INSPECTION
OF
PRESSURE RELIEVING DEVICES

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OIL INDUSTRY SAFETY DIRECTORATE
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INSPECTION
OF
PRESSURE RELIEVING DEVICES

Prepared by

FUNCTIONAL COMMITTEE ON
INSPECTION OF PRESSURE RELIEVING DEVICES

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FOREWORD

The Oil Industry in India is 100 years old. Because of various collaboration agreements a variety of international codes, standards and practices have been in vogue. Standardisation in design philosophies and operating and maintenance practices at a national level was hardly in existence. This, coupled with feedback from some serious accidents that occurred in the recent past in India and abroad, emphasized the need for the industry to review the existing state of art in designing, operating and maintaining oil and gas installations.

With this in view, the then Ministry of Petroleum & Natural Gas, in 1986, constituted a Safety Council assisted by Oil Industry Safety Directorate (OISD), staffed from within the industry, in formulating and implementing a series of self regulatory measures aimed at removing obsolescence, standardising and upgrading the existing standards to ensure safer operations. Accordingly, OISD constituted a number of Functional Committees comprising of experts nominated from the industry to draw up standards and guidelines on various subjects.

The present standard on “Inspection of Pressure Relieving Devices” has been prepared by the Functional Committee on “Inspection of Static Equipment”. This document is based on the accumulated knowledge and experience of industry members and the various national and international codes and practices. This document is meant to be used as a supplement and not as a replacement for existing codes and practices. It is hoped that the provisions of this document, when adopted may go a long way to improve the safety and reduce accidents in the Oil and Gas Industry. Users are cautioned that no standard can be a substitute for judgment of a responsible qualified Inspection Engineer. Suggestions are invited from the users, after it is put into practice, to improve the document further. Suggestions for amendments to this document should be addressed to

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This standard in no way superscedes the statutory regulations of CCE, Factory Inspectorate, IBR or any other Govt. body which must be followed as applicable.
First edition --- August 1999

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In addition to the above, several other experts from the industry contributed in the preparation, review and finalisation of this document.
# Functional committee on revision of OISD-STD 132

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INSPECTION OF PRESSURE RELIEVING DEVICES

1.0 INTRODUCTION

Pressure relieving devices are installed on process equipment, storage tanks and piping to release excess pressure resulting from process upsets operational errors and/or exposure to excessive heat radiation during fire.

These devices protect equipment and personnel by automatically opening at predetermined pressures and prevent the destructive consequences of excessive pressures in process systems and storage tanks.

Periodic inspection and repair of these devices is, therefore, essential to prevent their failure due to material defects and malfunctioning.

Latest editions of API-RP-576 on “Inspection of Pressure-Relieving Devices” is a well recognised document widely used in the petroleum industry all over the world and the guidelines mentioned in this publication are also applicable to petroleum installations in India. However, certain provisions of these guidelines are modified to conform to Indian climatic conditions, local practices and statutory requirements, and supplement with the provisions which are not addressed specifically in these guidelines and are in practice through other statutory rules and regulations such as Static & Mobile Pressure Vessels (unfired) Rules (SMPV), 1981.

2.0 SCOPE

This standard outlines the minimum inspection and testing requirements applicable to all pressure relieving devices including those for vacuum service used in the petroleum industry.

The standard does not cover the pressure relieving safety arrangement provided in the process / mechanical design like weak seams or weak sections in storage tanks, explosion doors, Motor operated isolation valves for vents etc.

Inspections and testing of Pressure Relieving devices during manufacturing at manufacturer’s premises are not covered by this publication.

Control valves / ball valves used as a means of relieving system pressure into flare system are also not covered in this standard.

The provisions of this standard are not intended to supersede requirements of applicable statues in force.

3.0 DEFINITION AND TYPES OF PRESSURE RELIEVING DEVICES

3.1 DEFINITIONS

Definitions of terms related to pressure relieving devices are given in Annexure-I. Graphic relationship between these terms is illustrated in Annexure-II & III.
### 3.2 TYPES OF SAFETY PRESSURE RELIEF VALVES

There are basically five types of safety devices used for relieving pressure in a system. These are:

**i) Re-closing type Safety/Pressure relief valves**
- a. Conventional
- b. Balanced Pressure relief valves
- c. Pilot-operated relief valves

**ii) Non Reclosing type Safety/Pressure Relief Valves.**
- a. Rupture disk Device
- b. Pin-actuated device

**iii) Emergency depressurisation Valves.**

**iv) Surge Relief Valves**

**v) Pressure and vacuum relief devices**

Detail of different types of pressure relieving devices is given at Annexure-V of this document.

### 4.0 ROLE OF INSPECTION

The following are the responsibilities of the personnel / division involved with the activities (In-house and/or outsourced) related to inspection of pressure relieving devices:

**i) To prepare and ensure implementation inspection schedule of pressure relieving devices as per the frequencies outlined in Section 7.0 of this document**

**ii) To ensure the testing and certification of new pressure relieving devices prior to their installation as per the requirements laid down in Section 6.0 of this document.**

**iii) To inspect and determine the physical condition of the different parts (sub assemblies) of the device, record abnormalities and recommend repairs involving welding & replacement of damaged components.**

**iv) To study the cause of abnormalities /deterioration of parts and suggest suitable remedial measures.**

**v) To ensure engineering quality during repair / overhauling of pressure relieving devices**

**vi) To witness and certify “after-maintenance testing” of the device and ensure that the device is fitted back at its own place.**

**vii) To maintain Data Sheets and History Sheets of all Pressure Relieving Devices, and keep them updated.**

### 5.0 INSPECTION OF NEW PRESSURE RELIEVING DEVICES

#### 5.1 ORDERING SPECIFICATIONS

The ordering information for the pressure relieving devices shall be sufficient for selection and sizing of the valve. A sample specification sheet for pressure relieving valves is attached as Annexure-VI.

#### 5.2 A detailed Inspection and test Plan (ITP), covering all applicable aspects of inspection and testing of the new pressure relieving devices shall be prepared and approved. All new pressure relieving devices shall be inspected at following three stages.

**i) At the manufacturers shop,**

**ii) On receipt at the users work site and**

**iii) Prior to its installation.**
A sample inspection and test plan covering all the aspects for stage wise inspection of new pressure relieving devices is placed at Annexure-VII for reference.

5.3 STORAGE, PACKING AND SHIPMENT

a. Precautions shall be taken to keep out all foreign materials.
b. The inlet and outlet of the valve shall be fully covered.
c. The valve shall not be subjected to shocks which can result in damage/misalignment during transportation.
d. Threaded openings (if any) shall be plugged with suitable protective devices. It shall be ensured that the temporary plugs are easily identifiable from the permanent metal plugs.
e. Pressure relieving valves shall always be kept in upright position for shipment.

6.0 PRE-COMMISSIONING CHECK LIST OF PRESSURE RELIEVING DEVICES

Before installation and commissioning the following shall be ensured:

i) All new devices have been inspected and tested as detailed in Section-5.0
ii) That the upstream/downstream system has been flushed thoroughly.
iii) Before start-up of the installation the test gag, if any, shall be removed.

6.1 SAFETY RELIEF VALVE

The following shall be checked:

i) Tag number for proper location and service.
ii) Name Plate for capacity & set pressure.
iii) Gaskets, nuts & bolts for correct specifications.
iv) Installation of valve.
v) Relief valve isolation valves are in line and in locked open position.
vi) Connecting pipelines do not strain the valve.
vii) Outlet piping is connected to a safe location away from all likely sources of ignition.

6.2 RUPTURE DISC

The following shall be checked:

i) Disc tag Number for proper location & service.
ii) The name plate for capacity, pressure & temperature.
iii) Isolation valve is in line and locked open.
iv) Use of proper gasket, nuts & bolts.
v) Outlet piping is connected to a safe location.
vi) When used in combination with pressure relief valve, vent for the intervening space, if specified, is provided.

6.3 PRESSURE VACUUM RELIEF VALVES/DEVICES

The following shall be inspected:

i) The tag number for proper location and service.
ii) The Name Plate for Pressure/temperature & capacity.
iii) Use of specified gasket, nuts and bolts.
iv) In the case of breather valves, the checks shall be for:
   Correct weight & free movement of pallets.
v) In the case of hydraulic Safety Valves, check shall be for:
   
a. Right type of sealing liquid.

b. Proper level of the sealing liquid.

vi) In case of vents, check shall be for:

c. Proper size of vent.

d. Proper size of mesh of flame arrestor, if provided.

A sample check list for precommissioning checks of pressure relieving devices is placed at Annexure-XIII of this document.
7.0 FREQUENCY OF INSPECTION AND TESTING

7.1 Safety relief valves

The frequency of inspection depends upon following factors:

i) Statutory requirements
ii) Service fluids.
iii) Service load like pulsating / fluctuating type loads
iv) Difference between set and operating pressures.
v) Operating History

Unless documented experience and/or a RBI assessment indicates that a longer interval, the Testing and Inspection intervals for pressure relieving devices shall be governed as per the following guidelines:

<table>
<thead>
<tr>
<th>Service</th>
<th>Inspection and Testing Intervals</th>
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<td>As per the requirement of Govt Boiler Regulation</td>
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<tr>
<td>LPG / Gas Storage</td>
<td>As per requirement of SMPV Rules</td>
</tr>
<tr>
<td>Hydrocarbon Service(Unit area)</td>
<td>First inspection and testing within two years of commissioning subsequent inspection &amp; testing shall be based on the operating history / every turn around, but in no case later than five years.</td>
</tr>
<tr>
<td>Hydrocarbon Service(Offsite area)</td>
<td>First inspection and testing within three years of commissioning subsequent inspection &amp; testing shall be based on the operating history / every turn around, but in no case later than five years.</td>
</tr>
<tr>
<td>Utility Service</td>
<td>Every turnaround but not more than 10 years</td>
</tr>
</tbody>
</table>
7.2 Pressure and/or vacuum relief valves.

