Causas de Sobrepressão em Vasos de Pressão

1. Introdução

Para a seleção e especificação da Válvula de Alívio de sobrepressão, de equipamentos e sistemas de tubulação, a 1ª providência é analisar os possíveis cenários de aumento de pressão e em seguida calcular, para cada um, a vazão do fluido necessária ao alívio.

1.1. Cenários de sobrepressão

A norma API RECOMMENDED PRACTICE 521 - Guide for Pressure-Relieving and Depressuring Systems - SECTION 2-CAUSES OF OVERPRESSURE lista os vários cenários que provocam a ocorrência da sobrepressão.

2.3 Potentials for Overpressure

1.2. Closed Outlets on Vessels

The inadvertent closure of a block valve on the outlet of a pressure vessel while the plant is on stream may expose the vessel to a pressure that exceeds the maximum allowable working pressure.

1.3. Inadvertent Valve Opening

The inadvertent opening of any valve from a source of higher pressure, such as high-pressure steam or process fluids, should be considered.

1.4. Check-Valve Malfunction

The failure of a check valve to close must also be considered.

1.5. Utility Failure

The consequences that may develop from the loss of any utility service, whether plantwide or local, must be carefully evaluated.

Table 1—Possible Utility Failures and Equipment Affected

Utility Failure	Equipment Affected
Electric	Pumps for circulating cooling water, boiler feed, quench, or reflux
	Fans for air-cooled exchangers, cooling towers, or combustion air
	Compressors for process vapor, instrument air, vacuum, or refrigeration
	Instrumentation
	Motor-operated valves
Cooling Water	Condensers for process or utility service
	Coolers for process fluids, lubricating oil, or seal oil
	Jackets on rotating or reciprocating equipment
Instrument air	Transmitters and controllers
	Process-regulating valves
	Alarm and shutdown systems
Steam	Turbine drivers for pumps, compressors, blowers, combustion air fans, or electric generators
	Reboilers
	Reciprocating pumps
	Equipment that uses direct steam injection
	Eductors
Fuel (oil, gas, etc.)	Boilers
	Reheaters (reboilers)
	Engine drivers for pumps or electric generators
	Compressors
	Gas turbines
Inert gas	Seals
	Catalytic reactors
	Purge for instruments and equipment

1.6. Partial Failure
An evaluation of the effect of overpressure that is attributable to the loss of a particular utility service should include the chain of developments that could occur and the reaction time involved.

1.7. Electrical *or* Mechanical Failure
The failure of electrical or mechanical equipment that provides cooling or condensation in process streams can cause overpressure in process vessels.

1.8. Loss of Fans
Fans on air-cooled heat exchangers or cooling towers occasionally become inoperative because of a loss of power or a mechanical breakdown.

1.9. Loss of Heat In Series Fractionation Systems
In series fractionation (that is, where the bottoms from the first column feed into the second column. and the bottoms from the second feed into the third), the loss of heat input to a column can overpressure the following column.

1.10. Loss of Instrument Air or Electric Power
The complexity of instrument automation on process units requires the provision of reliable and continuous sources of air or electric power, or both, for dependable operation.

1.1 1. Reflux Failure
The loss of reflux as a result of pump or instrument failure can cause overpressure in a column because of condenser flooding or loss of coolant in the fractionating process.

1.12. Abnormal Heat Input From Reboilers
Reboilers are designed with a specified heat input. When they are new or recently cleaned, additional heat input above the normal design can occur.

1.13. Heat-Exchanger Tube Failure
In shell-and-tube heat exchangers, the tubes are subject to failure from a number of causes, including thermal shock, tube rupture, vibration, and corrosion.

