

GUIDANCE

IN-SERVICE INSPECTION PROCEDURES

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SITUATION:

The following guidelines generally apply to all pressure systems and when followed can lead to a consistent approach.

***Note:** This guidance is applicable to the testing required by a Competent Person in accordance with a Written Scheme of Examination (WSE). It does not cover any testing completed as part of the maintenance programme of the valve which may have maintenance intervals less than those specified in the WSE.*

GUIDANCE:

There are usually two types of examination of safety valves, the 'Out of Service' examination (or thorough examination) and the 'In service' examination (or working examination).

Note: Related documents occasionally refer to the term "Maximum Allowable Operating Pressure" is used, this can be used interchangeably with the term "Safe Operating Limit" when related to pressure.

Reference should be made to PSG 23 when using this document.

1. Out of Service Examination.

The extent of the examination and testing depends on the type of system being protected, the contents of the system, potential failure mechanisms and whether the strip down / overhaul is carried out on site or the safety valves sent away to a specialist company. This will be detailed in the written scheme of examination (WSE).

Simple air receiver safety valves can be functionally tested and there would generally be little need to strip them down unless they do not function properly or damage is evident or suspected.

Steam boiler safety valves should be stripped down to determine the condition of the pressure retaining parts and the springs. Often site staff do not have the competence to overhaul safety valves so they would be sent away and returned suitably certified.

For systems where damage to the safety valve is likely and there may be a risk of blockage a more rigorous inspection regime is often required. Typically, this may involve testing in the as removed condition, documentation of the condition of the safety valve as removed and proving that connections and relief systems are clear.

Where the overhaul and testing is carried out by a third-party facility, the Competent Person should assure themselves that the work is carried out satisfactorily. For example, the facility should have documented procedures to ensure accuracy of results, ideally traceable to national standards and/or approved by a 3rd party e.g. to ISO 9001 and safe systems of work. The report produced should detail the pre-overhaul pop test, the condition of the valve as found and the post-overhaul pop test. The Competent Person is encouraged to carry out periodic checks of the valve overhaul/testing facility for assurance.

Typically an out-of-service examination will entail the following:

- Examination of the valve in the as-removed condition to check for blockages/fouling, wear, corrosion and mechanical damage
- Verification that the valve removed was set at the correct set pressure, if applicable.
- Examination of the inlet nozzle and discharge piping (also see PSG23 for further details)¹

¹ PSG23 Guidance for the Competent Person in relation to the examination requirements for relief systems, SAFed PEC 13 Issue 08.

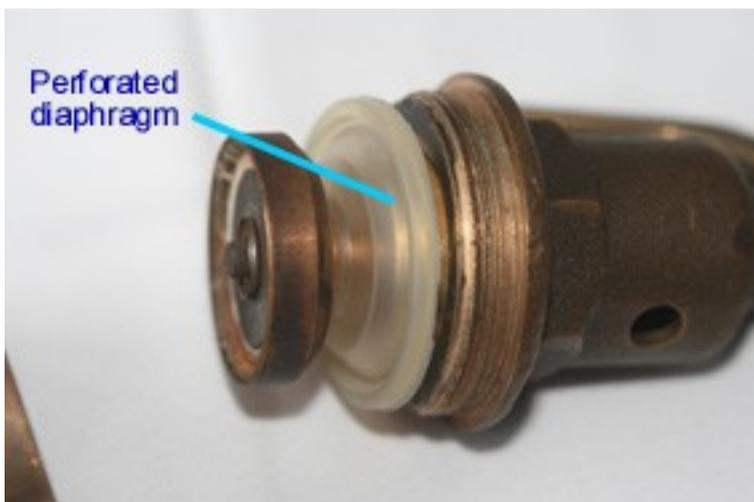
Example Defects Found during Examination.



Excessive wear of upper valve guide and damage to valve spindle.



Excessive wear of valve spindle.



Perforated diaphragm. Allows any fluid to corrode parts of the valve.

Corrosion caused by damaged diaphragm



Broken spring, missing ball bearing between seat and spindle



Broken spring due to hydrogen embrittlement





Pitting/corrosion damage on valve body.