7.2.1 Insitu. Inspection of all types of pressure and vacuum relief valves shall be carried out every six months.

7.2.2 Following should be the frequency for shop inspection of pressure and vacuum relief valves:

- **a) Weight operated valves:**
  - Once in two years for valves installed in fouling services.
  - Once in four years for valves installed in clean services.

- **b) Pilot Operated Valves:**
  - Once in a year for valves installed in fouling services.
  - Once in two years for valves installed in clean services.

7.3 Rupture Disc

7.3.1 Visual Inspection, torque check and cleaning (without removing the disc from the holder) shall be carried out during every turnaround or every five years whichever is earlier.

7.3.2 In the event of loose bolts and/or removal of the disc from the holder, the rupture disc shall be replaced.

7.3.3 Since rupture discs cannot be tested the replacement strategy of these devices shall be based on factors like application, past experience and/or manufacturer’s recommendations. However, regardless of the applications, all rupture discs shall be replaced on or before ten years.

7.4 Vents

7.4.1 Inspection and cleaning of vents including emergency vents shall be carried out once in a year.

7.5 PSV’s installed in (E&P) Installations

**Offshore**

7.5.1 All PSVs installed in offshore (E & P) installations shall be tested for operation at a frequency of at least once in twelve months. These valves shall be either bench tested or equipped to permit testing with an external pressure source.

7.5.2 Inspection (and subsequent testing) of PSV’s installed in offshore (E & P) installations should be carried out at least once in every five years or as per the valve manufacturer’s recommendations whichever is earlier.

**Onshore**

7.5.3 All PSVs installed in onshore (E & P) installations shall be tested inline with the requirements of the Oil Mines Regulations, 1984.

7.5.4 Inspection (and subsequent testing) of PSVs installed in onshore (E & P) installations should be carried out at least once in every five years or as per the valve manufacturer’s recommendations whichever is earlier.

8.0 INSPECTION OF ONLINE PRESSURE RELIEVING DEVICES

8.1 ONSTREAM INSPECTION

8.1.1 Safety Valves/Relief Valves

An on stream visual inspection should be carried out at least once in a year to check the following:

- a) Gags, blinds do not exist.
- b) Upstream and down stream isolation valves, if any, are opened and sealed.
- c) Seals protecting the spring setting have not been broken.
- d) Relief device is not leaking. This may be checked visually and by thermography, contact thermometers or by hand touch or acoustic emission at outlet nozzle wherever practicable.
e) The continuous operation of heat tracing provision, if any, provided for low temperature application on valve and discharge piping.

f) Condition of insulation and cladding on the heat traced piping and valves.

8.1.2 Pressure and Vacuum Relief Valve on Storage Tanks

i) The following inspection checks shall be carried out once in every six months for breather valves on Storage Tanks.

a) Discharge opening should be checked for obstruction.

b) Flame arrestor wherever provided shall be inspected, for fouling, bird nests or clogging. Element shall be inspected for mechanical damage, deposits, scaling etc. and cleaned before onset of monsoon.

c) Oil filled type liquid seal valve shall be inspected for oil level, fouling, bird nests, foreign material etc.

d) Free movement of pallet shall be checked.

8.1.3 Rupture Disc

The integrity of the rupture disc shall be verified with the help of thermography, temperature indicating crayons contact thermometers or by hand touch at a frequency not exceeding one year.

8.2 SAFETY PRECAUTIONS

8.2.1 ISOLATION OF PRESSURE RELIEVING DEVICES

Prior to execution of any repairs on pressure-relieving devices some very important precautions need to be taken to maintain the safety of the equipment protected by such devices, especially if the equipment is in operation. For inspection and repair of such devices when the unit is in operation; it should be ensured that the unit operation is normal and proper work permits should be obtained from concerned authorities prior to execution of the job.

Pressure relieving valves which are provided with isolation facility and wherein the flange rating of the outlet isolation valve flange is less than the set pressure of the relief valve, need to be very carefully isolated. Following should be the sequence of isolation of such valves:

a) Close the inlet isolation valve of the relief valve.

b) Close the outlet isolation valve of the relief valve.

c) Venting of the pressure relief valve body to be done immediately after step (b) as above.

All the above precautions must be exercised when installing a blind in the pressure relief valve outlet. Installation of drain valves between the inlet and outlet block valves and the pressure relief valve can also be considered.

8.2.2 REMOVAL / REINSTALLATION

a) It should be ensured that the connected piping and valves are sufficiently supported before the relief valve is disconnected.

b) At the time of reinstallation of relief valve, thoroughly check the related piping to ensure that it is not imposing loads that would cause problems with the pressure relief valve body such as distortion leading to in-service leakage.

c) For devices which are likely to trap hazardous toxic process material in bonnet cavities or dome cavities; special steps during decontamination should be taken to minimize exposure of shop personnel.

d) Ensure that each relief valve is having an identifying tag, stencil, plate, or other means to show its company equipment number before its dispatch to shop for inspection.

8.2.3 Balanced safety valve(Bellow type)
Balanced type valves are provided with vented bonnets. In the event of bellows failure, process media from the discharge side of the valve will release from the bonnet vent. Based on the nature of the process media (e.g., liquid/vapour, toxicity, and flammability) likely to be discharged, a suitable mechanism for safe disposal of the same should be put in place. For example bonnet vents can be typically routed to a drain, a closed system.

8.3 SHUTDOWN / SHOP INSPECTION

8.3.1 Safety Valves/Relief Valves

Following inspection and tests shall be carried out:

a) Inspection and test of all safety valves in hydrocarbon service shall be done in as received condition.

Note: If the valve is extremely fouled and dirty when received and the “as received” popping of the valve is likely to damage the valve’s seats, the “as received” test may be waived by the user by reducing the inspection interval of such valves. After reducing the valve’s inspection interval, the valve should be clean at the next inspection. If it is not clean, the inspection interval should further be shortened or other measures should be taken to reduce the fouling.

b) Visual inspection of different parts of safety valve shall be done after dismantling to check the following:

   i) Condition of flanges for pitting, roughening, decrease in width of seating surface etc.

   ii) Spring, for evidence of bending, corrosion or cracking, free length of spring.

   iii) Bellows (if applicable) for damage.

   iv) Position of set screws and opening in bonnet.

   v) Inlet/outlet nozzles for evidence of deposits foreign material and corrosion.

   vi) Condition of external surface and evidence of mechanical damage.

   vii) Body wall thickness.

   viii) Conditions of stem, guide disc, nozzles etc. for evidence of wear and corrosion.

   ix) Seating surface of disc and nozzle shall be critically examined for roughness or damage which could result in valve leakage and may need correction. Care must be taken to ensure flatness of seats.

   x) It is recommended that springs be tested for stiffness.

      a) 10th year after installation and subsequently every 5 years.

      b) Immediately where malfunctioning is suspected. If load and compression valves do not match with original valves, the spring should be replaced.

8.3.2 Rupture Disc

During shutdown inspection, the rupture disc shall be examined for:

i) Cracks and fatigue of the disc.

ii) Mechanical distortion, wire drawing and damage in gasket seating face of the disc holding flanges.

8.3.3 Pressure and/or Vacuum Relief Devices (PVRV)

These devices shall be checked for the following damage, depending on the type of the device.

i) Loss in weight/fouling of pallets
ii) Corrosion and surface roughening of pallets.

iii) Quality of sealing liquid.

iv) Internal corrosion of vents & flame arrestor bodies.

9.0 TESTING PROCEDURE FOR PRESSURE RELIEVING DEVICES

Testing of all Pressure Relieving Devices shall be carried out at frequencies indicated in Section 7.0 of this document.

9.1 SAFETY RELIEF VALVE

9.1.1 Set Pressure Test

It shall be ensured that correct calibrated test gauge is used. All safety relief valves shall be tested in accordance with the relevant code to which the protected equipment is designed. After final adjustment the valve shall be popped at set pressure at least once to prove the accuracy of setting. PSV test pressure tolerance shall be $\pm 2$ lbf/sq. inch (0.138 Kg/cm$^2$g) for pressures less than 70 lbf/sq inch (4.83 Kg/cm$^2$g) and $\pm 3\%$ for pressures greater than 70 lbf/sq inch. Allowance for hot setting shall be made as per manufacturer’s recommendations. The set pressure adjustment shall be sealed.

9.1.2 LEAK TEST

Leak test shall be performed in accordance with the relevant code.

9.1.3 LOCKING

After set pressure test and leak test, the valve shall be sealed after tightening the lock nut of gap, as well as hand popping (if provided).

