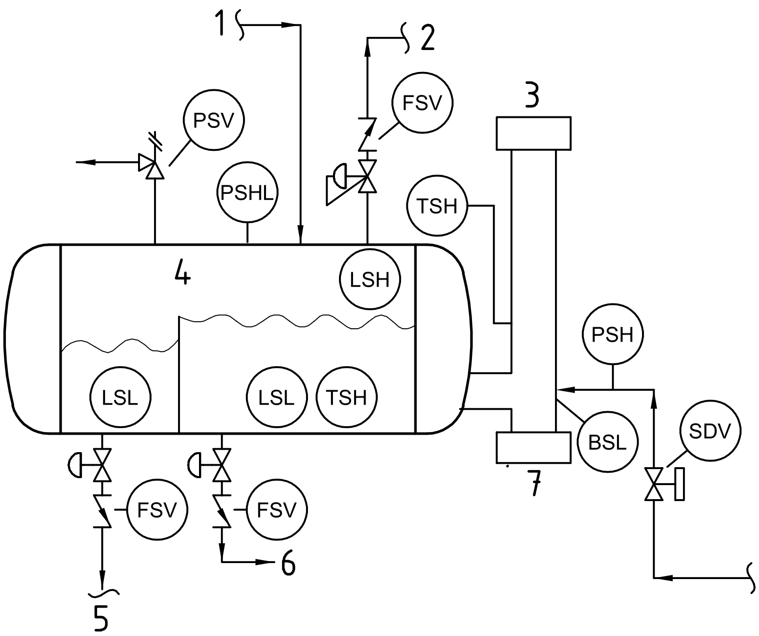
B.7.3.3 Temperature safety devices (TSH)

TSH sensors, other than fusible or skin contact types, should be installed in thermowells for ease of removal and testing. The thermowell should be located for accessibility and should be continuously immersed in the process fluid.

B.8 Fired and exhaust-heated components

B.8.1 Description

Fired and exhaust-heated components are used for processing and heating hydrocarbons. Included are both direct and indirect fired atmospheric and pressure vessels and tube-type heaters equipped with either automatically controlled natural or forced-draft burners. Also included are exhaust-heated components that use exhaust gases from other equipment such as turbines and engines as a heat source, and that may or may not be supplementary fired. This clause discusses the required protection for firing equipment of a fired component and for the heating section of exhaust-heated components. Protection for the process portion of a fired or exhaust-heated component is discussed under the appropriate component. Recommended safety devices for a typical fired vessel equipped with a natural-draft burner or a forced-draft burner are shown in Figures B.8 and B.9, respectively. Recommended safety devices for a typical exhaust-heated component are shown in Figure B.10.

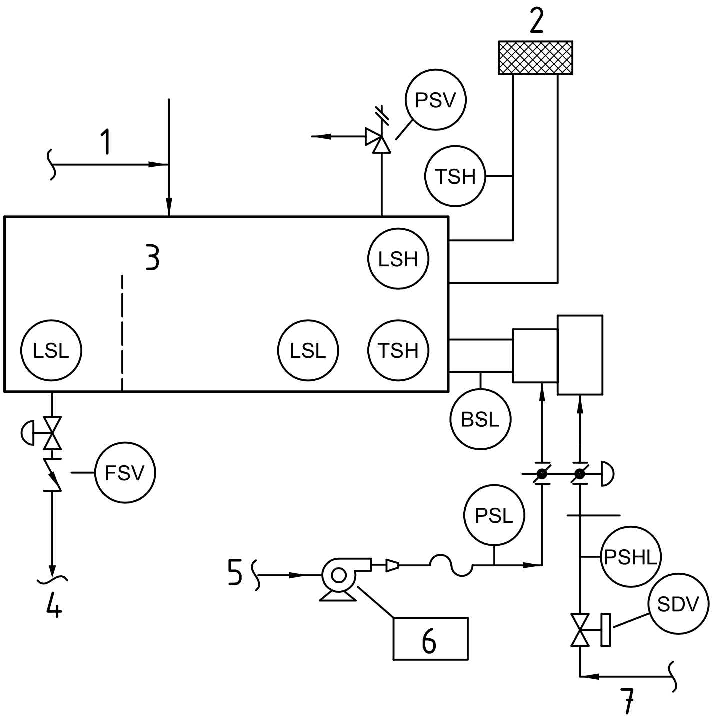


Key

1 inlet
2 gas outlet
3 stack arrestor
4 heater-treater
5 oil outlet
6 water outlet
7 flame arrestor

The vessel portion should be analysed in accordance with B.6 or B.7.

