INTRODUCTION TO PRESSURE SAFETY VALVE (PSV) SIZING

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RELIEF SYSTEM IMPORTANCE

THE IMPORTANCE OF CORRECTLY SIZING THE PSV

- **Too small**
  - **Pressure rises**
  - **Inadequate relief**
  - **Vessel rupture risk**
    - **Dangerous (flammable/explosive) chemicals into the atmosphere**
    - **Risk to other equipment items, staff and population**
- **Too large**
  - **Chattering = damaging effects to PSV, prevents correct operation**
  - **Blow down bottleneck**
    - **Flare extinguished**
    - **Flammable gases leak into the atmosphere**

RELIEF SYSTEM DEFINITION

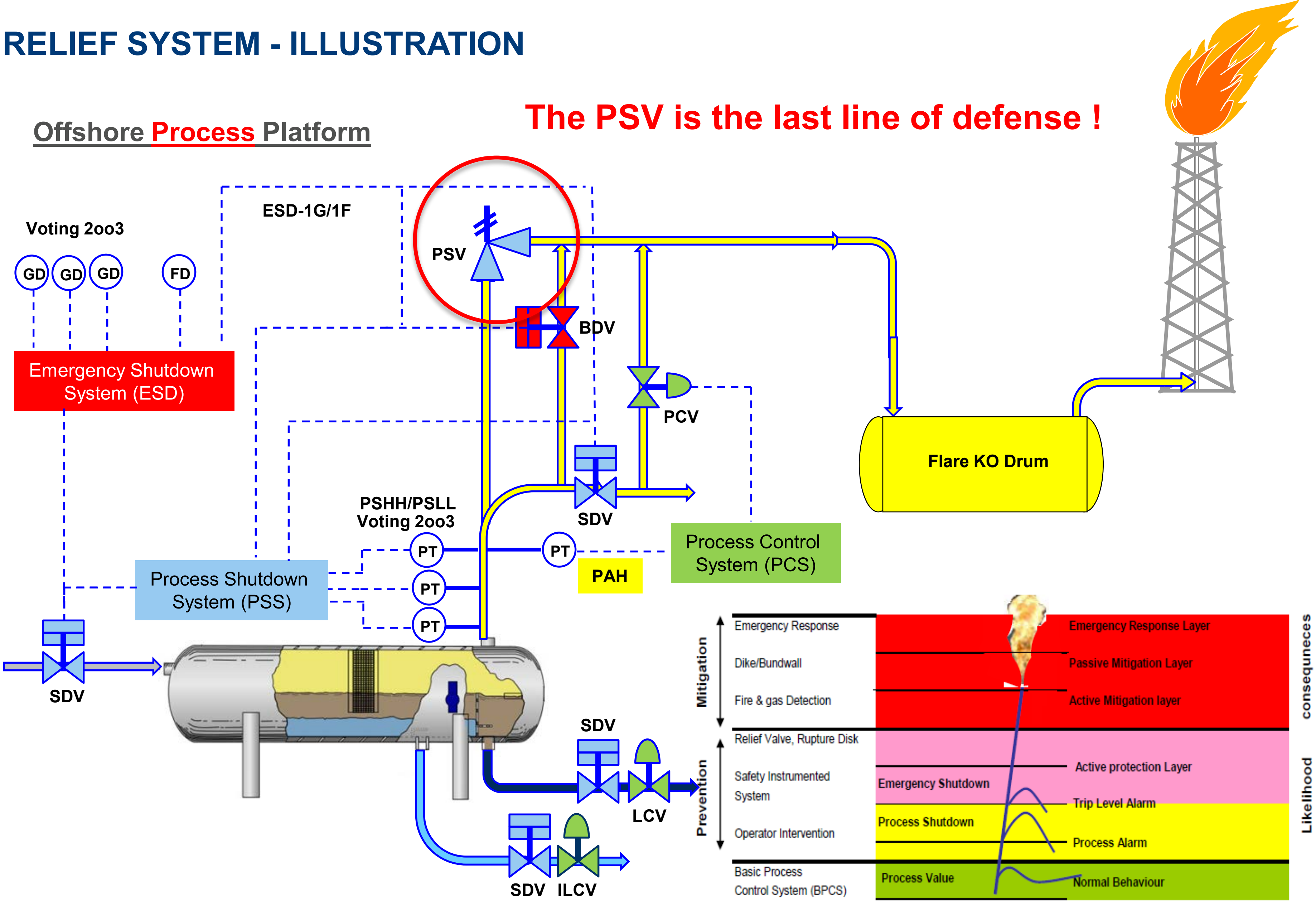
- **<u>API 14J:</u>**

A relief system is an emergency system to discharge gas or liquid during abnormal condition, by manual or controlled means or by an automatic pressure relief valve, from a pressurized vessel or piping systems to the atmosphere for the purpose of relieving pressure in excess of Maximum Allowable Working Pressure (MAWP).

- **<u>Our “home” definition</u>**

A relief system is a system that aims to protect the process facilities from overpressure damage by discharging mass (with an energy content) contained in the process facilities to safe location for final release.

RELIEF SYSTEM - ILLUSTRATION



PRESSURE SAFETY VALVE

- **Release to relief system:**
  - Normal Condition :
    - ❖ Pressure control ➔ Gas release from PCV
  - Abnormal Condition:
    - ❖ Depressurization through BDV to limit inventory
    - ❖ Pressure relief through pressure protection devices to protect equipment from over-pressurization :
      - ✓ Rupture Disk
      - ✓ Pressure Safety Valve (PSV) or Pressure Relief Valve (PRV)

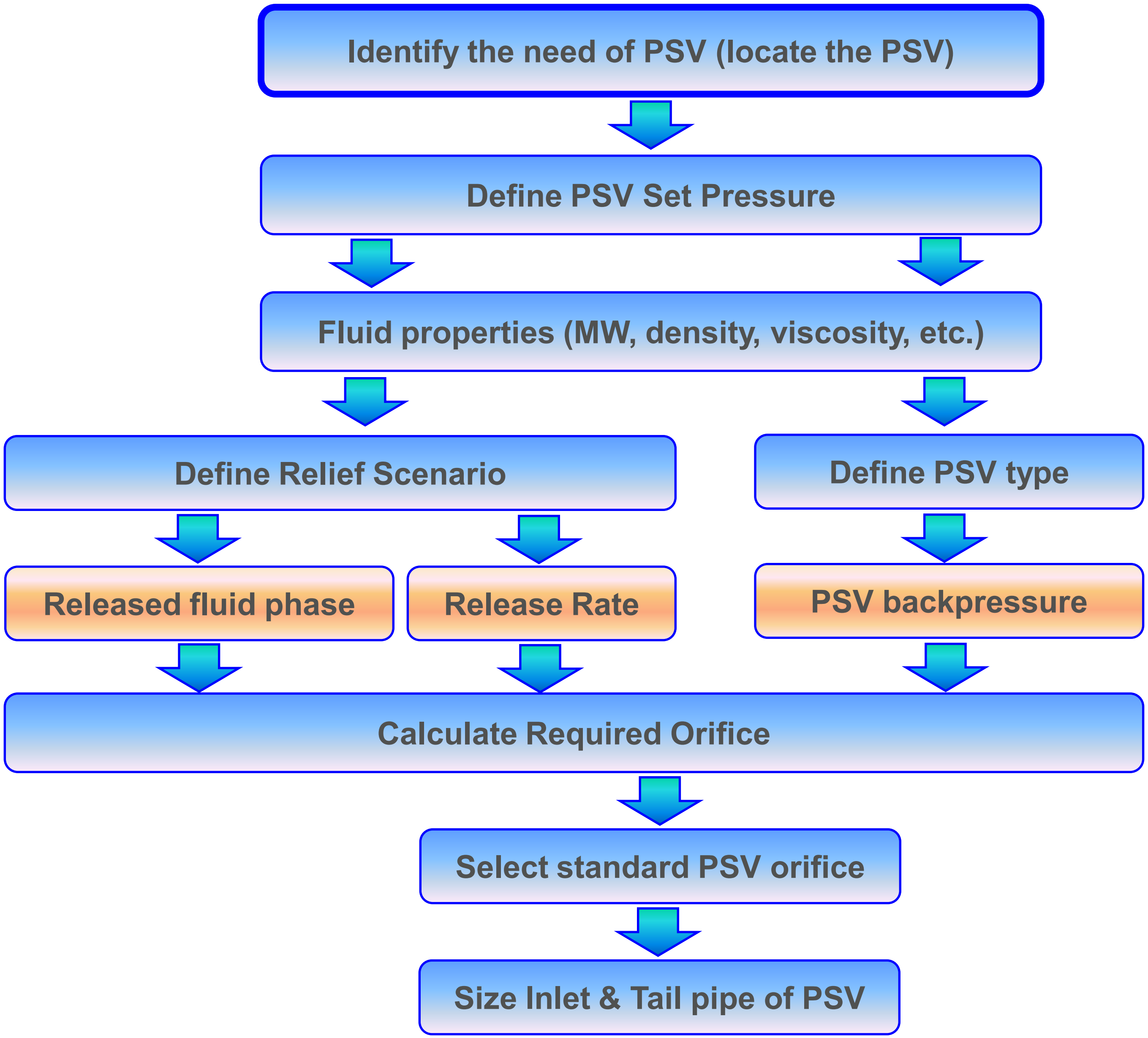
- **Pressure Safety Valve (PSV)**

PSV is a type of valve used to limit the pressure in a system or vessel which can build up by a process upset, instrument or equipment failure, or fire

- **References for PSV**

GS-EP-ECP-103, GS-EP-SAF-262, API Standard 520 Edition 2008, ISO 23251 (API 521), API 526, API 2000, API 14C, PRODEM Section XXXII

PSV– SIZING METHODOLOGY



STEP 1 - NEED OF PSV

- **PSV needed if a scenario leading to overpressure is identified <> Rules**

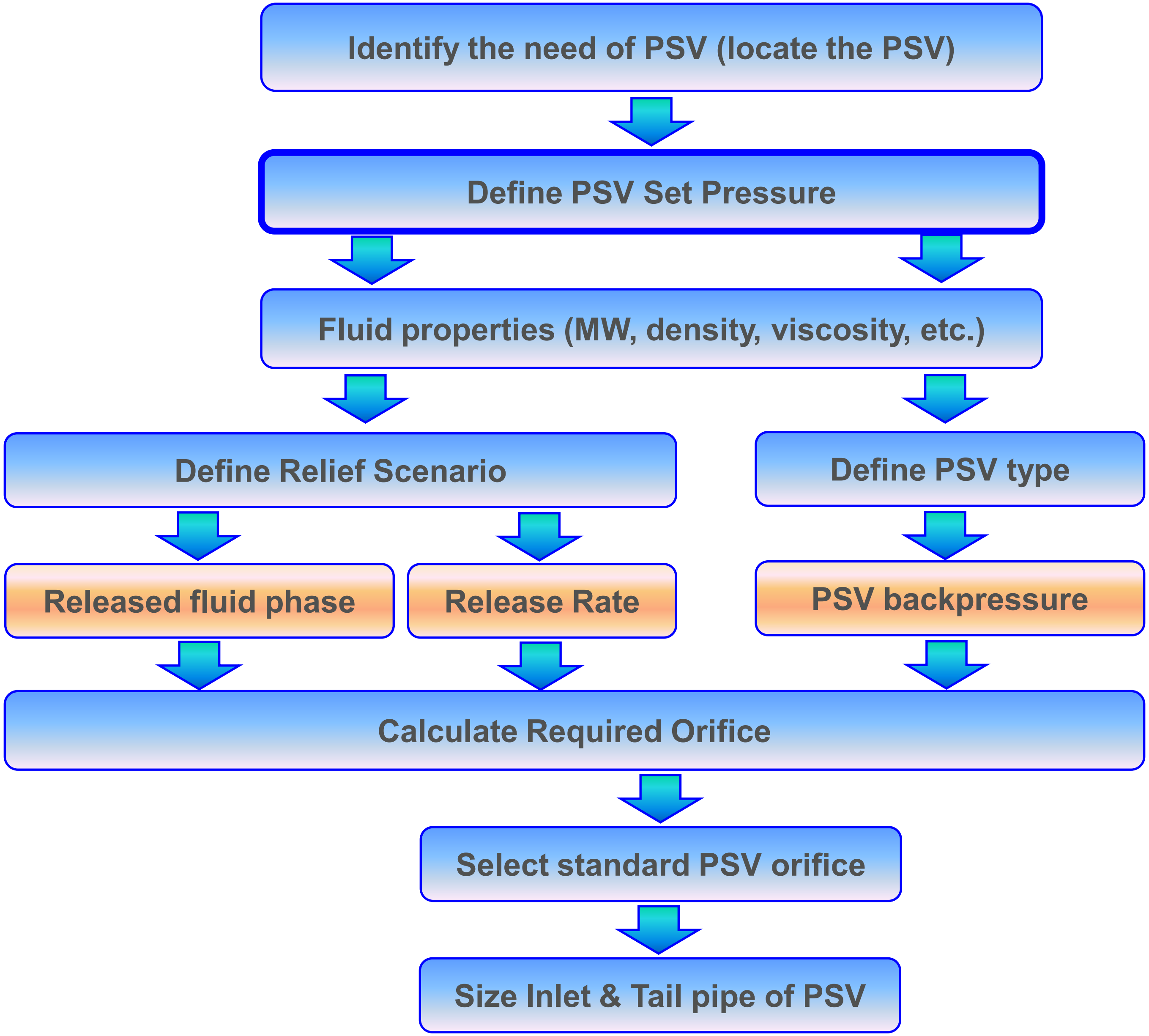
- **PSV requirement as per GS-EP-SAF-262**