9.2 SAFETY VALVES ON BOILERS

Safety Valves shall be tested as per IBR at the time of the statutory inspection. Initial setting of the safety shall be checked in workshop.

9.3 INSPECTION AND TESTING OF PILOT OPERATED SAFETY RELIEF VALVE

Inspection of pilot operated valves is divided into two separate phases, the pilot mechanism & the main valve. In some types of valves, the pilot can be blocked off from the vessel for inspection and testing while the spring loaded main valve continues to protect the vessel. The diaphragms in both the pilot and the main valve of certain designs shall be inspected and replaced, if necessary with the main valve in service. Manufacturer’s recommendation for inspection, testing and repairs shall be followed.

9.4 INSPECTION & TESTING OF PV VALVES

PV Valves shall be inspected and tested as per relevant code for tightness & positive operation at the welded type high pressure safety valves shall be tested in-situ.

Reseating Pressure and blowdown shall also be checked as per IBR, by adjusting blowdown rings. The blowdown shall be kept within 3-5% of set pressure.

When a safety valve fails to operate at the set popping pressure, attempt should not be made to free it by striking the body or other parts of the valve. The valve shall be popped by means of the lifting lever and allowed to reseat, after which the pressure of the boiler should be raised to the set pressure. If the valve does not still pop, the boiler shall be taken out of operation and safety valve attended.

It is advisable to check lifting lever for free operation when there is at least 75 % of full working pressure on boiler. This ensures that moving parts are free to operate.
set pressure. Testing shall be done as outlined in API 2521.

10.0 DOCUMENTATION

The documents to be maintained shall include:

(i) Data sheets covering the type, make, design, and constructional aspects of the device.
(ii) History card depicting the number and frequency of failures/repairs with probable causes type of failure/repair.
(iii) Test/inspection report revealing the status of the device and its parts, its suitability for continued use and suggestions for present/future repair and maintenance.

Typical Formats of combinations of above three documents are given in Annexure-IX,X & XI.
11.0 REFERENCE

i) API-RP-576 “Inspection of pressure relieving devices”

ii) API-RP-520 Part I & II Design and installation of pressure relieving system in Refineries.

iii) API-RP-521 “Guide for pressure and depressurising system.”

iv) API - 526 “Flanged Steel Safety Relief Valves.”

v) API - 527 “Seat tightness of Safety Relief Valves.”

vi) API 2000 “Venting atmospheric and low pressure storage tanks.”

vii) API 2521 “Use of PV Vent Valves for Atmospheric Pressure Tanks to reduce Evaporation Loss.”

viii) API Guide Chapter XVI Pressure Relieving Devices.


x) ASME Boiler and Pressure Vessel Code Sec. VIII Div. 1 and Div. 2.

xi) The Static and Mobile Pressure Vessels (unfired) Rules 1981.

xii) Indian Boiler Regulation (IBR).


xiv) API-RP-14C “Recommended Practice for Analysis, Design, Installation, and Testing of Basic Surface Safety Systems for Offshore Production Platforms”

xv) 30 CFR MINERAL MANAGEMENT SERVICES USA.

xvi) Oil Mines Regulations 1984
DEFINITIONS OF RELATED TERMS

1. Accumulation

Accumulation is the pressure increase over the maximum allowable working pressure (MAWP) of the vessel allowed during discharge through a pressure relief device, expressed in pressure units or as a percentage of MAWP or design pressure.

2. Back Pressure

Back pressure is the increase in pressure at the outlet of a pressure relief valve as a result of the pressure in the discharge system. This is the sum of superimposed and built-up back pressures.

3. Blow Down

Blow down is the difference between set pressure and closing pressure of a pressure relief valve, expressed as a percentage of set pressure or in pressure units.

4. Built-up Back Pressure

Built-up back pressure is the increase in pressure at the outlet of a pressure relief valve that develops as a result of flow after the pressure relief valve opens.

5. Burst pressure of a rupture disk

The burst pressure of a rupture disk at the specified temperature is the value of the upstream static pressure minus the value of the downstream static pressure just prior to when the disk bursts.

6. Burst Pressure Tolerance

The variation around the marked burst pressure at the specified disk temperature in which a rupture disk shall burst.

7. Car Seal

A closing seal which when placed in position and closed gets locked and the same need to be cut using wire cutters or has to be physically broken for its removal.

8. Closing Pressure

The decreasing inlet static pressure at which the valve disc re-establishes contact with the seat or at which lift becomes zero as determined by seeing, feeling or hearing.

9. Cold differential test Pressure

The cold differential test pressure is the pressure at which a pressure relief valve is adjusted to open at the test stand. A brief write up about CDTP with sample calculations is placed at Annexure-IV of this document.

10. Design Pressure

The design pressure of the vessel along with the design temperature is used to determine the minimum required thickness or physical characteristic of each vessel component as
determined by the vessel design rules. It can be used in place of Maximum allowable working pressure (MAWP) in all cases where MAWP has not been established. The design pressure is equal to or less than the MAWP.

11. **Leak Test Pressure**

The specified inlet static pressure at which a seat leak test is performed.

12. **Lift**

The actual travel of the valve disc away from the closed position when the pressure relief valve is relieving.

13. **Maximum Allowable Working Pressure (MAWP)**

The maximum operating working pressure is the maximum gauge pressure permissible at the top of the completed vessel in its operating position for a designated temperature. The MAWP is based on the calculations for each element in a vessel using normal thickness, exclusive of additional metal thickness allowed for corrosion and loadings other than pressure. Normally the MAWP is the basis for pressure setting of the pressure relief devices that protect the vessel.

14. **Maximum Operating Pressure**

The maximum pressure expected during normal system operation.

15. **Non-closing Pressure Relief Device**

A pressure relief device, which remains open after operation.

16. **Opening Pressure**

The value of increasing inlet static pressure at which there is a measurable lift of the disk or at which discharge of the fluid becomes continuous, as determined by seeing, feeling or hearing.

17. **Over Pressure**

Overpressure is the pressure increase over the set pressure of the relieving device allowed to achieve rated flow. Overpressure is expressed in pressure units or as a percentage of set pressure.

18. **Pressure And/Or Vacuum Relief Valve**

A pressure and/or vacuum relief valve is an automatic pressure or vacuum relieving device actuated by the pressure or vacuum in the protected equipment.

19. **Pressure Relief Valve**

It is a generic term applied to relief valves, safety valves and safety relief valves. A pressure relief valve is designed to automatically open during emergency or abnormal conditions to prevent a rise of internal fluid pressure in excess of specified design value and automatically reclose and prevent the flow of fluid.
20. **Pressure Relieving Device**

A pressure relief device is actuated by inlet static pressure and designed to open during emergency or abnormal conditions to prevent a rise of internal fluid pressure in excess of a specified design value.

21. **Rated Burst Pressure**

The rupture disk burst pressure established by tests for the specified temperature and marked on the disk tag by the manufacturer.

22. **Rated Relieving Capacity**

The relieving capacity used as the basis for the application of a pressure relief device determined in accordance with the applicable code.

23. **Relief Valve**

Relief Valve is a spring loaded pressure relief valve actuated by the static pressure upstream of the valve. The relief valve opens in proportion to the pressure increase over the opening pressure. A relief valve is used primarily with incompressible fluids.

24. **Rupture Disc Device**

A combination of rupture disc holder and rupture disc is known as rupture disc device. It is a non-reclosing device actuated by the static differential pressure between the inlet and outlet of the device and designed to function by the bursting of a rupture disc.

25. **Safety Valve**

Safety valve is a spring loaded pressure relief valve actuated by the static pressure upstream of the valve and characterized by rapid opening or pop action. A safety valve is used primarily with compressible fluids.

26. **Safety Relief Valve**

Safety relief valve is a spring loaded pressure relief valve that is used either as a safety or relief depending on the application.

27. **Set Pressure**

The set pressure is the inlet gauge pressure at which the relief device is set to open under service conditions.

28. **Simmer**

The audible or visible escape of compressible fluid between the seat and disc which may occur at an inlet static pressure below the set pressure prior to opening.

29. **Superimposed Back Pressure**

Superimposed back pressure is the static pressure that exists at the outlet of a pressure relief device at the time the device is required to operate.
### Pressure Vessel Requirements

<table>
<thead>
<tr>
<th>Pressure Vessel Requirements</th>
<th>Vessel Pressure</th>
<th>Typical Characteristics of a Single Safety Relief Valve When Used for Process or Fire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Allowable Accumulated Pressure (Fire Exposure Only)</td>
<td></td>
<td>Alternate Relieving Pressure Under Fire Conditions</td>
</tr>
<tr>
<td>Accumulation</td>
<td></td>
<td>Margin of Safety Due to Selection of Orifice (Varies)</td>
</tr>
<tr>
<td>Max. Allowable Accumulated Pressure (Other Than Fire Exposure)</td>
<td></td>
<td>Relieving Pressure Under Process Conditions</td>
</tr>
<tr>
<td>Max. Allowable Working Pressure</td>
<td></td>
<td>Max. Set Pressure (Tolerance)</td>
</tr>
<tr>
<td>Usual Margin</td>
<td></td>
<td>Set Pressure (AVG Set)</td>
</tr>
<tr>
<td>Usual Max. Normal Operating Pressure</td>
<td></td>
<td>Start to Open Pressure (AVG Set)</td>
</tr>
</tbody>
</table>

Operating pressure may be any lower pressure required Set pressure, and all other values related to it (noted with ↑), may be moved downward if operating pressure permits.