> **API STANDARD 521 SIXTH EDITION, JANUARY 2014**
> **Pressure-relieving and Depressuring Systems**
> **Shell-and-tube Heat Exchangers**
> **Pressure Considerations**
> Complete tube rupture, in which a large quantity of high-pressure fluid flows to the lower-pressure exchanger side, is a remote but possible contingency. Minor leakage can seldom overpressure an exchanger during operation, however such leakage occurring where the low-pressure side is closed in can result in overpressure. <u>Loss of containment of the low-pressure side to atmosphere is unlikely to result from a tube rupture where the pressure in the low-pressure side (including upstream and downstream systems) during the tube rupture does not exceed the corrected Hydrotest pressure.</u> The user may choose a pressure other than the corrected hydrotest pressure, given that a proper detailed mechanical analysis is performed showing that a loss of containment is unlikely. The use of maximum possible system pressure instead of design pressure may be considered as the pressure of the high pressure side on a case-by-case basis where there is a substantial difference in the design and operating pressures for the high-pressure side of the exchanger.
> Pressure relief for tube rupture is not required where the low-pressure exchanger side (including upstream and downstream systems) does not exceed the criteria noted above. The tube rupture scenario can be mitigated by increasing the design pressure of the low-pressure exchanger side (including upstream and downstream systems), and/or assuring that an open flow path can pass the tube rupture flow without exceeding the stipulated pressure, and/or providing pressure relief.

1.14. Transient Pressure Surges
1.14.1. Water Hammer

The probability of hydraulic shock waves, known **as** *water hammer,* occurring in any liquid-filled system should be carefully evaluated.

1.14.2. Steam Hammer
An oscillating peak pressure surge, called *steam hammer,* can occur in piping that contains compressible fluids. The most common occurrence is generally initiated by rapid valve closure.

1.15. Plant Fires
Fire as a cause of overpressure in plant equipment is discussed in 3.15.
A provision for initiating a controlled shutdown or installation of a depressuring system for the units can minimize overpressure that results from exposure to external fire.

1.16. Process Changes in Chemical Reactions
In some reactions and processes, loss of process control may result in a significant change in temperature and/or pressure.

2. Bases para o cálculo da vazão de alívio

A mesma norma API RECOMMENDED PRACTICE 521 - Guide for Pressure-Relieving and Depressuring Systems – propõe as bases do cálculo da vazão de alívio para cada cenário.

Table 2—Bases for Relief Capacities Under Selected Conditions

Item No.	Condition	Pressure Relief Device (Liquid Relief)[a]	Pressure Relief Device (Vapor Relief)[a]
1	Closed outlets on vessels	Maximum liquid pump-in rate	Total incoming steam and vapor plus that generated therein at relieving conditions
2	Cooling water failure to condenser	—	Total vapor to condenser at relieving conditions
3	Top-tower reflux failure	—	Total incoming steam and vapor plus that generated therein at relieving conditions less vapor condensed by sidestream reflux
4	Sidestream reflux failure	—	Difference between vapor entering and leaving section at relieving conditions
5	Lean oil failure to absorber	—	None, normally
6	Accumulation of noncondensables	—	Same effect in towers as found for Item 2; in other vessels, same effect as found for Item 1
7	Entrance of highly volatile material	—	
	Water into hot oil	—	For towers, usually not predictable
	Light hydrocarbons into hot oil	—	For heat exchangers, assume an area twice the internal cross-sectional area of one tube to provide for the vapor generated by the entrance of the volatile fluid due to tube rupture
8	Overfilling storage or surge vessel	Maximum liquid pump-in rate	—
9	Failure of automatic controls	—	Must be analyzed on a case-by-case basis
10	Abnormal heat or vapor input	—	Estimated maximum vapor generation including non-condensables from overheating
11	Split exchanger tube	—	Steam or vapor entering from twice the cross-sectional area of one tube; also same effects found in Item 7 for exchangers
12	Internal explosions	—	Not controlled by conventional relief devices but by avoidance of circumstances
13	Chemical reaction	—	Estimated vapor generation from both normal and uncontrolled conditions
14	Hydraulic expansion:		
	Cold fluid shut in	See 3.14.3	—
	Lines outside process area shut in	See 3.14.3	—
15	Exterior fire	—	Estimated by the method given in 3.15
16	Power failure (steam, electric, or other)	—	Study the installation to determine the effect of power failure; size the relief valve for the worst condition that can occur
	Fractionators	—	All pumps could be down, with the result that reflux and cooling water would fail
	Reactors	—	Consider failure of agitation or stirring, quench or retarding stream; size the valves for vapor generation from a runaway reaction
	Air-cooled exchangers	—	Fans would fail; size valves for the difference between normal and emergency duty
	Surge vessels	Maximum liquid inlet rate	—