	PSV (Process)	PSV (Fire case)	TSV
Piping that cannot be isolated (5):			
- All fluids	No	No	No
Piping that can be isolated (5) but cannot be exposed to fire:			
- Flammable gas	No (1)	No	No
- Liquefied HC	No (1)	No	Yes (7) (6)
- Liquid HC	No (1)	No	Yes (7) (6)
PIPING that can be isolated (5) and can be exposed to fire (8):			
- Flammable gas	No (1)	if > 3 tonnes	No
- Liquefied HC	No (1)	if > 2 tonnes	Yes (6)
- Liquid HC	No (1)	if > 2 tonnes	Yes (2) (6)
Vessels that cannot be isolated (5):			
- All fluids	Yes (3)	No	No
Vessels that can be isolated (5) but cannot be exposed to fire:			
- All fluids	Yes (3)	No	No
Vessels that can be isolated (5) and can be exposed to fire (8):			
- All fluids	Yes (3)	Yes	No

Note :

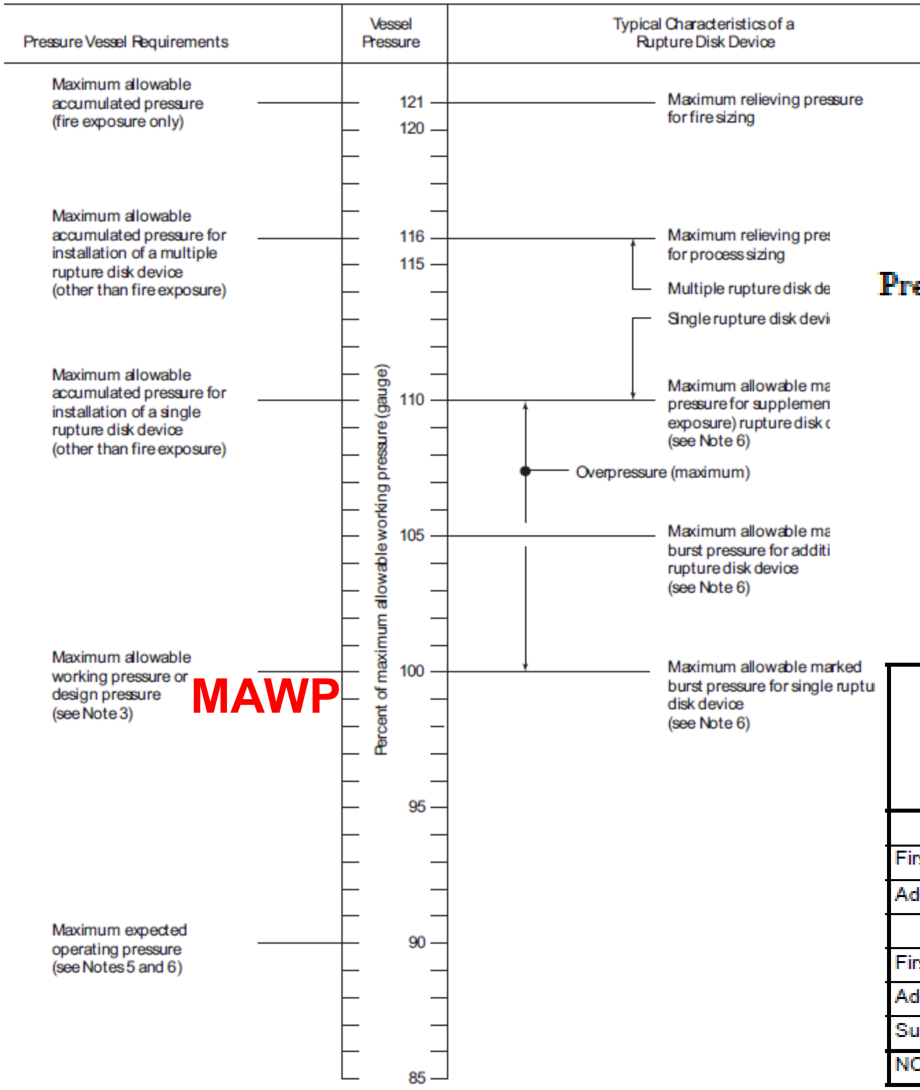
(1) Assuming piping is protected against maximum possible pressure under upset condition or fully rated.
(6) TSV is not required if process or fire case PSV fire is already installed
(7) Ambient temperature condition and/or sun radiation may lead to prevailing pressure exceeding piping design pressure
(8) Possible exposed to fire if more than 10% of external surface area engulfed in pool fire or submitted to jet fire likely to last more than 3 minutes

PSV– SIZING METHODOLOGY

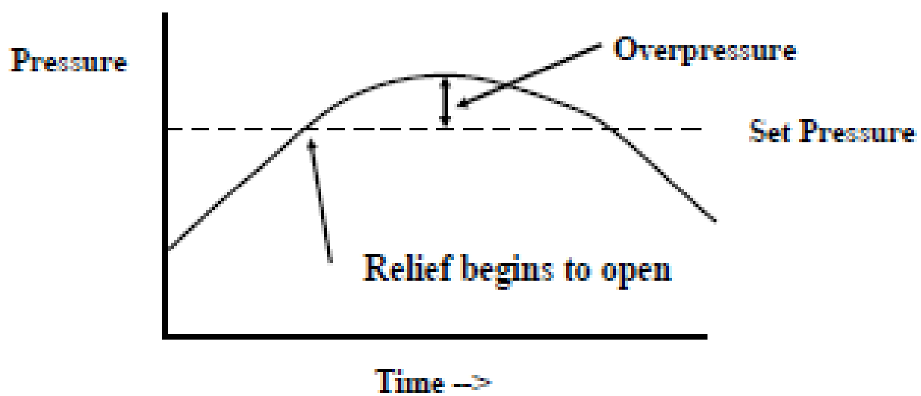


STEP 2 - PSV SET PRESSURE

- **API Standard 520 Edition 2008 Part I**

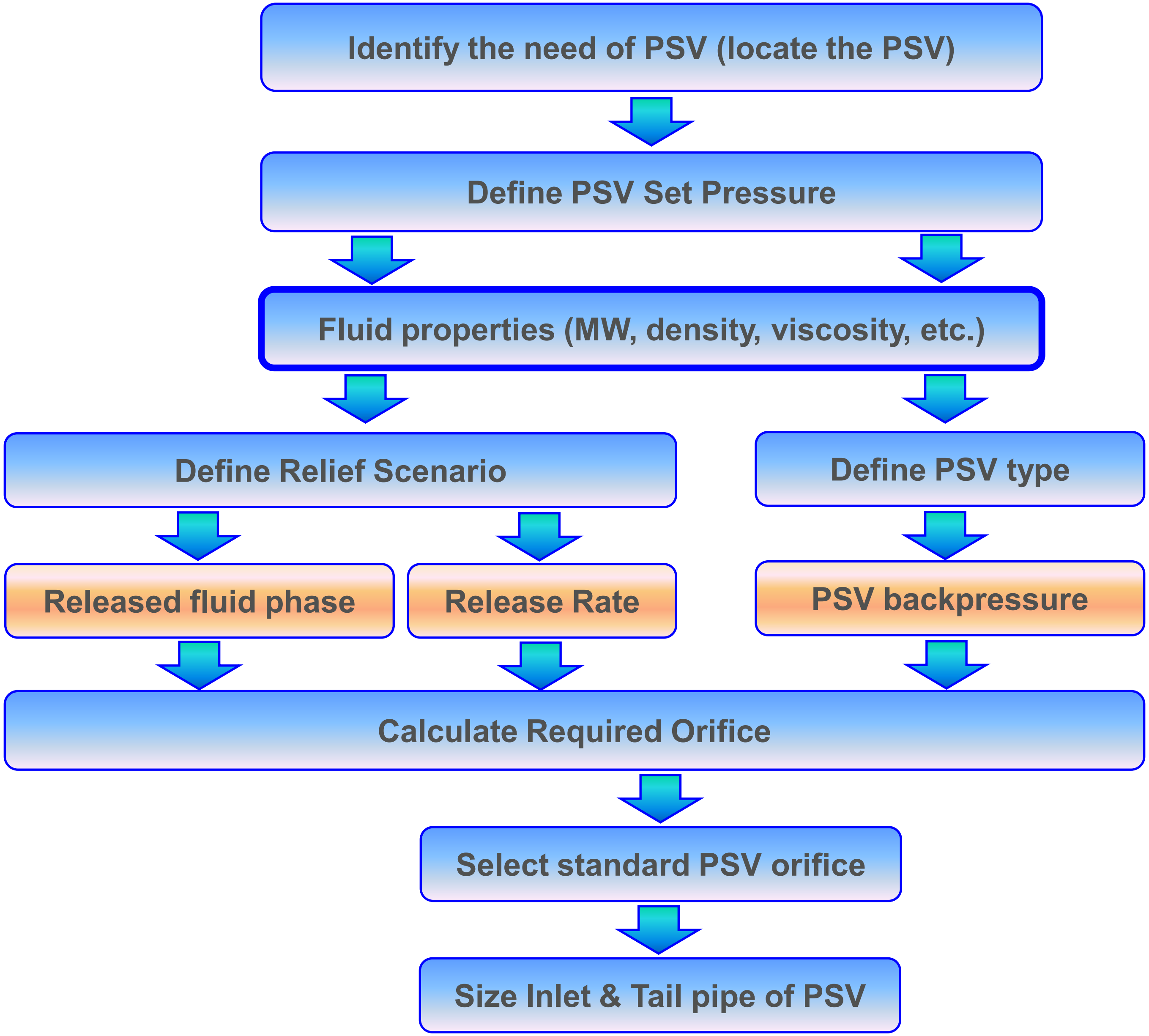


- **Rules of thumb**
  - **PSV set point = P_{design} and/or MAWP**
  - **PSV opening : $\pm$ 3%**
  - **PSV closing : $\pm$ 5%**



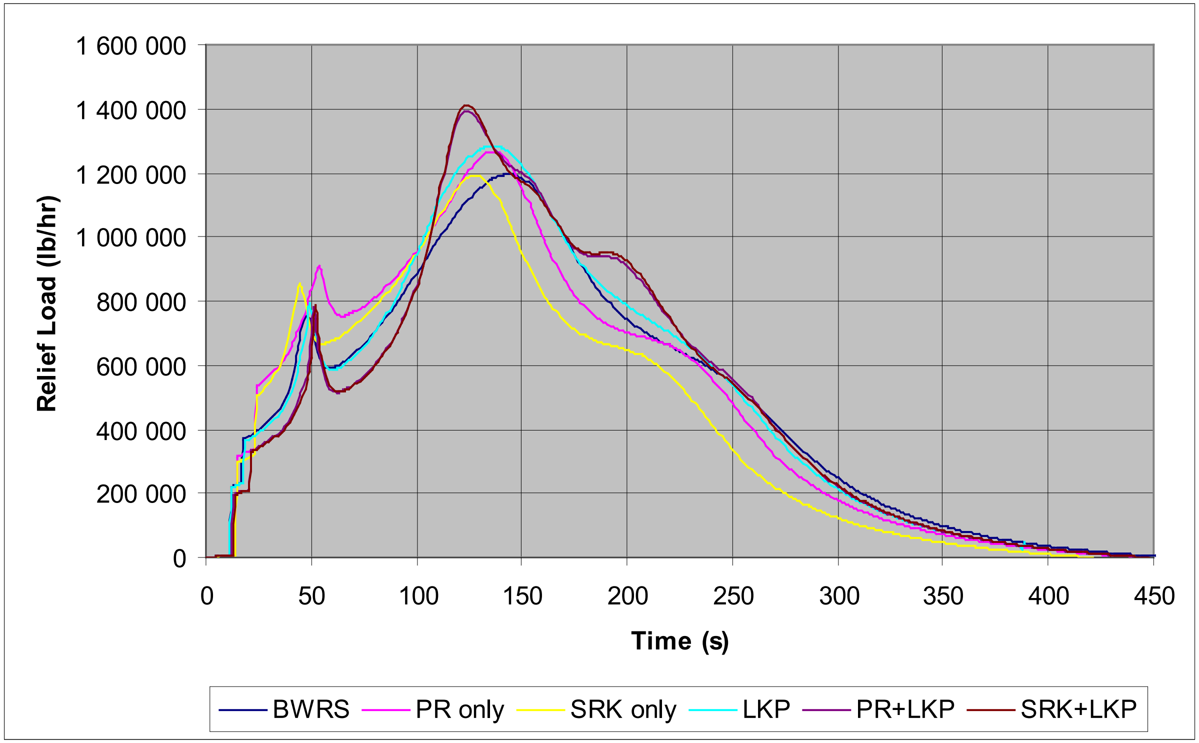
Contingency	Single Device Installations		Multiple Device Installations	
	Maximum Set Pressure %	Maximum Accumulated Pressure %	Maximum Set Pressure %	Maximum Accumulated Pressure %
Non-fire Case				
First relief device	100	110	100	116
Additional device(s)	—	—	105	116
Fire Case				
First relief device	100	121	100	121
Additional device(s)	—	—	105	121
Supplemental device	—	—	110	121
NOTE All values are percentages of the maximum allowable working pressure.				