Figure B.8 — Recommended safety devices — Typical fired vessel (natural draft)



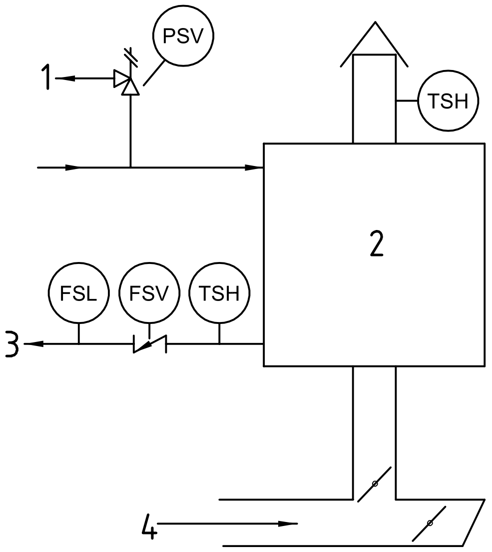
Key

1 glycol inlet
2 stack arrestor
3 glycol reboiler
4 glycol outlet
5 air inlet
6 motor interlock
7 fuel gas

The vessel portion should be analysed in accordance with B.6 or B.7.

NOTE The stack arrestor could be eliminated — see Table B.14, stack arrestor.

Figure B.9 — Recommended safety devices — Typical fired vessel (forced draft)



Key

1 medium inlet
2 exhaust-heated component
3 medium outlet
4 heat source (turbine exhaust, etc.)

Figure B.10 — Recommended safety devices — Exhaust-heated component

B.8.2 Safety analysis

B.8.2.1 Safety analysis table

The SAT for fired components with natural-draft burners is presented in Table B.11, for those with forced-draft burners in Table B.12, and for exhaust-heated components in Table B.13. The undesirable events that can affect a fired component or supplementary fired exhaust-heated component are excess temperature, direct ignition source, excess fuel in the firing chambers, and overpressure. The undesirable events that can affect an exhaust-heated component are excess temperature and overpressure.

Table B.11 — Safety analysis table (SAT) — Fired components (natural draft)

Undesirable event	Cause	Detectable condition at component
Excess temperature	Temperature control system fails Inadequate flow Limited heat transfer Ignition of medium leak into firing chamber Exposed heat transfer surface	High temperature (process) High temperature (stack) Low flow rate Low liquid level
Direct ignition source	Flame emission from air intake Spark emission from exhaust stack Excess stack temperature Exposed hot surface	Fire High temperature
Excess combustible vapours in firing chamber	Fuel control system failure	Flame failure High fuel pressure
Overpressure (flow tubes in firing chamber)	Blocked outlet Vaporization Thermal expansion	High pressure

Table B.12 — Safety analysis table (SAT) — Fired components (forced draft)

Undesirable event	Cause	Detectable condition at component
Excess temperature	Temperature control system fails Inadequate flow Limited heat transfer Ignition of medium leak into firing chamber Exposed heat transfer surface	High temperature Low flow High temperature High temperature High temperature
Direct ignition source	Flame emission from air intake Spark emission from exhaust stack Excess stack temperature Exposed hot surface	Fire High temperature stack
Excess combustible vapours in firing chamber	Fuel control system failure Air supply control system failure Blocked air inlet Blower failure	Low air pressure Flame failure High fuel pressure Low fuel pressure Low air velocity
Overpressure (flow tubes in firing chamber)	Blocked outlet Vaporization Thermal expansion	High pressure

Table B.13 — Safety analysis table (SAT) — Exhaust-heated components

Undesirable event	Cause	Detectable condition at component
Excess temperature	Temperature control system fails Inadequate flow Limited heat transfer Ignition of medium leak into firing chamber Exposed heat transfer surface	High temperature (medium) High temperature (stack) Low flow rate Low liquid level High temperature (process stack) Low liquid level
Overpressure (flow tubes in firing chamber)	Blocked outlet Vaporization Thermal expansion	High pressure
NOTE When supplemental firing is used, the component should also be analysed in accordance with Table B.11 or Table B.12, as applicable.		

