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PROCESS DESIGN OF PRESSURE RELIEVING SYSTEMS INCLUSIVE SAFETY RELIEF VALVES

(PROJECT STANDARDS AND SPECIFICATIONS)

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SCOPE

This Project Standards and Specifications covers minimum requirements for process design and engineering of pressure relieving devices in OGP Industries excluding cryogenic services.

For the rating and adjustment of safety valves on power boilers refer to the ASME Boiler and Pressure Vessel Code, Section I, "Power Boilers".

REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

1. API (American Petroleum Institute)

RP 520	"Sizing, Selection and Installation of Pressure –Relieving Devices in Refineries"
RP 520 Part I	"Sizing and Selection"
RP 520 Part II	"Installation"
RP 521	"Guide for Pressure – Relieving and Depressuring Systems"
Standard 526	"Flanged Steel Pressure Relief Valves"
Standard 527	"Seat Tightness of Pressure Relief Valves"
Standard 2000	"Venting Atmospheric and Low-Pressure Storage Tanks Nonrefrigerted and Refrigerated"

2. ASME (American Society of Mechanical Engineers)

ASME B 31.3	"Process Piping"
ASME B 16.5	"Pipe Flanges and Flanged Fittings"

3. ASME Boiler and Pressure Vessel Code

Section I	"Rules for Construction of Power Boilers"
Section VIII	"Rules for Construction of Pressure Vessels"
Division 1 :UG 134	"Pressure Setting of Pressure Relief Devices"

4. NEC (National Electrical Code)
   Division 2 "Electrical Classification Areas"

DEFINITIONS AND TERMINOLOGY

Accumulation - Pressure increase over the maximum allowable working pressure of the vessel during discharge through the pressure-relief valve (expressed as a percent of that pressure) is called accumulation

Back Pressure - Pressure on the discharge side of safety-relief valves is back pressure.

Balanced bellows safety-relief valve - A valve incorporating a bellows which has an effective area equal to that of the valve seat to eliminate the effect of back pressure on the set pressure of the valve and which effectively prevents the discharging fluid entering the bonnet space.

Blowdown - Difference between set pressure and reseating pressure of a safety valve expressed in percent of the set pressure or in bar or kPa.

Built-Up back pressure - Built-up back pressure is the pressure in the discharge header which develops as a result of flow after that the **safety-relief** valve opens.

Conventional safety-relief valve - A valve of the direct loaded type, the set pressure of which will be affected by changes in the superimposed back pressure.

Design Pressure - The pressure used or designated in the design of equipment for the purpose of determining the minimum permissible thickness of the pressure parts at a designated temperature, exclusive of any thickness allowances added for corrosion and for loadings other than pressure.

Direct loaded safety-relief valve - A safety-relief valve in which the loading due to the fluid pressure underneath the valve disk is opposed only by direct mechanical loading such as a mass, a lever and mass, or a spring.

Lift - The actual travel of the disc from the closed position when a valve is relieving.

Maximum Allowable Working Pressure - The maximum gauge pressure permissible at the top of a completed vessel in its operating position for a designated temperature. The vessel may not be operated above this pressure or its equivalent at any metal temperature other than that used in its design. Consequently, for that metal temperature, it is the highest pressure at which the primary pressure-relief valve is set to open.

Non-Reclosing Pressure Relief Device - A pressure relief device which remains open after operation. A manual resetting means may be provided.

Overpressure - Pressure increase over the set pressure of the relieving device is overpressure. It is the same as accumulation when the relieving device is set at the maximum allowable working pressure of the vessel and may be greater than the allowable accumulation if the valve is set lower than the vessel MAWP.

Pilot operated safety-relief valve - A safety-relief valve, the operation of which is initiated and controlled by the fluid discharged from a pilot valve which is itself a direct loaded safety-relief valve subject to the requirements of this Standard.

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

Reclosing Pressure Relief Device - A pressure relief device designed to open and relieve pressure and to reclose and prevent the further flow of the fluid after normal conditions have been restored.

Relief valve - A relief valve is an automatic pressure-relieving device actuated by the static pressure upstream of the valve. The valve opens in proportion to the increase in pressure over the opening pressure. It is used primarily for liquid service.

Reseating Pressure of a Safety Valve - The values of inlet static pressure at which the disc re-establishes contact with the seat or at which lift becomes zero.

Rupture disc - A rupture disk consists of a thin metal diaphragm held between flanges and bursts when a predetermined pressure is reached below the disk, so preventing a predetermined safe pressure being exceeded in the vessel to be protected.