Note: This valve meets the requirement of *ASME Boiler and Pressure Vessel Code*, Sec. VIII, "Unfired Pressure Vessels," PAr. UG-125 (a and c) and Par. UG-133 (a).

Pressure Conditions for Safety Relief Valve Installed on a Pressure Vessel (Vapor Phase), Single Valve Used for Process or Fire.
### Pressure Vessel Requirements

<table>
<thead>
<tr>
<th>MAX. ALLOWABLE ACCUMULATED PRESSURE (FIRE EXPOSURE ONLY)</th>
<th>VESSEL PRESSURE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>120</td>
</tr>
</tbody>
</table>

### Typical Characteristics of a Single Safety Relief Valve When Used for Fire Exposure Only

- **Margin of Safety Due to Selection of Orifice (Varies)**
- **Max. Set Pressure (Tolerance)**
- **Set Pressure (AVG Set)**
- **Min. Set Pressure (Tolerance)**
- **Reset Pressure (AVG Set)**
- **Reset Pressure (MIN Set with Indicated Blowdown)**
- **Seating Loading Available (MIN)**

---

**Operating Pressure** may be any lower pressure required. Set pressure, and all other values related to it (noted with ↑), may be moved downward if operating, pressure permits.

**Note:** This valve meets the requirements of ASME Boiler and Pressure Vessel Code, Sect. VIII, "Unfired Pressure Vessels." Par. UG-125 (d) and Par. UG-133(b).

**Pressure Conditions for Safety Relief Valve Installed on a Pressure Vessel (Vapor Phase), Supplemental Valve Used for Fire Exposure Only.**

---

23
WRITE UP ON COLD DIFFERENTIAL TEST PRESSURE (CDTP)

Definition: The cold differential test pressure is the pressure at which a pressure relief valve is adjusted to open at the test stand.

The actual service conditions, under which a pressure relief valve is required to open, may be different from the conditions at which the pressure relief valve is set to operate on a test bench. To compensate for this effect, a CDTP is specified for adjusting the set pressure of the valve for its testing on the bench. The CDTP may include a correction for actual service conditions of back pressure and/or temperature.

A temperature correction factor (multiplier) is typically required when the relieving temperature exceeds 250°F. The factor compensates for variations in spring load due to thermal growth in valve components as well as changes in the spring material properties. Compensation may also be required or low temperature service below –75°F. When such temperature compensation is required, the correction factor should be obtained from the pressure relief valve manufacturer.

A conventional pressure relief valve, operating with a constant superimposed back pressure, normally requires a correction factor to compensate for the back pressure. In this case the required set pressure minus the superimposed back pressure is equal to the CDTP. This change accounts for the additional closing force exerted on the valve disk by the back pressure. In the case of a balanced spring loaded pressure relief valve, the change in closing force due to the superimposed back pressure is negligible and no correction is required.

When the CDTP is to include correction for back pressure and temperature, the differential pressure is calculated and then multiplied by the temperature correction to determine the CDTP.

Pilot-operated pressure relief valves may require a CDTP when used in high temperature or back pressure service. The valve manufacturer should be consulted regarding back pressure and temperature limits, and required correction factors.

Effect of back pressure on relief valves

Back-pressure can affect either the set pressure or the capacity of a relief valve. The set pressure is the pressure at which the relief valve begins to open. Capacity is the maximum flow rate that the relief valve will relieve. The set pressure for a conventional relief valve increases directly with back-pressure. Conventional valves can be compensated for constant back-pressure by lowering the set pressure. For self-imposed back-pressure—back-pressure due to the valve itself relieving—there is no way to compensate. In production facility design, the back-pressure is usually not constant. It is due to the relief valve or other relief valves relieving into the header. Conventional relief valves should be limited to 10% back-pressure due to the effect of back-pressure on the set point.

The set points for pilot-operated and balanced-bellows relief valves are unaffected by back-pressure, so they are able to tolerate higher backpressure than conventional
valves. For pilot-operated and balanced-bellows relief valves, the capacity is reduced as the back-pressure goes above a certain limit.

All relief valves are affected by reaching critical flow, which corresponds to a back-pressure of about 50% of the set pressure. Pilot-operated relief valves can handle up to 50% back-pressure without any significant effect on valve capacity. Back-pressure correction factors can be obtained from the relief valve manufacturers for back-pressures above 50%, API RP 520 gives a generic method for sizing a pilot-operated relief valve for sub-critical flow.

The relief piping design pressure is an additional limit to back-pressure. Relief piping is usually designed as ANSI 150 piping with a MAWP of 285 psig. Relief valves with ANSI 600 inlets usually have outlet flanges rated ANSI 150. A pilot-operated relief valve set at 1,480 psig could have a back-pressure of 740 psig without affecting the valve’s capacity, but that would overpressure the relief piping so the allowable back-pressure is limited to 285 psig. For this reason, ANSI 900 and above relief valves often have ANSI 300 outlet flanges to allow for higher back-pressure in the relief piping.
ANNEXURE V

TYPES OF PRESSURE RELIEVING / SAFETY DEVICES

1. RECLOSING TYPE SAFETY/PRESSURE RELIEF VALVES

1.1. Conventional

Conventional pressure relief valve is a spring loaded pressure relief valve whose operational characteristics are directly affected by changes in the back pressure. These safety/relief /thermal safety (TSV) valves are susceptible to both superimposed and built-up back pressure and are not recommended when the total back pressure exceeds 10% of the set pressure.

These types of valves are shown in figure 1 and 3. In figure 3a, the bonnet is open vented to atmosphere and the effect of back pressure is to reduce the set pressure. In figure 3b, the bonnet is vented to valve outlet and the effect of back pressure is to increase the set pressure.

1.2. Balanced Pressure relief valves

Balanced pressure relief valve is a spring loaded pressure relief valve that incorporates bellows or other means for minimizing the effect of back pressure on the operational characteristics of the valve. Balanced Bellow valves are not susceptible to back pressure and can be used for back pressure up to 50% of set pressure.

These valves are of two types:

a. Piston type
b. Bellow type

a. Piston Type

A typical piston type balanced valve is shown in figure 4a. In this valve, the guide is vented so that the back pressure on opposing faces of the discs cancels itself. The top face of the piston which has the same area as the nozzle seat area is subjected to atmospheric pressure by venting the bonnet. The bonnet vented gases from balanced piston type valve should be disposed of safely.

b. Bellow type

Typical bellow type valves are shown in figure 2 and 4b. In the bellow type of balanced valve, the effective bellow area is the same as the nozzle seat area and by attachment to the valve body excludes the back pressure from acting on the top side of the area of the disc to provide for a possible bellow failure or leak. The bonnet must be vented separately from the discharge to a safe location.

1.3. Pilot-operated relief valves

A pilot operated pressure relief valve is a pressure relief valve in which the major relieving device or main valve is combined with and controlled by a self actuated
auxiliary pressure relief valve (pilot). In pilot-operated safety valves, the main safety valve opens through a pilot valve.

These relief valves essentially employ a self-actuated auxiliary (pilot) pressure relief valve to control main pressure relieving device (main valve) which results in keeping system operating pressure within 5% of set pressure without the danger of increased seat leakage in the main valve. Pilots are generally designed with a separate control for set pressure and blow-down. Valves can be set to open fully at the set pressure and close with very short blow down. Modulating designs are available to take care of minor overpressure conditions without fully opening main valve to limit fluid loss and shock. Pilot operated valves result in lower valve sizes and reduced costs.

Pilot operated valves are provided with filters to protect against foreign matter and are used for relatively clean service (non-plugging, non-freezing). A typical pilot operated valve is shown at Figure-5.

2. NON-RECLOSING PRESSURE RELIEF DEVICES:

2.1. Rupture disk Device:

Rupture disk is a non-reclosing pressure relief device actuated by static differential pressure between inlet and outlet of the device and designed to function by bursting of the disc. Ruptures Discs are thin metal diaphragms held between flanges and are designed to burst at the set pressure. Once burst, these are not reusable and have to be replaced. Their set pressure cannot be tested without destroying them. After the test, the rupture disc has to be replaced but there is no guarantee that the second rupture disc will burst at the same pressure. This is a major disadvantage of rupture disc, especially when the bursting pressure is low. For these reasons, rupture discs alone shall not be used. However, they shall be used between the vessel and a relief/safety valve for fluid of highly corrosive, congealing or fouling nature and also vacuum systems. Prolonged exposure of safety valve directly to such conditions can cause damage to valve components. Another area where rupture discs shall be installed at the safety valve on top of column/vessels operating under vacuum where leakage across safety valve can lead to pressurization of column/vessel. Suitable mechanism shall be provided to monitor the pressure across rupture disk to identify its bursting.

2.2. Pin-actuated Device:

A non-reclosing pressure relief device actuated by static pressure and designed to function by buckling or breaking of the pin, which holds a piston or a plug in place. Upon buckling or breaking of the pin, the piston or plug instantly moves to full open position.