B.8.2.2 Safety analysis checklist (SAC) (see Table B.14)

Table B.14 — Safety analysis checklist (SAC) — Fired and exhaust-heated components

SAC Ref. No.	Device SAFE (see Tables B.11, B.12, B.13)	Checklist
a)	TSH (medium or process fluid)	1) TSH installed. 2) Component is a steam generator protected by a PSH and, if fired, by an LSL. 3) Component is an indirect water-bath heater in atmospheric service and is protected by an LSL.
b)	TSH (stack)	1) TSH installed. 2) Component is isolated and does not handle combustible medium or process fluids other than fuel. 3) Component is exhaust-heated without supplemental firing and medium is not combustible.
c)	See Note.	—
d)	PSL (air supply)	1) PSL installed. 2) Component is equipped with a natural-draft burner. 3) Forced-draft burner is equipped with another type of low air supply sensor. 4) Component is exhaust-heated without supplemental firing.
e)	PSH (fuel supply)	1) PSH installed. 2) Component is exhaust-heated without supplemental firing.
f)	PSL (fuel supply)	1) PSL installed. 2) Component is equipped with a natural-draft burner. 3) Component is exhaust-heated without supplemental firing.
g)	BSL	1) BSL installed. 2) Component is exhaust-heated without supplemental firing.
h)	FSL (heated medium)	1) FSL installed. 2) Component is not a closed heat-transfer type in which a combustible medium flows through tubes located in the firing or exhaust-heated chamber.
i)	Motor interlock (forced-draft fan motor)	1) Motor interlock installed. 2) Component is equipped with a natural-draft burner. 3) Component is exhaust-heated without supplemental firing.
j)	Flame arrestor (air intake)	1) Flame arrestor installed. 2) Component is equipped with a forced-draft burner. 3) Component is located in an isolated area and not handling combustible medium or process fluids other than fuel. 4) Component is exhaust-heated without supplemental firing.
k)	Stack arrestor	1) Stack arrestor installed. 2) Component is equipped with a forced-draft burner and (1) the fluid being heated is non-flammable, or (2) the burner draft pressure at the exit of the transfer section is higher than the fluid pressure (head). 3) Component is isolated so process fluids will not contact stack emissions. 4) Component is exhaust-heated without supplemental firing.
l)	PSV (medium circulating tube)	1) PSV installed. 2) Component is not a tube-type heater. 3) PSV installed on another component will provide necessary protection and the PSV cannot be isolated from the tube section.
m)	FSV (medium circulating tube)	1) FSV installed on each outlet. 2) The maximum volume of combustible medium that could backflow from downstream equipment is insignificant, or medium is not combustible. 3) Component is not a tube-type heater.

NOTE This option was deleted from the original checklist in API RP 14C[8] when the second edition was published. The number reference is retained here to allow easy comparison of SAFE charts.

B.8.2.2.1 Temperature safety devices (TSH)

The medium or process fluid temperature in a fired component should be monitored by a TSH sensor to shut off the fuel supply and the inflow of combustible fluids. If a component is exhaust-heated, the exhaust should be diverted or the source of exhaust shut down. A TSH sensor is not necessary on a steam generator protected by a PSH sensor to detect high pressure caused by high temperature and by an LSL sensor to detect a low level condition that could cause high temperature. A TSH to sense medium or process fluid temperature is generally not necessary for an indirect water bath heater in atmospheric service, since the maximum temperature is limited by the boiling point of the water bath.