Safety valve - A safety valve is an automatic pressure-relieving device actuated by the static pressure upstream of the valve and characterized by rapid full opening or pop action. It is used for gas or vapor services.

Safety-relief valve - A safety-relief valve is an automatic pressure-relieving device suitable for use as either a safety or relief valve, depending on application. It is used in either gas and vapor or liquid services.

Set Pressure - Inlet pressure to which a safety valve is adjusted, in a test stand or other source of pressure, to open with an atmospheric discharge or atmospheric back pressure.

Superimposed back pressure - Superimposed back pressure is the pressure in the discharge header before the safety-relief valve opens.

Vacuum Relief Valves - Vacuum Relief Valves are usually installed on storage tanks and shall normally be of the mass loaded or pilot operated type. For full description and determination of size of vacuum relief valves reference shall be made to API 2000 "Venting Atmospheric and Low Pressure Storage Tanks (Non-Refrigerated and Refrigerated)".

SYMBOLS AND ABBREVIATIONS

SYMBOL/ABBREVIATION	DESCRIPTION
Con.	Contractor.
DN	Diameter Nominal, in (mm).
DP	Design Pressure.
F	Environment Factor.
L	Liquid.
LSAP	Limiting System Allowable Pressure.
MAWP	Maximum Allowable Working Pressure.
MRP	Maximum Relief (Relieving) Pressure.
NEC	National Electrical Code.
OGP	Oil, Gas and Petrochemical.

P & ID	Piping & Instrumentation Diagram.
RF	Raised Face.
SP	Set Pressure.
TRC	Temperature Recorder Controller.
V	Vapor.

UNITS

This Standard is based on International System of Units (SI) except where otherwise specified.

DESIGN REQUIREMENTS

General

1. Safety relief valves shall be provided to protect all equipment subject to overpressure and under certain other conditions as specified herein.
2. The pressure relieving devices shall be designed in accordance with the following codes and standards:

   API-RP 520 Part I and Part II , API Standard 526 and 527, ASME Boiler and Pressure Vessel Code Section I and Section VIII
3. Pressure/vacuum relief requirement and relief load capacity for atmospheric and low pressure storage tanks shall be evaluated based on API-Standard 2000.
4. Snuffing steam shall be provided for safety valves discharging to atmosphere in the following services:

   a. Material above its auto-ignition point.
   b. Light hydrocarbon service at locations listed in the job specification where hazard of exposure to lightning is prevalent due to high rate of electrical storms.

   When snuffing steam is required, provide a DN 25 (one inch) snuffing steam connection approximately 300 mm from outlet end of the discharge piping. The steam line to this connection shall be run to grade, provided with a double valve and bleeder at grade and a steam condensate trap upstream of the double valves.

5. The design requirements shall be determined in accordance with API Recommended Practice 520 Part I.
6. All safety relief valves shall be provided with pressure tight bonnets except bellows type valve.
7. All pressure relief valves (except thermal relief valves) with the inlet nozzle sizeof DN 25 (1 in.) and larger should be flanged, spring loaded, high lift, high capacity type with a top guided disc. Pressure relief valves in services other than steam, hot water, and air should not be provided with a lifting device. Pressure relief valves with the inlet nozzle size under DN 25 may be of the screwed type connection.

Provisions of Pressure Safety Relief Valves

Pressure safety or relief valve shall be provided for all cases as specified herein below.

1. Vessels
   a. When designed in accordance with Section VIII, ASME Unfired Pressure Vessel Code and the overpressure exceed the Design Pressure.

      Special attention shall be made to the cases, where process conditions are changed during the engineering stage or after initial start-up of the plant and require increased operating pressure.
   b. When designed in accordance with Section I, ASME Power Boiler Code and the overpressure exceeds the Maximum Allowable Working Pressure as defined in that code.
2. Pump
   a. On discharge of positive displacement pumps.
   b. On discharge of centrifugal pumps to protect downstream equipment from overpressure based on pump shutoff pressure. Where the downstream equipment are not designed for pump shut-off pressure.
   c. On pump suction lines from a "bottled in" system where overpressure can be imposed on suction piping by backflow through the pump or through a control valve bypassing from pump discharge to suction.

