources	18
7.2	Method for evaluating acoustic fatigue	18
7.3	Acceptance level	19
7.3.1	Additional evaluation to further increase of the acceptance level	19
7.4	Design improvements	20
7.5	Remedial action to reduce noise from the source	20
8	Vibrations	20
8.1	Bracing of nozzles and branches	20
9	Line sizing and optimisation	20
10	Arrangements of piping functions	21
10.1	Depressurisation	21
10.1.1	Location and pressure rating of flare system block valve for maintenance	21
10.1.2	Wall thickness upstream a reducer	21
10.2	Pressure class break for manual or control valves to flare	21
10.3	Nitrogen purging	22
10.4	Flushing and cleaning	22
10.5	Standpipes (bridles)	22
10.6	Equalisation of pressure across valves	22
10.7	Break out spools	22
10.8	Galvanic isolation between materials	22
10.9	Closed drain pressure class from pressure vessel and safety critical valves	23
10.10	Pressure test connection	23
10.11	Drainage of piping	23
11	Pipe stress evaluation and analysis	24
11.1	General	24
11.2	Critical lines	24
11.3	Explosion load on piping	25
11.4	Vessel/deck deflections	26
11.5	Fatigue	26
11.6	Dynamic loads	27
11.7	Loads from piping systems on equipment	27
11.8	Flange external bending moment	28
11.9	Expansion bellows in piping systems	28
11.10	GRE analysis	28
11.11	Pipe stress documentation	28

12	Securing of valves in correct position	29
13	Additional information	29
13.1	Definitions and abbreviations	29
13.2	Changes from previous version	30
13.3	References	31
14	App A Testing of barriers, examples (Informative, ref. ARIS OM05.07.01.01)	32
14.1	A.1 Example 1: DI&B using two valves with mechanical activated sealing and interposed bleed-off	32
14.2	A.2 Example 2: DI&B using two valves with pressure activated sealing and interposed bleed-off	33
14.3	A.3 Example 3: DI&B using valve with mechanical activated sealing	34
14.4	A.4 Example 4: DI&B where the second barrier has a pressure boosted sealing that gives leakage at the low pressure test	35
14.5	A.5 Example 5: Single barrier	36

1 Objective, target group and provision

1.1 Objective

The objective of this document is to describe the Company requirements and design practices within Piping Engineering. TR1951 shall apply to both onshore and offshore facilities.

For offshore facilities TR1951 shall apply to all piping systems contained within the facility (topsides and hull). The facility limits shall with respect to external interfaces on offshore plants be considered as being the following:

- Import risers – from and including riser ESD valves
- Export risers – to and including riser ESD valves
- Xmas tree and wellhead assemblies – from / to flanged interface on Xmas tree or wellhead.

For onshore facilities TR1951 apply to all piping systems contained within the facility.

The facility limits shall, with respect to external interfaces for onshore plants be considered as being the plant isolation valve, i.e. the first or last valve on any pipe or pipeline that has an interface outside of the plant

See GL1951 for guidance on the design and engineering of piping systems

1.2 Target group

The target group for this document is personnel involved in conceptual studies, FEED studies, pre-engineering, project execution, detail design and modifications.

1.3 Provision

Provision is made in Management System (TR3010 "Mechanical Technology Technical Requirements and Standards").

2 TR2000 - Piping and valve material specification

2.1 General

TR2000 is a Piping and Valve Specification System. The basic principles of the system are to standardize requirements to components and to tailor the menu of Piping Class Sheets (PCS) to each plant's need, i.e. process requirements.

The TR2000 "Plants" includes piping and valve material specifications for Plant Categories "Operative Plants" including existing plants and realization projects, "Best Practice" library with piping class sheets (typical naming E MAS) and "Frame Agreements".

For each plant, all relevant datasheets are collected in an Issue. The Issue contains a set of plant specific PCS's, with specific revisions of all referenced datasheets i.e. MDS, VDS etc. To avoid frequent changes of a plant specific Issue, an Issue is not always updated to include the latest revision of datasheets referenced from PCS.

SR-15915 - For projects in the study phase "Best Practice" library should be used as the basis for the studies. In cases where the project is mature and requires special piping classes, a plant for the project specific piping and valve specification shall be developed in the TR2000 database and will be located in Plant Category "Operative Plant".

Reference is made to www.TR2000.net.

SR-15916 - The TR2000 shall be developed along with material selection and process requirements to achieve a good

technical and economical solution as described below.

SR-15917 - New piping classes and Valve Data Sheets shall be generated from the TR2000 based on existing piping component articles. All adjustments and/or additional piping classes/Valve Data Sheets etc. shall be approved.

SR-15868 - The development of the TR2000 must be started early in the project phase and will be a "living" document as the development of the project progresses. This includes all project development phases.

2.2 Design codes

SR-12659 - Design code is specified in TR2000 Piping Class sheet. ASME B31.3 shall normally be used. Other codes may be used when required and it shall then be identified in the TR2000 Piping Class sheets.

2.3 The European Pressure Equipment Directive (PED)

SR-12661 - The European Union Pressure Directive (PED) is mandatory for plants located within the European Economic Area (EEA). If changes in the TR2000 are proposed relative to PED, then Company shall be addressed with the objective to participate in discussion and communications in order to maintain the TR2000 technology. Contractor shall develop and present a PED strategy to Company, detailing Contractor's methods to achieve PED compliance. Each project shall be responsible for PED compliance by a Notified Body's formal approval. Engagement of Notified Body in this process is dependent on the Contractor's quality system and the selected quality module.

SR-15918 - A general conformity assessment of use of ASME B31.3 / TR2000 under PED has been performed by two independent Norwegian Notified Bodies DNV GL and Kiwa. Discussions regarding use of ASME B31.3 as design code and materials (ASTM) are hence not any issue as long as any of these Notified Bodies are selected. Ref. PED tab in TR2000.

If another Notified Body is selected for a project, the selected Notified Body has to perform an evaluation of TR2000 and use of ASME B31.3 under PED (preferable as an endorsement of DNV GL's and Kiwa's conclusions).

2.4 Line sizing and material selection

SR-12663 - Line sizing and material selection is a part of the development of a project's TR2000 and shall be based on how material selection, piping class selection and process requirements affect the economical result.

Reference is made to section 9 below for line sizing and optimization.

2.5 Piping specification in mechanical packages

SR-12665 - Piping specification in mechanical packages or system modules shall be according to TR2000. However, for equipment where it is unreasonable to use this specification, the supplier may request a deviation. The deviation can only be implemented after acceptance. Deviation request shall include details enabling Company to evaluate if the alternative solution shall be included in TR2000.

2.6 Valve selection

SR-12667 - TR3017 Valve Selection Manual shall be used in projects. Engineering evaluation shall be performed with the objective to evaluate all affecting parameters and to achieve an optimal solution. Deviations to TR3017 may be proposed, but shall only be implemented if accepted.

2.7 Flanges and mechanical joints (Clamp connector)

SR-15919 - Flanges and/or mechanical joints are specified in each of the Piping Classes in TR2000. ASME B16.5 and ASME B 16.47 Series A (MSS-SP-44) shall generally be specified for pressure Class 150 and up to an including class 2500. Clamp connector may be specified for Class 1500 and higher up and including 12" size, see table 1.

Valves are normally specified with flanged or mechanical joint connections. Piping inline equipment should be specified similarly. Deviation to this may be accepted if the equipment clearly is designed for the life time of the plant without need of disconnection, or if needed for special reasons, e.g. toxic fluids.

Other equipment connected to piping shall be specified with the same connection as stated in the Piping Class.

See also section 3, "Flange pressure rating and design pressure" regarding design pressure for ASME and MSS-SP flanges.

	ASME B16.5	ASME B16.47A	Compact flange	Mechanical Joints
CL150	<=24"	26"-60"		
CL300	<=24"	26"-60"		
CL600	<=24"	26"-60"	3"-48"	
CL900	<=24"	26"-48"	3"-48"	
CL1500	<=24"		3"-48"	1"-12"
CL2500	<=12"		3"-24"	1"-12"
CL4500 →				1"-12"

Table 1 Table for selection of flanges and mechanical joints

2.7.1 ASME B16.5 flanges versus Compact flanges

SR-12673 - ASME B16.5 (ASME B 16.47 Series A) ring joint facing shall be used as default for CL 600 to CL 2500.

SR-12674 - Compact flanges should be used when the following conditions and design requirements are important for the project:

- Weight saving is critical or required.
- Beneficial to the stress calculation (more resistant to explosion loads).
- The present design and layout will require or benefit in smaller flange dimensions.
- Credited for safety (more safe than ASME B16.5 flanges) due to two sealing faces (heel and ring) and static behaviour of the flange.
- The ring (gasket) is less exposed to the fluid, external environment and thereby corrosion.

SR-12675 - When Compact flanges are selected they shall not be used for equipment listed below:

- Sensitive Rotating Equipment
- Spectacle blinds and spacers that are frequently used (every 6 month or more frequent)

SR-12676 - The project shall standardise on one type of flange/joint (to the maximum extent).

SR-14734 - Manufacture/machining shall be prequalified prior to fabrication of Compact flanges.

2.7.2 Compact flanges

2.7.2.1 General requirements

Compact flanges according to the standard ISO 27509 may be specified for pressure class 600 and higher and for pipe sizes 3" and larger.

SR-16831 - Compact flange shall not be evaluated for use for pressure class below class 600 for austenitic stainless steel materials due to undesirable welding heat effects that can cause deformation on the flange.