The flow of combustible medium in a closed heat-transfer system, where the medium is circulated through tubes located in the firing or exhaust-heated chamber, should not be shut off until the chamber has cooled. An ESD system and fire loop should immediately shut off medium flow if an uncontrolled fire has occurred in the area or the medium is escaping from a closed system.

Temperature in the burner exhaust stack should be monitored by a TSH sensor to shut off the fuel supply and the inflow of combustible fluids. Temperature in the exhaust-heated component stack should be monitored by a TSH sensor to shut off the inflow of combustible medium and to shut down the exhaust source. A TSH sensor is not required on a fired component located in an isolated area not handling combustibles other than fuel. A smoke detector (YSH) should be provided in the stack of glycol reboilers to detect any leakage of glycol into the fire tubes.

B.8.2.2.2 Flow safety devices (FSL and FSV)

If a combustible medium is circulated through tubes located in the firing or exhaust-heated chamber, the medium flow rate should be monitored by an FSL sensor to shut off the fuel supply to a fired component or to divert the exhaust flow from an exhaust-heated component. In this type of component, high temperature of the medium could occur before being detected by a TSH (medium) sensor located outside the heater. An FSL sensor is not required in other types of heater because the TSH (medium) sensor is located in the medium section and should immediately detect the high temperature condition. A check valve (FSV) should be located in tube outlet piping to prevent backflow into the fired or heated chamber in the event of tube rupture.

B.8.2.2.3 Pressure safety devices (PSH, PSL and PSV)

The pressure in the fuel supply line should be monitored by a PSH sensor to shut off the fuel supply to the burner. On a forced-draft burner, a PSL sensor should be installed on the fuel supply; in addition, the air intake pressure of a forced-draft burner should be monitored by a PSL sensor to shut off the fuel and air supply. A low air supply sensor may be used to monitor air supply in lieu of a PSL sensor. The PSL sensor is not required on a natural-draft burner because of the low air-intake pressure. Flow tubes located in the firing or exhaust-heated chamber of a tube type heater should be protected by a PSV from overpressure caused by expansion of the medium or process fluid.

B.8.2.2.4 Ignition safety devices

The air intake of a natural-draft burner should be equipped with a flame arrestor to prevent flame migration back through the air intake. A flame arrestor is not required on a forced-draft burner because the air velocity through the air intake prevents flame migration, or the PSL sensor in the air intake and fan motor starter interlock shut off the air intake.

The stack on a natural-draft burner should be equipped with a stack arrestor to prevent spark emission. If the fired component is not handling combustibles other than fuel and is located in an isolated area, the arrestor is not necessary. A stack arrestor may not be necessary on a forced-draft burner due to the higher combustion efficiency that prevents carbon build-up. A stack arrestor is required if the fluid being heated is flammable or the burner draft pressure at the exit of the transfer section is lower than the fluid pressure (head).

The motor on a forced-draft fan should be equipped with a motor starter interlock to sense motor failure and shut off the fuel and air supply.

The flame in the firing chamber should be monitored by a BSL or TSL sensor that will detect a flame insufficient to immediately ignite combustibles entering the firing chamber and will prevent fuel valves opening or shut off fuel supply.

Facilities should be installed to ensure fuel and air valves are opened and closed in the correct sequence.

B.8.3 Safety device location

B.8.3.1 Temperature safety devices (TSH)

Temperature sensors, other than fusible or skin contact types, should be installed in a thermowell for ease of removal and testing. If the fire tube is immersed, the TSH sensor should be located in the heated liquid medium or process fluid. If the liquid medium or process fluid flows through tubes within the firing or exhaust-heated chambers, the TSH sensor should be located in the discharge line as close as practical to the heater, and upstream of all isolating devices. A TSH sensor in the stack should be located near the base of the exhaust stack.

B.8.3.2 Flow safety devices (FSL and FSV)

In a closed heat-transfer system with a combustible medium, an FSL sensor should be located in the medium circulating tube piping. The sensor should be located in the medium outlet line as close to the heater as practical, and should monitor total flow through the heater. A check valve (FSV) should be installed in the tube outlet piping.

