

DEP SPECIFICATION

**OVERPRESSURE AND UNDERPRESSURE –
PREVENTION AND PROTECTION**

DEP 80.45.10.11-Gen.

February 2017

ECCN EAR99

DESIGN AND ENGINEERING PRACTICE

DEM1



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INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for the protection of equipment against overpressure and underpressure. This DEP is used in conjunction with API STD 521 and API STD 2000.

This DEP does not apply for the following cases:

- For pressure relief facilities of liquefied petroleum gas in bulk storage installations apply DEP 30.06.10.12-Gen.
- For overpressure protection of pipelines apply DEP 31.40.00.10-Gen.
- For LPG supply/distribution facilities (for retail and commercial distribution), the relieving facilities for vessels with capacities not greater than 135 m³ (4767 ft³) apply NFPA 58.
- Design of pressure relief, flare and vent systems is covered by DEP 80.45.10.10-Gen.
- Emergency depressuring and sectionalizing is covered by DEP 80.45.10.12-Gen.

This DEP contains mandatory requirements to mitigate process safety risks in accordance with Design Engineering Manual (DEM) 1 – Application of Technical Standards.

This is a revision of the DEP of the same number dated February 2012; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorized by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorized access to DEPs does not for that reason constitute an authorization to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in facilities related to oil and gas production, gas handling, oil refining, chemical processing, gasification, distribution and supply/marketing. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process shall be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The capitalised term **SHALL [PS]** indicates a process safety requirement.

The word **should** indicates a recommendation.

The word **may** indicates a permitted option.

1.3.2 Specific definitions

Term	Definition
Administrative Controls	Operational and maintenance procedures that, along with proper training and/or supportive measures, seek to ensure that personnel actions do not compromise overpressure protection. Refer to (2.15).
Car Seal	Tear resistant band or wire that has to be broken in order to change the valve position. Car seals installed on a valve inhibit unauthorized valve operation. A valve can be Car Seal Open (CSO) or Car Seal Closed (CSC). Have to be auditable, i.e., authorized operation of car sealed valves is ensured via structured procedures.
Closed in Tubing Head Pressure (CITHP)	The pressure at the top of a well riser when the choke valve is closed. This pressure can be dramatically higher than operating pressure due to static head effects and loss frictional pressure drop.
Common Mode Scenario	An overpressure scenario that affects more than one pressure system. For example, cooling water failure.
Corrected Hydrotest Pressure	Applied hydrotest pressure multiplied by the ratio of design stress value at upset temperature over the design stress value at test temperature. For new ASME Section VIII equipment the corrected hydrotest pressure would be 1.3*MAWP. For before 2000 ASME Section VIII vessels this would have been 1.5*MAWP
Class 1 Check Valves (also known as Critical check valves)	Check valves that are inspected (or tested) to assure reliable operation. These check valves are used to prevent backflow to suction vessels and tanks, prevent reverse overspeed on turbomachinery, and minimize damage from furnace tube ruptures.
Double Jeopardy Scenario	Scenario caused by two unrelated initiating events. For example, power failure simultaneous with exchanger tube rupture.
Equipment	Pressure vessels, piping, heat exchangers, rotating equipment, tanks, and fired heaters.
Expected Pressure	This is the pressure that would exist in the high pressure side of the pressure system being evaluated. Depending on how the high pressure system responds to the scenario, this pressure might be "normal" operating pressure, a pressure higher than operating (e.g., settle out pressure), design pressure, or relieving pressure.
Favourable Instrument Response	Any expected normal response (the instrument's intended function) that would reduce the relief loads on the pressure system under study

Term	Definition
Maximum Allowable Accumulated Pressure (MAAP)	Maximum internal pressure allowed by this DEP during a pressure relieving event. This is equal to the Design pressure (or Maximum Allowable Working Pressure) plus the maximum allowable accumulation by the relevant pressure vessel code. Refer to (2.13) for allowable accumulations.
Operating Pressure	The OP is the gauge pressure which prevails inside equipment and piping during any intended operation (this is consistent with the definition in DEP 01.00.01.30-Gen.)
Overpressure	Pressure increase over the set pressure of a pressure relief device during discharge and is usually expressed as a percentage of the set pressure.
Pressure System Safety Study (PSSS)	Structured examination of each pressure system for all potential overpressure and underpressure scenarios.
Process Engineering Flow Schemes (PEFS)	Pictorial representation of a process or utility unit which shows all the equipment, including installed spares and the associated piping and piping components, instrumentation, heat tracing and insulation. PEFS are also known as Piping and Instrument Diagrams (P&IDs) and Engineering Flow Diagrams (EFDs).
Process Safeguarding Flow Scheme (PSFS)	Simplified flow diagram that highlights all pressure systems and their elements and those elements that protect the system against overpressures. This diagram is included as part of the Safeguarding Memorandum. The requirements for the PSFS are specified in DEP 01.00.02.12-Gen. PSFS are also known as Process Safeguarding Flow Diagrams (PSFD)
Relief Pressure	Set pressure plus the overpressure. Also known as the relieving pressure.
Remote Contingencies	Overpressure scenarios that Shell has identified as being sufficiently likely to be “credible” but so unlikely that the scenario does not need to meet the accumulation criteria associated with design scenarios. Specifically, equipment accumulations higher than what is specified for design scenarios can be tolerated.
Safeguarding Memorandum	Document that summarizes the PSSS and other related issues. These are also referred to as Process Safeguarding Memorandum (PSM) or Safeguarding Memorandum (SGM). The Safeguarding Memorandum requirements are specified in DEP 01.00.02.12-Gen.
Pressure System	An individual equipment item or groups of equipment including associated piping that, within its boundaries, remains open under all conditions, and it can be demonstrated that no blockage due to freezing, solidification, fouling, sublimation, damage of internals, scale, debris, foreign objects can occur within that system.

Term	Definition
Thermal Liquid Expansion Relief Overpressure	A trapped volume of liquid is heated up and the volumetric growth of the heated liquid results in equipment overpressure. This is also known as hydrostatic relief.
Thermal Relief Overpressure	A trapped volume of refrigerated/cryogenic liquid is heated by the environment and the resulting vapour pressure of the heated liquid is greater than the design pressure of the equipment.
Very toxic (substances)	Refer to DEP 01.00.01.30-Gen. for additional details concerning the definitions of "very toxic - acute", "very toxic - chronic", and "very toxic - environment".