The project Piping Class will show the type of joints to be used.

2.7.2.2 Compact flanges installed upstream of ESDV (riser side for offshore)

SR-12681 - If flanges can be used on the riser side of a flow line, compact flanges shall be the preferred selection. For technical safety requirements see TR1055 (offshore) and TR2237 (onshore).

SR-14739 - Riser components on battery limit pipeline side of ESDV shall comply with TR1098, Submarine pipeline systems.

SR-12682 - Where compact flanges are used on risers, the following additional technical requirements shall be adhered to:

- Special design of compact flanges outside ISO 27509 shall be verified according to ISO 10423 Annex F or qualified according to ARIS, Qualify technology for first use.
- Compact flange design shall be verified and accepted by technical personnel - typically discipline responsible (internal or external) having relevant competence on compact flanges.
- Weld neck compact flanges shall be made according to ISO 27509.
- The compact flanges shall be subject to individual dimensional checks.
- A test procedure for testing of flange after welding to pup piece or riser shall be developed and accepted. The test procedure shall as a minimum include the following requirements:
 - The flange shall be individually pressure tested to verify and document that the sealing surfaces in both heel and ring groove are tight.
 - The flange shall be tested with blind flange designed with a test port between flange heel and ring groove.
 - Test no. 1 shall be performed with a IX seal ring in the compact flange ring groove with 1.5 times the design pressure to verify the flange heel sealing capability. The pressure shall be monitored and any leakage shall be measured through the blind flange test port.
 - Test no. 2 shall be performed with a IX seal ring in the compact flange ring groove with 1.5 times the design pressure of the Piping Class in both flange bore and blind flange test port to verify the flange ring groove sealing capability. Any leakage shall be measured with a pressure gauge through the blind flange test port by monitoring any pressure decrease.
 - Alternative test procedures may be proposed for evaluation and acceptance.
- In addition to the assembly requirements in ISO 27509 the following shall be added and included in a procedure that shall be developed and accepted:
 - Perform visual inspection to verify that there are no damages or corrosion on the flange sealing surface immediately prior to flange assembly and bolt-up.
 - For preservation, apply a layer of thin oil on flange sealing surfaces and on the IX seal ring.
 - Apply grease on the middle section of the bolt (the part of the bolt that will be inside the flange). The

remaining part of the bolt shall be lubricated with special paste for bolt torque.

- Protection caps should be provided for bolt and nut protruding out from flange.
- Apply a wax layer on the outside of the flange wedge in order to protect bolting from environmental moist etc.
- The seal ring shall not be re-used if the flange connection has been opened.
- A procedure shall be developed if the joint has to be re-opened including the requirements listed above.

3 Flange pressure rating and design pressure

3.1 Occasional variation of pressure and temperature

SR-12688 - ASME B31.3 allows for the piping to be exposed to temperature and pressure over the design in periods as defined in ASME B31.3 § 302.2.4. The use of this paragraph is encouraged where significant cost and weight savings can be achieved. To ensure safe and consistent practice and to document the use for the operational phase, the use of this paragraph shall be documented and approved in deviation system; DISP. The content of the deviation request shall be as specified in 3.1.4. The two Norwegian Notified Bodies DnV and TIS have accepted the use of this paragraph under PED.

3.1.1 Example of application of deviation

- Shut-in pressure of well stream when considerably higher than normal operating conditions
- Shut-in pressure of pumps and compressors
- Equalising pressure across discharge to suction pressure of compressors and pumps.
- When PSHH or PSH dependent on process case can be set high enough compared to normal operating condition to avoid operating limitation. In such cases design condition should be at the PSHH or PSH if considerable saving in piping material is achieved
- Pressure surge, e.g. water hammer, see GL1951.

These are examples only and other cases may be evaluated.

3.1.2 PSV set pressure

SR-12693 - ASME B31.3 § 322.6.3 (b) and (c) with respect to PSV set pressure shall be included in the evaluation, also noting that note 13 in (c) of the § is met. This means that set pressure of PSV that is protecting the piping may be set at a higher pressure than the design pressure given in the piping class.

3.1.3 Exposure time

SR-16833 - For exposure above the design pressure, Company philosophy is that the nature of and potential for the exposure time should be evaluated and grouped within the time frames in ASME B31.3, § 302.2.4 (f) (1) and (2), based on the time being nominal time. In each case of occasional overload scenarios, fulfilments of the ASME B31.3 Chapter 302.2.4 requirements shall be documented. In most cases the nature of and potential for exposure over design will be sufficient documentation of fulfilment of code requirements. Logging of time will normally not be required.

The effect of fatigue of the piping and the effect the enhanced condition may have on other connected pressure equipment, i.e. valves, fittings, vessels etc., shall be taken into account.

3.1.4 Justification of piping overpressure

SR-12698 - For piping systems with possible overpressure scenarios, the following minimum documentation shall be included in a deviation request.

- Based on process data
 - Per cent overpressure above design (100%) ASME B31.3 § 302.2.4
 - Cause of overpressure
 - Expected frequency of overpressure
 - Expected duration and mechanisms that will limit the duration
- Measures to document that the ASME requirements are satisfied
- Cost / benefit assessment
- Evaluation of potential risk in case of leakage from rated components or damage to equipment.
- Confirmation from the suppliers that involved valves and equipment will handle the overpressure if the pressure exceeds 1,1 times the valve design pressure.

There shall be an approved deviation application before it is designed for overpressure and implementation in a project. This is to ensure a uniform treatment within Company of such cases.

3.2 ASME B16.5 flange pressure rating including valves and equipment flanges

SR-12701 - For certain materials, Company uses higher pressure rating than tabulated in ASME B16.5. This is based on experience prior to the time the material was included in ASME B16.5, and based on evaluation and calculation according to ASME B31.3 and ASME VIII Div. 1. The Piping Classes and valves in TR2000 are specified with the rating as determined by Company. Flanges on equipment that are connected to the piping shall be according to the rating of ASME B16.5 or TR2000, whichever is the higher rating.

Example of material that is used with higher pressure rating than in ASME B16.5 are 22 and 25 Cr duplex material, 6Mo and titanium.

4 Equipment and system isolation for maintenance

4.1 General

Isolation barriers as it is handled in this chapter, is defined as an isolation barrier between a pressurised system and a part that will be needed to open for maintenance or modifications. The relevant types of isolation barrier and the conditions and limitations attached to them are described below.

SR-12704 - Beyond the specific requirements given in this document and TR3017 Valve Selection Manual, design of isolation barrier philosophy with valve type shall be based on life cycle cost of installation and maintenance operations.

SR-12705 - New products, which shall be used as an isolation barrier, shall be qualified for the purpose in accordance with ARIS, Qualify technology for first use.

4.2 Requirements to isolation barrier practice

SR-14743 - Table 2 states the isolation barrier requirements for different services and ratings. Comments are as noted below the table.

	Isolation barrier requirement				Additional isolation barrier requirements
Service\Rating ³⁾	≤ CL150 ⁸⁾	CL300 ⁸⁾	≥ CL600	Segments where a barrier leakage can result in a severe incident caused by leakage of large volumes from the segment ⁶⁾ , all ratings	Equipment or systems that may be disconnected for longer periods, all ratings ⁷⁾
Non-hazardous medium	Single barrier			Same as CL150, CL300 & CL600	Line blinds not required
Flammable ¹⁾ or hazardous medium	Single barrier with possibility to blind off ⁵⁾ , or DI&B ⁴⁾			DI&B ⁴⁾	Line blinds
Liquefied gas (LNG or LPG) or medium at a temperature above the self-ignition temperature	DI&B ⁴⁾				
Toxic gas ²⁾ (e.g. H2S)	DI&B				

Table 2 Isolation barrier type

Notes:

1. Excluding liquefied gas (LNG or LPG) or medium at a temperature above the self-ignition temperature
2. Toxic gas means that the concentration of the toxic gas can be high enough to cause permanent injury or death by breathing it in case of a leakage.
3. Classification according to ASME B16.5, specific pressure limits are dependent upon temperature and material quality, but typically CL150 covers pressures up to 20 bar, CL300 covers pressures up to 50 bars and CL600 covers pressures up to 100 bars.
4. For valves with dimensions up to and including 3" it is acceptable to use two block valves without bleed, with a simplified barrier test.
5. E.g. equipment that can be removed and then blinded off with a blind flange, threaded plug/cap or isolated by a physical blind (Spectacle blind or spade).
6. Typical liquid systems that cannot be depressurised within one hour. For barriers where the system to be opened is in an area where any liquid leakage will be collected by an open drain system with sufficient capacity, time to drain of liquid could be prolonged.

7. Valid for duplicated equipment's, typical A & B trains, where maintenance normally will last for typical several weeks
8. For instrument connections as specified in TR2325, isolation between piping and instruments, a single valve is acceptable for CL150 through CL2500 provided that instrument equipment includes a built-in isolation valve and a bleed facility

4.3 Blinding and physical disconnection/ removal of spool piece

SR-12710 - Blinding and gaskets shall be of the same pressure class as the flanges to which they are fitted.

4.4 Single isolation barrier by use of valves

SR-12712 - A single isolation barrier is achieved by establishing a barrier that can be tested prior to use and be maintained and monitored as long as it is used as a barrier. See appendix A (example 5) for description of how a typical single barrier is arranged.