3. EMERGENCY DEPRESSURISATION VALVES

When metal temperature is increased above the specific design temperature due to fire or exothermic or runaway reactions, the metal temperature can reach a level at which stress rupture can occur. This is possible even though the system pressure does not exceed the maximum allowable accumulation. Emergency depressurisation
valves are provided in high pressure systems to quickly depressurise the system during operational emergencies. These valves do not have specific set point and are part of shut down logic. These valves can also be operated from control room/ local operating panel manually. (Examples: Dump Valves in Hydro cracker, DHDS etc).

4. **SURGE RELIEF VALVES:**

The liquid pipelines can be subjected to surge pressures, when there is a sudden change in the velocity of the moving fluid. This surge pressure can create a major disaster if the rate of change is too rapid.

Some of the eventualities which shall lead to creation of surge pressure in a liquid pipeline are:

- rapid closure of a manual or motor/ hydraulic/ pneumatic actuated valve
- closure of an emergency shut down valve
- stopping of a pump
- Combination of above

In order to protect the pipeline against surge pressure, a surge relief valve shall be provided. The surge relief valve is a relief valve which responds quickly at the time of pressure surge.

5. **Pressure and/or Vacuum Relief Devices**

a) **Breather Valve**

Pressure and/or Vacuum Relief Valves are automatic pressure or vacuum relieving devices actuated by the pressure or vacuum in the storage tank. These valves are usually weight loaded on both the sides, pressure as well as vacuum side, the pallets being calibrated to open at very low pressures. Although pressure and vacuum valves are available as separate units, they are usually built as combination units as an integral body and frequently referred to as breather valves.

b) **PRESSURE AND/OR VACUUM VENT VALVE**

A pressure and/or vacuum vent valve (also known as a pressure and/or vacuum relief valve) is an automatic pressure or vacuum-relieving device actuated by the pressure or vacuum in the protected equipment. A pressure and/or vacuum vent valve falls into one of three basic categories:

a. Weight-loaded pallet vent valve.
b. Pilot-operated vent valve.
c. Spring and weight-loaded vent valve.

A brief write up about pressure and/or vacuum relief valves is placed at **Annexure-XIV** of this document.

c) **Hydraulic Safety Valve/Liquid Seal Valves**

In liquid seal valve, a liquid provides the closure against flow through the vent until over pressure or over vacuum occurs.

d) **Emergency Vents**

Emergency vents / relief manways are mounted on storage tanks to release excessive pressure in case of a fire in the storage tank vicinity area. A brief write up about these vents is placed at **Annexure-XV** of this document.
## Sample pressure relief valve specification Sheet

**Job No. ___________________________ Date ___________________________**

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<td>Flange Rating</td>
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<td>Flange Faces</td>
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<td>15</td>
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<tr>
<td>18</td>
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<td>Lever /Test Gag</td>
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<th><strong>OPTIONS</strong></th>
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<td>Back Flow Preventer</td>
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<tr>
<td>23</td>
<td></td>
<td>Remote Pressure Pickup</td>
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<tr>
<td>24</td>
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| **BASIS** | 25 | Code |
|           |    | Fire |
|           | 26 | Rupture Disc |

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<th><strong>INPUT DATA</strong></th>
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**COMMENTS**
# SAMPLE INSPECTION AND TEST PLAN FOR NEW PRESSURE RELIEVING DEVICES

## A INSPECTION AT MANUFACTURER'S SHOP

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<tr>
<th>SL. No.</th>
<th>ACTIVITY DESCRIPTION</th>
<th>CODE OF CONFORMITY</th>
<th>PERFORMER</th>
<th>CHECKER</th>
<th>REVIEWER APPROVER</th>
<th>SAMPLE PLAN</th>
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<tbody>
<tr>
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<td>Compliance with the specifications and codes-as enumerated in the purchase order.</td>
<td>Specification, Purchase Order &amp; Vendor's As Built Docs./Manuals.</td>
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<td>ME</td>
<td>OE/ TPI</td>
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<td>OE/ TPI</td>
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<td>Inspection of Castings/weld joints, if any.</td>
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<td>ME</td>
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<td>6</td>
<td>Bench test for Set Pressure, blowdown and Leak Test.</td>
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<td>100% R*</td>
</tr>
<tr>
<td>7</td>
<td>Burst pressure test in the case of rupture disc.</td>
<td></td>
<td>ME</td>
<td>OE/ TPI</td>
<td>OE/ TPI</td>
<td>100% R*</td>
</tr>
<tr>
<td>8</td>
<td>Performance test in case of PV valves.</td>
<td></td>
<td>ME</td>
<td>OE/ TPI</td>
<td>OE/ TPI</td>
<td>100% R*</td>
</tr>
<tr>
<td>9</td>
<td>Quality of sealing liquid and performance test in the case of liquid seal type PV valves.</td>
<td></td>
<td>ME</td>
<td>OE/ TPI</td>
<td>OE/ TPI</td>
<td>100% R*</td>
</tr>
<tr>
<td>10</td>
<td>Stamping of device after inspection.</td>
<td></td>
<td>ME</td>
<td>OE/ TPI</td>
<td>OE/ TPI</td>
<td>100% S</td>
</tr>
<tr>
<td>11</td>
<td>Final inspection/ packaging</td>
<td></td>
<td>ME</td>
<td>OE/ TPI</td>
<td>OE/ TPI</td>
<td>100% S</td>
</tr>
</tbody>
</table>

## B INSPECTION ON RECEIPT AT SITE

<table>
<thead>
<tr>
<th>SL. No.</th>
<th>ACTIVITY DESCRIPTION</th>
<th>PERFORMER</th>
<th>CHECKER</th>
<th>REVIEWER APPROVER</th>
<th>SAMPLE PLAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Inspection of valve condition, damages, if any.</td>
<td>OE</td>
<td>-</td>
<td>OE</td>
<td>100% S</td>
</tr>
<tr>
<td>2</td>
<td>Checking of name plate, valve certificate and inspection release note.</td>
<td>OE</td>
<td>-</td>
<td>OE</td>
<td>100% S</td>
</tr>
</tbody>
</table>

## C INSPECTION PRIOR TO INSTALLATION

<table>
<thead>
<tr>
<th>SL. No.</th>
<th>ACTIVITY DESCRIPTION</th>
<th>PERFORMER</th>
<th>CHECKER</th>
<th>REVIEWER APPROVER</th>
<th>SAMPLE PLAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bench test for Set Pressure &amp; seat leakage.</td>
<td>OE</td>
<td>-</td>
<td>OE</td>
<td>100% W</td>
</tr>
<tr>
<td>2</td>
<td>Blowdown ring adjustment if required.</td>
<td>OE</td>
<td>-</td>
<td>OE</td>
<td>100% W</td>
</tr>
<tr>
<td>3</td>
<td>Car sealing of the valve</td>
<td>OE</td>
<td>-</td>
<td>PE</td>
<td>100% W</td>
</tr>
</tbody>
</table>

Legends:
- **ME** - Manufacturer's quality control Engr., **OE** - Owner's representative/ Engr., **TPI** - Third party inspector,
- **PE** - Plant Engr., **W** - Witness Point, **RW** - Review of Manufacturer/Contractor's Documentation, **S** - Surveillance Inspection by Owner/TPI, **R** – Random witness inspection.

* 10% of each size, type and class rating subject to minimum one number of each size, type and class rating.
ANNEXURE VIII

Leak Test for Seat tightness of Safety Relief Valves

A. Test Apparatus

A typical test arrangement for determining seat tightness for safety relief valves is shown in figure (6) leakage measurement shall be made with the use of 0.8 mm OD tubing. The tube end shall be cut square and smooth. It shall be parallel to and 13 mm below the surface of water.

B. Procedure

With the valve mounted vertically the leakage rate in bubbles/mnt shall be determined with pressure at the 90% of the CDTP. The test pressure shall be applied for a minimum of 1 minute for valves of inlet sizes through 50 mm, 2 mins, for sizes 63 mm, 75 mm and 100mm, 5mins for 150mm and 200mm. Air at approximate ambient temperature shall be used as the pressure medium.

C. Tightness Standard

The leakage rate in bubbles per minute shall not exceed the value indicated in figure in the graphs (figure 7).
ANNEXURE- IX

TECHNICAL DATA, TEST & HISTORY CARD OF SAFETY RELIEF VALVES.