1.3.3 Abbreviations

Term	Definition
ALARP	As Low As Reasonably Practicable
DIERS	Design Institute for Emergency Relief Systems
HEMP	Hazard and Effects Management Process – overall work process for identifying, assessing, and managing risks associated with a hazard.
HSSE-MS	Health Safety Security and Environment - Management Systems
LMTD	Log Mean Temperature Difference
LNG / LPG	Liquefied Natural Gas / Liquefied Petroleum Gas
LOPA	Layers of Protection Analysis – a quantitative method to determine the frequency of a scenario outcome.
PFD	Probability of Failure on Demand
PRV	Pressure Relief Valve
TEMA	Tubular Exchanger Manufacturer's Association

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section or clause number is shown in brackets (). Other documents referenced by this DEP are listed in (8).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a full revision of the DEP of the same number dated February 2012. The following are the main non-editorial changes:

Section/Clause	Change
All	Major change in structure. Moved from a narrative paragraph format to a stream-lined bulleted format that has only the requirements with minimal narratives. Most of the narratives have been moved to the informative.
All	There have been numerous significant technical changes made in the DEP.
2.6	Guidance is given on what pressures to assume when calculating flows from upstream systems to downstream systems
2.10.1.3	Demoted SHALL [PS] to shall
2.10.3.3, item 5	Relaxed the minimum number of prescribed control barriers required if using SIF to reduce relief loads.
2.10.4.1	Added guidance on use of mechanical valve stops.
2.10.4.2	Added guidance on use valve speed controls.
2.10.4.3	Added guidance on what coefficient of discharge for orifice plates.
2.11.2, item1	Cautioned that replacing check valves without inspecting valve for functionality is not sufficient to demonstrate check valve reliability.
2.11.3	Clarified that check valve failure is a remote contingency.
2.11.4	Introduced new requirement to verify that the low pressure system has sufficient relief to handle check valve leakage (due to normal wear and tear).
2.11.5	For evaluating backflow due to severe check valve leakage scenario, the assumed flow area is 1 % of the check valve area. This is in-line with API-521. Previous version of this DEP specified 10 % of the check valve area.
2.11.6. item 5 and 6	Previous version of this DEP had probability of failure data for various backflow mitigation options (for both clean and fouled services) and the selection of backflow barriers was based on LOPA. This version simplifies this by pre-defining acceptable backflow mitigation options to choose from.
2.11.7	Simplified the work process for assessing backflow into atmospheric storage tanks.
2.13.2	Added clarification that the remote contingency accumulation is based on what the Code would allow for hydrotesting, not what pressure testing was actually performed. This is consistent with past practice but not stated overtly.
2.15.1, item 1	Clarified use of administrative controls to apply only to manual valve operation. Added application to start-up and shutdown activities. Previous DEP was silent on this.
2.15.1, item 1	Deleted the restriction in using administrative controls for normal operation since this conflicted with 2.15.3.

Section/Clause	Change
2.15.1, item 3	Added philosophy that failures in blinding procedures are not credible. Previous DEP was silent on this.
2.15.3, item 2	Added “during normal operation” since 1) that has been our practice, and 2) to allow for assessing unusual scenarios associated with start-up or shut-down.
3.2.5, items 2 and 3	Defined quantitatively how what fraction of hard vs soft refractory insulation is allowed for the premised fired heater duty
3.5.2	Introduced new scenario associated with total instrument air failure. May need to consider fail-closed control valves move to the wide open position during instrument air if the actuator is double acting. This is a developing issue.
3.7.2, item 2	Added guidance on wide open choke valve assuming CIHTP conditions.
3.7.2, item 3	Noted that dynamic analysis may be used to assess wide open choke valve.
3.7.2, item 9	Introduced the concept that for assessing liquid swell, evaluate the vapour/liquid disengagement of the low pressure vessel similar to a flare KO vessel but using 1500 microns.
3.7.2, item 13.b	Introduced a new option to systems which exceed liquid level criteria but have limited liquid inventories.
3.7.3, item 3	Introduced option to allow use of SIFs to mitigate liquid swell where there are cascading liquid transfers.
3.7.5, item 3	Major change in design criteria for selecting the option of close coupling the relief device to the level control valve. The new guidance eliminates operability issues and risks that were not clearly described in the previous edition.
3.9.2, item 2.b	Introduced new fire case exclusion: vessels that have large body flanges with volumes less than 1500 litres (396 gal).
3.9.2, item 2.f	Added gasketed plate and frame exchangers to the fire exclusion list.
3.9.2, item 2.f	Introduced new fire case exclusion: shell and tube heat exchangers with large body flanges. Previous edition did not require vapour fire relief but did require a thermal relief path. With the new edition we have dropped the requirement that a thermal expansion relief path be provided for the fire case.
3.9.6, item 5	Revised method for calculating the process properties (latent heat of vaporization) for process streams that have a wide boiling range. Previous DEP method in some cases resulted in non-conservative values.
3.9.6, item 6	Added an upper temperature limit ((600 °C (1112 °F)) to keep process values sensible.
3.9.7, item 1	Revised to allow using 115 kJ/kg (50 BTU/lb) value when near the critical.
3.9.7, item 3	Added an upper temperature limit ((600 °C) (1112 °F)) to keep iterative analysis sensible.
3.10.5	Added a list of all remote contingency scenarios.

Section/Clause	Change
3.10.5, item 1	Demoted SHALL [PS] to shall
3.10.5, item 2	Added exclusion for thermal relief overpressure protection for valve stations. This is conceptually consistent with practice but 10 diameter criteria is introduced to manage potential poor design.
3.10.6	Deleted the requirement for TERVs on LPG pump cases.
4.1, item 1	Change the tube rupture viability criteria from high side design pressure to high side operating pressure.
4.2.2, item 1.c	The Cd assumptions for tube rupture flow have changed slightly. Previous DEP specified .975 for vapour flows.
4.2.2, item 3	Eliminated the requirement for rupture disks if pressure is greater than 70 barg. Recent test data show that PRVs can open very quickly during tube rupture.
4.2.2, item 3	Clarified to use steady state flows for designing PRV inlet and outlet piping.
4.2.3, item 1	Demoted SHALL [PS] to shall
4.2.5	Added requirement for assessing slug flow in cooling water return piping if there is a vapour tube rupture.
4.11	Added blocked outlet due to collapsed or plugged internals as a remote contingency to reflect actual practices with hydroprocessing units
5.1.1, item 4	Added technical assurance criteria when performing dynamic modelling of fractionator relief loads.
5.1.3	The instructions on how to calculate relief loads using a steady state simulator has been completely re-written in order to make it easier for the designer. The calculated results, however will not be much different than the work process described in the previous DEP.
5.1.4, item 3	We now specifically prohibit manual calculation methods that take into account accumulation of mass. A study of various methods being used showed that the approach is flawed.
5.1.6, item 2. a.	Revised guidance on how to set up the simulation to avoid convergence problems when assessing loss of fractionator feed
5.1.6, item 2. b.	Added caution to consider that loss of feed could also result in loss of outflows. Potential for designers to otherwise understate the amount of heat imbalance and understate relief load.
5.1.8	New section on how to assess fractionator overflow.
5.1.8.3, item 1	New guidance points out that as liquid levels rises above where vapours are introduced, significant froth can occur which might impact level detection and will reduce fractionator overflow time.
5.1.8.3, item 3	New guidance instructs when to include continued reboiler duty. Continued reboiler duty and/or continued vapour feeds can result in two phase relief during the overflow.
5.3, item 2	Added acceptance criteria if using differential pressure design approach on heat exchanger internals.