PSV– SIZING METHODOLOGY



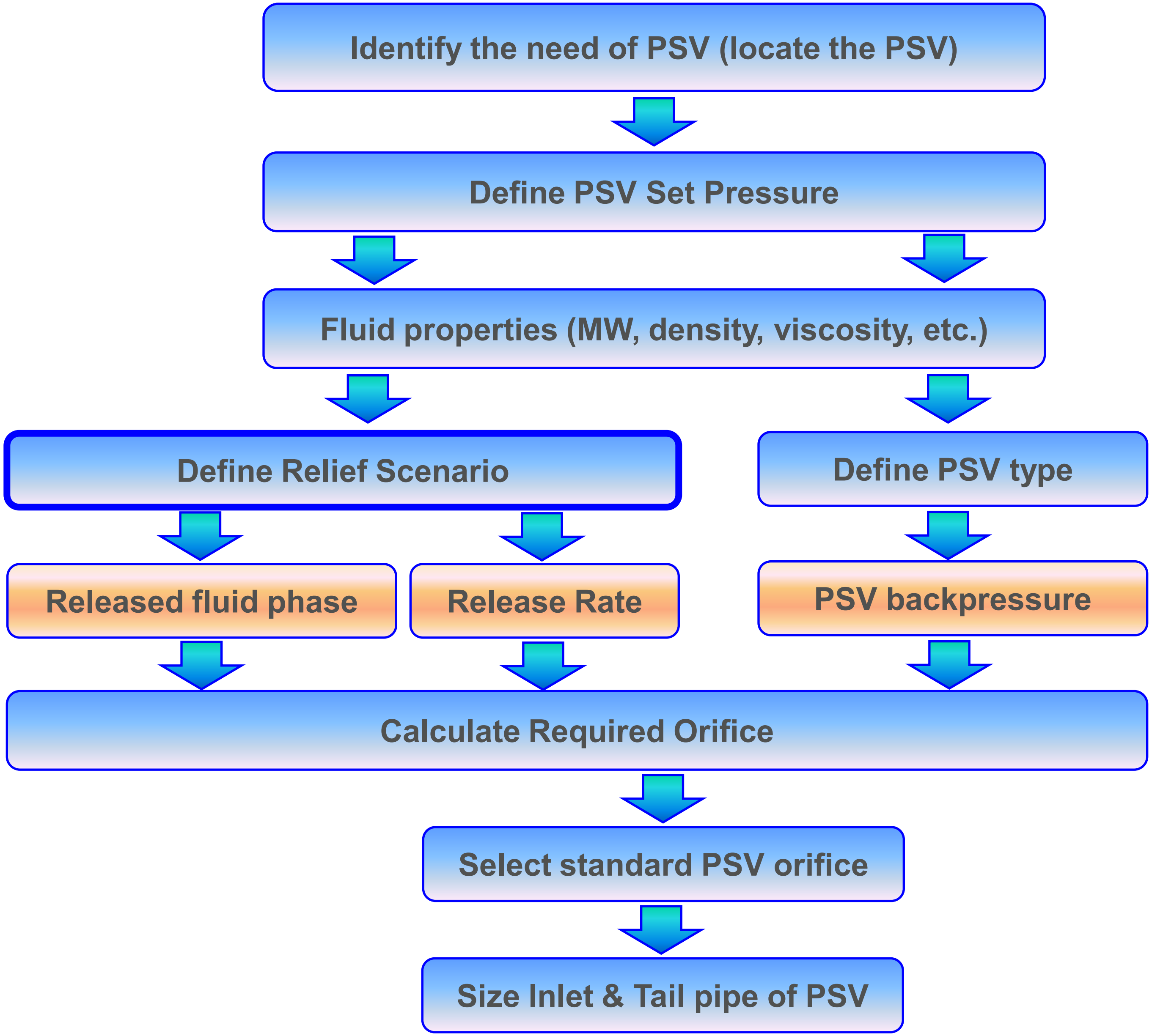
STEP 3 – GENERATION OF FLUID PROPERTIES

- **For PP loop reactors studies, we compared a range of different thermodynamic models**
- **Relief time profiles**



- **Large differences can be observed**
- **As usual, “garbage in, garbage out”**

PSV– SIZING METHODOLOGY



STEP 4A – RELIEF SCENARIO (1/6)

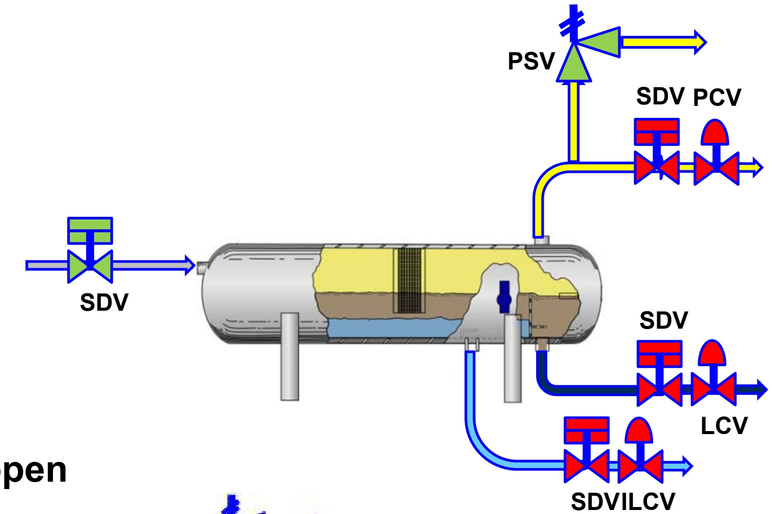
- **Identification of scenarios is a typical responsibility of HAZOP teams**

- **Process PSV**
  - **Blocked Outlet Case**

    - Outlet valves are closed & inlet valve remain open

    - Mass release rate = mass inlet rate

    - Released phase = inlet fluid phase



  - **Gas Blow-by**

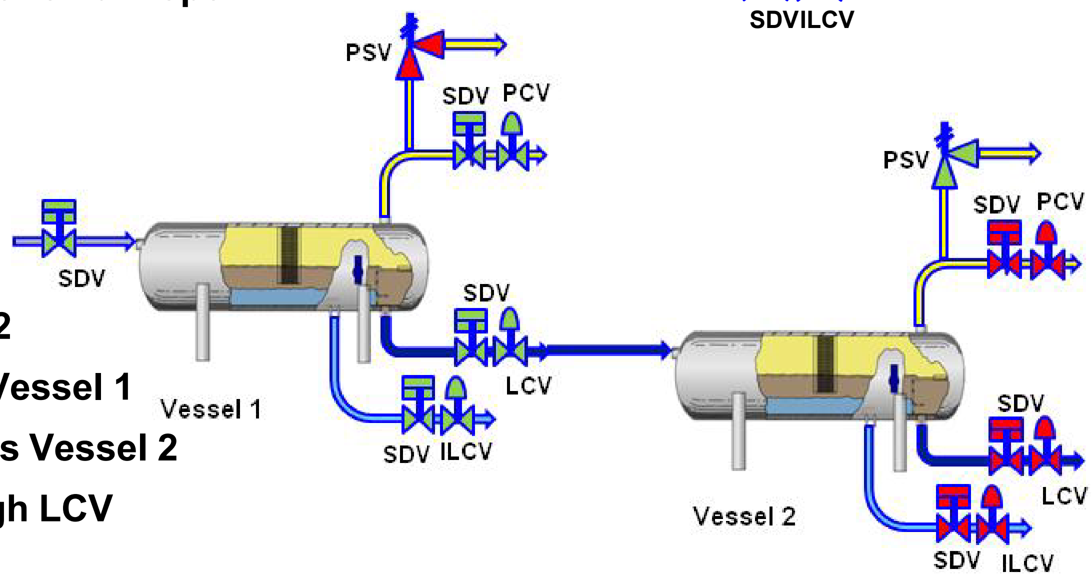
    - Pdesign Vessel 1 > Pdesign Vessel 2

    - Fail detection/action of low level in Vessel 1

    - Gas blows by to and overpressurizes Vessel 2

    - Mass release rate = Max Rate through LCV
    (considering P upstream = PSHH
    & P downstream = PSV vessel 2)

    - Released phase = gas phase



TOTAL

STEP 4A - RELIEF SCENARIO (2/6)

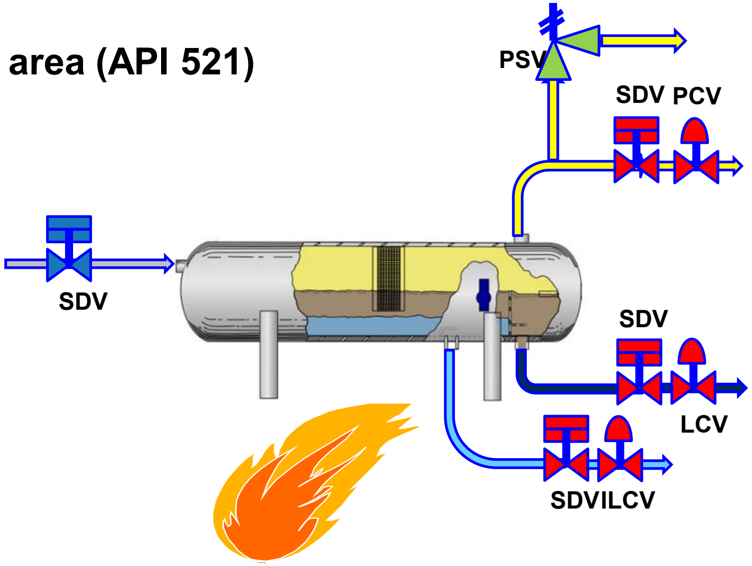
Fire Case PSV

Gas Expansion – vessel/piping without liquid

- Vessel/piping is isolated and exposed to fire
- Pressure increase due to gas expansion (PV = zRT)
- Released phase = gas phase
- Mass release is not determined ➔ directly orifice area (API 521)

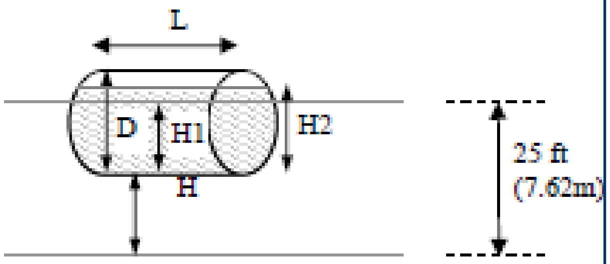
Liquid Vaporization – vessel with liquid

- Vessel/piping is isolated and exposed to fire
- vaporization of liquid and then gas expansion
- Released phase = gas phase
- Mass release:
  - calculate heat absorption
  - calculate max. release:
    - single component/below critical
      ➔ use of latent heat
    - multi-components
      ➔ use of rigorous method



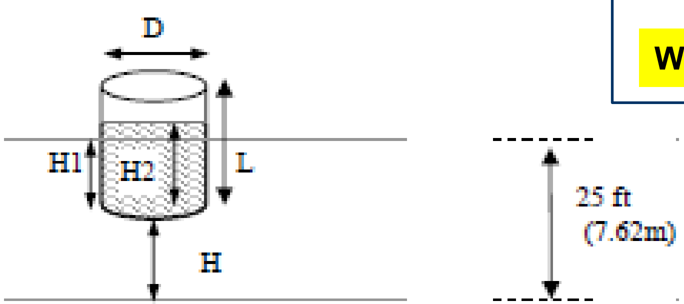
STEP 4A - RELIEF SCENARIO (3/6)

- **Fire Case PSV : Wetted Area**
  - **Horizontal Vessel**



$H1 = 7.62 - H$

  - **Vertical Vessel**



$H1 = 7.62 - H$

$$Q = C_1 \cdot F \cdot A_{ws}^{0,82}$$

where

Q is the total heat absorption (input) to the wetted surface, expressed in W (Btu/h);

C_1 is a constant [= 43 200 in SI units (21 000 in USC units)];

F is an environment factor (see Table 6);

A_{ws} is the total wetted surface, expressed in square metres (square feet).