4.5 Double isolation and bleed (DI&B) by use of valves

SR-12714 - "Double isolation and bleed" is achieved by establishing two independent isolation barriers that both can be tested prior to use and be maintained and monitored as long as they are used as barrier. See appendix A (examples 1 to 4) for procedure for alternative DI&B barriers.

SR-12715 - DI&B can be achieved using the following two arrangements:

1. Two block valves set in series with an interposed bleed-off valve stubbed in between the two block valves to provide a means to bleed to a safe location (see valve arrangement on left hand side below).
2. DI&B achieve in a single valve body with a barrier on each side of the closing device (ball, gate, plug or similar, that is activated through the valve stem or in combination with spring and pressure forces), and with a bleed-off facility from the cavity. See the valve arrangement on the right hand side of Figure 1 below.

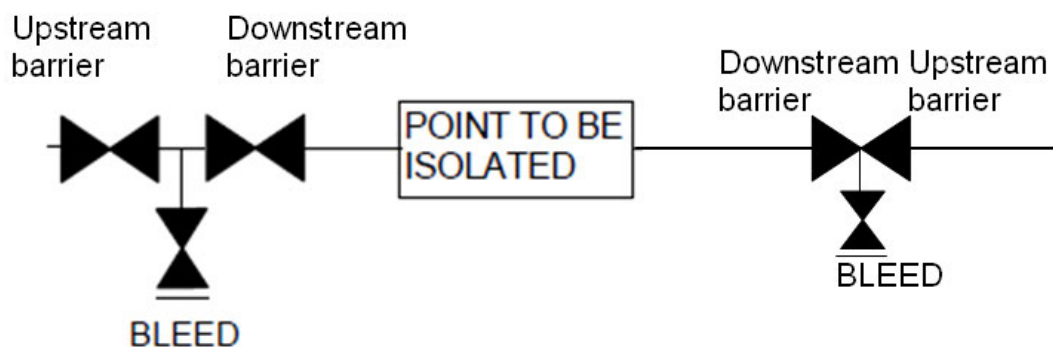


Figure 1 Example DI&B with two valves on left side and by single valve on right side

SR-12716 - For valves where the seat sealing surface is activated through the pressure from the media, it is important to ensure that the downstream barrier is maintained in correct position (e.g. slabs in gate valves can move with external movement or by gravity when not pressurised).

4.6 Requirements for valves when used as isolation barriers

SR-12718 -

- It shall be possible to secure the valve in the closed position, and the securing device shall be unlocked/ broken before the valve can be operated.
- There shall be no (cavity entrapped) pressurised hydrocarbons, toxic or dangerous medium downstream the upstream barrier (for valves <6" with a small cavity volume, deviation to this requirement could be acceptable)
- Any pressure activated sealing shall be kept in desired position
- For actuator-operated barrier valves, it shall be physically checked that the valves cannot be operated once it has been taken into use as a barrier. The actuator energy supply shall be disconnected if the valve is not secured with mechanical equipment that is significant stronger than the actuator. Barriers that are mechanically activated by stem force shall have an actuator spring return that force the valve in correct position, if not secured with mechanical equipment that is strong enough to ensure this. Barriers that are not mechanically activated by stem force shall have all springs in the actuator in the relaxed position if the valve is not secured with mechanical equipment that is significant stronger than the actuator. Any gravity induced forces shall also be considered (e.g. for reverse acting slab gate valves).

SR-12719 - Table 3 gives an overview of how typical valve types can be used in a DI&B barrier. The intension of this table is to give the designer an overview of the connections needed and work required to establish a safe isolation barrier. (Handling of old valves with large leakages are not covered by this table, e.g. use of a pressurised fluid to block a leakage).

Valve type	Case 1 Two independent valves used as DI&B barrier ^{2,3})	Case 2 Single valve used as DI&B barrier
Floating ball, fixed seat	-bleed required between the two barriers -high pressure performance test of both barriers, max pressure -depressurise cavity of downstream valve -low pressure performance test of downstream barrier with 7-10 barg -periodic surveillance for any increase in leakage through the bleed	-cannot be used as DI&B
Floating ball, floating seat	-bleed required between the two barriers -high pressure performance test of both barriers, max pressure -depressurise cavity of downstream valve -low pressure performance test of downstream barrier with 7-10 barg -periodic surveillance for any increase in leakage through the bleed	-cavity bleed required -high pressure performance test of both barriers, max pressure -periodic surveillance for any increase in leakage through the bleed
Trunnion mounted (fixed) ball, self-relief seats	-bleed required between the two barriers -high pressure performance test of both barriers, max pressure -depressurise cavity of downstream valve -low pressure performance test of downstream	-cannot be used as DI&B

	barrier with 7-10barg -periodic surveillance for any increase in leakage through the bleed	
Trunnion mounted (fixed) ball, double piston seat downstream (Note 4)	-bleed required between the two barriers -high pressure performance test of both barriers, max pressure -depressurise cavity of downstream valve -low pressure performance test of downstream barrier with 7-10 barg -periodic surveillance for any increase in leakage through the bleed	-cavity bleed required -high pressure performance test of both barriers, max pressure -low pressure performance test of downstream barrier with 7-10 barg -periodic surveillance for any increase in leakage through the bleed
Non-contact ball, single seated	-bleed required between the two barriers -high pressure performance test of both barriers, max pressure -depressurise cavity of downstream valve -low pressure performance test of downstream barrier with 7-10 barg -periodic surveillance for any increase in leakage through the bleed	-cannot be used as DI&B
Non-contact ball, double seated	-bleed required between the two barriers -high pressure performance test of both barriers, max pressure -depressurise cavity of downstream valve -periodic surveillance for any increase in leakage through the bleed	-cavity bleed required -high pressure performance test of both barriers, max pressure downstream valve -periodic surveillance for any increase in leakage through the bleed
Wedge gate	-bleed required between the two barriers -high pressure performance test of both barriers, max pressure -depressurise cavity of downstream valve -periodic surveillance for any increase in leakage through the bleed	-generally cannot be used as DI&B, but can be considered if it has cavity bleed
Slab gate, floating seat	-bleed required between the two barriers -high pressure performance test of both barriers, max pressure -depressurise cavity of downstream valve -pressurise downstream barrier with N2, 16barg -periodic surveillance for any pressure changes between the barriers, stop work if pressure below 16 barg or above 20 barg1)	-cavity bleed required -high pressure performance test of both barriers, max pressure -periodic surveillance for any increase in leakage through the bleed
Slab gate, fixed seat or floating seats without sealing between seat and body	-bleed required between the two barriers -high pressure performance test of both barriers, max pressure -pressurise downstream barrier with N2, 16barg -periodic surveillance for any pressure changes between the barriers, stop work if pressure below 16barg or above 20barg1)	-cannot be used as DI&B
Expanding gate	-bleed required between the two barriers -high pressure performance test of both barriers, max pressure	-cavity bleed required -high pressure performance test of both barriers, max pressure

	-depressurise cavity of downstream valve -periodic surveillance for any increase in leakage through the bleed	-periodic surveillance for any increase in leakage through the bleed
Globe	-bleed required between the two barriers -high pressure performance test of both barriers, max pressure -low pressure performance test of downstream barrier with 0.5barg -periodic surveillance for any increase in leakage through the bleed	-cannot be used as DI&B
Plug, expanding	-bleed required between the two barriers -high pressure performance test of both barriers, max pressure -depressurise cavity of downstream valve -periodic surveillance for any increase in leakage through the bleed	-cavity bleed required -high pressure performance test of both barriers, max pressure -periodic surveillance for any increase in leakage through the bleed
Plug, other	-bleed required between the two barriers -high pressure performance test of both barriers, max pressure -depressurise cavity of downstream valve -periodic surveillance for any increase in leakage through the bleed	-cannot be used as DI&B

Table 3 Minimum requirements to different valve types when used as DI&B barrier

NOTE:

1. In case of pressure increase in bleed section to above 20bar after 4 hours use as barrier, the work shall be temporary stopped, while the segment is fully depressurised to safe location and then re-pressurised with Nitrogen to 16bar.
2. When two different valve types are used as barrier, the downstream valve type shall be ruling for these requirements.
3. The two independent valves can be arranged together in a single body or be flanged/welded together to a double isolation and bleed arrangement.
4. If the valve is supplied with only one DP seat, the DP seat to be downstream only to obtain DI&B.

4.7 Simplified test for small bore valves

SR-16848 - Instruments connected to piping systems normally have ports that can be used as bleed. For barrier valves to such instruments, introducing of an extra bleed port can cause a higher risk during normal operation than what a simplified barrier test will cause during a maintenance situation.

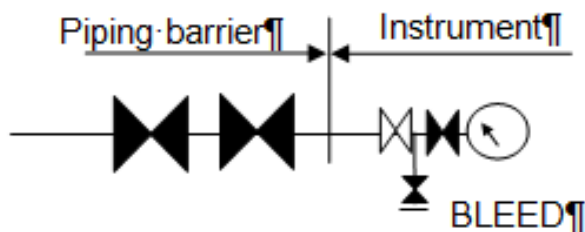


Figure 2 Double isolation barrier without bleed between

For double isolation barriers where the valve port sizes are 3" or smaller, bleed between them can be avoided if there are ports on the instrument that can be used to performance test the barrier.

The barrier procedure shall contain the following aspects:

- Check the downstream valve for leakage by closing it, with the upstream valve open
- Check the upstream valve for leakage by closing it, with the downstream valve open (to be *carefully open to release pressure*)
- Close the downstream valve
- Carry out required work immediately
- For situations where the barrier shall be kept for more than 2 hours, blind it off with equipment that's allows possibility for re-testing.