3. Compressors
   a. Where each stage of reciprocating compressors to protect interstage, intercooler, compressor frame or cylinder.
   b. On suction lines where overpressure may occur on suction lines or frame, or overload electric motor driver before interstage or discharge safety valve opens. Also for conditions specified above.
4. Compressor & pump couplings

   On discharge where under blocked discharge the design torque of the driver coupling or keyway may be exceeded due to an oversized motor or turbine.
5. Steam boilers & superheaters

   The following equipment falling under the jurisdiction of Section I, ASME Power Boiler Code when the overpressure exceeds the Maximum Allowable Working Pressure as defined by that Code:
   a. Steam drums
   b. Superheater outlet.
   c. Externally fired superheater coils installed in a process heater.
6. Fired process heaters

   To prevent overpressure due to heat input resulting from an action blocking the lines at downstream of the heater, where check valves or other valves upstream of the heater are closed by the same action blocking the upstream line(s), except for the condition covered under (a) below. The safety valve may be located anywhere between the upstream and downstream blocking valves:
   - A safety valve will not be required to protect the heater if the only block valve(s) between a fired heater and a tower are operable manually and intended to be used to prevent backflow from the tower to the heater in case of heater tube failure.
7. Turbines & surface condensers
   a. Condensing or non-condensing steam turbine cases where the exhaust outlet may be blocked, thus preventing the turbine from discharging to atmosphere, a low pressure steam header or a surface condenser.
   b. Gas turbine cases, where exhaust outlet is blocked, thus preventing the turbine from exhausting to atmosphere, or to waste heat generators(HRSG), etc.

c. Exhaust outlet where the design pressure of an expansion joint is less than the turbine casing design pressure.
d. Surface condensers for condensing turbines.

8. Piping & connected equipment

   For protection of piping, heat exchangers and other equipment served by the piping against overpressure under the following conditions:

   a. Downstream of steam reducing valves (including protection to steam engine and turbine drivers in this case).
   b. On the exhaust steam header leaving a Unit regardless of overpressure considerations. Use a chain operated multiport relief valve located on the Unit side of the block valve where the header connects into the plant exhaust steam system.
   c. Downstream of restriction orifices or manually operated valves in steam make-up or other services where closing a valve would result in overpressure.
   d. Fuel inlet to gas engine drivers.
   e. Pressure line to pressure balanced valves used to control fuel supply where the steam breaking point, diaphragm bursting point or diaphragm case breaking point may be exceeded.
   f. Downstream of steam control or regulating valves.
   g. Downstream or upstream of all control valves when the piping or equipment would be subjected to overpressure assuming that the control valve will fail in the open or closed position.
   h. On pedestal or gland water systems to pumps and turbines where overpressure is caused by water pump shutoff pressure. One safety valve may be provided on the supply line to a group of pumps, turbine glands or pedestals in lieu of a safety valve on the line to each equipment.
   i. Overpressure resulting from any of the conditions outlined above.

9. Cold side blockage & tube failure in exchangers

   To prevent overpressure due to heat input resulting from an action blocking the line(s) downstream of the cold side of the exchanger, where check valves or other valves upstream of the exchanger are closed by the same action blocking the upstream line(s). A safety valve is required where heating the cold fluid within the exchanger when the hot side inlet temperature will raise the pressure of the fluid contained between the upstream and downstream

blockages to more than 1.5 times of the design pressure of any item of equipment (excluding piping) in the contained system.

10. Pressure safety relief valves not required

    Pressure safety relief valves shall not be provided on the following systems:

    a. Interconnected vessels (excluding those falling under the requirements of Section I ASME Power Boiler Code), if they meet the following conditions:
        i) The vessel which is the source of pressure shall be equipped with a safety valve sized to protect all of the interconnected vessels or equipment and the interconnected piping (including heat exchanger equipment) shall be sized or checked for pressure drop to insure that the design pressure on the downstream vessel or vessels is not exceeded by more than the percentage accumulations allowed.
        ii) At least one interconnecting piping system between the protected vessel and any other vessel must be free of:
            - Any equipment which may fail or stop in a closed position.
            - Any block valves, control or check valves.
            - Any orifices, or similar restrictions to flow.
    b. Where a lower pressure piping system such as pumpout is routed to an offsite slop or emergency tank with overshot connections (connections entering the top of the tank without block valves).
    c. Depressuring systems routed to a flare, if all valves at the Unit limit, cooling boxes, or downstream depressuring valves are locked open.

Provisions of Temperature Safety Valves

Temperature safety valve shall be provided for all cases as required herein below:

1. Heat exchangers

   Temperature safety valves shall be provided on the cold side of heat exchange equipment, including compressor jackets operating full of liquid and subject to being blocked off, where heat may be applied internally or externally and other forms of pressure relief valves are not provided.