Where adequate drainage and firefighting equipment do not exist,

$$Q = C_2 \cdot F \cdot A_{ws}^{0,82}$$

where C_2 is a constant [= 70 900 in SI units (34 500 in USC units)]

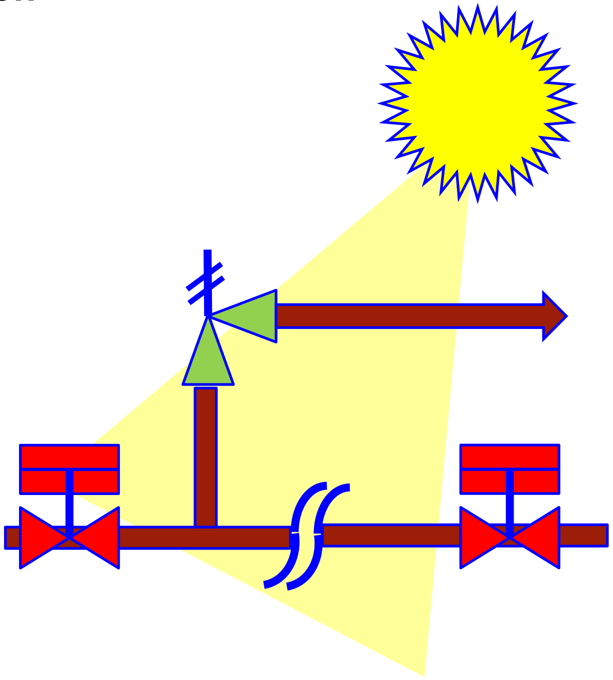
Wetted Area = wetted by fluid & ≤ 7.6m (25 ft) above source of flame

Fire Case PSV : Environment Factor F

Type of equipment		Environment factor [a] F
Bare vessel		1,0 [c]
Insulated vessel [b], with insulation conductance values for fire exposure conditions in W/m²·K (Btu/h·ft²·°F)	22,71 (4)	0,3
	11,36 (2)	0,15
	5,68 (1)	0,075
	3,80 (0,67)	0,05
	2,84 (0,5)	0,037 6
	2,27 (0,4)	0,03
	1,87 (0,33)	0,026
Water-application facilities, on bare vessel [c]		1,0 [e]
Depressurizing and emptying facilities [d]		1,0 [e]
Earth-covered storage		0,03
Below-grade storage		0,00

STEP 4A - RELIEF SCENARIO (5/6)

- **TSV (Thermal Expansion)**
  - **Piping filled fully with liquid HC or liquified HC is isolated**
  - **It is exposed to ambient condition and/or solar radiation**
  - **Liquid expansion leads to overpressurize the piping**
  - **Released phase = liquid phase**



STEP 4A - RELIEF SCENARIO (6/6)

- **Other Scenarios (*Refer to ISO 23251 ex.API 521) on case by case basis***
  - **Tube Rupture in S&T Heat Exchanger**

    Shell Design Pressure < 2/3 MOP of Tube.
  - **Check Valve Failure**

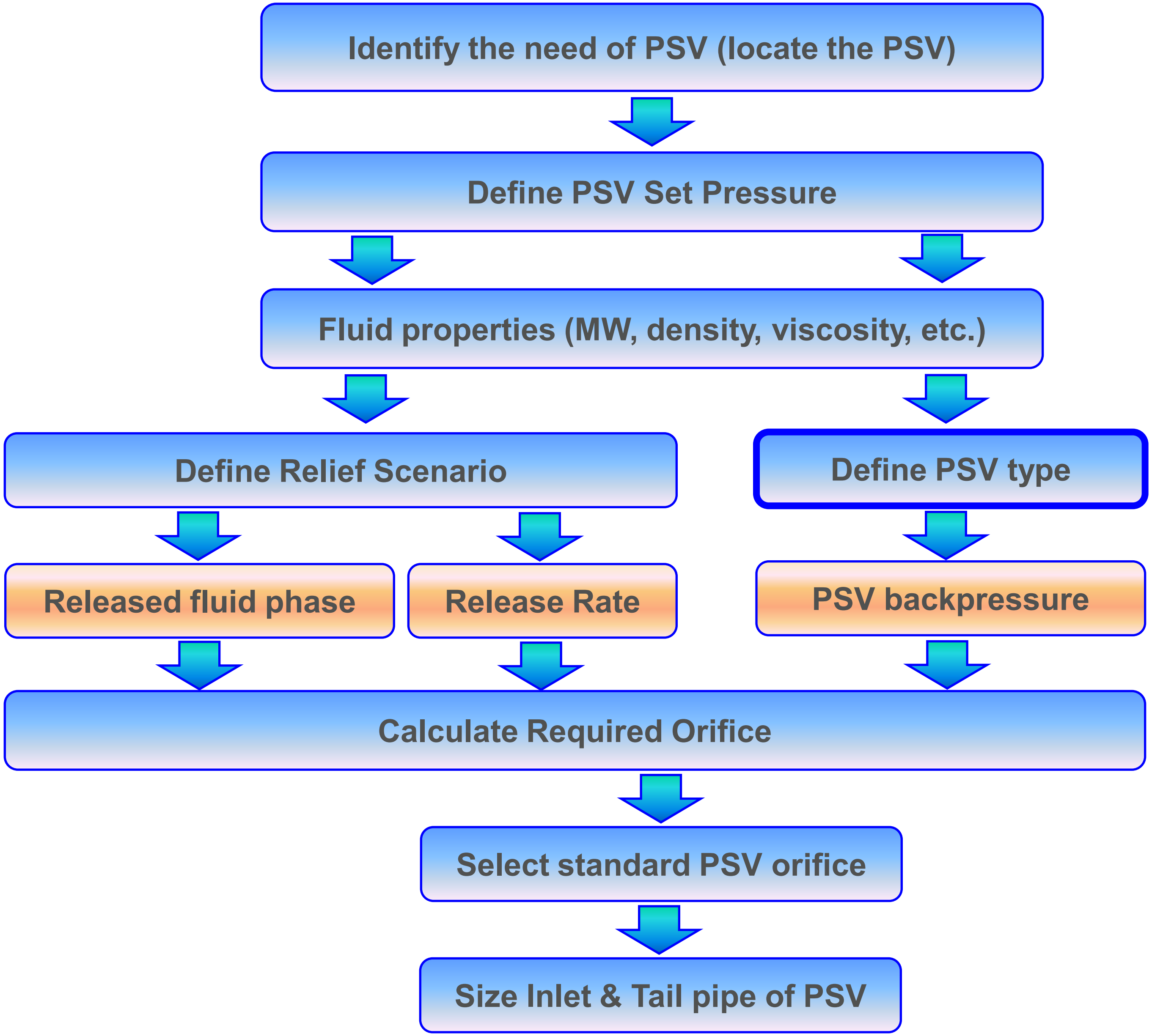
    Two check valves (not similar type) ➔ consider orifice of 1/10 of bigger nominal check valve flow diameter
  - **Loss of cooling or reflux failure(e.g. power loss of pump)**

    It may need dynamic simulation to defined the release rate (typical for polymerization reactors)
  - **Absorbent flow failure**

    Dynamic simulation may be needed to defined the release rate
  - **Abnormal process heat Input**

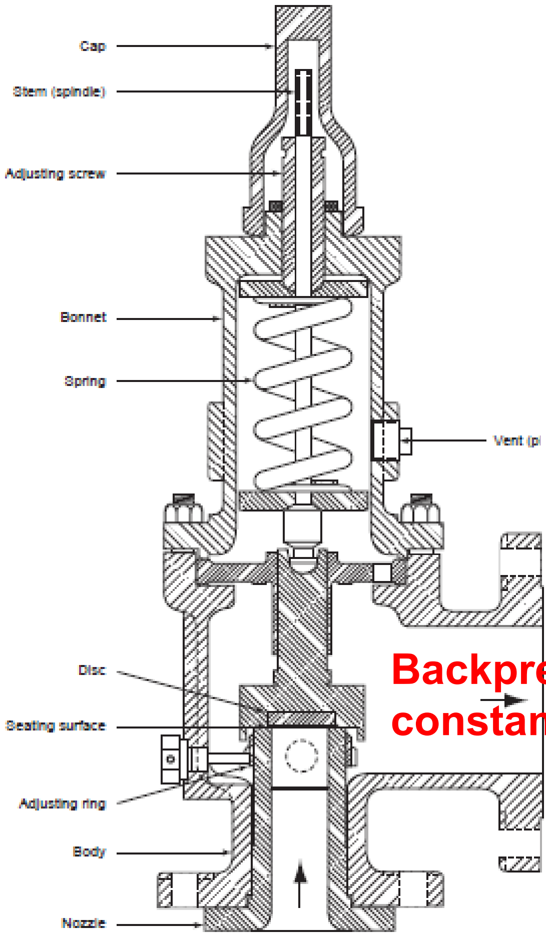
    It may need dynamic simulation to defined the release rate
  - **Etc…**

PSV– SIZING METHODOLOGY

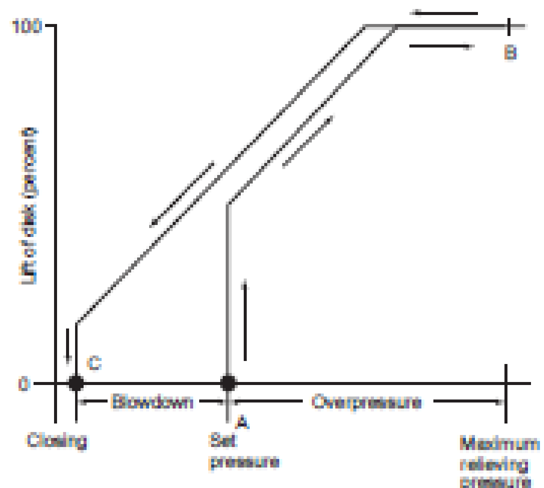


STEP 4B - PSV TYPE (1/4)

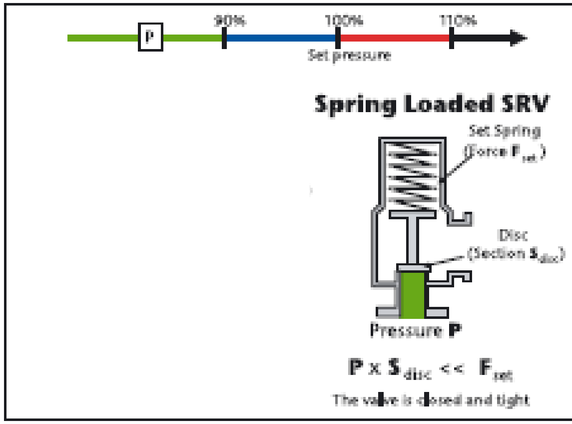
Conventional Spring Loaded PSV

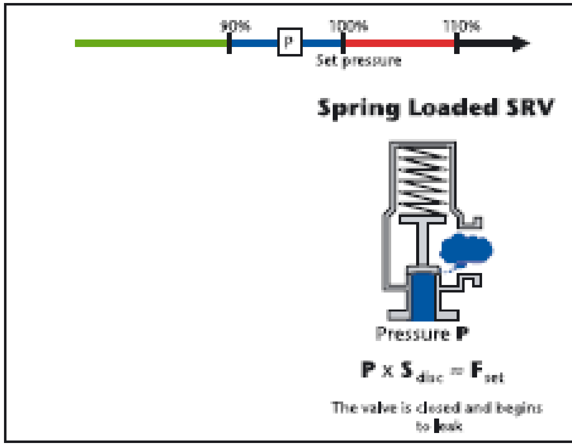


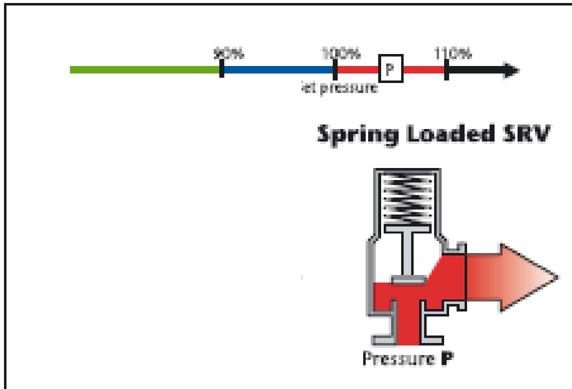
Backpressure : constant + dynamic



Closing typically at 93-97% of set pressure



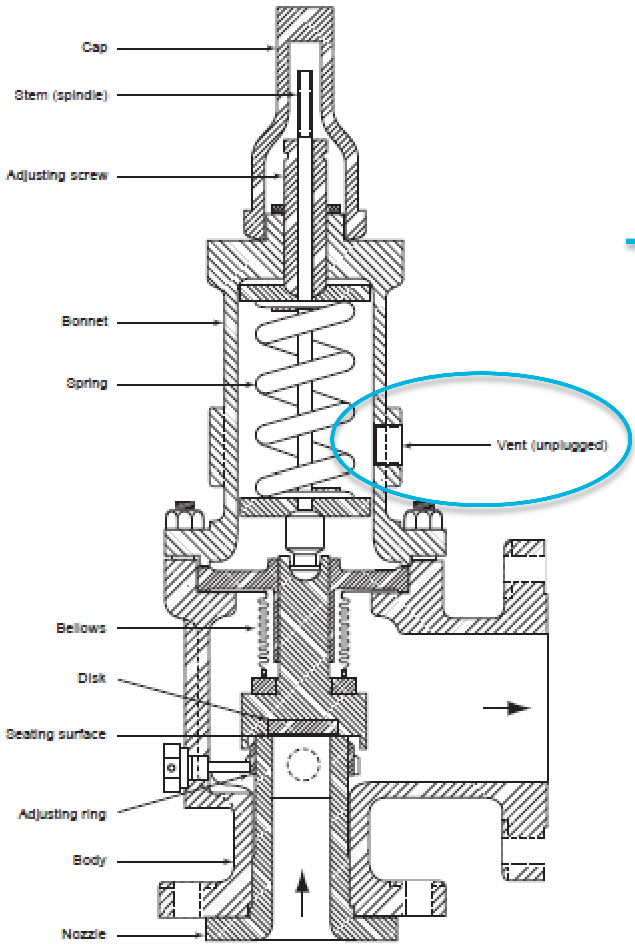




- Application : gas, liquid, multiphase (suitable for TSV)
- Max backpressure = 10% of PSV set pressure