3. In-service examination

The purpose of the in-service examination is to confirm that the safety valve is correctly set and has been properly installed. For example, for steam plant this may involve a functional test of the safety valve under service conditions or by an assisted lift procedure such as Trevitest. For toxic or flammable contents a functional test cannot be carried out and the set pressure should be determined from the documentation provided or by witnessing testing on a suitable rig prior to refitting.

Typically the in-service examination will entail the following:

- Verification that the correct valve has been fitted and that the set pressure indicated on the valve enables the system to be protected safely
- That the valve has not been inadvertently isolated
- Witness live lift testing of the device if applicable (e.g., fired boilers)
- A review of the valve overhaul report including scrutiny of the pre- and post-overhaul lift test. For new valves the certificate of conformity from the manufacturer may suffice

4. Set pressure

The safety valve should be set so that the safe operating limits cannot be exceeded (see paragraph 57 of PSSR ACOP – Safety of Pressure Systems). Where a valve has been sent to a refurbishment/test house the Competent Person should check that the set pressure on the certificates and valves is correct for the safe operating limits of the plant to be protected. If the design pressure of a pressure vessel or boiler is 10.0 bar the maximum set pressure of the safety valve is 10.0 bar and this would normally be the safe operating limit. A margin below the safety valve setting should be allowed for the actual operating pressure (pressure switch cut-out) to prevent feathering or spurious operation of the safety valve - usually 0.5 to 1 bar on air or steam systems. The pressure at which the maximum required relief capacity is reached will be in excess of the vessel's safe operating limit however design codes include an allowance for this e.g., 6% for power boilers to ASME I², 10% for vessels designed to

² ASME I para PG-67
PEC 13 Issue 08.

PD5500³ and ASME VIII div 1⁴. An example of relationship between the operating pressure, design pressure and valve set pressure can be seen in PD 5500 annex J (excerpt below).

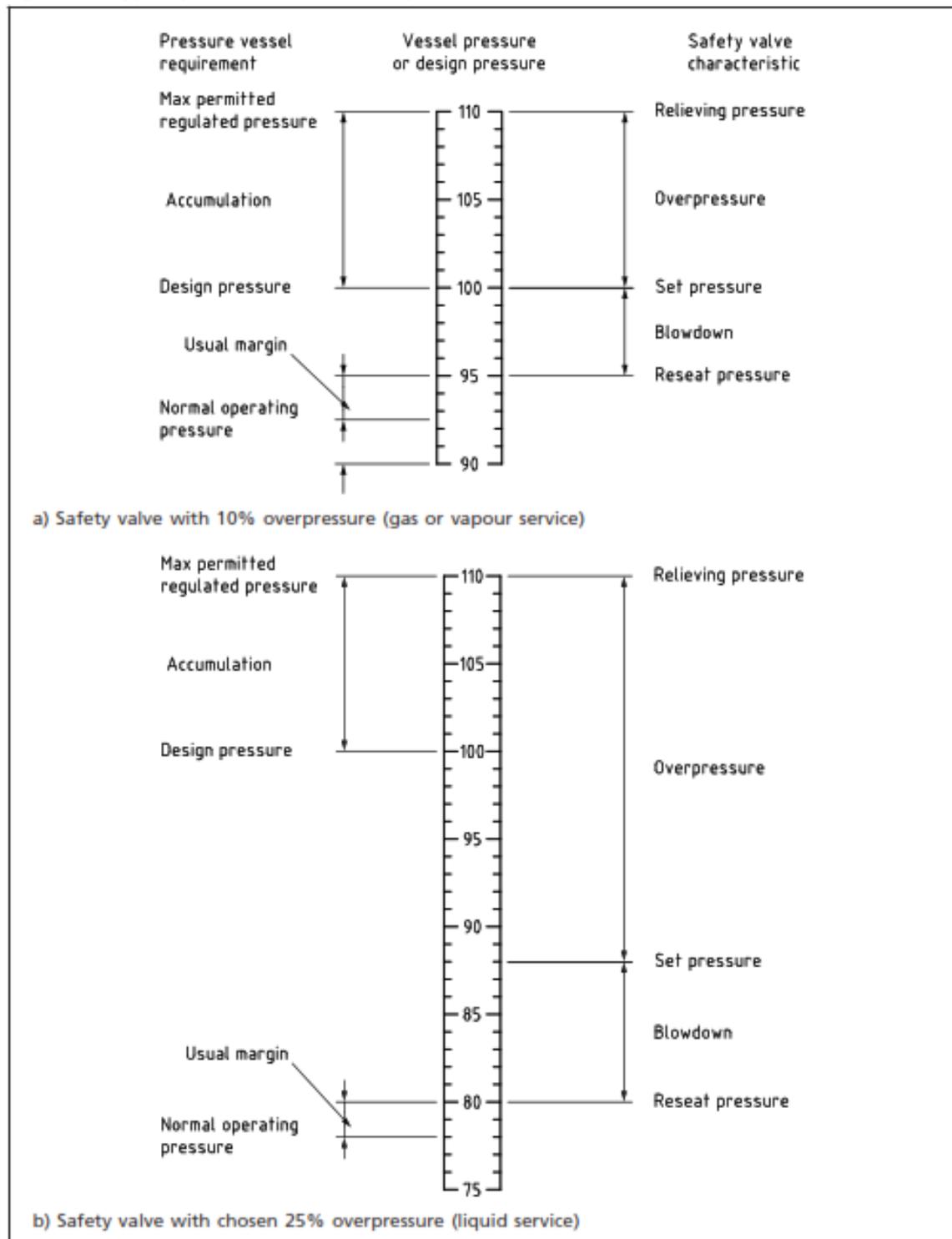
Where the system safety valve protects other plant with a lower safe operating limit downstream then the maximum set pressure of the safety valve should be the lower safe operating limit.