4.8 Use of stem backseat as isolation barrier

Use of backseat as barrier for packing box replacement can be considered for valves with stem leakage through a gland compressed packing box, and where the leakage is stopped by setting the valve in backseat.

The barrier procedure for backseat shall contain the following aspects

- The system pressure shall be stable, and shall be expected to be constant for the whole operation
- Documentation logs for the valve gives no indications of defective backseat or damaged stem
- Gas-sniffer is used during the entire work
- Packing box leakage is defined and that the backseat stops the leakage
- Packing box leakage arise again when the valve is taken out of backseat
- The valve is locked in backseat
- The valve is regularly checked to be free for leakage for minimum one hour
- Gland nuts are careful unfastened until the gland flange is unstressed, but both nuts shall be fully engaged to the gland bolts
- The valve is regularly checked to be free for leakage for minimum 5 minutes continuously
- With any detection of leakage, the operation shall be stopped and the gland nuts be retightened (if possible)
- The packing box shall be removed with approved equipment
- New packing box is mounted, and the gland is carefully pre-stressed
- The valve is carefully opened and the packing box is adjusted according to applicable procedure
- The valve is regularly checked to be free for leakage for minimum 5 minutes
- Documentation log for the valve is updated with services rendered

4.9 Use of other types of isolation barriers

SR-12730 - Other types of barriers, such as mechanical or hydraulically expanding plugs, ice plugs, etc. shall not be used as a primary isolation except in special cases where calculations and Safe Work Analysis (SJA) has been performed and special acceptance has been given by the responsible leader of the respective plant. Mechanical or hydraulically expanding plugs shall be qualified according to ARIS, Qualify technology for first use.

5 Piping detail standard

Requirements for Piping Detail Standard are defined in TR2325.

6 Piping fabrication, installation, flushing and testing

6.1 General

Reference is made to TR2323 "Piping Fabrication, Installation and Testing Specification".

6.2 Code hydro-test pressure

SR-12735 - The test pressure shall be derived based on the design pressure of the Piping Class, multiplied by the factor as required by the design Code.

6.3 Bolt tensioning

SR-12737 - Bolt tension force shall be according to TR1968. For installations and plants where the specific tables are based on the available local tools, lubrication and gaskets defined, bolt tension force and torque shall be according to TR2000 Plant Specific tables.

6.4 Tubing as replacement for piping

SR-12740 - For tubing used as replacement for piping, the following shall apply:

- Tubing shall not be used on pressurised HC system.
- All tubing used as replacement for piping shall be defined with piping line number.
- The tubing used shall be defined in the TR2000 piping class sheet.

SR-12741 - Typical interface definition between piping and instrument related to use of tubing shall be according to TR2325 "Piping Detail Standard".

For selection of piping tubing materials reference is made to TR3032 "Field instrumentation".

SR-12742 - The project specific service code list shall include applicable tubing piping classes.

6.5 Piping repair and cold installations methods

Reference is made to TR3016 "Piping repair and cold installation methods" for repair of flanges and pipe and specifies accepted cold installation methods on installations and plants in operation.

7 Acoustic fatigue in piping systems

7.1 Excitation from pressure reduction sources

Not many methods exist to calculate the risk for acoustic fatigue realistically. Company has established a method which should be used if no better method can be provided.

For modification on existing piping and events such as blowby gas case with low probability and short duration the methods described in GL1951 may be used.

7.2 Method for evaluating acoustic fatigue

Reference for equation (a) and (e) below, ASME publication PVP-Vol. 328, Flow induced vibration, ASME 1996, by Eisinger.

SR-12749 - Sound power level from the pressure reduction source (typically a valve or orifice) is calculated according to equation (a). In some cases the pressure drop in a branch junction may be large enough to contribute as source and should then be added with any other source.

$$PWL = 10 \cdot \log \left[\left(\frac{P_1 - P_2}{P_1} \right)^{3.6} \left(\frac{W}{3600} \right)^2 \cdot \left(\frac{T_1 + 273}{M} \right)^{1.2} \right] + 126.1 \quad \text{--- (a)}$$

Where:

PWL	= Sound power level (dB)
P ₁	= Upstream pressure of pressure letdown source (bar)
P ₂	= Downstream pressure of pressure letdown source (bar)
T ₁	= Upstream temperature of pressure letdown source (°C)
W	= Gas flow (Kg/h)
M	= Molecular weight

NOTE: For valves equipped with low noise trim, equation (a) should not be used. See the acceptance level below under subheading section 7.3, "Acceptance level". PWL for low noise trim valves should be obtained from the valve manufacturer if required.

SR-12751 - Attenuation along the pipe downstream the source can be calculated by equation (b):

$$PWL_{At} = 0.06 \cdot \left(\frac{L}{D_i} \right) \quad \text{--- (b)}$$

Where:

PWL _{At}	= Sound power attenuation along the pipe (dB)
L	= Distance from source along the pipe (mm)
D _i	= Inside diameter of pipe (mm)

Bend, tee junctions, reducers etc. in the piping give also attenuation of the noise along the pipe. Methods for calculation of attenuation through such fittings may be proposed by the project.

The Sound power level at the L distance along pipe from the source is thus:

$$PWL_L = PWL - PWL_{At} \quad \text{--- (c)}$$

NOTE: The fatigue evaluation need only extend down to entrance of any vessel, unless new noise sources are located in downstream piping from the vessel.

SR-14744 - If more than one source generates noise, the noise shall be added at the pipe junctions where the piping from the sources meets:

$$\sum PWL_L = 10 \cdot \log \left[10^{\{PWL_1/10\}} + 10^{\{PWL_2/10\}} + \dots + 10^{\{PWL_n/10\}} \right] \quad \text{--- (d)}$$

Where:

PWL	= Sound power level
PWL _{1, 2 etc}	= The power level PWL _L for each source at location L in the downstream piping

7.3 Acceptance level

SR-12754 - The acceptance level can be calculated from the following equation:

$$PWL_A = 173.6 - 0.125 \cdot \left[\frac{D_i}{t} \right] \quad \text{--- (e)}$$

Where:

t	= pipe wall thickness (mm)
---	----------------------------

The acceptance level can be increased by 5 dB if the source is a PSV (Pressure Safety Valve) or a pressure relieving device that operates 12 hours cumulatively or less during the entire life time of the plant under the condition that design improvements are applied. Design improvements are required downstream the PSV as described in section 7.4 for a distance corresponding to the calculated sound power above the acceptance level in equation (e) and the calculated attenuation along the pipe in equation (b).

SR-12756 - For valves that will be in use for much shorter time than 12 hours or for a one off event during the entire life time additional increase of the acceptance levels can be evaluated, but this requires company acceptance.

SR-12757 - If the source is a valve designed for maximum 110 dBA SPL at an outside distance of 1 m from the valve, then the pipe inside noise power level is regarded as being too small to create acoustic fatigue and further calculations is thus not required.

SPL = Sound pressure level (dBA)

7.3.1 Additional evaluation to further increase of the acceptance level

SR-12759 - Further increase of acceptance level should be considered instead of specifying larger wall thickness or design improvement. Parameters that will contribute to increased acceptance level, for example:

- Pressure let-down scenario
- Piping configuration
- Pipe attachments
- Nozzles and branches

The evaluation to increase acceptance level should be done in cooperation with Company.

See GL1951 for additional evaluation to further increase of the acceptance level

7.4 Design improvements

SR-12762 - The following design improvements shall be considered to reduce the risk of acoustic fatigue:

- "O-lets" larger than 2" should be substituted by Sweepolet-type or Tee (eg. ASME B16.9 tee, not fabricated tee)
- Any reinforcement plate or attachment plate should envelope the full circumference of the pipe.

7.5 Remedial action to reduce noise from the source

SR-12764 - If the acceptance level above cannot be met, then the noise generating source should be considered:

- Select valves with low-noise trim.
- Evaluate to use more valves in parallel which will reduce the noise.
- Reduce pressure in steps.

However, if it is more economical to increase the wall thickness of the piping resulting in increased acceptance level of noise, then this should be the solution.

8 Vibrations

8.1 Bracing of nozzles and branches

SR-12768 - Piping nozzles, such as vent & drain, and branches in services that give potential for piping vibration shall be designed with bracing in accordance with TR2325. Care shall be taken on insulated pipes due to risk of water ingress from the bracing into the insulation. These types of services are:

- Well stream piping
- Process rotary Compressor piping
- Reciprocating pumps- and compressors piping
- Piping subject to slugging
- Gas piping. Velocities larger than $V = 175 \times (1/\rho)^{0.43}$ shall have special attention where V is the velocity in m/s (See section 9 for line sizing)
- Other services that can excite pipe vibration

Exemption, on not to brace these systems, can be accepted if it can be demonstrated that the nozzles are not likely to be exposed to vibration that can lead to fatigue.

See GL1951 for bracing of nozzles and branches.

9 Line sizing and optimisation

Requirements for line sizing are defined in TR3500.

10 Arrangements of piping functions

10.1 Depressurisation

10.1.1 Location and pressure rating of flare system block valve for maintenance

SR-12815 - Location and pressure rating of flare system block valve for maintenance.