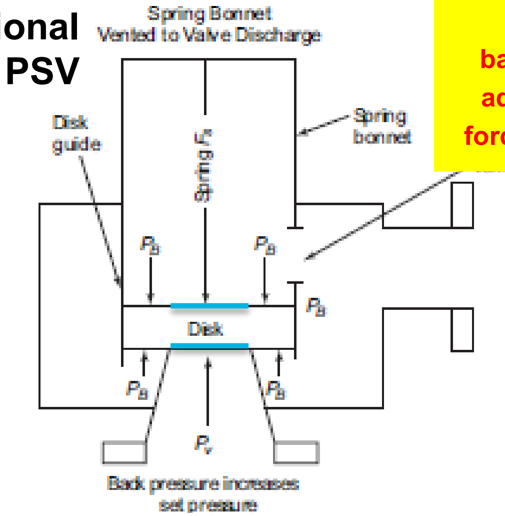
STEP 4B - PSV TYPE (2/4)

Balanced PSV

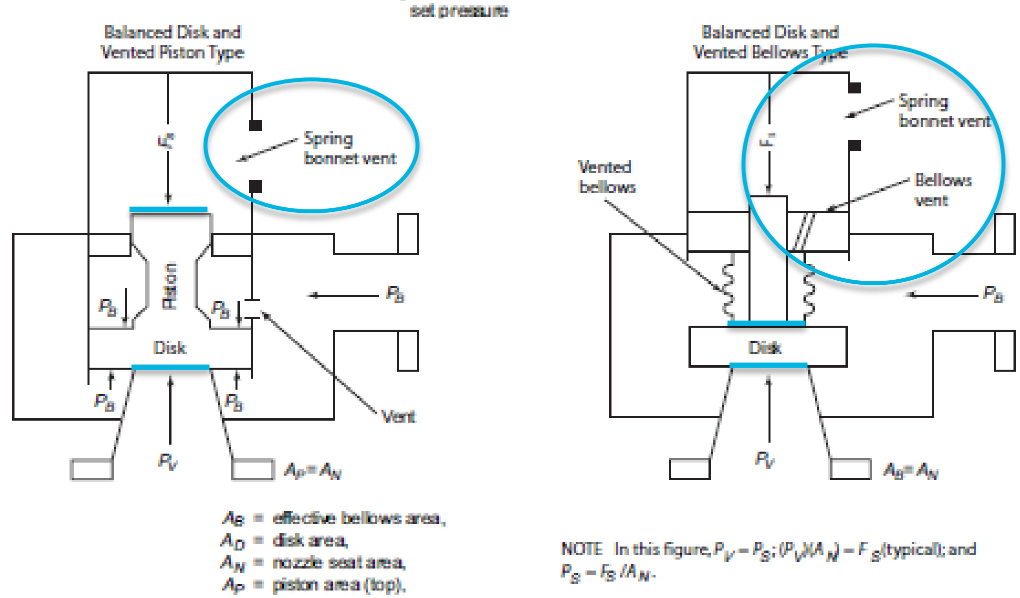


Equivalent areas

Conventional PSV



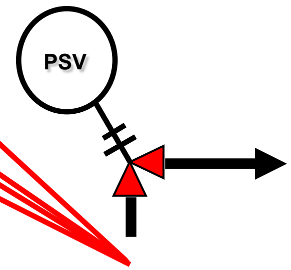
Superimposed backpressure gives additional pressure force to the valve disc



- **Application : gas, liquid, multiphase**
- **Reducing superimposed backpressure by additional balanced piston or balanced bellows**
- **Max backpressure = 10 - 50% of PSV set pressure**

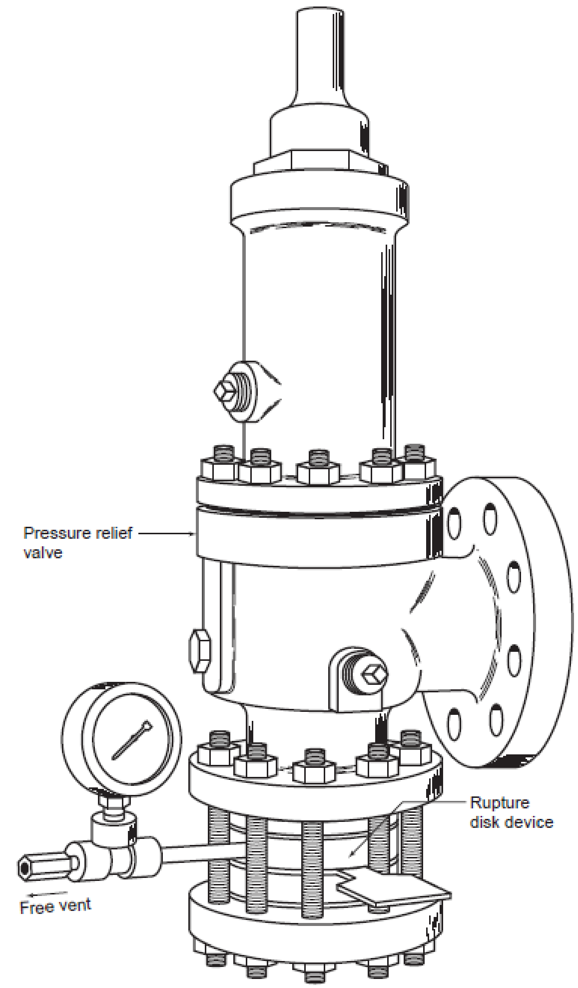
STEP 4B – PSV EXAMPLE (3/4)

- **FEMA flush-mounted models**

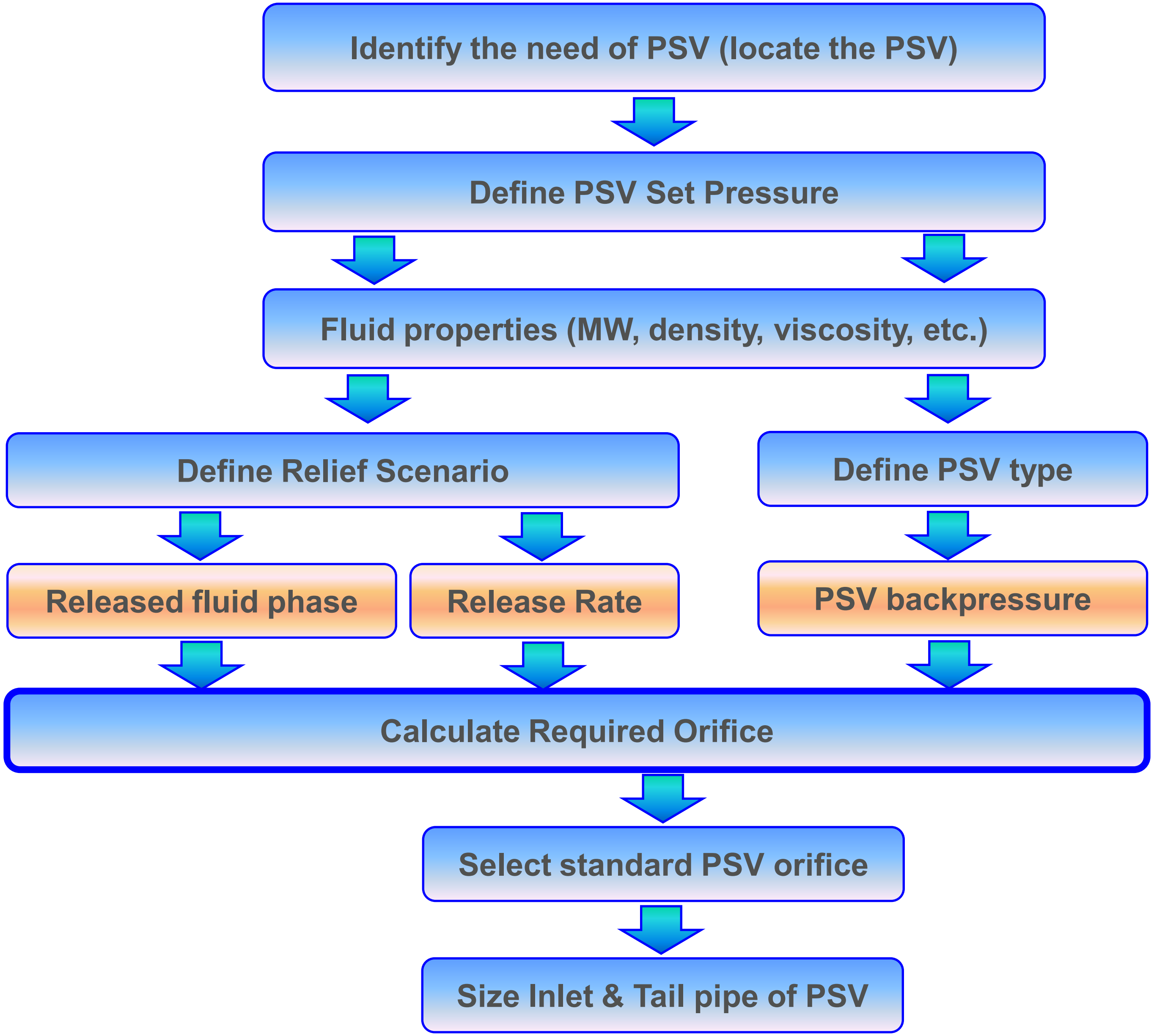


STEP 4B – RUPTURE DEVICES (4/4)

- **Can be used as standalone protection**
- **Once open, will not reset**
- **Can be used to protect PSV**
- **Subject to fatigue if operating pressure too close to set point – Depends on type / material**
- **Use PAH between flanges to check for status**



PSV– SIZING METHODOLOGY



TOTAL

STEP 5 - PSV ORIFICE CALCULATION (1/12)

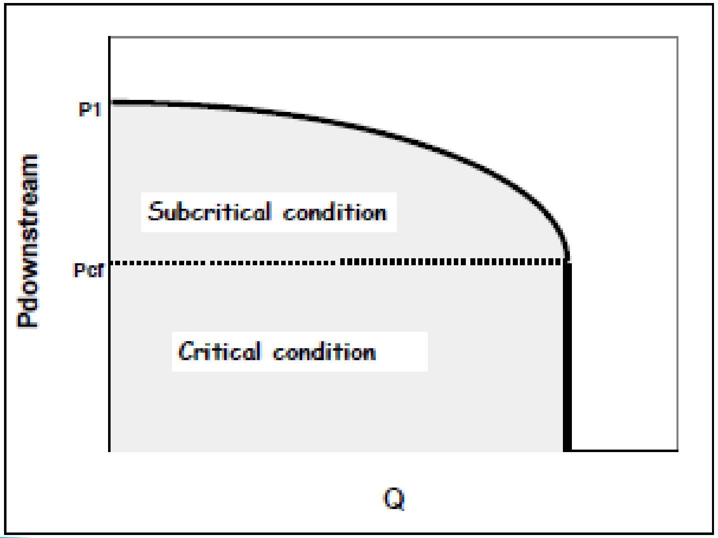
$$\boxed{\text{Orifice size} = \frac{\text{Max Relief}}{\text{Max Mass Velocity}} = \frac{W}{G}}$$

$$\boxed{G^2 = \left(v_n^{-2} \int_{p_0}^{P_n} -2v\,dP \right)_{\max}^{isentropic}}$$

$$\boxed{c^2 = \frac{\partial p}{\partial \rho}}$$

c = speed of sound

- Depending on the fluid nature, the maximum mass velocity G will be computed in various simplified ways



- Single Gas Phase
  - Critical & Sub-critical flow

$$\frac{P_{cf}}{P_1} = \left[\frac{2}{k+1}\right]^{\frac{k}{k-1}}$$

where

P_{cf} is the critical flow nozzle pressure;

P_1 is the upstream relieving pressure;

k is the ratio of specific heats (C_p/C_v) for an ideal gas at relieving temperature.