Section/Clause	Change
5.4	Reference normal check valve leakage for rotating equipment that have internal or external check valves.
5.4.4, item 2	Added horsepower limit for defining when small PD pumps might use internal PRVs.
5.4.6	Demoted SHALL [PS] to shall
5.4.7	Demoted SHALL [PS] to shall
6.1	Demoted SHALL [PS] to shall
7	Added significant detail on the documentation requirements.
APPENDIX A	Added Appendix A to capture DEP 80.45.10.13-Gen. guidance

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be submitted to the Administrator using one of the following options:

Shell DEPs Online (Users with access to Shell DEPs Online)	Enter the Shell DEPs Online system at https://www.shelldeps.com Select a DEP and then go to the details screen for that DEP. Click on the "Give feedback" link, fill in the online form and submit.
DEP Feedback System (Users with access to Shell Wide Web)	Enter comments directly in the DEP Feedback System which is accessible from the Technical Standards Portal http://www.shell.com/standards . Select "Submit DEP Feedback", fill in the online form and submit.
DEP Standard Form (other users)	Use DEP Standard Form 00.00.05.80-Gen. to record feedback and email the form to the Administrator at standards@shell.com .

Feedback that has been registered in the DEP Feedback System by using one of the above options will be reviewed by the DEP Custodian for potential improvements to the DEP.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

1.8 NON NORMATIVE TEXT (COMMENTARY)

Text shown in italic style in this DEP indicates text that is non-normative and is provided as explanation or background information only.

Non-normative text is normally indented slightly to the right of the relevant DEP clause.

2. DESIGN PHILOSOPHY

2.1 PRESSURE SYSTEM SAFETY STUDY (PSSS)

1. A PSSS of all potential overpressure and underpressure scenarios SHALL [PS] be performed to verify that all equipment is adequately protected against overpressure and underpressure
2. The PSSS shall be based on a series of heat and material balances that reflect the intended range of unit operation, including unit start-up and shut-down conditions.
3. If the MAWP is used in the PSSS in lieu of the equipment design pressure, the MAWP shall be added to the PEFS and PSFS where applicable.
4. A summary of the PSSS shall be documented in a Safeguarding Memorandum conforming to DEP 01.00.02.12-Gen.
5. Management of Change procedures shall assure that process modifications are assessed and the PSSS updated as required.

2.2 DESIGN PRESSURE

1. Refer to DEP 01.00.01.30-Gen. for requirements on establishing the upper and lower (vacuum) design pressure for equipment.

2.3 DESIGN FOR CONTAINMENT

2.3.1 Design for internal pressure

1. Design should be based on containment in order to avoid large liquid reliefs.
 - a. See (5.4.1) for guidance on determining pump deadhead pressures.

2.3.2 Design for vacuum

1. Equipment that can be subjected to steam purging/cleaning may be designed for full vacuum or managed via procedure to ensure proper venting.

2.3.3 Design for external pressure

1. Piping and equipment subjected to external pressures (e.g., subsea) shall be designed for the full hydrostatic pressures at installation depth assuming no internal pressure.

2.4 PRESSURE SYSTEM

1. See (1.3.2) for definition of a Pressure System.
2. The flow path used to provide overpressure protection for the pressure system shall be open.
3. The flow path shall not go through any of the following:
 - a. normally-closed check valves;
 - b. backwards through check valves;
 - c. rotating equipment (e.g., pumps, compressors).
4. The effects of static head with interconnected equipment shall be taken into account when establishing the design pressure.
5. If multiple equipment items in a pressure system are protected by a relief device(s) located in one part of the pressure system, the relief device set pressure and system hydraulics shall assure both of the following:
 - a. no equipment exceeds its design pressure before a pressure relief device activates;

- b. during relieving conditions, no equipment exceeds its allowable accumulation (2.13).
- 6. If a systems approach is taken and the interconnecting piping's normal flow is very low (i.e., < 25 %) relative to the relieving flow, then the relief device should be located upstream of this interconnecting piping.

This is to address the possibility of undetected line fouling.

- 7. If parallel equipment trains are valved in order to permit on-stream isolation for maintenance, and both are normally on-line, the increased pressure drop when only one system is lined up shall be accounted for in the design.

2.5 UNIT TURNDOWN CONSIDERATIONS

- 1. Credit for flows leaving a pressure system may be taken to reduce relief loads in accordance with API STD 521 and this DEP provided they meet all of the following:
 - a. they are based on the minimum turndown operating limit for the equipment or process unit.
 - b. they are clearly documented in the PSSS and the Safeguarding Memorandum.
- 2. In new designs, credit should not be taken for flows leaving a pressure system, in order to keep the analysis simple.

2.6 PRESSURE ASSUMPTIONS

When calculating the flow across a pressure interface (e.g., flow through an exchanger tube rupture, or flow through a wide open control valve) the assumptions on what pressures to use in the upstream and downstream equipment is important.

- 1. When calculating the relief load for the downstream equipment, it should be assumed that the downstream vessel is at relieving conditions.
- 2. When calculating the relief load for the downstream equipment, the upstream pressure shall be at least the operating pressure as defined by the heat and material balance.
 - a. The operating pressure may be based on operating data provided the following is satisfied:
 - i. The operating pressure is based on operating data with the pressure swings averaged over hours (not weeks or months).
 - ii. Operating data is available that covers the full range of operating pressures.

Operating pressures can change over time due to, for example, decaying well pressure, or system fouling.
 - b. Where there is uncertainty in the upstream operating pressure or where additional conservatism in operation is needed, the assumptions for high pressure alarm point, high pressure trip point, or design pressure shall be subject to the approval of the Principal.
- 3. The Contractor shall assess how upstream system pressure may be affected by the scenario under study.
 - a. If the scenario results in a pressure higher than the operating pressure, then this expected pressure shall be used in the flow calculations.

For example, when evaluating the wide open vapour breakthrough scenario from a high pressure vessel to a low pressure vessel, usually the upstream vessel is assumed to be at normal operating pressure. However, when evaluating this system during a common mode failure (e.g., power failure) and the level control valve between the high pressure vessel and the low pressure vessel is in normal position, the upstream vessel pressure might reach relieving pressure.