There are occasions, on large plant, where multiple relief devices are installed to ensure the actual relief capacity exceeds the required relief capacity. In these cases the primary device will be set at, or below, the design pressure and secondary devices may be set at a higher pressure, usually no higher than 5% above the design pressure (ref: PD 5500 3.13.3 and ASME VIII div 1 para UG-134)

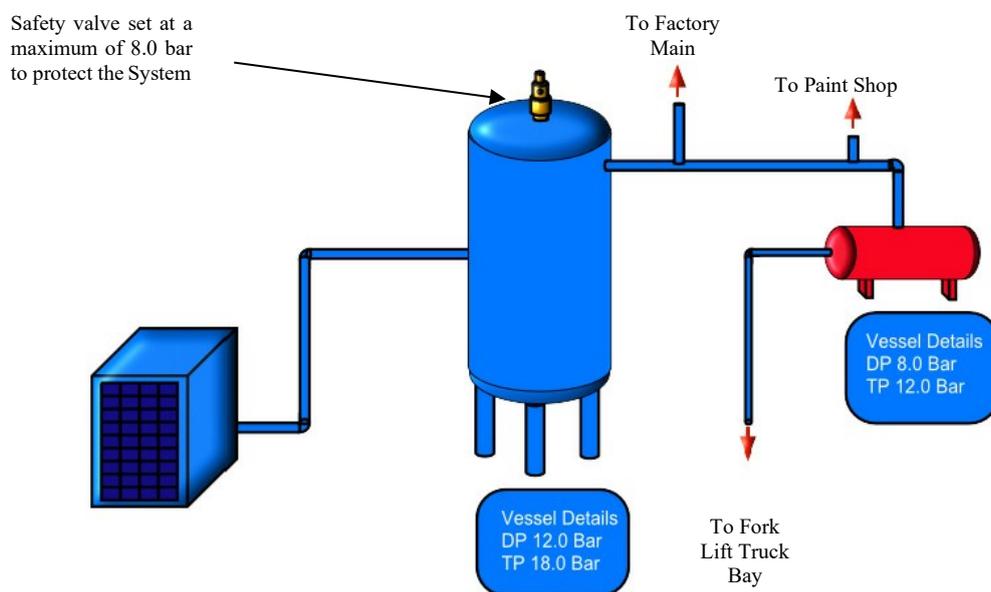
³ PD5500 para 3.13.2

⁴ ASME VIII para UG-125
PEC 13 Issue 08.