2. Piping

   Provide temperature safety valves for the following:

a. Heat/Steam traced lines

For sections of pipe which are heat/steam traced and contain liquid and may be blocked in.

b. Lines containing cold solvent or refrigerant

For blocked in sections of pipe which contain cold liquid and may develop excessive pressure under ambient temperature.

c. Exposed liquid-filled lines

For blocked in sections of pipe which may be subjected to excessive pressure due to rays of sun when exposed length of line is 30 meters or greater.

3. Temperature safety valves not required

On pedestal or gland water piping to pumps, turbines, compressors, blowers, etc. when the improbability that blocking off both the inlet and outlet valves and heating of the glands would occur simultaneously temperature safety valve is not required.

4. Provisions of Vacuum Safety Valves

a. Pressure vessels

Vessels in the following services shall be provided with vacuum breaking device, if they cannot withstand full vacuum:

i) Vessels where stripping steam is used and overhead condensing systems are provided.

ii) Vessels operating under partial vacuum.

iii) Vessels operating full of liquid having a vapor pressure less than atmospheric pressure at the operating temperature.

iv) Vessels on suction to compressors(As process requirement).

v) Vessels such as hot process softeners, deaerating heaters, hot water storages where cold water is heated by direct contact with steam and the vessel is not open to atmosphere.

Before vacuum safety valves are provided for vessels where explosive mixtures may occur due to bleeding air into the vessel through a vacuum safety valve and if the set pressure of the vacuum relief valve is so low that special consideration is needed to hold leakage to a minimum, consideration should be given to the alternate method of bleeding gas into the vessel by means of a regulator or control valve using the bleed gas as the operating medium instead of instrument air.

Vacuum relief valves allowing air to enter a hydrocarbon system shall not be used without prior approval of the Company. The Contractor shall provide adequate back up documents to support the design applied to the system.

b. Spheres & spheroids vessels

The necessity for vacuum relief valves on spheres and spheroids shall be investigated for each case, depending on the vapor pressure and corrosivity of the fluid handled and design of such equipment in regard to vacuum.

When required the precautions specified above shall be observed.

Provisions of Rupture Disks

1. Rupture disk alone

A rupture disk alone shall not be used to protect vessels or equipment but it may be used in combination with safety valves as a second relief device.

2. Rupture disk on inlet to safety valve

A rupture disk shall be provided at the inlet to a safety valve in the following instances:

a. Where it is difficult to keep safety valves from leaking either due to high pressure involved or to combination of high pressure and fluctuating pressure such as high pressure reciprocating compressors.
b. Where toxic material is being handled and contamination of the atmosphere is to be avoided due to possible leakage.
c. Where the fluid handled is expensive and possibility of safety valve leakage is to be avoided.
d. Where material which will make the safety valve inoperative is to be kept out of the safety valve.
e. Where corrosive material is handled and a safety valve can not be obtained of satisfactory material to resist corrosion.
f. Where corrosive material is handled and cost of safety valve to resist corrosion is prohibitive.

3. Rupture disk on outlet of safety valve

Rupture disks shall be provided on outlet of safety valves in the following instances:

a. To keep corrosive product out of a safety valve connected into a vent system.
b. Where it is necessary to confine safety valve leakage and there is insufficient space available on safety valve inlet.

4. Rupture discs used in conjunction with safety valves

   Rupture discs shall be provided in parallel with safety valves which discharge to the atmosphere or to a vent system in special cases ,e.g. where exothermic reactions may develop abnormally high and uncontrollable pressure conditions.

Provisions of Spare Safety Valves

The necessity for provision of spare safety valves shall be based on process Units where the required time interval between safety valve inspection periods is less than the time interval between designated inspection and test periods of the Unit, or is less than the normally anticipated frequency of Unit shut-downs for other reasons such as clean up or catalyst change, and the vessel or item of equipment can not be taken out of service without shutting down the Unit.

When a spare safety valve is required, the size of the safety valves shall be such as to provide the least number of safety valves which will have a total capacity equal or greater than the calculated required relieving capacity.

A spare relief valve is not required when two or more pressure or safety relief valves are required for the calculated relieving capacity on spheres or spheroids. However, where only one valve is needed for the required capacity, a spare valve shall be provided for spheres or spheroids.

When a vacuum relief valve or valves are required on spheres or spheroids, no spare relief valve is required.

Spare temperature safety valves are not required.

Emergency Vapor Depressuring Requirements

In addition to (not in lieu of) the pressure relief facilities described in this Section, a depressuring system shall be provided for reducing the pressure under fire conditions. To this end all process equipment, except as mentioned below, containing more than 2 metric tonnes of liquid C4 or more volatile liquid under