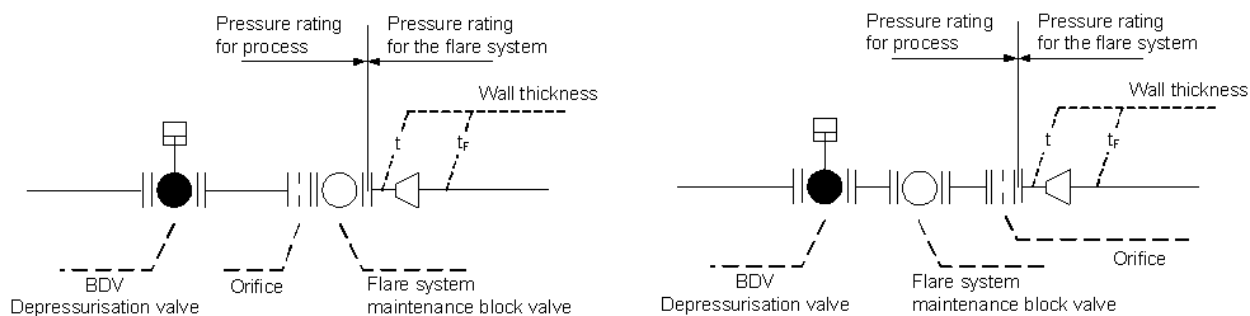


Figure 3 – Location and pressure rating of flare system block valve for maintenance.

If a block valve is installed for the purpose of blocking the flare system for maintenance purpose, it should be installed upstream of the reducer. This is the more cost effective and thus the preferred solution. See TR3003 for location of the orifice/block valve, heat trace and slope requirements, and location of the temperature spec break. Nominal size and pressure rating of the block valve shall be the same as the upstream piping. There shall be no change in flow direction (elbows or tees) between orifice and reducer. In figure 3 an actuated BDV is shown, but it will also apply for a manual operated valve.

10.1.2 Wall thickness upstream a reducer

SR-12817 - Reference is made to the figure above. The thickness t_f may be relatively large, ref Section 7 ("Acoustic fatigue in piping systems"). The thickness t of a small bore pipe including the flange, shall be specified with a thickness that results in a fairly robust transition piece from the smaller to the larger piping.

10.2 Pressure class break for manual or control valves to flare

SR-12819 - If a block valve is installed for the purpose of blocking the flare system for maintenance this valve and upstream piping shall have full pressure rating as shown in figure 4.

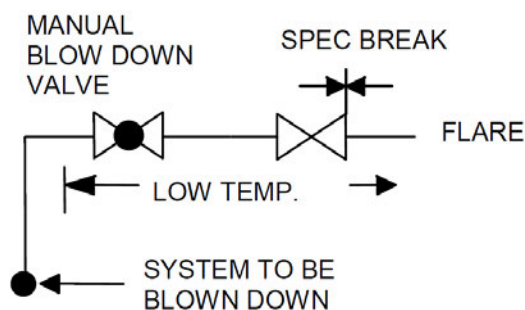


Figure 4 - Manual blow down for maintenance purposes

10.3 Nitrogen purging

SR-12821 - Connections for purging with nitrogen shall be provided for gas freeing at each item of process equipment. Reference is made to TR2325 Piping Detail Standard for details.

10.4 Flushing and cleaning

SR-12823 - Piping systems shall be arranged to facilitate effective internal flushing and cleaning after installation. This includes:

- All systems containing CMR-substances (e.g. benzene), shall be possible to drain 100%. This includes the volume on top of valves for primary barriers in vertical lines.
- Dead ends should be avoided. If necessary, use line blind flange instead of cap.
- Branches for flushing shall be 6" size for flushing of lines larger than 6", and 2" for flushing of lines from 2" to 6".

Other proposals may be accepted.

10.5 Standpipes (bridles)

SR-12826 - Provisions for methanol/MEG injection shall be included in all condensate standpipes (bridles), if hydrate formation is a potential risk (ref. TR2325 for details).

10.6 Equalisation of pressure across valves

SR-12828 - For valves that are unsuitable for opening against full operating pressure difference, provision shall be made for equalisation of pressure across the valves, as required for functional purposes.

SR-12829 - The sizing of the equalisation line shall be based on the size permitting full opening of the by-pass valve during equalisation.

10.7 Break out spools

SR-12831 - Break out spools shall be provided for all equipment that may require removal unless easy removal of the equipment is achieved without spool.

10.8 Galvanic isolation between materials

SR-12833 - Dissimilar materials connected together in a process or utility system may create a risk for galvanic corrosion. Special care shall be taken to avoid galvanic corrosion in sea water systems, i.e. Seawater, Firewater, Produced water, Ballast water or any other corrosive service. Unless effective corrosion inhibition is ensured, use of isolation spools shall be used. Length of an isolation spool need to evaluated case by case, depending upon service, material requirements, temperature/ pressure and the local layout (typical length can be 2 meters). Internal painting of the material should also be evaluated in cooperation with the material department.

10.9 Closed drain pressure class from pressure vessel and safety critical valves

SR-12835 - Piping arrangement for drain connections on equipment shall typically be as shown on figure 5 i.e pressure class spec. break location on the outlet flange of the last valve, and the distance between bleed and spectacle blind shall be as short as possible. Valve types are defined in TR2325/TR3017.

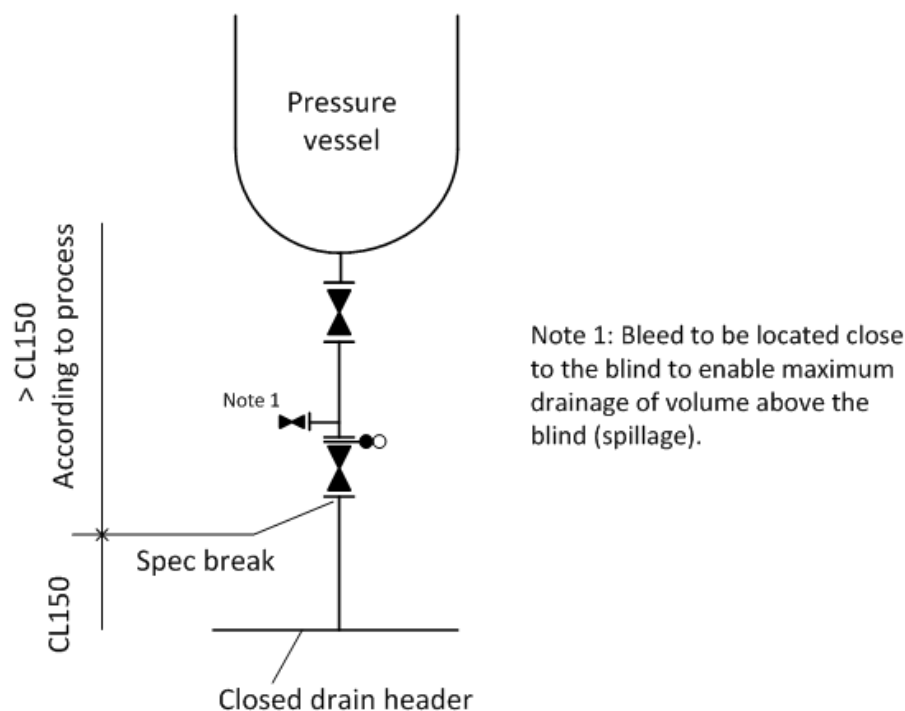


Figure 5 – Double barrier with bleed between

SR-97207 - All valves classified as safety critical valves, with requirements for regular leakage testing according to operation requirements, shall be installed with permanent connections to closed drain/flare system from the valve body with the same arrangement as for equipment in SR-12835. See TR3138 for classification of valves.

10.10 Pressure test connection

SR-12837 - Pressure test connection installed only for vent or drain related to pressure test shall be screwed plugs in weld-o-lets/ half couplings and finally seal welded prior to start up.

10.11 Drainage of piping

SR-98009 - All systems containing CMR-substances (e.g. benzene), shall be possible to drain 100%, this include the volume on top of valves for primary barriers in vertical lines. See TR0926 (SR-3183/SR-3186).

11 Pipe stress evaluation and analysis

11.1 General

SR-12840 - In general all lines shall be analysed to verify the integrity of the piping and supports according to the rules. The analysis shall ensure that the pipe stress and loading on equipment is minimized and kept within the defined maximum allowable.

SR-12841 - The method to determine the integrity may be by evaluation or simple- or comprehensive calculation as required.

SR-12842 - Temperatures used in calculations shall be the temperature that gives the worst load condition relative to pipe and equipment. This may not be the maximum and minimum design- or operating temperatures. It depends on piping geometry and process scenario. Likewise, for the pressure, the worst combination of pressure or pressure and temperature shall be evaluated.

SR-16841 - Minimum design pressure lower than atmospheric shall be checked against the capacity of the pipe.

SR-12843 - The reaction forces shall be based on the worst combination of loads.

SR-12844 - All external forces that are relevant for the integrity of the piping system shall be included in the analysis.

SR-12845 - All main piping subject to multiphase flow at velocities of 10m/s or above shall be subject to vibration evaluation according to Energy Institute "Guidelines for the Avoidance of Vibration Induced Fatigue Failure in Process Pipework" or equivalent.

Pipe support requirements are specified in TR2320, and are also applicable for the pipe stress work. For evaluation of the need for new stress analysis when replacing existing piping see GL1951.

11.2 Critical lines

SR-12847 - As a general guidance, a line shall be subject to comprehensive stress analysis if it falls into any of the following categories:

- a) all lines at design temperature above 180 °C;
- b) 4 in NPS and larger at design temperature above 130 °C;
- c) 16 in NPS and larger at design temperature above 105 °C;
- d) all lines which have a design temperature below -30 °C provided that the difference between the maximum and minimum design temperature is above;
 - 190 °C for all piping,
 - 140 °C for piping 4 in NPS and larger,
 - 115 °C for piping 16 in NPS and larger.