A. Technical Data:

<table>
<thead>
<tr>
<th>Information</th>
<th>Conditions</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location:</td>
<td>Service:</td>
<td>Inlet:</td>
</tr>
<tr>
<td>Tag No.</td>
<td>Relief Pressure:</td>
<td>Outlet:</td>
</tr>
<tr>
<td>Make:</td>
<td>Cold set Pressure:</td>
<td>Orifice:</td>
</tr>
<tr>
<td>Model/Type:</td>
<td>Back Pressure:</td>
<td>Spring:</td>
</tr>
<tr>
<td>Catalogue Ref.</td>
<td>Operating Pressure:</td>
<td>Materials:</td>
</tr>
<tr>
<td>Drawing No.</td>
<td>Operating Temp.</td>
<td>Body:</td>
</tr>
<tr>
<td>Order No.</td>
<td>Changes in operating:</td>
<td>Disc:</td>
</tr>
<tr>
<td>Relief Capacity:</td>
<td>Conditions:</td>
<td>Nozzle:</td>
</tr>
<tr>
<td></td>
<td>(if any, with date)</td>
<td>Spring:</td>
</tr>
</tbody>
</table>

B. Test Report & History:-

<table>
<thead>
<tr>
<th>Sl. no.</th>
<th>Date of REMOVAL</th>
<th>Date of R E M O V A L</th>
<th>Reason of removal</th>
<th>Set pressure before dismantling</th>
<th>Date of test</th>
<th>Cold Set Pr. After Repair</th>
<th>R E S E T P R.</th>
<th>Leakag e rate</th>
<th>Details of Repair &amp; Replacement</th>
<th>Recom mendations/Remarks</th>
<th>Date of installation</th>
<th>S I G N A T U R E</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
ANNEXURE- X

Card No.____________

TECHNICAL DATA, TEST & HISTORY CARD OF RUPTURE DISC

A. Technical Data:-

<table>
<thead>
<tr>
<th>Information:</th>
<th>Conditions</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location: __________</td>
<td>Service: __________</td>
<td>Size: __________</td>
</tr>
<tr>
<td>Tag. No. __________</td>
<td>Bursting Pressure: __________</td>
<td></td>
</tr>
<tr>
<td>Make __________</td>
<td>Design Temp. __________</td>
<td>Materials:</td>
</tr>
<tr>
<td>Lot No. __________</td>
<td>Operating Pressure __________</td>
<td>Disc: __________</td>
</tr>
<tr>
<td>Catalogue Ref. __________</td>
<td>Operating Temp. __________</td>
<td></td>
</tr>
<tr>
<td>Drawing No. __________</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Order No. __________</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relief Capacity __________</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

B. Test Report & History:-

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Date of Removal</th>
<th>Reason for Removal</th>
<th>Inspection Observations</th>
<th>Recommendations for Reuse/Replacement</th>
<th>Date of installation</th>
<th>Signature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
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</table>
### A. Technical Data:-

<table>
<thead>
<tr>
<th>Information</th>
<th>Conditions</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locations:</td>
<td>Service:</td>
<td>Inlet</td>
</tr>
<tr>
<td>Tag. No.</td>
<td>Set Working range over</td>
<td>Outlet</td>
</tr>
<tr>
<td></td>
<td>Pressure Vacum</td>
<td></td>
</tr>
<tr>
<td>Make:</td>
<td>Pallets weight</td>
<td></td>
</tr>
<tr>
<td>Model/Type:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catalogue Ref:</td>
<td></td>
<td>Materials</td>
</tr>
<tr>
<td>Drawing No.</td>
<td>System Operating</td>
<td>Body:</td>
</tr>
<tr>
<td></td>
<td>Pressure:</td>
<td>Seat:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pallets</td>
</tr>
<tr>
<td>Order No.</td>
<td></td>
<td>Sealing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Liquid</td>
</tr>
<tr>
<td>Relief capacity:</td>
<td>Operating Temp:</td>
<td></td>
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</table>

### B. Test Report and History:-

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Date of removal</th>
<th>Reason for removal</th>
<th>Leakage rate before dismantling</th>
<th>Date of Test</th>
<th>Leakage rate after Testing</th>
<th>Details of Repair &amp; Replacement</th>
<th>Recommendations/Remarks</th>
<th>Date of installation</th>
<th>Signature</th>
</tr>
</thead>
</table>


CAUSES OF MALFUNCTION OF PRESSURE RELIEF VALVES

A) Corrosion

Nearly all types of corrosion i.e. acid, chloride and sulphide corrosion are present in refinery, gas processing and petrochemical plants which is a basic cause of many difficulties encountered in proper functioning of pressure relief valves.

Corrosion often appears as pitted, broken valve parts or deposits of corrosive residue that interfere with the operation of the moving parts or causes deterioration of the material of the relief valve. The corrosion can be slowed down or stopped by taking one or more of the following measures:-

i) Selection of more suitable device or device material.
ii) Proper maintenance of device, since leaking valve allows fluid to pass in the upper parts of the valve which contribute to the corrosion of its moveable parts.
iii) Providing protective coating in some services.
iv) Installation of a rupture disc on inlet or outlet of a device to protect the valve internals.
v) Different construction in some services to avoid, reduce or eliminate the effects of corrosion.
vi) Use of an o-ring seat in a pressure relief valve may stop leakage past the seating surface and eliminate corrosion in the valve’s working parts. However, o-ring elastomers may have a limited life under stress due to degradation caused by temperature, aging or swelling. A bellows seal can be used to protect the spring bonnet cavity and the discharge side of the valve from the corrosive lading fluid.

B) Damaged Seating Surfaces

Differential loading must be small to prevent leakage of the fluid from pressure relief valve. This can be achieved by maintaining an optical precision on the order of 3 beads/bands (0.0000348 inch or 0.0008838 mm) in the flatness of seating surfaces on metal seated pressure relief valves. Any imperfection in these seating surfaces will contribute to improper valve action in service. The cause of damaged valve seats are:-

i) Corrosion.
ii) Foreign particles that get into the valve inlet and pass through the valve when it opens. The particles may damage the seat contact required for tightness in most pressure relief valves. The damage can occur either in the shop during maintenance of the valve or while the valve is in service.
iii) Improper or lengthy piping to the valve inlet or obstruction in the line. These can cause a valve to chatter. The pressure under seat may become great to open the valve, however, as soon as the flow is established, the built-up pressure drop in the connecting piping may be so great that the valve pressure under the seat falls and allows the valve to close. A cycle of opening and closing may develop, become rapid and subject the valve seating surfaces to severe hammering, which damage the seating surfaces sometimes beyond repair.
iv) Careless handling during maintenance such as bumping, dropping, jarring, or scratching of the valve parts.
v) Leakage past the seating surfaces of a valve after it’s installation. The leakage contributes to seat damage by causing erosion or corrosion of the seating surface and thus aggravating itself. It may be due to improper maintenance of installation such as misalignment of the parts, piping strains resulting from improper support or absence of support to discharge piping. Other causes of leakage include improper alignment of the spindle, improper fitting of the springs to the spring washers and improper bearing between the spring washers and their respective bearing contacts or between the spindle and disc or disc holder. Spindle should be checked for straightness. Springs and spring washers should be kept together as a spring assembly during the life of the
spring. Seat leakage may also result from the operating pressure being too close to the set pressure of the valve.

vi) Improper blow down settings. These can cause chattering in the pressure relief valves. The manufacturer should be contacted for specific blow down ring settings for liquid and vapour service.

vii) Over sizing of the pressure relief valve for the relief loads encountered can cause the valve to close abruptly, resulting in disc and nozzle seating surface damage.

C) Spring Failure

- Spring failures occur in two forms. The first is a weakening of the spring, which causes a reduction in set pressure and the possibility of premature opening. The second is a total failure of the spring, which causes uncontrolled valve opening.

- Springs may weaken due to the use of improper materials in high temperature service and corrosion. Surface corrosion and stress corrosion cracking are the most prevalent of this type of failures.

- Surface corrosion attacks the spring surface until the cross sectional area is not sufficient to provide the necessary closing force. It also produce pits that act as stress risers and cause cracks in the spring surface and subsequent spring failure.

- Stress corrosion cracking sometimes causes rapid spring failure. It is insidious because it is very difficult to detect before the spring breaks. Hydrogen sulfide frequently causes stress corrosion cracking of springs.

- Select an appropriate spring in susceptible applications since the material strength, hardness and heat treatment of the spring can affect it’s resistance to stress corrosion cracking.

Where corrosion prevails, the following measures may be taken to prevent corrosion.

i) The spring material may be used that will satisfactorily resist the action of the corrosive agent.

ii) The spring may be isolated from the process by a bellows.

iii) The spring may be coated with a corrosion resistant coating that can withstand the operating temperature and environment.

D) Improper Setting & Adjustment

- Operating Manuals provided by the valve manufacturers help eliminate improper setting and adjustment by indicating how to adjust their valves for temperature, back pressure, and other factors.

- Setting a pressure relief valve which it is in place on the equipment to be protected may be impractical and should be performed only after special consideration. Generally, direct spring-loaded valves should be set in the valve maintenance shop while on appropriate test equipment. During inspection and repair, a properly designed test block facilitates the setting and adjusting of the pressure relief valve.

- Water, air, or an inert gas such as bottled nitrogen may be used as the testing medium. It is better to set a pressure relief valve on air, or some other gas, rather than on water since, a gaseous effluent will produce either a definite pop or a clearly defined audible opening at the set pressure.

- To ensure that the valve is opening, some overpressure should be carefully applied because an audible leak could otherwise be misinterpreted as the result of reaching the set pressure. However, most pressure relief valves produce a distinct pop at the set pressure, making misinterpretation unlikely.

- The size of the test stand is important since insufficient surge volume might not cause a distinct pop, and may cause an incorrect set pressure.