B.8.3.3 Pressure safety devices (PSH, PSL and PSV)

A PSL sensor in the air intake of a forced-draft burner should be located downstream of the blower. The PSH and PSL sensor in the fuel supply line should be located between the last pressure regulator and the fuel control valve. A PSV on the tubes of a tube-type heater should be located where it cannot be isolated from the heated section of the tubes.

B.8.3.4 Ignition safety devices

The flame and stack arrestors on fired components should be located to prevent flame emission from the air intake and spark emission from the exhaust stack. The BSL sensor should be located in the firing chamber.

B.8.4 Safe operating procedures

In addition to the safety devices indicated in Table B.14, the procedures shown in Table B.15 are required to safely operate a fired or exhaust-heated component.

Table B.15 — Safe operating procedures for fired or exhaust-heated components

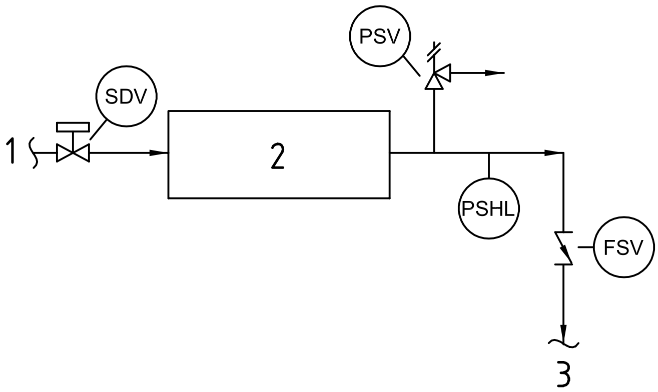
Step	Action
1	Assure complete fuel shut off.
2	Void firing chamber of excess combustibles prior to pilot ignition.
3	Limit time on trial for ignition of pilot and main burner to prevent excess fuel accumulation in fire chamber. After the time limit is exceeded, the fuel should be shut off and a manual reset start-up required.
4	Prove pilot and assure fuel-air proportioning dampers and burner controls are in low fire position prior to opening fuel supply to main burner.
5	Manually reset start-up controls following a flame failure of either the pilot or main burner.
6	Assure fuel is clean from all residue and foreign materials by providing adequate fuel-cleaning equipment.
7	Assure that exhaust is diverted around exhaust-heated component prior to starting up heat source, if applicable.

B.9 Pumps

B.9.1 Description

Pumps transfer liquids within the production process and into pipelines leaving the platform, or from the containment system to the process system (booster/charge pumps, sump pumps, chemical injection pumps, heating pumps). Pipeline pumps transfer produced hydrocarbons from the process system to a pipeline. Pumps that occasionally transfer small volumes of hydrocarbons from ancillary equipment (swab tanks, sumps, etc.) to a pipeline that receives the bulk of its volume from another source are not considered pipeline pumps. Glycol-powered glycol pumps circulate glycol within a closed system. Other pumps transfer produced liquids, heat-transfer liquids, or chemicals within the production process system, or from the containment system to the process system (booster/charge pumps, sump pumps, chemical injection pumps, heating-medium circulating pumps, glycol pumps, etc.). Recommended safety devices for typical pump installations are shown in Figures B.11, B.12 and B.13.