NOTE These temperatures above are based on a design temperature 30 °C above maximum operating temperature. Where this is not the case, max design temperature may be replaced with max operating temperature + 30°C for d) above.

- e) lines 3 in NPS and larger with wall thickness in excess of 10 % of outside diameter. Thin walled piping of 20 in NPS and larger with wall thickness less than 1 % of the outside diameter;
- f) all lines 3 in NPS and larger connected to sensitive equipment, e.g. rotating equipment. However, lubrication oil lines, cooling medium lines etc. for such equipment shall not be selected due to this item;
- g) all piping expected to be subjected to vibration due to internal and external loads (e.g. pressure, transients, slugging, flow pulsation, external mechanical forces, vortex shedding induced oscillations, high gas velocities) and hereby acoustic vibration of the pipe wall;
- h) the ring-main and distribution firewater lines up to the firewater monitors and sprinkler headers. Pressure surges (water hammer) and blast to be considered for the entire system;
- i) all hydrocarbon lines containing oil and gas which shall be de-pressurized after a design blast/explosion event (see

the design accidental load report for selection of lines);

- j) all relief lines connected to pressure relief valves and rupture discs;
- k) all blow down lines 2 in NPS and larger excluding drains;
- l) all piping along the derrick and the flare tower;
- m) lines affected by external movements from structural deflections, connecting equipment, bridge movements, platform settlements, X-mas tree/wellhead, vessel hogging/sagging etc.;
- n) GRP piping 3 in NPS and larger;
- o) all lines 3 in NPS and larger subject to steam out;
- p) long straight lines (typical 20 m);
- q) all production and injection manifolds with connecting piping;
- r) other lines as requested by the project "stress" engineer or Company;

Manual calculations may be used in cases of simple configurations and low stresses.

SR-16842 - All other piping systems outside the criteria's above shall be evaluated in a simplified method to confirm that the line is acceptable according to the code.

For European Economic Area (EEA) :

SR-12852 - Lines falling into Category III according to the PED. The requirement is applicable for installations that require conformity with PED. All Category III lines shall be identified on critical line list.

11.3 Explosion load on piping

SR-12854 - The effect of blast loads shall be evaluated for piping which is required to maintain the installation integrity in an explosion event. Normal working conditions with respect to temperature and pressure may be used for the blast calculations.

SR-12855 - Drag load from explosion shall be calculated in the following way:

$$F = p \times A \times CD \times DAF$$

Where:

p = is the drag pressure from the blast [Pa]

A = is the projected area [m²]

CD = is the coefficient of drag (to be determined for the actual pipe or equipment)

DAF = is the dynamic amplification factor (minimum 1,5, if not evaluated in detail)

Note: For selection of drag factor reference is made to API RP 2FB.

SR-12856 - A simplified approach may be used in lack of accurate data. The static overpressure used for structural dimensioning may be used as basis, and an estimated drag pressure calculated as 1/3 x static overpressure may be used.

SR-12857 - Maximum allowable stress in blast case shall be the minimum of $2.4S$ or $1.5S_y$ at normal operating temperature (S = ASME B 31.3 allowable stress limit, S_y = pipe yield stress).

SR-12858 - The standard Stress Intensification Factor (SIF) values shall be multiplied with a factor of 0,75 for the explosion design case. However, the SIF values shall not be less than 1,0.

SR-16843 - The potential effects of deck and wall deflections, due to blast loads (movement of equipment and pipe supports), need to be evaluated.

SR-12859 - It shall be checked that the mechanical joints and flange connections on piping systems selected for blast calculations are leak free after the explosion event. The method used shall be documented in the stress report. However, it is acceptable that the mechanical joints and flange connections leaks during the explosion event.

Note: ASME VIII may be used for documenting the tightness requirement for the critical mechanical joints and flange connections (for bolt tensioning, see also TR1968).

See also GL1951.

11.4 Vessel/deck deflections

SR-12862 - FPSO will be exposed to constant environment loads. These conditions will cause inertial accelerations and deflections to both the hull and topsides structures. Piping systems have to withstand such loads throughout the design life. Sufficient piping flexibility shall be designed so that the equipment loading and pipe stresses are maintained at acceptable levels.

Deflections due to wave loads shall also be considered for piping on other installation types.

Examples are:

- Deck deflections and deflections on tall vessels on Semisubmersible production platforms
- X-mas tree movements
- Bridge piping between platforms

11.5 Fatigue

SR-12864 - Structural deflections due to wave motion response shall be included in the pipe stress analysis when relevant. One typical method to be used for fatigue evaluation is specified in PD 5500 Annex C. This method enables the calculated stresses for both process and wave cycles to be combined. The fatigue damage produced by the stress range for combined loading events is calculated by use of equation:

$$N = A \left(\frac{22}{e} \right)^{\frac{m}{4}} \times \left(\frac{S_r \times 2.09 \times 10^5}{E} \right)^{-m}$$

Where:

- N is the fatigue life for a stress range S_r .
- The fatigue design curve constants A and m, are found in PD 5500 Annex C, table C1

The fatigue damage from combined loading events are summarised and checked according to equation:

$$C-4 \quad \sum \frac{n_i}{N_i} \leq 0.6 \left(\frac{22}{e} \right)^{\frac{3}{4}}$$

Where:

- e is the greatest value of 22mm or pipe nominal wall thickness and n is the number of cycles.
- The fatigue life is acceptable if the above equation is true.

11.6 Dynamic loads

SR-12866 - A piping system may be subject to dynamic loads such as, but not limited to

- a) PSV reaction forces,
- b) slug loads,
- c) dynamic loads from density variations in two-phase flow,
- d) water hammer,
- e) earth quake.

These loads may be taken into account by either estimating an equivalent static load combined with a conservative dynamic amplification factor or by performing more elaborate dynamic analysis.

Large dynamic forces can be generated in cases of operation with differential pressures when equipment's installed in the piping systems can open or close quickly. Typical equipment's that can generate this force are rupture disc, quick acting valves, including valve systems like HIPPS and valves with a fast characteristic near closed position.

SR-12869 - The dynamic impulses of quick action valves shall be evaluated for both normal operation scenarios and openings or closings due to system errors. Effects due to fluid with different phases shall also be considered, e.g. a high pressurised gas that is rapidly expanded and accelerates a low pressurised liquid.

See TR3001 and GL3001, Process Safety for more information regarding dynamic loads in piping systems.

SR-12870 - In order to reduce the potential for dynamic movements, the lowest natural frequency of the flow line should preferably be above 4 Hz. A too stiff supporting may on the other hand lead to unacceptable load and stress levels. The need for fatigue calculations shall be considered.

See also GL1951.

11.7 Loads from piping systems on equipment

SR-12872 - When analysing piping connected to parallel located equipment, the relevant worst temperature combination case shall be used.

SR-12873 - Calculation of thermal nozzle loads shall be based on the maximum or minimum design temperature.

SR-12874 - Piping connected to compressor and pump suction and discharge nozzles shall be force balanced through its supports in installation and operating condition, and shall exert only minimal loads on the nozzles in order to minimise equipment misalignment caused by external loads. The point of resolution for the compressor nozzle load calculations shall be agreed with the vendor.

SR-12875 - Calculated loads on equipment shall be evaluated in accordance with allowable loads submitted by the vendor.

See also GL1951.

11.8 Flange external bending moment

SR-12877 - External axial force and resulting bending moments on flanges should be within the stated criteria as given in TR1968.

SR-12878 - External force and bending moments on mechanical equipment flange connections shall be within the vendor requirements.

SR-12879 - Generally, effort shall be made to reduce the level of piping loads and risk of leakage onto mechanical equipment and flange connections.

11.9 Expansion bellows in piping systems

The following list is proposed requirements for use of expansion bellows on piping systems on installations and plants.

SR-12881 - Use of expansion bellows, sliding joints, swivel, etc. shall in generally be avoided. Effort shall be made to avoid the use of expansion bellows by building sufficient flexibility into the design of piping systems.

SR-12882 - Where all other methods have been explored and found unacceptable the following requirements shall be met prior to use of expansion bellows:

- Expansion bellows may be installed if approved. Written confirmation shall be obtained before proceeding.
- Expansion bellows shall normally not be used on pressurized systems.
- The lifetime of the expansion bellow shall be defined
- The stress engineer shall specify the type of expansion bellows or joints by issuing a complete data sheet.
- A comprehensive stress analysis shall demonstrate that any relevant load case will not exceed the allowable limits for the expansion bellow.
- Sufficient anchoring and guiding shall be ensured adjacent to flexible couplings/expansion bellows.
- Expansion joints shall be designed according to ASME B 31.3 and EJMA.
- The expansion bellows shall be defined as a special item
- Location to be shown on P&ID and Piping isometric.

11.10 GRE analysis

SR-12884 - For GRE piping the details regarding stress calculation shall be based on instructions and parameters for the relevant software and design code from the GRP manufacturer.

See also GL1951.

11.11 Pipe stress documentation

SR-12886 - Typical documentation of the analyses shall be subject to approval at start of piping stress analysis.

SR-12887 - A pipe stress procedure describing the stress analysis activities shall be prepared and issued for acceptance before start of stress analysis.

12 Securing of valves in correct position

Requirements for securing of valves are specified in TR2315.