Used in place of the isentropic expansion coefficient.
Never to be estimated by Cp/Cv at relief pressure

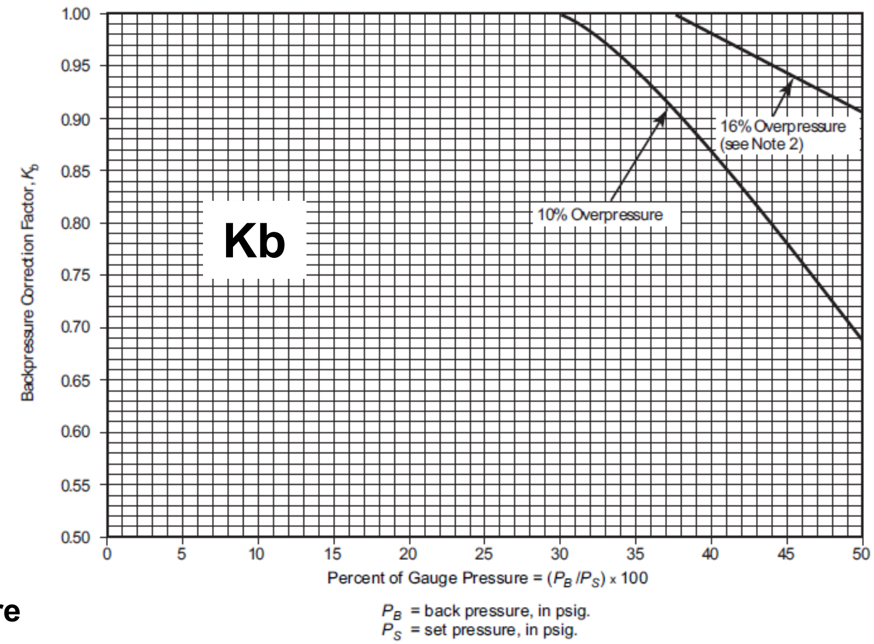
How do we know a priori that the flow is critical or sub-critical?

We don't, but we'll assume it is critical and check afterwards

STEP 5 - PSV ORIFICE CALCULATION (2/12)

- **Single Gas Phase**
  - **Orifice Area for Critical Flow**

$$A = \frac{W}{CK_dP_1K_bK_c}\sqrt{\frac{TZ}{M}} \qquad C = 0.03948\sqrt{k\left(\frac{2}{k+1}\right)^{\frac{(k+1)}{(k-1)}}}$$



A = orifice area (mm^2)

W = mass release rate (kg/hr)

k = specific heat ratio (Cp/Cv)

Kd = coefficient of discharge (0.975 default value)

Kb = capacity correction factor due to backpressure

(Kb = 1 for conventional PSV**, see graph for balanced PSV)

Kc = correction factor combination of PSV and rupture disk

(Kc = 1 if PSV only, 0.9 if installed in combination with rupture disk)

M = molecular weight (kg/kmol)

T = relieving temperature (K)

Z = compressibility factor

P1 = (set pressure + allowable overpressure)$_g$ + 1 atm (kPa)

110% of design pressure for process PSV if 1 PSV installed

116% & 110% for lowest & highest process PSV set pressure respectively if multiple PSV are installed

121% for fire case PSV

** Such PSVs should not be used if backpressure exceeds 10%

STEP 5 - PSV ORIFICE CALCULATION (3/12)

- **Single Gas Phase**
  - **Orifice Area for Sub-Critical Flow (Conventional & Pilot PSV)**

$$A = \frac{17.9 \times W}{F_2 K_d K_c} \sqrt{\frac{ZT}{M \times \underline{P_1(P_1 - P_2)}}}$$

$$F_2 = \sqrt{\left(\frac{k}{k-1}\right) r^{\left(\frac{2}{k}\right)} \left[\frac{1 - r^{\left(\frac{k-1}{k}\right)}}{1 - r}\right]}$$

A = orifice area (mm^2)

W = mass release rate (kg/hr)

k = specific heat ratio (Cp/Cv)

Kd = coefficient of discharge (0.975 default value)

Kc = correction factor combination of PSV and rupture disk

(Kc = 1 if PSV only, 0.9 if installed in combination with rupture disk)

M = molecular weight (kg/kmol)

T = relieving temperature (K)

Z = compressibility factor

P1 = (set pressure + allowable overpressure)$_g$ + 1 atm (kPa)

110% of design pressure for process PSV if1 PSV installed)

116% & 110% for lowest & highest process PSV set press respectively fi multiple PSV is installed

121% for lowest fire case PSV

P2 = downstream pressure (kPa)

r = P2 / P1

For balanced PSV ➔ use critical flow equation with Kb for sub-critical flow (obtained from manufacturer)

STEP 5 - PSV ORIFICE CALCULATION (4/12)

- **Single Liquid Phase**
  - **Orifice Area**

$$A = \frac{11.78 \times Q}{K_d K_w K_c K_v}\sqrt{\frac{G_l}{P_1 - P_2}} \qquad K_v = \left(0.9935 + \frac{2.878}{Re^{0.5}} + \frac{342.75}{Re^{1.5}}\right)^{-1.0}$$

A = orifice area (mm^2)

Q = volume release rate (liter/min)

Kd = coefficient of discharge (0.65 default value)

Kw = capacity correction factor due to backpressure

(Kb = 1 for conventional PSV, see graph for balanced PSV)

Kc = correction factor for combination of PSV and rupture disk

(Kc = 1 if PSV only, 0.9 if rupture disk is also installed)

Kv = 1 for non viscous fluid (refer to graph)

P1 = set pressure + allowable overpressure (kPag)

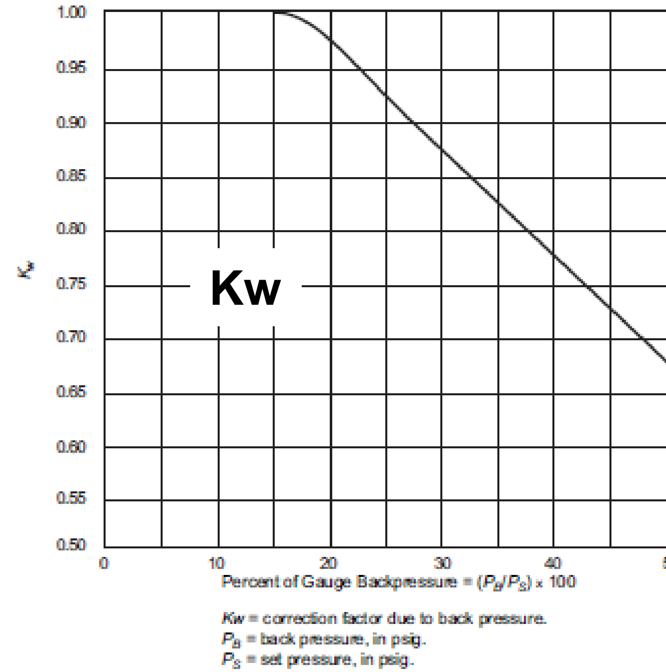
110% of design pressure for process PSV if 1 PSV installed)

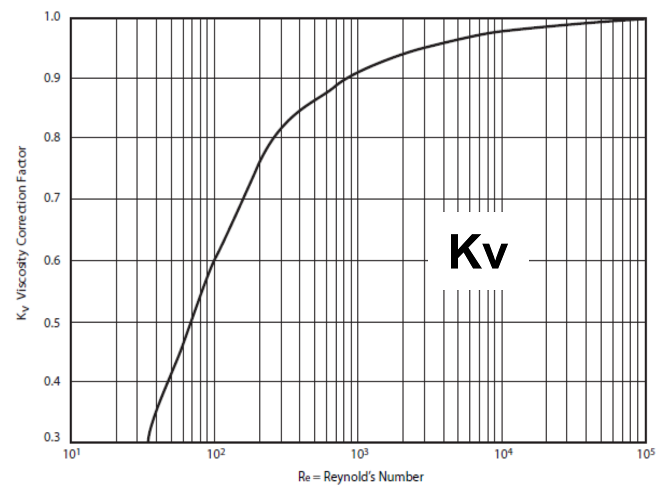
116% & 110% for -lowest & highest process PSV set press respectively if multiple PSV are installed.

P2 = downstream pressure (kPag)

For viscous fluid ➔ determine 1st by using non viscous fluid to obtain A then recalculate Re and required A (iteration)

$$Re = \frac{Q(18{,}800 \times G_l)}{\mu\sqrt{A}}$$





STEP 5 - PSV ORIFICE CALCULATION (5/12)

- **Two Phase**
  - **API 520 edition 1993**

    Total Area = Area Gas + Area Liquid (based on volume fractions)

  - **API 520 edition 2008**

    Leung Omega Method (HEM from DIERS)
    (*Homogeneous Equilibrium Method /* Design Institute for Emergency Relief Systems)

PP
and
PE
loop
reactors

Table C.1—Two-phase Liquid/Vapor Relief Scenarios for PRVs

Two-phase Liquid/Vapor Relief Scenario	Example	Section
Two-phase system (liquid vapor mixtures, including saturated liquid) enters PRV and flashes. No non-condensable [a] gas present. Also includes fluids both above and below the thermodynamic critical point in condensing two-phase flow.	Saturated liquid/vapor propane system enters PRV and the liquid propane flashes.	C.2.1 or C.2.2
Two-phase system (highly subcooled [b] liquid and either non-condensable gas, condensable vapor or both) enters PRV and does not flash.	Highly subcooled propane and nitrogen enters PRV and the propane does not flash.	C.2.1 or C.2.2
Two-phase system (the vapor at the inlet contains some non-condensable gas and the liquid is either saturated or subcooled) enters PRV and flashes. Non-condensable gas enters PRV.	Saturated liquid/vapor propane system and nitrogen enters PRV and the liquid propane flashes.	C.2.1 or C.2.2
Subcooled liquid (including saturated liquid) enters PRV and flashes. No condensable vapor or non-condensable gas enters PRV.	Subcooled propane enters PRV and flashes.	C.2.1 or C.2.3

[a] A noncondensable gas is a gas that is not easily condensed under normal process conditions. Common noncondensable gases include air, oxygen, nitrogen, hydrogen, carbon dioxide, carbon monoxide and hydrogen sulfide.
[b] The term highly subcooled is used to reinforce that the liquid does not flash passing through the PRV.

STEP 5 - PSV ORIFICE CALCULATION (6/12)

Two Phase – Leung Omega Method (Two Phase at Inlet)

Step 1 – Determine Omega

$$\omega = \frac{\frac{\rho_o}{\rho_x} - 1}{\frac{P_o}{P_x} - 1} = \frac{\frac{v_x}{v_o} - 1}{\frac{P_o}{P_x} - 1}$$

where

P is the pressure from the flash calculation (absolute);

ρ is the overall two-phase density from the flash calculation;

v is the overall two-phase specific volume from the flash calculation;

o is the initial condition (e.g. PRV inlet condition) for the flash;

x is the flash result at one lower pressure.

In most case , flash at 90% of PSV inlet pressure provides a reasonable correlation parameter; therefore :

$$\omega = 9\left(\frac{v_9}{v_o} - 1\right)$$

v_9 is the specific volume evaluated at 90 % of the PRV inlet pressure, P_o in m3/kg when determining v_9, the flash calculation should be carried out isentropically, but an isenthalpic (adiabatic) flash is sufficient for low-quality mixtures far from the thermodynamic critical point.

v_o is the specific volume of the two-phase system at the PRV inlet, m3/kg

Two Phase – Leung Omega Method

Step 2 – Determine the Flow : Critical or Sub-critical

$P_c \geq P_a \Rightarrow$ critical flow

$P_c < P_a \Rightarrow$ subcritical flow

where

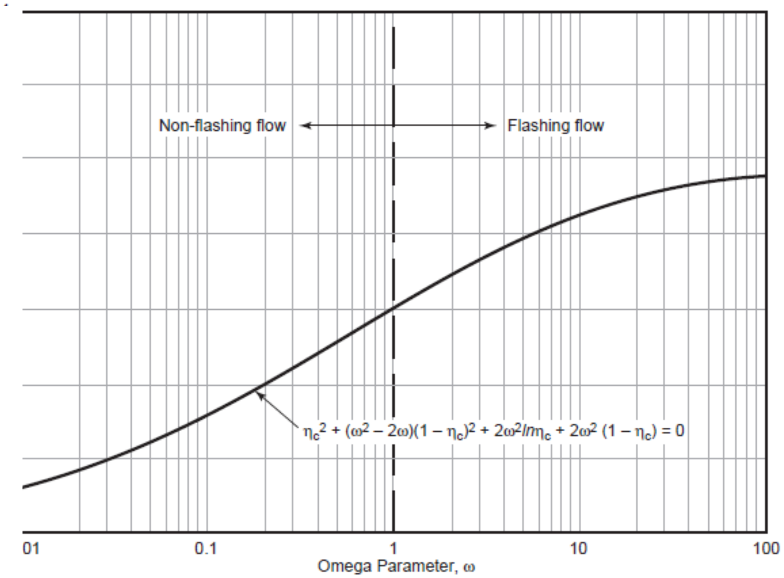
P_c is the critical pressure, psia (Pa);

$P_c = \eta_c P_o$

where

η_c is the critical pressure ratio from Figure C.1.