- Vapor service valves should be set using air or inert gas. Steam service valves should be set using steam, but air may be sued if suitable corrections are applied. Liquid service valves should be set using water.
• Consult the manufacturers for the proper technique for setting pilot-operated pressure relief valves on liquid as the water in the dome area and pilot assembly may create problems when placed in service.
• Incorrect calibration of pressure gauges is another frequent cause of improper valve setting. To ensure accuracy, gauges should be calibrated frequently on a regularly calibrated dead weight tester.
• The pressure range of the gauge should be chosen so that the required set pressure of the pressure relief valve falls within the middle third of the gauge pressure range. Snubbers on pressure gauges are not generally recommended since they tend to clog and produce pressure lag.
• Adjustment of the ring or rings controlling the valve is frequently misunderstood. The valve adjusting ring or rings will control either the valve blow down – the difference between the set pressure and the reseating pressure – or valve blow down and simmer, depending on the design of the valve being tested.
• Because the density and expansion characteristics of material handled through pressure relief valves are variable and the volume of testing facilities is limited, it is usually impractical to adjust the valve rings on a maintenance shop test block.
• The rings should therefore be adjusted to obtain a pop on the valve test drum and then inspected and readjusted for proper blow down according to the manufacturer’s recommendations.
• This should permit the best average performance characteristics of the valve when installed.
• For liquid for vapor service, the relief valve manufacturers should be contacted regarding the proper blow down ring settings. Full understanding of terminology is important.

E) Plugging & Sticking

• Process solids such as coke or solidified products can sometimes plug various parts of the valve and connected piping. Additionally, monomer service can lead to polymer formation and plugging. All valve parts, particularly guiding surfaces should be checked thoroughly for any type of fouling. Lubricate all load bearing surfaces such as spindle to disk holder, spring buttons to spindle, disk-to-disk holder and threads with a lubricant that is comparable with the process materials and service temperatures.

• Valve malfunction may also be due to sticking of the disk or disk holder in the guide which may be caused by corrosion or galling of the metal or by foreign particles in the guiding surfaces.
• Foreign particles in the guiding surfaces tend to roll metal up, causing severe galling. The use of a bellows can keep the foreign particles away from the guiding surfaces. Sticking of valves can also result from machining of valve parts outside the manufacturer’s tolerance limits.
• A disk can get frozen in the guide as a result of corrosion in sour gas service.
• If corrosion is the cause of the sticking, three possible cures are available. First, the use of a bellows can protect moving parts from the corrosive substance, especially in closed systems. Second, an o-ring seat can seal the guiding surfaces from the lading fluid until a relief cycle occurs. Third, the use of a rupture disk on the valve inlet will isolate the valve internals from the upstream process material.
• When galling of the metal in the guiding surfaces is not due to corrosion or foreign particles, it is often due to valve chatter or flutter caused by improper piping at the valve inlet or outlet or by severe over sizing of the valve.
• Correction of improper piping at the valve inlet or outlet will usually stop galling. Improper finishing of the guiding surfaces can also cause galling caused by chatter or flutter. To reduce the chances of galling, they should be polished until they are as smooth as possible. Varying the materials and hardness of the contacting parts until the best combinations are found may minimize galling. Consult valve manufacturers for recommendations.
• Sticking of pressure relief valves may also be caused by poor alignment of the valve disk, which is usually due to debris on the contact surface between the guide and the body of the valve, or misalignment of a gasket at assembly.
F) Misapplication of Materials

- In general, the temperature, pressure, corrosion resistance requirements and the atmospheric conditions of the service determine the materials required for a pressure relieving device in given service. The selection of standard valves that meet those requirements and are appropriate for those conditions is advisable. Occasionally, however, severe corrosion or unusual pressure or temperature conditions in the process require special consideration. Manufacturers can usually supply valve design materials that suit special services. Catalogues show a wide choice of special materials and accessory options for various chemical and temperature conditions. Addition of a rupture disk device at the inlet or outlet may help prevent corrosion. The hydrogen sulphide attack on the carbon steel spring and the chloride attack on the 18Cr-8Ni steel disk exemplify the results of the misapplication of materials. Where service experience indicates that a selected valve type or material is not suitable for a given service condition, an immediate correction that will ensure dependable operations should be made. Great care should be taken to record and identify the special materials and the locations requiring them. An adequate system of records should provide the information needed for the repair or reconditioning of valves in special service and for developing optimum purchase specifications.

G) Improper Location, History or Identification

- If not installed at the exact location for which it was intended, a pressure relief valve might not provide the proper protection. To assist in the identification of valve and provide information necessary for correct repairs installation, a comprehensive set of specifications and history card should be maintained and referred to when valves are removed for inspection and repairs. Pressure relief valves may be provided with identifying serial number or shop number placed on the valve by manufacturer or an identifying number tagged, stamped or otherwise placed on the valve by the user. Sometimes user may stamp mating pipe flanges with device number.

H) Rough Handling

- Valves are checked for tightness in the manufacturer's plant before they are shipped to the user. Valve tightness is sometimes checked by the user in the maintenance shop before initial use and usually checked after subsequent cleaning, repair, or testing. This subsequent rough handling of the valve can change the set pressure, damage lifting levers, damage tubing and tubing fittings, damage pilot assemblies or cause internal or external leakage when the valve is in service. Rough handling can occur during shipment, maintenance or installation.

- Because of their operation, pressure relief valve have a sturdy appearance which obscure a fact that they are delicate instruments with very close tolerances and sensitive dimensions. Hence, commercial carriers sometimes subject them to rough handling during shipment, which cause a valve to leak excessively in service or during testing. This mishandling may expose the valve inlet to dirt or foreign particles that could damage the valve seating surface the first time the valve opens and cause leakage thereafter. These valves should be shipped in an upright position, especially large valves and valves with low set pressures because if they are allowed to lie on their sides, the spring may not exert the same force all around the seating surfaces.

- Pressure relief valves are usually precision items manufactured to exactly close tolerances. Rough handling during maintenance, can degrade these tolerances and also destroy the basic valve alignment on which the fine, exacting performance of the device depend. Both before and after repairs, rough handling of the completely assembled valve should be avoided. Before the valve leaves the shop, valve inlet and outlets should be covered. Rough handling during maintenance includes application of excessive back pressure, which should not be applied to a bellow type valve during maintenance related tests.

- Pressure relief valves should be transported in an upright position. Rough handling of a pressure valve by personnel during installation may cause poor valve performance in service. Bumping or dropping the valve should be carefully avoided.
I) Improper Differential between Operating & Set Pressure

- The differential between operating and set pressure provides seat loading to keep the pressure relief valve tightly closed. Due to variety of service conditions and valve designs, only general guidelines can be given for designing a system. However, individual applications and experience must ultimately be relied on. Although greater differential between operating and set pressures promote trouble free operation, they may also increase the cost of equipment. Inspections should record operating experience and provide feedback to be considered in future design and remedial action.

J) Improper Discharge Piping Test Procedures

- Blinds must be installed when hydrostatic tests of discharge piping are performed. Otherwise, it will result in the following:
  a) The disc, spring, and body area on the discharge side of the valve are fouled.
  b) The bellows of a balanced relief valve are damaged by excessive back pressure.
  c) The dome area and/or pilot assembly of a pilot operated pressure relief valve are fouled and damaged by the backflow of fluid.
ANNEXURE(XIII)

COMPONENTS OF SAFETY RELIEF DEVICES SUCEPTIBLE TO DETERIORATION

Different components of the various pressure relieving devices are likely to deteriorate due to any one or more of the following reasons.

**Relief Valves / Pressure Relief Valves**

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>LIKELY NATURE OF DETERIORATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Inlet and outlet nozzles</td>
<td>Fouling/plugging due to deposits, foreign material and corrosion products</td>
</tr>
<tr>
<td>b) Flanges of inlet and outlet nozzles</td>
<td>Pitting and roughening due to corrosion, mechanical damage.</td>
</tr>
<tr>
<td>c) Disc and nozzle</td>
<td>Roughness, uneven surface fouling and corrosion, chattering mark.</td>
</tr>
<tr>
<td>d) Stem</td>
<td>Roughening, wear, corrosion.</td>
</tr>
<tr>
<td>e) Guide</td>
<td>Roughening, wear, corrosion.</td>
</tr>
<tr>
<td>f) Spring</td>
<td>Bending, corrosion, cracking, loss of stiffness / tension.</td>
</tr>
<tr>
<td>g) Bellow</td>
<td>Corrosion and cracking</td>
</tr>
<tr>
<td>h) Body and Bonnet</td>
<td>Metal loss, corrosion and mechanical damage</td>
</tr>
</tbody>
</table>

**RUPTURE DISCS**

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>LIKELY NATURE OF DETERIORATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Disc</td>
<td>Cracks, Fatigue</td>
</tr>
<tr>
<td>b) Disc holding flanges</td>
<td>Mechanical distortion, wire drawing, damage in gasket seating face.</td>
</tr>
</tbody>
</table>

**BREATHER VALVES**

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>LIKELY NATURE OF DETERIORATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Body</td>
<td>Mechanical damage, external corrosion</td>
</tr>
<tr>
<td>b) Inlet and discharge opening.</td>
<td>Fouling, obstruction in the opening.</td>
</tr>
<tr>
<td>c) Oil</td>
<td>Contamination of Oil or fall in level.</td>
</tr>
<tr>
<td>d) Pallets</td>
<td>Fouling, obstruction to movement, loss in weight, corrosion/surface roughening.</td>
</tr>
<tr>
<td>e) Flame arrestor Body</td>
<td>Mechanical damage, external corrosion.</td>
</tr>
</tbody>
</table>
f) Flame arrestor inlet and discharge opening
   Fouling, obstruction in the openings.

g) Flame arrestor internal corrugated sheets/mesh
deposit/fouling/blockage, corrosion and erosion.