13 Additional information

13.1 Definitions and abbreviations

Shall (requirement)	Requirement strictly to be followed in order to confirm to the document and from which no deviation is permitted, unless a deviation permit is approved.
Should (recommendation)	Indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required, or that (in the negative form) possibility or course of action is deprecated but not prohibited.
May	Indicates a course of action permissible within the limits of the document.
Can	Statements of possibility and capability, whether material, physical or causal.

TR2000	TR2000 Piping and Valve Material Specification made for the project.
Piping Class	Piping Class in TR2000
Topside riser	By topside riser it is meant the terminating end of a pipeline from pipeline ESD-valve to the pig station or blind end.
accepted	The acceptance shall be given by Company if not specified otherwise
approved	The approval shall be given by Company if not specified otherwise
Company	
Contractor	Contractor as stated in the contract with Company
plant(s)	Meaning and including Construction site, Installation, factory or works

Abbreviations:

SCH	Wall thickness designation according to ASME B36.19 and ASME B36.10 (e.g. 8" pipe SCH 20 is identical to 6.35 mm wall thickness)
PSHH	Pressure Switch High High
PSH	Pressure Switch High
DI&B	Double isolation and bleed
ESD	Emergency shutdown
PSD	Process shutdown
PSE	Pressure safety element
PSV	Pressure safety valve
TSV	Temperature safety valves
HIPPS	High integrity pressure protection system
EEA	European Economic Area
EU	European Union
PED	Pressure Equipment Directive
E MAS	European Master (pipe class sheet library)

ARIS	Architecture of Integrated Information Systems
DP	Differential Pressure

13.2 Changes from previous version

Changes from 7.02 to 7.03

Section	Change
2.3	"DnV" and "TI" in text have been replaced with "DNV GL" and "Kiwa" respectively
3.1.4	Added "if the pressure exceeds 1,1 times the valve design pressure" to last bullet point. (no need to ask valve vendor when occasional pressure is within seat test)
4.2	Replaced "150# and 300#" with "CL150 through CL2500" in note 8 (to match new TR2325)
4.7	Replaced "3/4"" with "3"" (to match note 4 in 4.2)
9	Replaced the whole chapter contents with "Requirements for line sizing are defined in TR3500."
10.9	Added "Valve types are defined in TR2325."
10.11	New element with reference to TR0926 regarding benzene etc.

Changes from 7.01 to 7.02

TR1951	Free-text have been marked with information-element
TR1951	"Statoil" in text have been replaced with ""

This version has been released for the purpose of including experience from the Gudrun incident February 2015. All other ongoing changes to this TR have been postponed to allow for a quick document release process.

	Previous version (TR1951 ver. 6)		New version (TR1951 ver. 7)
Sec.	Affected text Added text to previous version ~~Deleted text from previous version~~	Sec.	Modification, reasoning and effect
11.1	"... All external forces that are relevant for the integrity of the piping system shall be included in the analysis. All main piping subject to multiphase flow at velocities of 10m/s or above shall be subject to vibration evaluation according to Energy Institute "Guidelines for the Avoidance of Vibration Induced Fatigue Failure in Process Pipework" or equivalent. Pipe support requirements are specified in TR2320, and are also applicable for the pipe stress work. ..."	11.1	This requirement is added as a consequence of the Gudrun incident February 2015 to reduce the risk of vibrations in lines with two-face flow. Ref. synergi case no. 1431597.

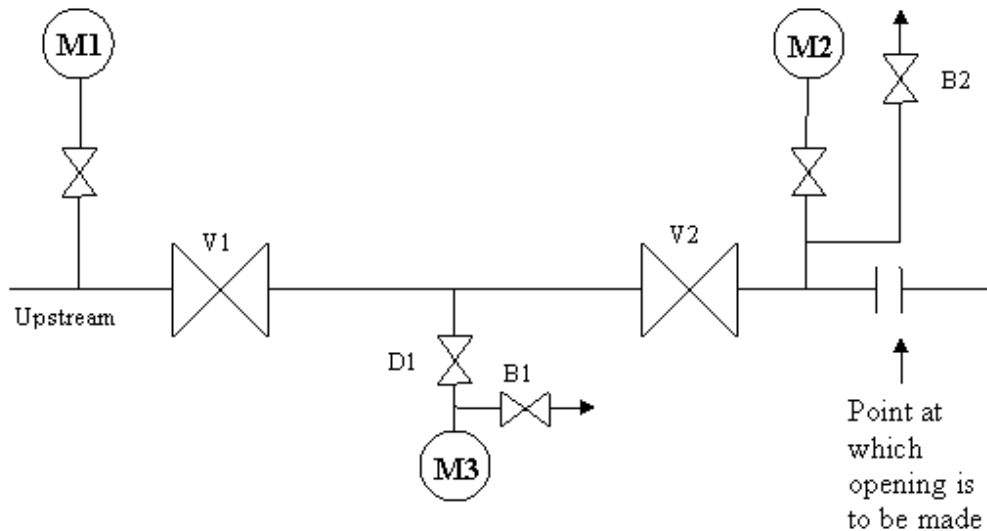
13.3 References

References listed are documents and standards that have been mentioned in this document only. It does not include all standards applicable to Piping Engineering.

API RP 2FB	Recommended Practice for the Design of Offshore Facilities Against Fire and Blast Loading
API RP 14E	Recommended Practice for Design and Installation of Offshore Products Platform Piping Systems
ASME VIII	Boiler and Pressure Vessel Code
ASME B16.5	Pipe Flanges and Flange Fittings NPS ½ through NPS 24
ASME B16.9	Factory-Made Wrought Steel Butt welding Fittings
ASME B16.47	Large Diameter Steel Flanges, NPS 26 Through 60
ASME B31.3	Process Piping
ASME B36.10	Welded and Seamless Wrought Steel Pipe
ASME B36.19	Stainless Steel Pipe
ASME publication PVP-Vol. 328	Flow induced vibration, ASME 1996, by Eisinger
DnV RP O501	Erosive Wear in Piping System
EJMA	Expansion Joint Manufacturers Association
Energy Institute	Guidelines for the Avoidance of Vibration Induced Fatigue Failure in Process Pipework
EU Directive-2014/68/EU	Pressure Equipment Directive (PED)
MSS-SP-44	Steel Pipe Line Flanges
GL1951	Piping engineering
GL3001	Process Safety
ISO 10423	Petroleum and natural gas industries - Drilling and production equipment - Wellhead and christmas tree equipment
ISO 13703	Petroleum and natural gas industries Design and installation of piping systems on offshore production platforms
ISO 27509	Petroleum and natural gas industries - Compact flanged connections with IX seal ring
PD 5500	Specification for unfired fusion welded pressure vessels
TR1055	Performance standards for safety systems and barriers - offshore
TR1098	Submarine pipeline systems
TR1968	Flange bolt tension
TR2000	"Piping and Valve Material Specification, for the specific project" (TR2000)
TR2237	Safety design for onshore plants
TR2315	Valve Locking
TR2320	Pipe support requirements
TR2323	Piping fabrication, installation, flushing and testing
TR2325	Piping Detail Standard
TR3001	Process Safety
TR3002	Flare, vent and drain
TR3003	Emergency depressurisation
TR3016	Piping repair and cold installation methods
TR3017	Valve Selection Manual
TR3032	Field instrumentation
TR3500	Process System Design

14 App A Testing of barriers, examples (Informative, ref. ARIS OM05.07.01.01)

14.1 A.1 Example 1: DI&B using two valves with mechanical activated sealing and interposed bleed-off



Symbol explanation:

- V1: Upstream isolating valve
- V2: Downstream isolating valve
- M1: Upstream manometer
- M2: Downstream manometer
- M3 Manometer for monitoring pressure build-up
- B1: Bleed valve (pressure bleed-off point)
- B2: Pressure bleed-off point
- D1: Drainage valve

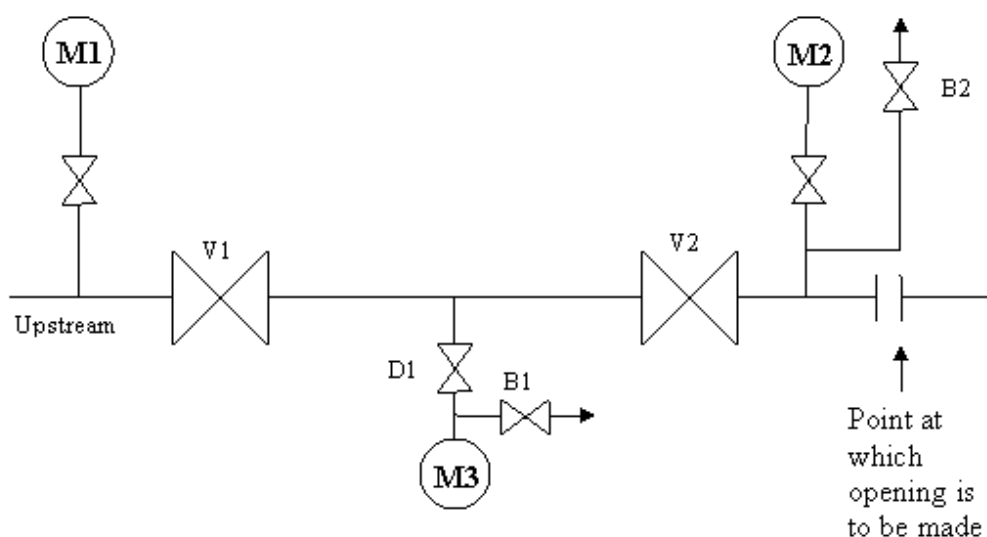
Procedure:

1. Check (if possible) that pipe ends at M1, M2, D1, B1 and B2 are not blocked and that manometers are in working order.
2. Close valve V2 and lock it in the closed position.
3. Note the pressure at M1 and M2.
4. Bleed off pressure downstream of V2 and check that the pressure at M2 falls to zero.
5. Close bleed-off valve B2 downstream of M2 and monitor the pressure at M1 and M2 for at least ten minutes. No indication of pressure build-up at M2 shows that V2 is tightly sealed.
6. Close valve V1 and lock it in the closed position.
7. Note the pressure at M1.
8. Bleed off the pressure between V1 and V2. Set both D1 and B1 to the open position.
9. Depressurise valve V2s cavity if its design can entrap pressure
10. Low pressure performance test the valve V2 by pressurise the volume between V1 and V2 with 7-10barg N2
11. Close bleed-off valve B1 downstream of M2 and monitor the pressure at M1, M2 and M3 for at least 16 minutes. If

no pressure build-up takes place at M2 or in the valve V2s cavity if its design can entrap pressure, and the pressure M3 do not drop, this shows that the V2 valves is tightly sealed on low pressure and that V1 valve is tightly sealed on high pressure.