NOTE This ratio can also be obtained from the following expression:



$$\eta_c^2 + (\omega^2 - 2\omega)(1-\eta_c)^2 + 2\omega^2 \ln \eta_c + 2\omega^2(1-\eta_c) = 0$$

P_o is the pressure at the PRV inlet (psia or Pa); this is the PRV set pressure (psig or Pag) plus the allowable overpressure (psi or Pa) plus atmospheric pressure.;

P_a is the downstream backpressure (psia or Pa).

- **Two Phase – Leung Omega Method**
  - **Step 3 – Determine Mass Flux**

$$G = \eta_c \sqrt{\frac{P_o}{v_o \omega}}$$

Critical Flow

$$G = \frac{\{-2 \times [\omega \ln \eta_a + (\omega - 1)(1 - \eta_a)]\}^{1/2}}{\omega\left(\frac{1}{\eta_a} - 1\right) + 1} \sqrt{P_o / v_o}$$

Sub-Critical Flow

where

G is the mass flux, lb/s·ft^2 (kg/s·m^2);

P_o is the pressure at the PRV inlet in psia (Pa);

v_o is the specific volume of the two-phase system at the PRV inlet in ft^3/lb (m^3/kg);

η_a is the backpressure ratio, $\eta_a = \frac{P_a}{P_o}$.

- **Two Phase – Leung Omega Method**
  - **Step 4 – Determine Orifice Area**

$$A = \frac{277.8\,W}{K_d K_b K_c K_v G}$$

where

A is the required effective discharge area, in.^{2} (mm^2);

W is the mass flow rate, lb/h (kg/h);

K_d is the discharge coefficient. For a preliminary sizing estimation, a discharge coefficient of 0.85 can be used;

K_b is the backpressure correction factor for vapor that should be obtained from the valve manufacturer; for a preliminary sizing estimation, use Figure 30. The backpressure correction factor applies to balanced-bellows valves only;

K_c is the combination correction factor for installations with a rupture disk upstream of the PRV (see 5.11.2);

— the combination correction factor is 1.0, when a rupture disk is not installed;

— the combination correction factor is 0.9, when a rupture disk is installed in combination with a PRV and the combination does not have a certified value.

K_v is the viscosity correction factor.

STEP 5 - PSV ORIFICE CALCULATION (10/12)

Gas Expansion – Fire Case

$$A = \frac{F' \cdot A'}{\sqrt{P_1}} \qquad F' = \frac{0{,}1406}{C \cdot K_D}\left[\frac{(T_W - T_1)^{1{,}25}}{T_1^{0{,}6506}}\right] \qquad C = 520\sqrt{k\left(\frac{2}{k+1}\right)^{\frac{k+1}{k-1}}}$$

A = orifice area (inch2)

Kd = coefficient of discharge (0.975 default value)

k = specific heat ratio (Cp/Cv)

T1 = gas temperature at relieving pressure (°R)

Tw = maximum wall temperature of vessel material (°R) ! (Carbon steel: 1100 °R / 593°C)

P1 = upstream relieving pressure (psia)

F' = 0.01 as minimum if calculated value < 0.01; if no data available for calculation then F = 0.045 to be used

A = exposed surface area of vessel

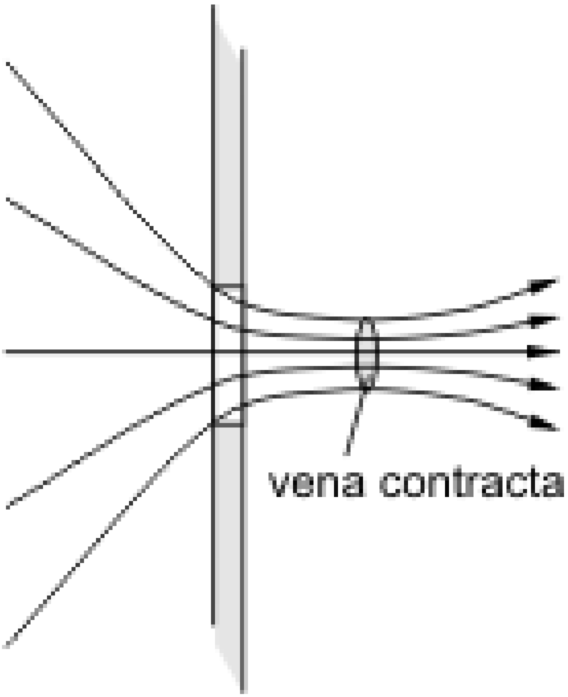
Exposed Area = non-wetted by fluid & ≤ 7.6m (25 ft) above source of flame

Liquid Vaporization – Fire Case

- Use Orifice area calculation for Process PSV - Single Gas
  Heat input Q computed as presented earlier and relief flow rate computed as $W = Q/\Delta H_{vap}$
- The latent heat used in calculating the rate of vaporization should pertain to the conditions that are capable of generating the maximum vapour rate.

STEP 5 – VALUE OF THE DISCHARGE COEFFICIENT (11/12)

- **API statement for Kd with the HEM method**
  - **Defined as the ratio of effective mass flow / ideal orifice mass flow**
  - **Kd defined as vena contracta area ÷ orifice area**
  - **0.975 for gas phase**
  - **0.85 for two phase or saturated liquids & 0.65 for liquid**
  - **It also states : « The user may select other methods… »**



STEP 5 - PSV DATA SHEET (12/12)

To be filled by Process Engineer

GENERAL	1	Tag No.	P&ID No.	SGP-PSV -11025-B		SGP-GEN-11-B-PI-203505-002	
	2	Service		VP1102 PIG LAUNCHER RECEIVER PRESSURE RELIEF			
	3	Line No.	Vessel No.	4"-HG-SGP11-0185-J23			
	4	Safety/ Relief Valve		Safety Valve			
	5	Type : Conventional, Bellow, Pilot Operated		Conventional			
PROCESS DATA	6	Process Fluid	Fluid State	Hydrocarbon		Gas/Vapor	
	7	Design Press. Min/Max	Design Temp. Min/Max	350	bar-g	-46 75	°C
	8	Operating Pressure	Set Pressure	11.7	bar-g	350	bar-g
	9	Operating Temperature	Relieving Temperature	-7	°C	276	°C
	10	Back Pressure	Constant	0.01		bar-g	
	11		Variable	1.2		bar-g	
	12		Total	1.21			
	13	Required Relieving Capacity		32288		kg/h	
	14	Density - Liquid				kg/m³	
	15	Molecular Weight - Gas		76.37			
	16	Compressibility Factor		1.32			
	17	Viscosity		0.11		cP	
	18	Specific Heats Ratio		1.04			
	19	Latent Heat of Vaporization		115		kJ/kg	
	20	Maximum Allowable Accumulation		21		% of MAWP	
	21	Blow Down		5-7%			
	22	Vessel Wall Temp.	Vessel Surface Area		°C		in²
BASIS AND SELECTION	23	Design Code	Vessel Design Code	API-526		ASME SEC VIII, DIV 1	
	24	Sizing Basis	Sizing Case	API-520		Fire Case	
	25	Calculated Area		0.163		in²	
	26	Selected Area		0.2214		in²	
	27	Orifice Designation		E			
	28	Valve Rated Capacity		41223.002		kg/h	
	29	Cold Set Pressure		349.99		bar-g	
	30	Reaction Force		5752.9 N			
BODY AND TRIM	31	Nozzle Type: Full/Semi		Full			
	32	Valve Size: Inlet/ Outlet		1.5"		3"	
	33	Flange Type, Rating, Facing & Finish Inlet/Outlet		2500#, RJ, 63 AARH		300#, RF, 125 - 250 AARH	
	34	Bonnet Type		Closed, Bolted			
	35	Body & Bonnet Material		SA351-CF8M			
	36	Nozzle Material	Nozzle Ring Material	316 SST		316 SST	
	37	Disc Material	Disc Holder Material	316 SST		316 SST	
	38	Guide Material		SS A297-HE			
	39	Spring Material		Inconel X750			
	40	Set Screw Material	Spindle Material	316 SST		316 SST	
	41	Bellows Material		-			
	42	Pilot Material	Tubing Material	-		-	
	43	Gasket Material	Seal Material	316 SST		-	
	44	Studbolt / Nut Material		A193 B8M Class 2/ A194 8MA			
	45	Leakage Class	Sound Lvl.	As per API 527		122	dB
	46	NACE Compliance		N/A			
ACCESSORIES	47	Cap: Screwed or Bolted		Bolted			
	48	Lever: Plain or Packed		No			
	49	Test Gag		No			
	50	Field Test Connection	Back Flow Preventer	-		-	
PURCHASE	51	Manufacturer		CROSBY			
	52	Model		JOS-E-75-S-L/SPL			
	53	Purchase Order No.		92005030046			

Notes: 1. Design condition on HP flare is 11.1 barg /FV and 200/-108 Deg C.
2. Maximum HP Flare back pressure expected during governing case is 9 barg.

No.	By	Date	Revision
C05	LBR	1/31/2012	Issued for Construction
A04	PBS	11/15/2011	Re-issued for approval
A03	RJS	9/20/2011	Issued for Approval
R02	RJS	7/20/2011	Re-issued for Review
R01	RJS	4/28/2011	Issued for Review