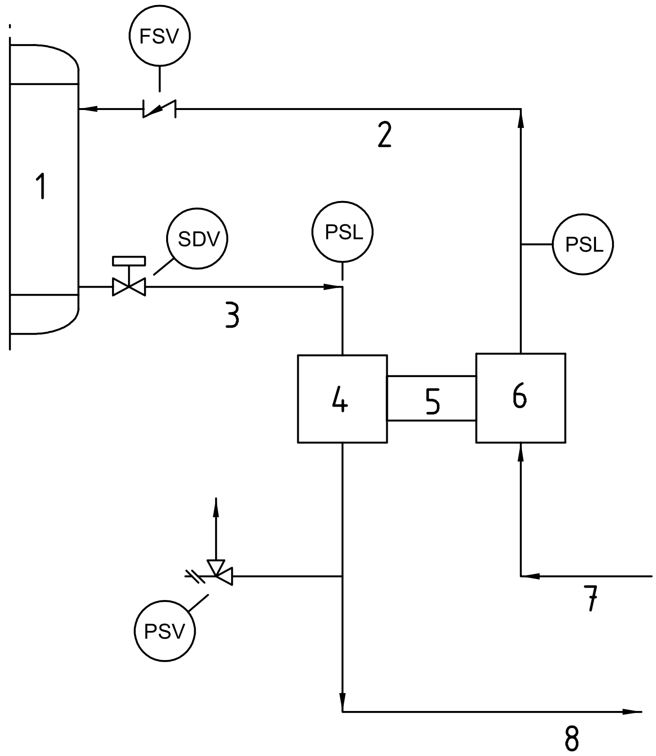
The recommendations of this clause do not apply to firewater pumps; in these cases the requirements of ISO 13702 apply.



Key

1 from storage component
2 pump
3 discharge

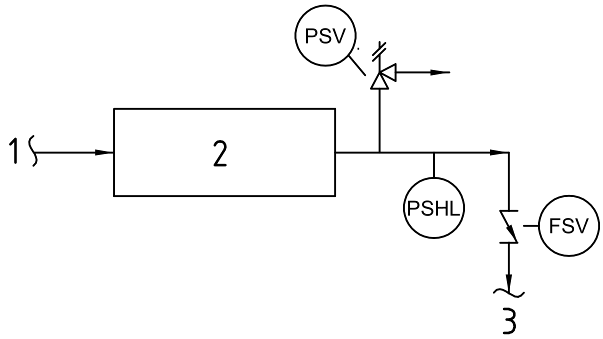
Figure B.11 — Recommended safety devices — Pipeline pumps



Key

1 glycol contactor
2 dry glycol to contactor
3 wet glycol from contactor
4 power end
5 pump
6 pump end
7 dry glycol from reboiler
8 wet glycol to reboiler

Figure B.12 — Recommended safety devices — Glycol-powered glycol pumps



Key

1 suction
2 pump
3 discharge

Figure B.13 — Recommended safety devices — Other pumps

B.9.2 Safety analysis

B.9.2.1 Safety analysis table

The SAT for pumps is presented in Table B.16. The undesirable events that can affect a pump are overpressure, leak, excess temperature and low flow.

Table B.16 — Safety analysis table (SAT) — Pumps

Undesirable event	Cause	Detectable condition at component
Overpressure	Blocked or restricted outlet Excess back pressure High inlet pressure (centrifugal) Overspeed Fluid density increase Reverse flow	High pressure
Leak	Deterioration Erosion Corrosion Impact damage Vibration Vacuum collapse	Low pressure
Excess temperature	High fluid temperature Gas pressure drop	High temperature Low temperature
Low flow	Blocked or restricted outlet or inlet	Low flow

B.9.2.2 Safety analysis checklist (SAC) (see Table B.17)