4. The expected pressures shall be based on single jeopardy scenarios.
5. The impact of upstream systems at abnormally high (upset) or relieving pressure on downstream systems shall be included when evaluating downstream system overpressure scenarios.

Higher upstream system pressures can result in higher flows to the downstream system. For example:

- *Open piping and chokes can pass more flow if the upstream pressure is higher.*
 - *Flow control valves between the upstream and downstream systems, which would normally react to maintain a design flow rate to the downstream system, are assumed to not respond, see (2.10.1). Thus with a higher differential pressure and the control valve in its normal position, more flow will enter the downstream system.*
 - *Pressure control valves between the upstream and downstream systems, which would normally open to maintain the upstream pressure, are assumed to function as designed, see (2.10.1). Thus with both a higher differential pressure and a potentially wide-open control valve, more flow will enter the downstream system.*
6. Common-mode relief scenarios shall be evaluated.

Common mode failures could for example result in a blocked outlet at the same time it flows into the system increase.

2.7 MIXING OF HOT MATERIALS WITH VOLATILE MATERIALS

1. For guidelines on the prevention of mixing hot materials with volatile materials, API 521 should be considered.

Mixing of hot materials with volatile materials, such as water and hot oil, can result in transient vaporisation rates that are difficult to quantify.

2. Overpressure risks associated with transient vaporisation shall be mitigated by one or more of the following:
 - a. system design (increased design pressure);
 - b. vessel inlet nozzle locations (to avoid injecting volatiles below hot liquids);
 - c. minimization of pockets in hot process piping;
 - d. low point drains to remove all water prior to starting up;
 - e. swing elbows, double block and blind, and other safeguards for utility connections;
 - f. equipment start-up and operating procedures;
 - g. Use of rupture disk.
3. As a minimum, overpressure protection shall be provided assuming steady state mixing of hot materials with volatile materials for any valid single jeopardy scenario.

2.8 INTERFACES WITH THIRD PARTIES

1. Managing source pressures from fixed systems owned and operated by third parties shall be covered by contractual agreements.
2. Where third parties provide mobile/temporary systems (e.g., ships, tank trucks, well intervention/maintenance equipment), the potential overpressure/underpressure of their equipment and the Project's equipment shall be understood and mitigated.

2.9 FAILURE POSITION OF CONTROL VALVES

1. The failure position of control valves shall be specified to allow each pressure system to reach an inherently safe condition (e.g., stop flows and process heat) during an instrument air failure scenario.

2.10 ROLE OF INSTRUMENTATION IN OVERPRESSURE PROTECTION**2.10.1 General**

Typically systems are designed with basic process controls and alarms to keep conditions within the operating envelope. Although this is good design practice, experience has shown that there can be some confusion on whether or not instrumentation can properly mitigate overpressure scenarios.

1. Except as described in (2.10) and (2.11), any instrumentation that could provide favourable response SHALL [PS] be assumed to be frozen (or on manual mode).
2. Instrumentation response that increases relief loads within the pressure system under study shall be assumed to function properly.
3. The use of Safety Instrumented Systems to eliminate a relief scenario or eliminate the relief device shall be subject to approval of the Principal. See (2.10.3).

2.10.2 Load reduction in pressure relief system design

The guidance on whether instrumentation can be used to address an overpressure issue depends on whether the issue relates to relief device sizing or relates to relief device discharge system sizing.

Table 2 conceptually summarizes which methods can be used to reduce the calculated relief load or discharge system load.

Table 2 Methods to reduce loads

Relief load reduction Method	Relief device sizing		Discharge system sizing- system sizing	
	API-521	DEP 80.45.10.11-Gen.	API-521	DEP 80.45.10.10-Gen.
Assessment of System Dynamics	Yes	Yes for system relief load	Yes	No, not for timing of multiple unit flare loads
Beneficial Response from Basic Process Control	No	No, except for some remote contingencies (2.11)	Yes	No, except for the "flare bundle method"
Emergency Shutdowns or Instrumented Protective Functions	Yes, in limited cases (Note 1)	Yes, in limited cases See (2.10.3), (2.11), (3.7.5)	Yes	Yes, with flare bundle and IPF methods
Operator Intervention	Yes	Yes See (2.14)	Yes	No
NOTE: 1. SIFs may be used if it is impossible or impractical to size the relief device for the scenario.				

2.10.3 Safety Instrumented Systems (and other measures) to reduce or eliminate the relief load**2.10.3.1 General**

Traditional overpressure protection design is based on the principle defined in (2.10.1, item 1 and item 2).

1. An alternative design approach which involves use of Safety Instrumented Systems (and/or other measures) to reduce or eliminate the relief load may be employed if one of the following applies:
 - a. There is no relief device that can reliably relieve.
 - b. The required relief capacity cannot practicably be achieved with relief devices.
 - c. The relief load for reactive systems cannot be determined with confidence due to lack of reactive chemistry knowledge or physical property data.
 - d. The relief load from the pressure system exceeds the capability of the flare/disposal system (including hydraulic capacity, liquid knock out capability, or temperature limits). See (2.10.3.2).
 - e. The relief stream composition from the pressure system creates a hazard for the flare/disposal system (this includes introduction of incompatible materials that result in violent chemical reactions, introduction of oxidizers, and materials that can plug the relief system).
 - f. The discharge to atmosphere from the pressure system would be a significant (RAM 4 or 5) safety, environmental, or community impact.

2.10.3.2 Relief stream disposal capability

1. When applying to reduce the relief load from the pressure system, the pressure relief valves should be reduced in size.
2. If instrumentation is used to reduce flare/disposal loads without reducing the size of the relief devices, then the design criteria in DEP 80.45.10.10-Gen. section 5.3.4.3. shall apply instead of (2.10.3).

2.10.3.3 Application of the alternative design approach

1. Application of the alternative design approach shall have documentation showing that designing or re-designing the equipment, the relief devices, or relief stream disposal system meets one of the criteria in (2.10.3.1).
2. The justification of the alternative design approach shall be documented and subject to approval by a Technical Safety Technical Authority (TA2).
3. Mitigation measures (barriers) SHALL [PS] be valid as defined by HEMP design criteria (i.e., independent, effective, and auditable).
4. If the credit for Safety Instrumented Systems is taken, the SIF design shall meet DEP 32.80.10.10-Gen. requirements.
5. If the mitigated overpressure scenario is not fire, the resulting equipment pressure shall assume the failure of all barriers except pressure relief devices.
 - a. If the calculated pressure does not exceed the corrected hydrotest pressure, then there shall be at least a SIL-1 SIF control barrier to prevent the overpressure (e.g., prevent the relief or prevent exceeding allowable accumulations).
 - b. If the calculated pressure exceeds the corrected hydrotest pressure, then there shall be at least a SIL-1 SIF control barrier to prevent the overpressure.
 - i. Additional control/recovery barriers shall be assessed based on risk.
 - ii. The control/recovery barriers risks shall be demonstrated to be ALARP using applicable HEMP methodologies.