Figure J.1 Typical pressure term relationships



PD 5500 Annex J “Recommendations for Pressure Relief Protective Devices”



Under a relief event, if designed and installed correctly, the safety valve will start to lift at or before the safe operating limit. The maximum discharge capacity will be achieved within the code-specified accumulation limit and the pressure in the system will be not rise beyond this value.

A safety valve is a mechanical device and the process of setting or re-setting a safety valve inevitably has a limit to how accurately it can be set in respect of the desired pressure. Manufacturer's certification for a new safety valve seldom states any tolerance figure on the nominal set pressure. The safety valve standard ISO 4126 Part 1 specifies tolerances on set pressure (typically $\pm 3\%$) for the characteristic testing (type testing) of safety valves. In the absence of any other criteria manufacturers tend to also apply these tolerances to their supplied product. When ordering replacement valves it is therefore good practice for the user/owner to take tolerances into consideration when determining the nominal safety valve set pressure, such that it is not too close to a pressure switch cut out set point for operation or exceeding the safe operating limit of the system.

When verifying safety valve set pressure and determining what is acceptable the Competent Person needs to take into account possible set pressure tolerance. If it is discovered the during a test that the set pressure of a safety valve exceeds the safe operating limit of the system the competent person will need to determine for the particular circumstances whether this is acceptable and safe. The following should to be taken into consideration as applicable:

- Whether the valve supplier's stated nominal set pressure for the valve is correct for the system being protected
- The extent to which the set pressure exceeds to safe operating limit
- Whether the valve can still achieve it full design discharge capacity within 110% of the safe operating limit pressure (this is an essential requirement)
- Whether the test is a cold bench test as opposed to a hot test in situ and the possible differences this may cause to the actual set pressure
- The practicability of being able to able to adjust the valve to achieve a set pressure within the safe operating limit
- Whether there is evidence that the set pressure has drifted since the valve was last tested.



Single Safety Valve Systems

Under no circumstances shall the safety valve be purposefully set at a pressure higher than the safe operating limit.

Multiple Safety Valve Systems*

At least one of the safety valves must be set at or below the safe operating limit. The other safety valves protecting the component or system in question may be set at higher pressures but in no case at a pressure higher than is allowed in the applicable design code. Other code requirements may also apply in terms of the overall range of pressure settings permitted.

* For some specific applications, design codes do allow all of the safety valves to be set above the safe operating limit, subject to an accumulation limit. Such applications should be considered on a case-by-case basis with specialist input.

5. Capacity

Safety valves should be sized so that the pressure in the system is prevented from rising above the accumulation limit specified in the applicable design code under the most onerous operating conditions, for example:

- Maximum output from air compressor with valve downstream from safety valve closed
- Pressure reducing valve stuck in fully open position.
- Maximum evaporative capacity of steam boiler with stop valve closed.
- Failure of refrigeration plant on refrigerated carbon dioxide storage vessel.
- Fire engulfment of liquefied petroleum gas (LPG) storage vessel.

Safety valve capacity depends on the nature of the fluid to be relieved together with the set pressure, the seat diameter and a coefficient of discharge, which is established for each type of safety valve.

Manufacturers provide capacity charts for their safety valves from which actual relief capacities can be determined where necessary. For more complex plant, the owner should be able to provide process safety documentation to demonstrate the required relief capacity for a range of relief cases. This paperwork should be made available to the Competent Person during the examination alongside the valve data sheet indicating the valve(s) actual relief capacity.

On newly installed steam boilers (without superheaters) there is generally a requirement to demonstrate the full rated discharge capacity by carrying out an accumulation test under maximum firing conditions before being put into service. As an example, the photograph below shows a washer inadvertently dropped in the relief valve inlet which caused the accumulation test to fail due to exceeding the overpressure.

This should be repeated if changes are made to the firing/fuel, safety valve discharge piping or safety valve rating.