Table B.17 — Safety analysis checklist (SAC) — Pumps

SAC Ref. No.	Device SAFE (see Table B.16)	Checklist
a)	PSH — Pipeline pumps	PSH installed.
b)	PSH — Other pumps	1) PSH installed. 2) Maximum pump discharge pressure does not exceed 70 % of the maximum allowable working pressure of the discharge piping. 3) Pump is manually operated and continuously attended. 4) Small, low volume pumps, e.g. chemical injection. 5) Pump discharges to an atmospheric pressure vessel. 6) Pump is a glycol-powered glycol pump.
c)	PSL — Pipeline pumps	1) PSL installed. 2) Pump does not handle hydrocarbons. 3) ESS is capable of detecting fire and gas accumulation such that the likelihood of escalation is minimized.
d)	PSL — Other pumps	1) PSL installed. 2) Pump is manually operated and continuously attended. 3) Adequate containment is provided. 4) Small, low volume pumps, e.g. chemical injection pumps. 5) Pump discharges to an atmospheric vessel. 6) ESS is capable of detecting fire and gas accumulation such that the likelihood of escalation is minimized.
e)	PSV — Pipeline pumps	1) PSV installed. 2) Pump is kinetic energy type and incapable of generating a head greater than the maximum allowable working pressure of the discharge piping.
f)	PSV — Other pumps	1) PSV installed. 2) Maximum pump discharge pressure is less than the maximum allowable working pressure of discharge piping. 3) Pump has internal pressure relief capability. 4) Pump is a glycol-powered glycol pump, and the wet glycol low-pressure discharge piping is rated higher than the maximum discharge pressure. 5) Pump is a glycol-powered glycol pump, and the wet glycol low-pressure discharge piping is protected by a PSV on a downstream component that cannot be isolated from the pump.
g)	FSV — All pumps	Check valve installed.
h)	TSH	1) TSH installed. 2) Fluid temperature does not cause design limits of piping to be exceeded.
i)	TSL	1) TSL installed. 2) Gas pressure drop does not cause design limits of piping to be exceeded.
j)	FSL	1) FSL installed. 2) Pump curve is such that the PSH installed is capable of detecting blocked outlet and PSL installed is capable of detecting blocked inlet 3) Pump is not damaged by low flow.

B.9.2.2.1 Pressure safety devices (PSH, PSL and PSV)

PSH and PSL sensors should be provided on all hydrocarbon pipeline pump discharge lines to shut off inflow and shut down the pump. A PSH sensor to shut down the pump should be provided on the discharge line of other pumps, unless the maximum pump discharge pressure does not exceed 70 % of the maximum allowable working pressure of the discharge line, or the pump is manually operated and continuously attended. A PSH sensor is not required on glycol-powered glycol pumps. Other hydrocarbon pumps should also be provided with a PSL sensor to shut down the pump, unless the pump is manually operated and continuously attended or adequate containment is provided. PSL sensors should be provided on glycol-powered glycol pumps to shut off wet glycol flow to the pump. In many cases a PSL will be incapable of detecting even severe leaks, and need not be provided if it can be shown that the ESS is capable of detecting fire and gas occurrences such that escalation can be prevented.

A PSV should be provided on all pipeline pump discharge lines, unless the pump is a kinetic energy type, such as a centrifugal pump, and is incapable of generating a head greater than the maximum allowable working pressure of the discharge piping. A PSV should be provided in the discharge line of all other pumps unless the maximum pump discharge pressure is less than the maximum allowable working pressure of the line, or the pump has an internal pressure relief capability. A PSV should be provided in the wet glycol low pressure discharge line of glycol-powered glycol pumps unless the line is rated higher than the maximum pump discharge pressure or is protected by a PSV on a downstream component that cannot be isolated from the pump.

B.9.2.2.2 Flow safety devices (FSV)

A check valve (FSV) should be provided in the pump discharge line to minimize backflow.

B.9.2.3 Temperature safety devices (TSH and TSL)

A temperature safety device is only required if fluid temperatures during fault conditions can cause design limits of the piping to be exceeded. Low temperatures can be caused by gas pressure drops or active cooling. High temperatures can be caused by fluid conditions or active heating.

B.9.2.4 Flow safety low (FSL)

A low-flow safety device (flow safety low) is only required if damage can result from low flow and the pump characteristic is such that the pressure safety devices (pressure safety low and pressure safety high) will not detect abnormal condition.

B.9.3 Safety device recommended locations

B.9.3.1 Pressure safety devices (PSH, PSL and PSV)

The PSH and PSL sensors should be located on the pump discharge line upstream of the FSV or any block valve. In a glycol-powered glycol pump, the PSL on the wet glycol high pressure line should be located between the pump and the SDV. On pipeline pumps and other pumps where it is required, the PSV should be located on the discharge line upstream of any block valve.

B.9.3.2 Flow safety devices (FSV)

The check valve (FSV) should be located on the pump discharge line to minimize backflow.

B.9.3.3 Temperature safety devices (TSH and TSL)

The TSH and TSL sensors, other than fusible or skin contact types, should be installed in thermowells for ease of removal and testing. The thermowell should be located for accessibility and should be continuously immersed in the process fluid.