**VENTS**

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>LIKELY NATURE OF DETERIORATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Body</td>
<td>Blockage, internal and external corrosion.</td>
</tr>
<tr>
<td>b) Flame Arrestor Body</td>
<td>Mechanical damage, external corrosion.</td>
</tr>
<tr>
<td>c) Flame Outlet</td>
<td>Fouling, obstruction in the openings.</td>
</tr>
<tr>
<td>d) Flame arrestor internal mesh</td>
<td>Deposits/fouling, blockage, corrosion and erosion.</td>
</tr>
</tbody>
</table>
# PSV INSTALLATION : PRECOMMISSIONING CHECK LIST

## UNIT -

## TOPIC - PSV INSTALLATION STATUS

## CHECKLIST NO: -

<table>
<thead>
<tr>
<th>Sr. no.</th>
<th>Loop no:</th>
<th>Tag no.</th>
<th>Description</th>
<th>P &amp; ID no.</th>
<th>Service</th>
<th>Type</th>
<th>Operating pressure Kg/cm²</th>
<th>Set pressure Kg/cm²</th>
<th>PSV sizing</th>
<th>Location</th>
<th>Approach</th>
<th>Installation date</th>
<th>Checked by (as part of PSSR)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

**Note:** Columns A to O to be filled as and when the PSVs are installed.
Pressure & Vacuum Relief Valves for Above Ground Atmospheric Storage Tanks:

Atmospheric tanks can be over pressurized or subjected to vacuum. Some of the probable scenarios for over pressurization and vacuum are described as below:

a) Overpressure scenarios in atmospheric tanks:
   - Pressure rise due to filling of tank.
   - Pressure rise due to external fire (can be huge!).
   - Pressure rise due to thermal expansion (can be significant with large tank).
   - Pressure rise due to control valve failure (such as tank blanketing regulator).
   - Pressure increase due to atmospheric pressure decrease.

b) Vacuum scenarios in atmospheric tanks:
   - Vacuum from tank outflow
   - Vacuum from cooling (such as thunderstorm)
   - Vacuum from fluid condensation
   - Vacuum from atmospheric pressure increase

#Note: Some of these circumstances are described more exhaustively in Sections 4.2.2 through 4.2.5 of API-2000.

Tank shall be protected from over pressurization and vacuum both. The PVRVs (Pressure & Vacuum relief valves) are the safety devices, which can protect the tanks from both over pressurization and Vacuum. These can be:

1. Dead weight type (metal seated or soft seated)
2. Pilot Operated type

Older tanks which have been constructed prior to 1970 may have most of the PVRVs which are dead weight type and having metallic seats. Metal seated PVRVs have an inherent problem of minor passing. Now-a-days most of the tanks are provided with soft seated Pressure and vacuum relief valve to control the fugitive emission losses. Cross section drawings of the same PVRV (Pressure Vacuum Relief Valves) used is as attached below:
Dead weight type soft seated PVRV

The basic principle of operation of soft/metal seated PVRVs is a primary physics formula i.e.

\[ F = \text{Force} = \text{Pressure} \times \text{Area} \]

The valve pressure pallet will operate when the pressure increases beyond set pressure since then the pressure force acting will be more than the dead weight of pressure pallet. Similarly if vacuum increases the vacuum pallet will operate allowing the outside atmosphere to enter the tank.

The Pilot operated PVRV’s are used to provide maximum available control technology and thereby ensuring dependable accurate operation.

The moving parts of the main valve are a soft seat assembly and flexible diaphragm. The System pressure is contained beneath the soft, main valve seat, and normally transmitted through a pilot tube up to and through the pilot, into the dome volume.

Since the effective diaphragm area is **MUCH** larger than the seat sealing area, the higher the system pressure, the higher the down force on the seat, the opposite of a common weight - loaded valve. System pressure acts upward on the underside of the main valve seat and also downward on the much larger main valve diaphragm area, holding the main seat tightly closed. The higher the system pressure, the higher the net down force on the main seat.
At set pressure, the pilot opens and reduces dome pressure by perhaps 75% or more, allowing the system pressure to open the seat assembly and establish flow through the main valve. According to the adjustment of the pilot, the main valve may have pop action and open fully at set pressure or it may modulate (open only enough to satisfy the relief demand). During the time the main valve is flowing, the pilot continually senses system pressure, normally through the pilot tube in the valve inlet. At reseating pressure, the pilot has closed and replenished dome pressure to be the same as the system pressure, closing the seat to a bubbletightness.

With a vacuum beneath the main seat and also above the main valve diaphragms, atmospheric pressure will push up the diaphragm(s) and open the main valve seat, allowing atmospheric pressure into the vessel to break the vacuum. The vacuum at which the valve opens depends on valve size, seat assembly materials, and whether one or two diaphragm chambers are utilized.
Annexure-XVI

Emergency vents/Lifting Man Ways for Above Ground Atmospheric Storage Tanks:

Emergency relief man ways/vents are mounted on storage tanks to release excessive internal pressure resulting from unusual conditions such as fire exposure or malfunctioning of the regular PV vents. These vents are commonly used as replacements for roof manways. A properly designed emergency device (i.e. emergency vent) can prevent a tank rupture in case of abnormal rise in tank internal pressure beyond the capability of the pressure relief vents.

Generally following two types of emergency vents are used for tank protection:

1. **Dead weight type/Weight loaded** (soft seated diaphragm or o-ring type)
2. **Spring Loaded type**

Typical cross section drawings of the various emergency vents is attached below:

![Figure: Typical Dead weight type soft seated Emergency Vent]
In the event of over pressurization, the emergency vent lifts at a pre-determined set pressure and provides large venting area, which allows the relief of the generated excessive pressure. Generally weight loaded emergency vents are used in the storage tanks.

The emergency vent setting should be higher than the full capacity pressure of the PV vents so as to assure the proper functioning of the regular venting equipment.
Operation sequence of dead-weight type emergency vent:

1. When pressure inside the tank is well below the set point, the deflated gasket diaphragm (Shown in fig-1) rests on the seat ring in a typical manner, retaining internal pressure.

2. As the pressure approaches the set point, the gasket inflates and wraps around the mating seat to achieve this unique sealing effect. The Teflon diaphragm expands like a balloon, and prevents any passing of product due to tight sealing (Shown in fig-2).

3. When pressure in the tank is at or above set point, the valve lifts to relieve the excessive pressure (Shown in fig-3)

Frequency for testing of Emergency Vents:

The frequency of inspection may be based on following conditions:

1. Diaphragm material
2. Corrosivity of fluid
3. Vent body material
4. Pressurization frequency/events of pressurization in storage tank
5. N2 blanketing (No/Yes)
6. Past failure history
Conventional Type valve

(Figure-1)

PART NAME
1 Body
2 Casing
3 Cap
4 Nozzle
5 Disc
6 Disc Holder
7 Reaction Head
8 Blowdown Ring
9 Guide Plate (D-R)
10 Spindle
11 Spindle Head
12 Spring Cap
13 Grooved Pin
14 Compression Screw
15 Locking Nut
16 Setting Screw
17 Set Screw Rod
18 Tab Washer
19 Pinning Screw
20 Body Stud
21 Body Nut
22 Casing Stud
23 Casing Nut
24 Spring
25 Body Gasket
26 Cap Gasket
27 Set Screw Gasket
28 Ball
29 Upper Spring Cap
30 Eyebolt
31 Drain Plug
PART NAME
1 Body
2A Casing
3 Cap
4 Nozzle
5 Disc
6A Disc Holder
7A Reaction Hood
8A Blowdown Ring
9A Guide Plate (O-R)
10A Spindle
11A Spindle Head
12 Spring Cap
13 Grooved Pin
14 Compression Screw
15 Locking Nut
16 Setting Screw
17 Serr. Screw Rod
18 Tab Washer
19 Pinning Screw
20 Body Stud
21 Body Nut
22 Casing Stud
23 Casing Nut
24 Spring
25 Body Gasket
26 Cap Gasket
27 Set Screw Gasket
28 Bolt
29 Upper Spring Cap
30 Eyebolt
33 Draw Plug
40 Piston
43 Bellows
46 Nozzle Gasket

Balanced Bellows Type Valve

(Figure 2)
Effect of Back Pressure on Set Pressure of Conventional Safety Relief Valves

[Figure 3]
Effect of Back Pressure on Set Pressure of Balanced Safety Relief Valves

(Figure 4)
Pilot Operated Pressure Relief Valve

(Figure-5)
Test Apparatus for Seal Tightness

(Figure-6)
Tightness Standard

The leakage rate in bubbles per minute shall not exceed the values indicated in Figure 7 in the graph.

Set Pressure, psig
Maximum Seal Leakage Rate, Bubbles Per Minute

Tightness Standard

(Figure 7)
Test Procedure for a Typical Pilot Operated Safety Valve