- c. Instrumentation shall be provided to alert operations that equipment pressure is above the MAWP.
- d. For applications involving ASME Section VIII equipment, the technical and documentation requirements in UG-140 of Division 1 shall be followed.
 - i. If the pressure system has a fire scenario, the accumulation used for fire relief device sizing shall be limited to 16 % (instead of 21 %).
- 6. If the mitigated overpressure scenario is fire, then the risk shall be demonstrated to be ALARP using applicable HEMP methodologies.
- 7. The portion of the calculated relief load for the scenario that is mitigated by the control barriers may be excluded from relief disposal system design.
- 8. The design of any SIL-3 SIFs for reducing relief load shall address common cause failures of transmitter sense lines and valves in accordance with DEP 32.80.10.10-Gen.

2.10.4 Instrumentation elements in pressure relief design

2.10.4.1 Valve stops

Valve stops are used in process design to limit how far open or how far closed a control valve can move. Valve stops may be soft (valve position is limited by software) or hard (physical stops that prevent the valve from opening or closing).

- 1. Credit shall not be taken for soft stops limiting the valve movement for pressure relief load calculations.
- 2. Credit may be taken for a hard (mechanical) stop limiting the valve movement in the pressure relief load calculations provided that all of the following apply:
 - a. The hard stop is shown on the PEFs (P&IDs) and noted as impacting pressure relief device sizing;
 - b. The purpose of the hard stop is documented in the relief device calculations;
 - c. The hard stop is noted in the Safeguarding Memorandum (if applicable).

2.10.4.2 Valve speed controls

The speed of valve closure is a common method to mitigate pressure surge that can occur with blocked outlets in long pipelines.

- 1. The Principal shall be consulted if the speed of the valve closure will be controlled by the DCS.

2.10.4.3 Restriction orifices

- 1. Restriction orifices may be used to limit process stream flows for pressure relief system design provided that all of the following apply:
 - a. The ROs are shown on the PEFs (P&IDs) and noted as impacting pressure relief device sizing;
 - b. The basis and size of the RO is documented in the relief device calculations;
 - c. The RO is noted in the Safeguarding Memorandum (if applicable).
- 2. For square edge orifice, the following assumptions for coefficient of discharge shall apply:
 - a. For liquid or flashing liquid, C_d for the square edge orifice is 0.65.

Flashing liquids are treated the same as non-flashing liquids because flow through the orifice is so fast that there may not be thermodynamic equilibrium.
 - b. For two phase, C_d for the square edge orifice is 0.85.
 - c. For subsonic vapour flow, C_d for the square edge orifice is 0.65.

- d. For choked vapour flow:
 - i. For t/d ratios of 1 or greater, C_d for the square edge orifice is 0.8.
 - ii. For t/d ratios less than 1, C_d for the square edge orifice is 0.85.

Where t = thickness of the orifice plated

d = diameter of the orifice

3. C_d values other than those in (2.10.4.3, item 2) may be used provided that the orifice characteristics are consistent with the flow equation being used.

2.10.5 Instrumentation to alert operations of relief device activation

1. Instrumentation (high pressure alarms, high flow alarms, or other indicators) to alert the operator that the relief device has activated should be consistent with the implementation of alarm management at the facility.

2.11 CHECK VALVES (NON RETURN VALVES) IN OVERPRESSURE PROTECTION

2.11.1 General

There are several key concepts in mitigating backflow:

- *mitigating backflow due to normal leakage is a design scenario;*
- *mitigating backflow due to check valve malfunction (severe check valve leakage or failure) is a remote contingency; The backflow mitigation requirements depend on the system pressure ratio. The system pressure ratio is defined as the backflow source gauge pressure (i.e., the normal operating pressure of the downstream system) divided by the low pressure side design pressure (or MAWP if available).*
- *where hydrotest pressure can be exceeded, the required mitigation is equivalent to three control barriers;*
- *where pressure ratio is greater than five the required mitigation is in most cases equivalent to four control barriers;*
- *Risks due to backflow can be mitigated by a number of means which include: check valves, basic process controls, SIFs, and/or relief device(s).*

1. The designer shall state how backflow (as applicable) is mitigated.
2. Flow paths that bypass backflow safeguards shall be evaluated.

Pump/compressor minimum flow recirculation (or anti-surge) lines can create flow paths that might bypass backflow safeguards.

2.11.2 Class 1 check valves

There are two types of check valves described in this DEP: regular check valves and Class I check valves. The key difference is a Class I check valve is inspected or tested for functionality while a regular check valve is not.

1. Class 1 check valves shall have the following:
 - a. Internal inspection (or performance tested) to detect gross deficiencies such as a stuck flapper, corroded seats, damaged hinge, or galling.
Replacing check valves without assessing and documenting the functionality of the check valve is not an alternative.
 - b. Inspection (or performance test) interval should be established using a condition based philosophy unless otherwise specified by applicable regulations.

This interval usually corresponds to the planned shutdown (turnaround) intervals.

- c. Inspection (or performance test) records for each Class 1 check valve shall be maintained.
2. Class 1 check valves shall be sized and specified so that under the range of design forward flow conditions the valve will have stable performance (i.e., not flutter) as specified by the check valve Manufacturer/Supplier.
3. Class 1 check valves shall be identified in the PEFS, PSFS, and listed in the Safeguarding Memorandum (if applicable).
4. Class 1 check valves shall have a unique number assigned for tracking purposes, and be labelled or tagged in the field with this identifying number.

2.11.3 Check valve failure modes

There are three failure modes with check valves (regardless of design or class):

- *Normal Check Valve Leakage—Potential for minor reverse flow due to normal check valve wear.*
 - *Severe Check Valve Leakage—Potential for significant reverse flow because of check valve seat damage or obstruction.*
 - *Complete Check Valve Failure—Potential for gross reverse flow because the check valve does not function at all. (e.g., it is stuck wide open or the internals are gone).*
1. The failure modes of check valves shall be assumed to be latent (covert).
That is, the check valve failure is not a scenario. It is an unrevealed condition that exists at the time when there is a loss of forward flow (e.g., due to loss of compressor/pump driver).
 2. Backflow with normal check valve leakage shall be a design scenario, see (2.12).
 3. Systems upstream of a check valve that can be blocked in shall have sufficient pressure rating or pressure relief (see guidance in (2.11.4)) to ensure code allowable accumulation limitations are not exceeded.
 4. The remote contingency accumulation limits shall be applied when assessing severe check valve leakage and sizing relief devices.