It should be noted that when the safe operating pressure of a boiler or vessel is reduced and a lower safety valve setting is required this will **reduce** the capacity of the safety valve. If this is reduced below the required capacity it will be necessary to fit a larger or increased capacity (e.g. high lift) safety valve or an additional safety valve. The owner should be able to demonstrate that, when modified, the relief system is capable of adequately protecting the system. It's important to note that valves identical in size but rated for steam or gas service will have different relief capacities to those on liquid service so valves may not be interchangeable.



Washer found using articulating borescope in boiler relief line inlet after failure of accumulation test.

Explosions have occurred when safety valves have not been able to relieve pressure generated or supplied to vessels. In most cases, where the manufacturer has provided a safety valve as part of a system, it will have been sized correctly, but when changes are made, or a safety valve does not appear adequate, its capacity should be confirmed.

6. System Protection

Where a pressure system is adequately protected at the source of supply there is generally no need for additional safety valves on individual vessels. If there is no other source of pressure an overpressure situation cannot occur so there is no need for additional protection.

Examples:

- Steam boiler with safety valve set at 5.5 bar supplying equipment with design pressure of 5.5bar. The safety valve on the boiler protects the system.
- Air system supplied from main air receiver with safety valve set at 8.0 bar supplying other small air vessels and hand tools each with a design pressure of >8.0 bar. The safety valve on the main air receiver protects the rest of the system.
- Steam boiler with safety valve set at 8.0 bar supplying equipment with design pressure of 5.5 bar. A reducing set (reducing valve, safety valve and pressure gauge) with the safety valve set at 5.5 bar is required. Providing it is correctly sized the reducing set safety valve protects the equipment downstream.

Note. When there are no means of isolating interconnecting pipework there is no question that a safety valve on the main receiver or supply pipe protects the rest of the system. Where individual vessels have inlet and outlet isolating valves fitted the need for each to be fitted with safety valves would depend on other sources of pressure. The pressure in an isolated air receiver would rise by about 3% for a 10°C rise in ambient temperature so extreme changes would generally be necessary to cause a dangerous situation.

For air systems HSE advise that a fusible plug should be fitted to air receivers on large (>100kW) compressor systems. Plant with flammable contents such as LPG storage needs to be specially considered because a leak could lead to a pool fire beneath a vessel.

7. Safety valve examination periodicity

The periodicity at which safety valves should be examined should follow the guidance of PSG1⁵, The periodicity should be reviewed at each examination and be based upon, as a minimum:

- The condition of the valve as found during removal for damage or blockage
- The valve's pre-overhaul pop-test results, if applicable.
- The history of the valve's performance

If the valve is found to be in poor condition or fails to relieve at the required pressure then this may warrant a decrease in the periodicity. It may also be possible to increase the periodicity of good-performing valves. Other factors may also limit the examination periodicity such as the inspection results of the valve inlet and discharge piping.

8. Safety valve examination reporting

The examination of safety valves is normally carried out at the same time as the equipment it protects⁶ however this may not always occur (e.g., the valve, due to poor performance, requires more frequent examinations). The report for the valve should contain:

- The unique identification mark of the valve (e.g., serial number)
- The results of the examination including the pre- and post- overhaul lift pressure
- A statement as to the condition of the valve and fitness for further use.
- The examination periodicity and date of the next examination if not already covered by the inspection report of the protected equipment.

The Pressure Equipment (Safety) Regulations (PE(S)R) permits the batch marking of safety valves, without the requirement for an individual serial number. This may present an issue with the requirement in the PSSR (see extract below from Regulation 9):

(5) The report required by paragraph (3) shall—

(a) state which parts of the pressure system have been examined, the condition of those parts and the results of the examination;

Where individual unique identification cannot be ascertained the user will need to uniquely mark the equipment so that it can be identified on their maintenance systems and the Competent Person reports.

⁵ PSG1 Guidelines – Pressure Systems – Guidelines on the periodicity of examinations SAFed

⁶ PSSR Approved Code of Practice L122 2nd ed para 109
PEC 13 Issue 08.

References.

1. API 576 – Inspection of Pressure Relieving Devices.
2. BS 6759 (withdrawn) - Safety valves. Specification for safety valves for steam and hot water.
3. EN ISO 4126 - Safety devices for protection against excessive pressure. Safety valves.