12. Bleed off the pressure between V1 and V2 by carefully opening B1
13. The downstream work can now be started
14. Periodical check that the leakage from B1 is stable, B1 shall be open during the downstream working process.

14.2 A.2 Example 2: DI&B using two valves with pressure activated sealing and interposed bleed-off



Symbol explanation:

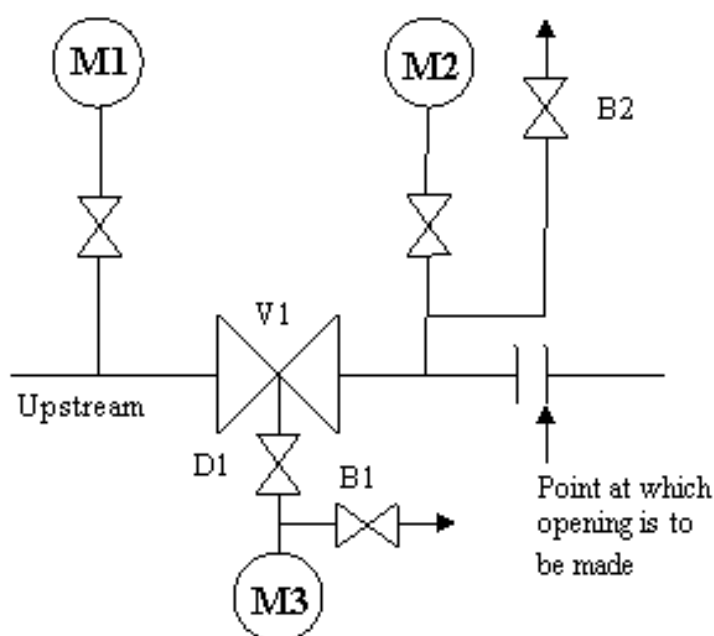
- V1: Upstream isolating valve
- V2: Downstream isolating valve
- M1: Upstream manometer
- M2: Downstream manometer
- M3: Manometer for monitoring pressure build-up
- B1: Bleed valve (pressure bleed-off point)
- B2: Pressure bleed-off point
- D1: Drainage valve

Procedure:

1. Check (if possible) that pipe ends at M1, M2, D1, B1 and B2 are not blocked and that manometers are in working order.
2. Close valve V2 and lock it in the closed position.
3. Note the pressure at M1 and M2.
4. Bleed off pressure downstream of V2 and check that the pressure at M2 falls to zero.
5. Close bleed-off valve B2 downstream of M2 and monitor the pressure at M1 and M2 for at least ten minutes. No indication of pressure build-up at M2 shows that V2 is tightly sealed.
6. Close valve V1 and lock it in the closed position.
7. Note the pressure at M1.
8. Bleed off the pressure between V1 and V2. Set both D1 and B1 to the open position.

9. Depressurise valve V2s cavity if its design can entrap pressure
10. Low pressure performance test the valve V2 by pressurise the volume between V1 and V2 with 7-10barg N2
11. Close bleed-off valve B1 downstream of M2 and monitor the pressure at M1, M2 and M3 for at least 16 minutes. If no pressure build-up takes place at M2 or in the valve V2s cavity if its design can entrap pressure, and the pressure M3 do not drop, this shows that the V2 valves is tightly sealed on low pressure and that V1 valve is tightly sealed on high pressure.
12. Pressurise the volume between V1 and V2 with N2 to 16barg
13. Close the valve B1
14. The downstream work can now be started
15. Periodical check that the M3 pressure is stable
16. Stop work if M3 pressure gets below 16bar or above 20bar

14.3 A.3 Example 3: DI&B using valve with mechanical activated sealing



Symbol explanation:

- M1: Upstream manometer
- M2: Downstream manometer
- V1: Valve with double seal, with mechanical activation
- M3: Manometer for monitoring of pressure build-up
- B1: Bleed valve (pressure bleed-off point)
- B2: Pressure bleed-off point
- D1: Drainage valve connected to valve body

Procedure:

1. Check that pipe ends at M1, M2, D1, B1 and B2 are not blocked and that the manometers are in working order.

2. Close V1 and lock it in the closed position.
3. Check that B1 is in the closed position.
4. Open D1 with care.
5. Note the pressure at M1, M2 and M3.
6. Bleed off the pressure downstream of V1 and check that the pressure at M2 falls to 0.
7. Close bleed-off valve B2 downstream of M2 and monitor the pressure at M1, M2 and M3 for at least 16 minutes. If no pressure build-up takes place at M2 and the pressure M3 do not drop, this shows that the V1 downstream seat is tightly sealed on high pressure.
8. Note the pressure at M1.
9. Bleed off the pressure from the valve body by carefully opening B1. (D1 should now be in the open position, see 4).
10. Low pressure performance test the downstream seat by pressurise the valve cavity with 7-10barg N2
11. Close bleed-off valve B1 downstream of M2 and monitor the pressure at M1, M2 and M3 for at least 16 minutes. If no pressure build-up takes place at M2 and the pressure M3 do not drop, this shows that the V1 downstream seat is tightly sealed on low pressure and that upstream seat is tightly sealed on high pressure.
12. Bleed off the pressure from the valve body by carefully opening B1. (D1 should now be in the open position, see 4).
13. The downstream work can now be started
14. Periodical check that the leakage from B1 is stable, B1 shall be open during the downstream working process.

Note:

The double-seal valve V is now closed.

The drainage valve D1 from the valve body is open.

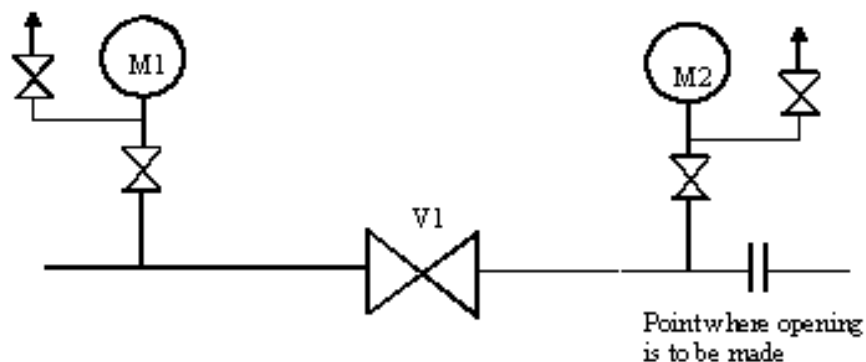
The bleed valve B1 is closed, and all three valves are locked in the closed position.

M3 must be monitored. In the event of pressure build-up, B1 will be opened with care at regular intervals.

14.4 A.4 Example 4: DI&B where the second barrier has a pressure boosted sealing that gives leakage at the low pressure test**Procedure:**

1. Ref appendix 1 or 3 for the barrier testing where the second barrier has given a leakage at the low pressure test.
2. Pressurise the system between the two barriers with N2 to 16barg
3. Close the valve B1
4. Stop work if M3 pressure gets below 16bar or above 20bar
5. Close bleed-off valve B2 downstream of M2 and monitor the pressure at M1, M2 and M3 for at least 16 minutes. If no pressure build-up takes place at M2 and the pressure M3 do not drop, this shows that the second barrier has been sealed and the first barrier is tightly sealed on high pressure.
6. Periodical check that the M3 pressure is stable
7. Stop work if M3 pressure gets below 16bar or above 20bar

14.5 A.5 Example 5: Single barrier

**Symbol explanation:**

- M1: Upstream manometer
- M2: Downstream manometer
- V1: Single isolation valve

Procedure:

1. Check that pipe ends at M1 and M2 are not blocked and that the manometers are in working order.
2. Close V1 and lock it in the closed position.
3. Note the pressure at M1 and M2.
4. Bleed off pressure downstream of V1 and monitor the pressure in M2 for at least ten minutes. (No pressure build-up at M2 indicates that V1 is tightly sealed.)
5. Open drainage/ bleed-off downstream of V1 and secure in the open position.

Note:

V1 is now closed, downstream bleed-off/ drainage is open and both are secured. Any liquid or gas that might pass through V1 will be registered during the preventive safety measures.