Complete check valve failure is considered a remote contingency for regular check valves.

Severe check valve leakage of dual Class I check valves is considered a remote contingency.

2.11.4 Pressure relief device sizing to mitigate normal valve leakage

1. Pressure relief devices on the low pressure side shall be sized for backflow due to normal valve leakage as follows:
 - a. If there is no check valve or other backflow safeguards, then the relief load is the backflow based on system hydraulics (from the high pressure source to the low pressure equipment).
 - b. If there is at least one check valve of any type, then assess the adequacy of the relief device to handle the normal check valve leakage as follows:
 - i. If the high pressure side pressure is less than the hydrotest pressure of the suction side, then provide a relief device equivalent to a D sized PRV.
 - ii. If the high pressure side pressure is greater than the hydrotest pressure of the suction side, then estimate the backflow relief load as the flow through an orifice that has an area of 0.1 % of the check valve flow area, assume one side of the orifice is at the operating pressure of the high pressure source and the other side of the orifice is the low pressure equipment at

allowable accumulation (e.g., 10 %). See (2.10.4.3) for calculating flow through the orifice.

- iii. Do not reduce the relief load if there are multiple check valves in series.
- iv. If the pressure relief device is sized per (2.11.5), then the relief device will satisfy the requirements in this clause.
- c. For instrumented valves used in addition to a check valve to mitigate the backflow, assume their seat leakage rate is equivalent to a fire damaged valve (see ISO 10497 or API STD 609).

The seat leakage rate will be smaller than that calculated in (2.11.4, item 1.b).

- d. If the instrumented valve is in series with a check valve, use the smaller of the two leakage rates.
- e. For pumps where vapour in the downstream vessel is driving the backflow, assess the backflow of vapour.

2.11.5 Pressure relief device sizing to mitigate severe check valve leakage or complete check valve failure

One of several backflow mitigation options involve sizing the relief device for severe check valve leakage or complete failure.

1. If a relief device will be used to mitigate backflow overpressure, then the pressure relief device shall be sized as follows:
 - a. Where there is a single Class 1 check valve or one or more regular check valves, assume complete check valve failure.
 - i. Do not take any flow restriction credits for the check valves (either ignore the flow resistance of the valves or assume the check valves are wide open).
 - b. Where there are dual Class 1 check valves, assume one check valve has complete check valve failure and the other check valve has severe check valve leakage.
 - i. Model the flow through the valve with the severe check valve leakage as an orifice that has an area of 1 % of the check valve flow area.
 - c. Calculate the backflow flow assuming the expected pressure of the high pressure source and the low pressure equipment at remote contingency accumulation (e.g., 30 %).

Using normal operating pressure is usually conservative. Loss of feed might result in a reduction in operating pressure.

Credit may be taken for the hydraulic resistance of the system (from the high pressure source to the low pressure equipment). However, do not consider that additional check valves restrict flow.

- d. For pumps where vapour in the downstream vessel is driving the backflow, take the vapour backflow into account in the backflow calculations.

The vapour backflow usually requires a larger relief device area than the initial liquid backflow.

2.11.6 Work process for backflow overpressure protection of equipment excluding low pressure and atmospheric storage tanks

1. The following steps shall be followed to provide overpressure protection against backflow:
 - a. See Figure 1 for the overall logic.

The magnitude of the backflow depends on the size of the downstream (high pressure) system and the compressibility of that fluid in sustaining a backflow that could overpressure the suction vessel.

- *Typically, loss of a pump into a liquid filled system where there are no other pumps supplying pressure will not result in backflow.*
 - *In pipeline applications the effects of liquid compressibility may result in a significant backflow.*
 - *Unless completely liquid full, process equipment typically have a source of vapour/gas large enough to sustain a backflow with loss of the feed pump.*
- b. If the backflow introduces a reactive hazard that can generate a pressure greater than the backflow source pressure, then this shall be evaluated separately as part of a reactive hazard scenario.
 - c. Risks (other than overpressure) caused by the backflow (e.g., environmental releases, contamination) shall be considered and evaluated on a case-by-case basis.
 - d. The designer shall state which option (as applicable) is being used to mitigate the backflow.
2. If there is no check valve in the flow path to stop the backflow (e.g., backflow is through the pump minimum flow line), the relief device shall be sized for the backflow using code allowable accumulation.
 - a. To prevent reverse overspeed of centrifugal equipment and/or motors, consider installation of Class I check valves on the discharge of each pump/compressor if the pressure ratio is higher than 1.5 but less than 5;
 - b. Consider dual Class I check valves if the system pressure ratio is five or higher.
 3. If there is a check valve in the flow path to stop the backflow, then pressure relief devices on the low pressure side shall be sized sufficient to handle backflow due to normal valve leakage; see (2.11.4).
 - a. If the pressure relief device is sized sufficiently to handle the backflow due to normal valve leakage, and the system pressure ratio is less than or equal to the corrected hydrotest pressure ratio (e.g., (1.3)), then overpressure from backflow should be considered as mitigated (do not proceed to (item 4)).

If the system pressure ratio is greater than the corrected hydrotest pressure ratio, then proceed to (item 4).
 4. If the pressure generating equipment is a centrifugal pump or compressor and the system pressure ratio is less than five, then severe check valve leakage or complete check valve failure shall be mitigated by any one of the following options:
 - a. Regular check valve(s) (i.e., not Class 1) in the flow path and the relief device sized for backflow assuming complete check valve failure (i.e., wide open).
 - i. To prevent reverse overspeed of centrifugal equipment and/or motors, provide a single Class I check valve on the discharge of each pump/compressor.
 - b. Dual Class 1 check valves in the flow path and the relief device sized for the backflow assuming severe check valve leakage (i.e., check valve flow area is 1 %).
 - c. Dual Class 1 check valves and an instrumented valve in the flow path.
 - i. The instrumented valve shall be able to close before the vapour backflow reaches the instrumented valve.