B.9.3.4 Flow safety low (FSL)

The FSL should be located in the pump discharge line upstream of any FSV or any block valve.

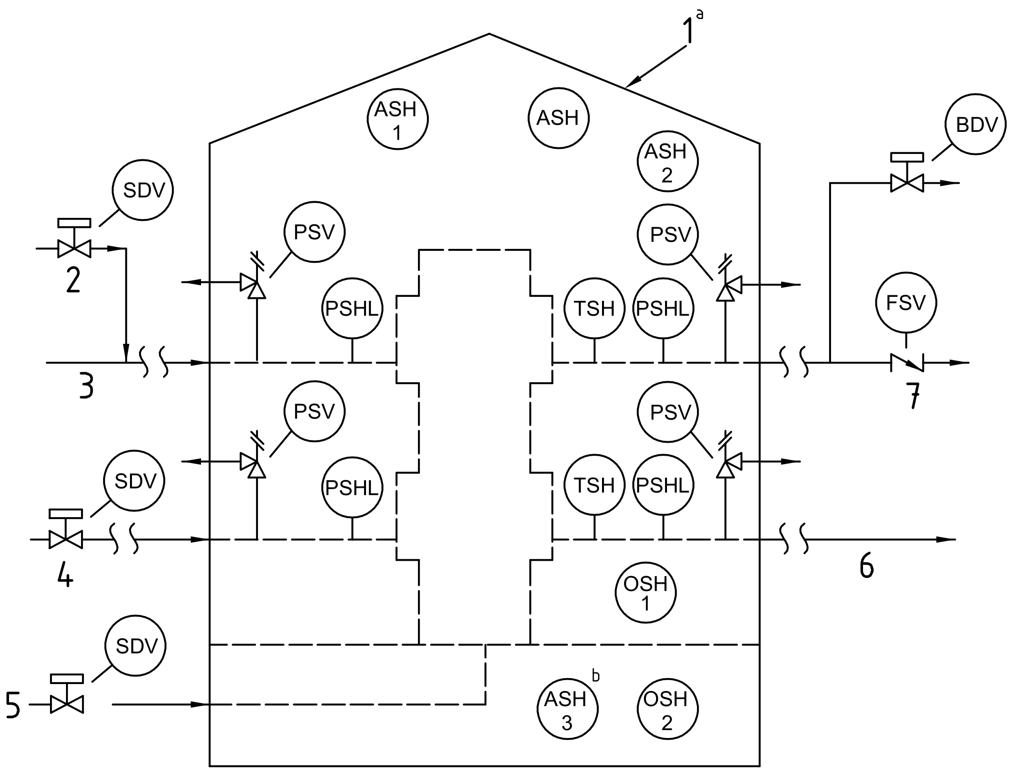
B.9.3.5 Shutdown devices (SDV)

An SDV should be located near the outlet of a storage component (tank, separator, etc.) that delivers product to a pipeline pump, to prevent the flow of hydrocarbons through the pipeline pump and into the pipeline in the event of a pipeline leak. If glycol-powered pumps are used, an SDV should be located near the high pressure wet glycol outlet of the glycol contactor to shut off flow from the contactor and to shut down the pumps.

B.10 Compressor units

B.10.1 Description

Compressor units transfer hydrocarbon gases within the production process and into pipelines leaving the platform. Recommended safety devices for a typical compressor unit are shown in Figure B.14.



Key

1 enclosure (optional)
2 external process inflow
3 intermediate suction
4 1st stage suction
5 fuel
6 intermediate discharge to next stage
7 final discharge

NOTE 1 Suction scrubbers are not shown; they should be analysed according to B.6. Shell-tube type discharge coolers are not shown; they should be analysed according to B.12.

NOTE 2 OSH should be considered based on the conditions stated in F.1 and F.2.

[a] ASH 1, 2 and OSH 1, 2 are not required if compressor is not installed in an enclosed building.

[b] ASH 3 is not required if compressor does not have piping or other potential source of gas leak below a solid subfloor.

Figure B.14 — Recommended safety devices — Compressor unit