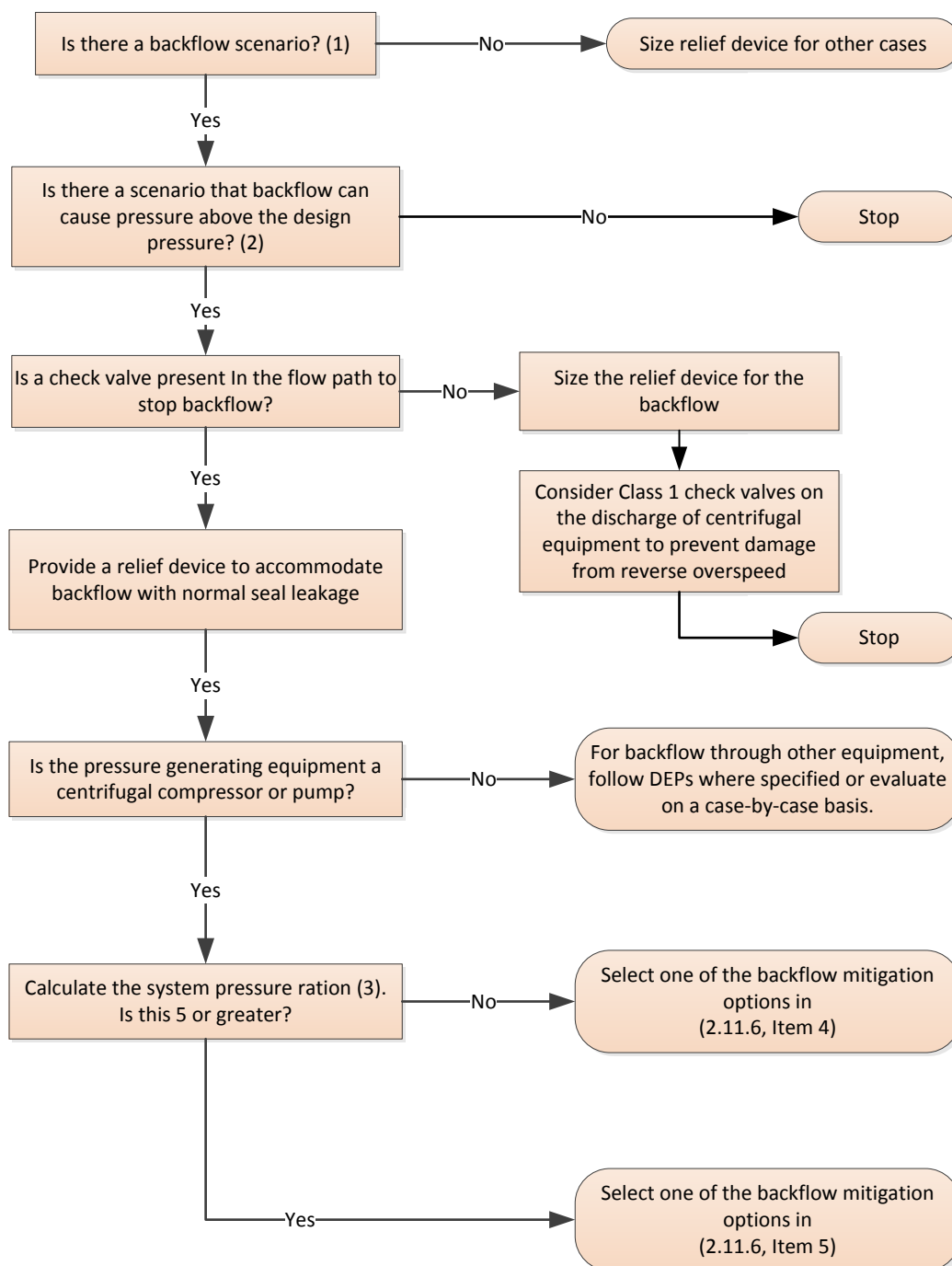
- ii. The instrumented valve may be a basic process control system or a SIL 1 SIF.

Systems where there is no vapour space in the suction equipment to absorb backflow could quickly pressurize to the downstream pressure with loss of the pump. In these cases, use of instrumented safeguards are not likely to be fast enough.

- d. Single Class 1 check valve and multiple instrumented valves (equivalent to SIL-2) in the flow path.
 - i. The instrumented valves shall be able to close before the vapour backflow reaches the instrumented valve.
- 5. If the pressure generating equipment is a centrifugal pump or compressor and the system pressure ratio is five or greater, then severe check valve leakage or complete check valve failure SHALL [PS] be mitigated by any one of the following options:
 - a. Regular (i.e., not Class 1) check valve(s) in the flow path and the relief device sized for backflow assuming complete check valve failure.
 - i. To prevent reverse overspeed of centrifugal equipment and/or motors, provide a single Class I check valve on the discharge of each pump/compressor.
 - b. An instrumented valve plus dual Class 1 check valves in the flow path and the relief device sized for the backflow assuming severe check valve leakage (i.e., check valve flow area is 1 %):
 - i. The instrumented valve may be a basic process control system or a SIL-1 SIF;
 - ii. The instrumented valve is able to close before the vapour backflow reaches the instrumented valve;
 - iii. When assessing available closure time, assume no flow restrictions through any check valves.
 - c. Dual Class 1 check valves and multiple instrumented valves (equivalent to SIL-2) in the flow path, where the instrumented valve is able to close before the vapour backflow reaches the instrumented valve.
 - i. When assessing available closure time, assume no flow restrictions through any check valves.
 - d. One Class 1 check valve and multiple instrumented valves (equivalent to SIL-3) in the flow path, where the instrumented valves are able to close before the vapour backflow reaches the instrumented valves.
 - i. When assessing available closure time, assume no flow restrictions through any check valves.

Systems where there is no vapour space in the suction equipment to absorb backflow could quickly pressurize to the downstream pressure with loss of the pump. In these cases use of instrumented safeguard are unlikely to be fast enough.

- 6. See (5.4) for specific guidance on backflow through other rotating equipment.
- 7. Backflow involving systems other than those in this clause (e.g., utility connections) should be evaluated on a case by case basis if no other guidance is provided in the applicable DEP.

Figure 1 Equipment backflow protection other than atmospheric storage tanks

- NOTES:
1. Figure 1 assumes installed relief device is routed to a closed system (i.e., flare); if to atmosphere, further assessment is required.
 2. Resulting pressures may not be limited by the source, for examples hot oil/water contact.
 - a. Subject matter experts should be consulted to determine the appropriate evaluation technique required.
 - b. When assessing evaluation techniques, consider the potential for the phase of the backflow stream to change from liquid to vapour if vapour is driving the backflow.
 3. Calculate the system pressure ratio by dividing the high-pressure system's operating pressure by the design pressure of the system that the backflow is flowing into.

2.11.7 Backflow overpressure protection of low pressure and atmospheric storage tanks

1. Backflow shall be mitigated as described in (2.11.6, item 5) if the high pressure vessel (downstream of the pump) has sufficient vapour volume to overpressure the tank.
 - a. If sizing the tank vent for backflow (as described in (2.11.5)) the tank pressure shall not exceed allowable accumulation.
2. If the backflow introduces a reactive hazard that can generate a pressure greater than the backflow source pressure, then this shall be evaluated separately as part of a reactive hazard scenario.
3. If backflow is mitigated by sizing the relief devices for the reverse flow, the consequences of potential reverse overspeed damage to mechanical equipment shall be assessed and mitigated as needed.
4. The flammable and toxic exposure risks at grade shall be assessed, and mitigated if required.

2.12 DESIGN AND REMOTE CONTINGENCY SCENARIOS

1. Refer to (3) for design scenarios.

Shell has identified a number of the scenarios described in API STD 521 as design scenarios.
2. Refer to (4) for remote contingency scenarios.
3. For design scenarios, the accumulations allowed by the vessel design code shall not be exceeded.
4. For remote contingencies, accumulations allowed by the vessel design code may be exceeded since the likelihood of these scenarios is low.

Shell has determined that some overpressure scenarios described in API 521 are possible but are so unlikely they are not considered as credible design scenarios. These are considered remote contingencies.
5. Design scenarios shall be based on single jeopardy events.

Double jeopardy is not used for design because calculations can show that the probability of two unrelated overpressure events occurring simultaneously (e.g., loss of power while there is a blocked outlet) is very small.

2.13 ALLOWABLE ACCUMULATION AND UNDERPRESSURES**2.13.1 Single jeopardy, code-allowable accumulations**

1. The applicable design code shall be followed when determining the allowable accumulation.

Some storage tank designs allow no accumulation (e.g., API STD 650) due to potential damage to the frangible roof weld, and lower safety factor in design.

10 % accumulation is allowed by the ASME Code for a single relief device and for all design scenarios for vessels built to EN 13445 and BSI PD 5500.

16 % accumulation is allowed by the ASME Code and GB150 for multiple relief devices under operational overpressure scenarios (i.e., non-fire). Other design Codes limit this accumulation to 10 %.

20 % accumulation is allowed for API STD 620 tanks under the fire case.

21 % accumulation is allowed for ASME Code equipment under fire exposure. Other design Codes may limit this accumulation to 10 %.

20 % or 33 % accumulation is allowed for piping designed in accordance with ASME B31.3, depending on the accumulation frequency and duration.

2.13.2 Remote contingency accumulations

1. For the identified remote contingencies, the maximum accumulation shall be the Corrected Hydrotest Pressure.
 - a. The corrected hydrotest pressure value may be used regardless of whether the vessel or piping was hydrotested, pneumatically tested, or if extra-ordinary fabrication and inspection QA/QC procedures were employed to waive a pressure integrity test.

2.14 OPERATOR INTERVENTION

1. If credit for operator intervention is taken to reduce design requirements, then all of the following criteria SHALL [PS] be met:
 - a. The alarm that alerts the operator is independent of the initiating event for the scenario.

For example, the cause of the overpressure will not disable the alarm instrumentation.
 - b. There is sufficient time for the operator to take action to stop the scenario, as agreed with the Principal.

This time includes the time to diagnose the alarm, to take action, and for the action to take effect.

The criterion will typically be 30 minutes (if operator action in the field is required) but no less than 15 minutes (if operator action from the control board is required).
 - c. There are clear, unambiguous, and effective operator actions specified for responding to the alarm.
 - d. All consequences (e.g., overpressure, impact of relief stream to disposal system, impact of relief to atmosphere) of no operator intervention or ineffective operator intervention are included in the assessment.
 - e. If credit for operator intervention is taken for the relief device sizing, then the overpressure consequences associated with ineffective operator intervention is evaluated as a remote contingency (4.3).

The equipment pressure is determined by calculating the pressure required to pass the relief load through the provided relief devices.
2. If the scenario is vessel overfill, the time-to-fill calculation should be based on the flow in minus any flows out for the scenario.
 - a. For calculating overfill times for fractionators, see (5.1.8.3).

2.15 ADMINISTRATIVE CONTROLS

2.15.1 General

1. Administrative controls may be applied to mitigate overpressure and underpressure scenarios associated with manual valve operation.

The use of administrative controls is often relied upon for commissioning and maintenance activity, and some start-up/shutdown activities.
2. Where administrative controls are applied to mitigate an identified overpressure scenario associated with manual valve operation, the following shall be met:
 - a. Clear written and effective procedures plus training of relevant personnel on these procedures;
 - b. Management systems to assure overall effectiveness;

- c. Application is approved by the Principal.
- 3. Overpressure due to failure of administrative controls associated with equipment blinding shall be considered not credible.

2.15.2 Removing/isolating equipment from operation

1. Administrative controls may mitigate fire relief scenarios for equipment isolated from operation if both of the following conditions are met:
 - a. Documented procedures are in place for draining and depressuring the equipment after it is isolated for maintenance.
 - b. Fire relief load can be relieved elsewhere in the system during normal operation (when the equipment is lined up again). Refer to (3.9).

This credit is typically taken only for spared equipment such as heat exchangers, reactors, filters, and driers that are intended to be put into operation at a pre-determined frequency.

2.15.3 Valve mechanical locking elements

Mechanical locking elements are locks or car seals. These are a physical barrier to the operation of the stop valve, such that the stop valve is not capable of being operated unless a deliberate action is taken to remove or disable the element. Administrative controls and mechanical locking elements are intended to ensure that personnel actions do not compromise the overpressure protection of the equipment.

1. If pressure due to closure of a single block valve during normal operation would not result in exceeding $116 \% \times \text{MAWP}$, then mechanical locking elements are not required and should not be used.
2. If pressure due to closure of a single block valve during normal operation could result in exceeding $116 \% \times \text{MAWP}$ (but not exceeding corrected hydrotest pressure), then valve lock or car seal shall be used.
 - a. For new designs these applications should be avoided.
3. If pressure due to closure of a single block valve during normal operation could result in immediately exceeding the corrected hydrotest pressure, then the overpressure shall be mitigated (e.g., specify higher design pressure or relief devices) because a mechanical locking element is not sufficient protection.
4. For equipment that will be drained and depressured when isolated (2.15.2), mechanical locking elements should not be required for any valves in that fire relief path if fire is the only source of overpressure.
5. Refer to DEP 80.45.10.10-Gen. for mechanical locking elements on relief device isolation valves.
6. All valves in the flow path in a relief header (e.g., a flare header battery limit isolation valve) SHALL [PS] be key locked or car-sealed open.
7. The use of car seals/valve locks other than those specified in (2.15.3) shall be subject to review and approval by the Principal.
8. A register that documents the valve location, intended valve position (open or closed) and purpose (safety, environmental, or operability) of each locked valve shall be developed and handed over by the project for the operating asset to maintain.

2.15.4 Valve operation control applications

1. Valve operational controls may be used, subject to the approval of the Principal, where valve mis-operation can result in pressures greater than hydrotest.

Valve operation controls are devices used to ensure that stop valves within the pressure relief path are in their proper (open/closed) position. Valve operation controls include mechanical interlocks (physical linkages such as shaft or lever