INSTRUMENT DATASHEET

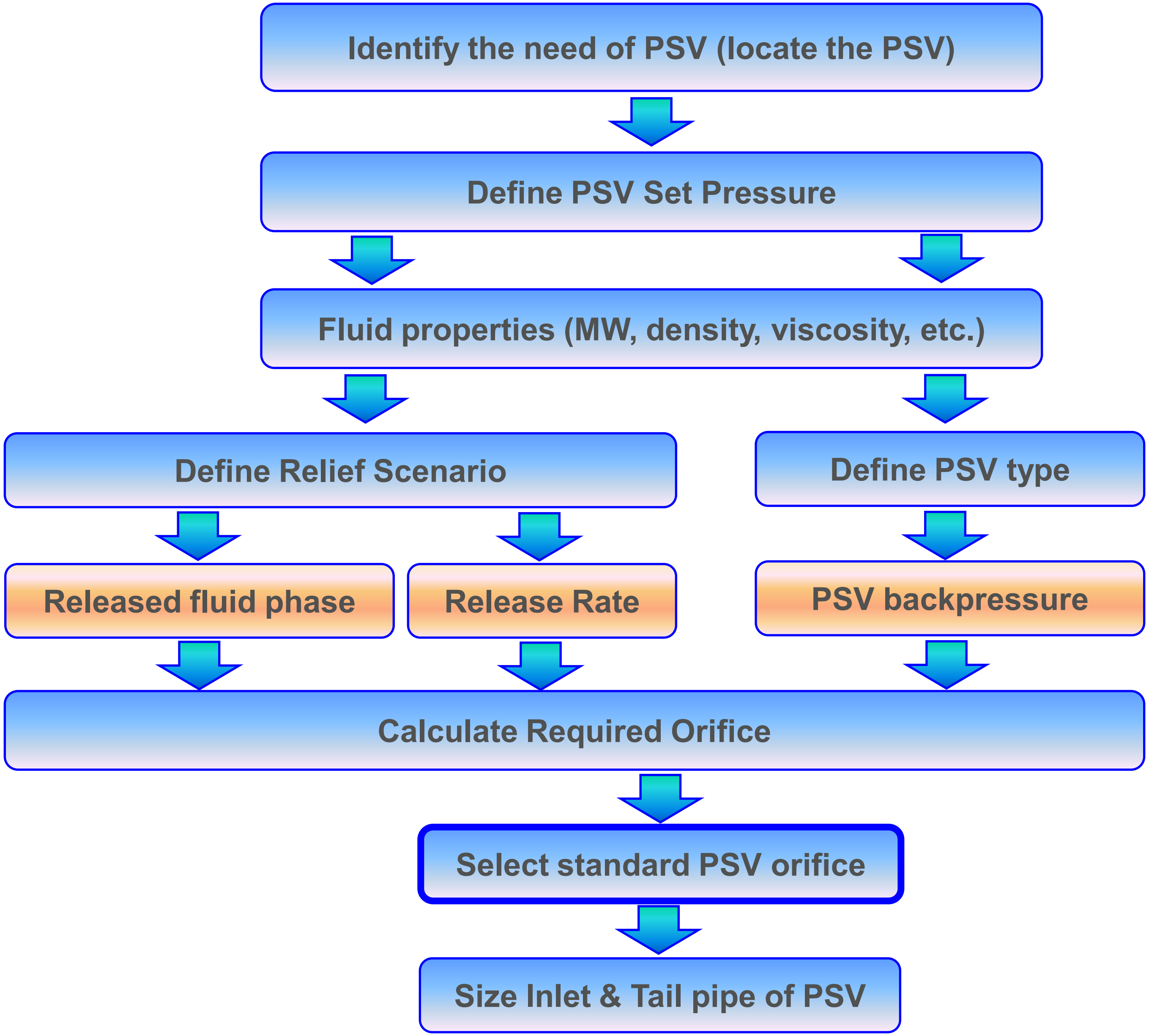
PRESSURE RELIEF VALVE

TOTAL Petrofac

Sheet 14 of 251

Code: 5006 | Dwg. No.: SGP-GEN-00-J-DS-502222-001 | Rev.: C05

PSV– SIZING METHODOLOGY



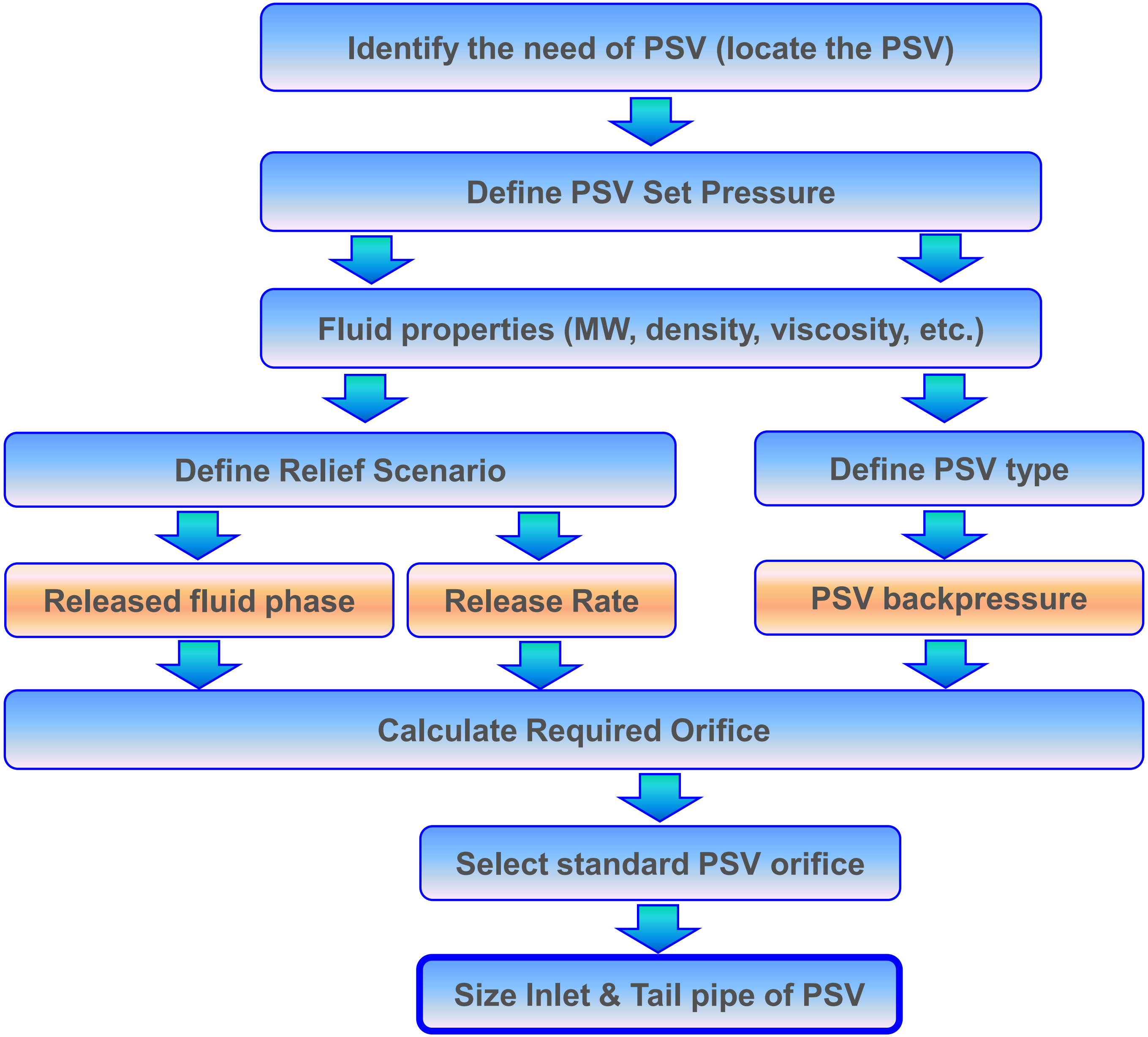
STEP 6 - STANDARD ORIFICE PSV

- **Normalization to the next larger standard orifice size**
- **Nozzles sizes alone do not tell you the size of your PSV !**

API Designation

Orifice letter	Effective area sq. inches	Inlet nozzle inches	Outlet nozzle inches	Designation
D	0.110	1	2	1 D 2
E	0.196	1	2	1 E 2
F	0.307	1 1/2 1 1/2	2 2 1/2	1 1/2 F 2 1 1/2 F 2 1/2
G	0.503	1 1/2 2	2 1/2 3	1 1/2 G 2 1/2 2 G 3
H	0.785	1 1/2 2	3 3	1 1/2 H 3 2 H 3
J	1.287	2 2 1/2 3	3 4 4	2 J 3 2 1/2 J 3 3 J 4
K	1.838	3 3	4 6	3 K 4 3 K 6
L	2.853	3 4	4 6	3 L 4 4 L 6
M	3.600	4	6	4 M 6
N	4.340	4	6	4 N 6
P	6.379	4	6	4 P 6
Q	11.045	6	8	6 Q 8
R	16.000	6 6	8 10	6 R 8 6 R 10
T	26.000	8	10	8 T 10

PSV– SIZING METHODOLOGY



STEP 7 - SIZING OF INLET & TAIL PIPE PSV (1/4)

- **Reference as per GS–EP–ECP–103**
  - **Inlet Pipe PSV**

    - ΔP between the protected equipment and the PSV < 3% of PSV set pressure (API RP 520 PT II)
    - Diameter of line ≥ Ø PSV inlet
    - $\rho V^2 \leq$ 25,000 Pa for Ø of line ≤ 2"
    - $\rho V^2 \leq$ 30,000 Pa for P ≤ 50 bar g
    - $\rho V^2 \leq$ 50,000 Pa for P > 50 bar g.

    Linked to PSV re-closing pressure

  - **Tail Pipe PSV**

    - Minimum line size 2 inch

    - Backpressure to be compatible with the installed relieving devices

    - Maximum Mach number of 0.7 and $\rho v^2 \leq$ 150,000 Pa for single phase

    - Maximum Mach number < 0.25 and $\rho v^2 \leq$ 50,000 Pa for 2 phase at inlet of relieving device

! **Flowrate to be used is PSV Rated Capacity upon selection of standard PSV orifice**

STEP 7 - SIZING OF INLET & TAIL PIPE PSV + MISC. (2/4)

- **Max pressure drop upstream of the PSV: 3% of set pressure**

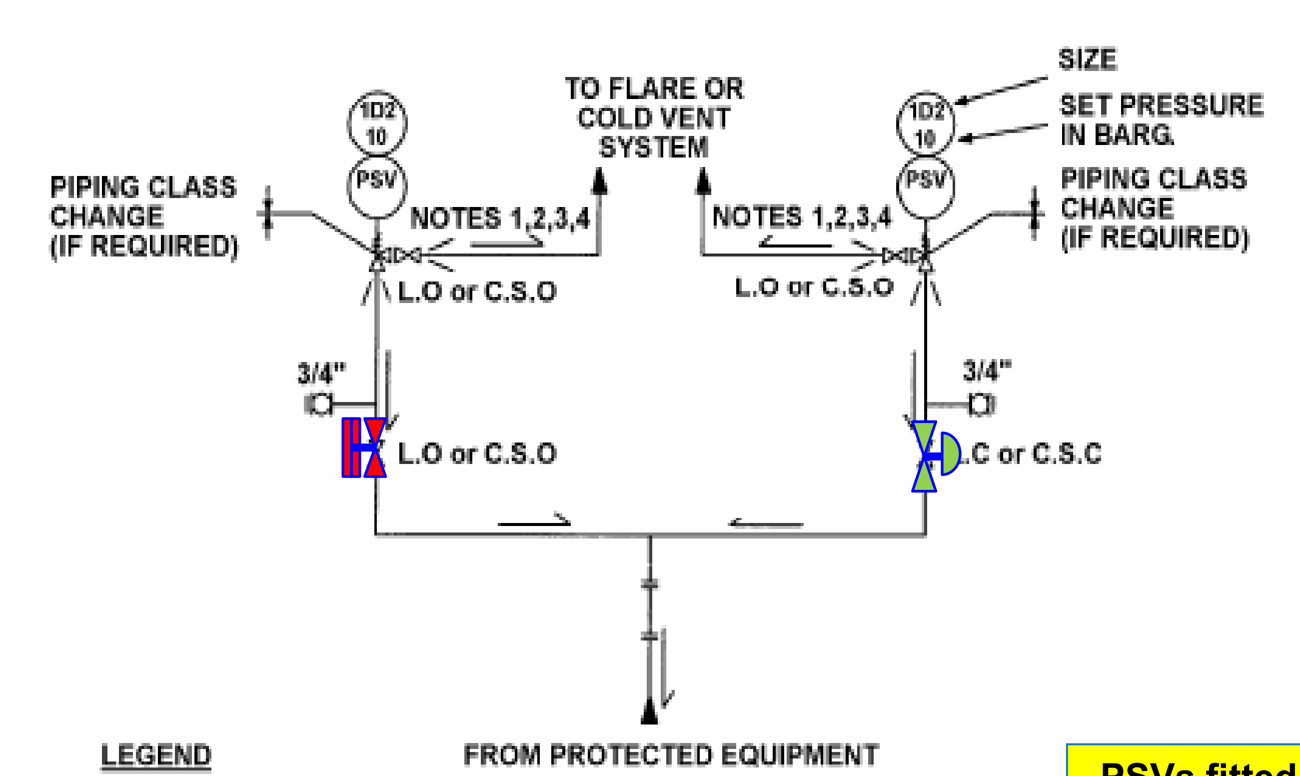
  Objective is to avoid chattering (rapid open-close cycles)

- **PSV outlet piping designed for PSV full capacity – Not the header**

- **Max backpressure**
  - **10% of Pset for conventional bellow PSV**
  - **50% of Pset for balanced bellow PSV**

- **Accumulation**
  - **Single orifice : 10% of Pset**
  - **Multiple orifice: first device at 10%, other at 16%**
  - **Fire case: set pressure allowed at 105% of MAWP, accumulation at 21%**

- **Single Isolation upstream of PSV**

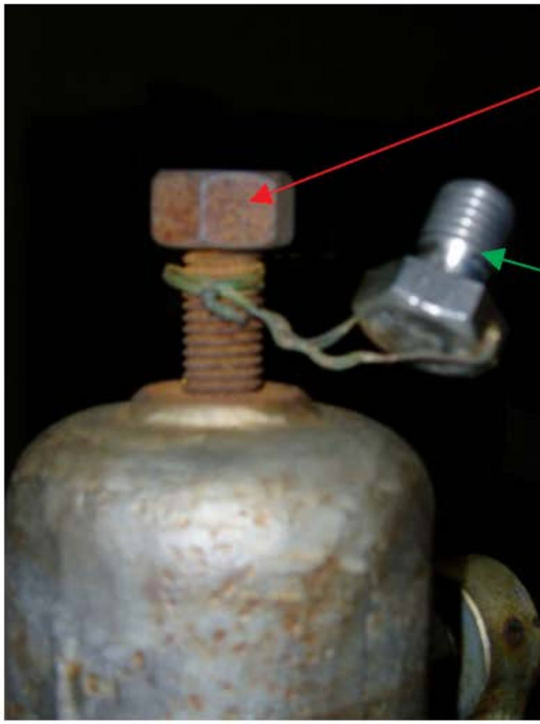


PSVs fitted with special locks to prevent isolation of vessel

STEP 7 - PSV INSTALLATION (4/4)

- **Do not forget to remove transport protection screw !**

Attachments/annex:



Blocking screw for transport.

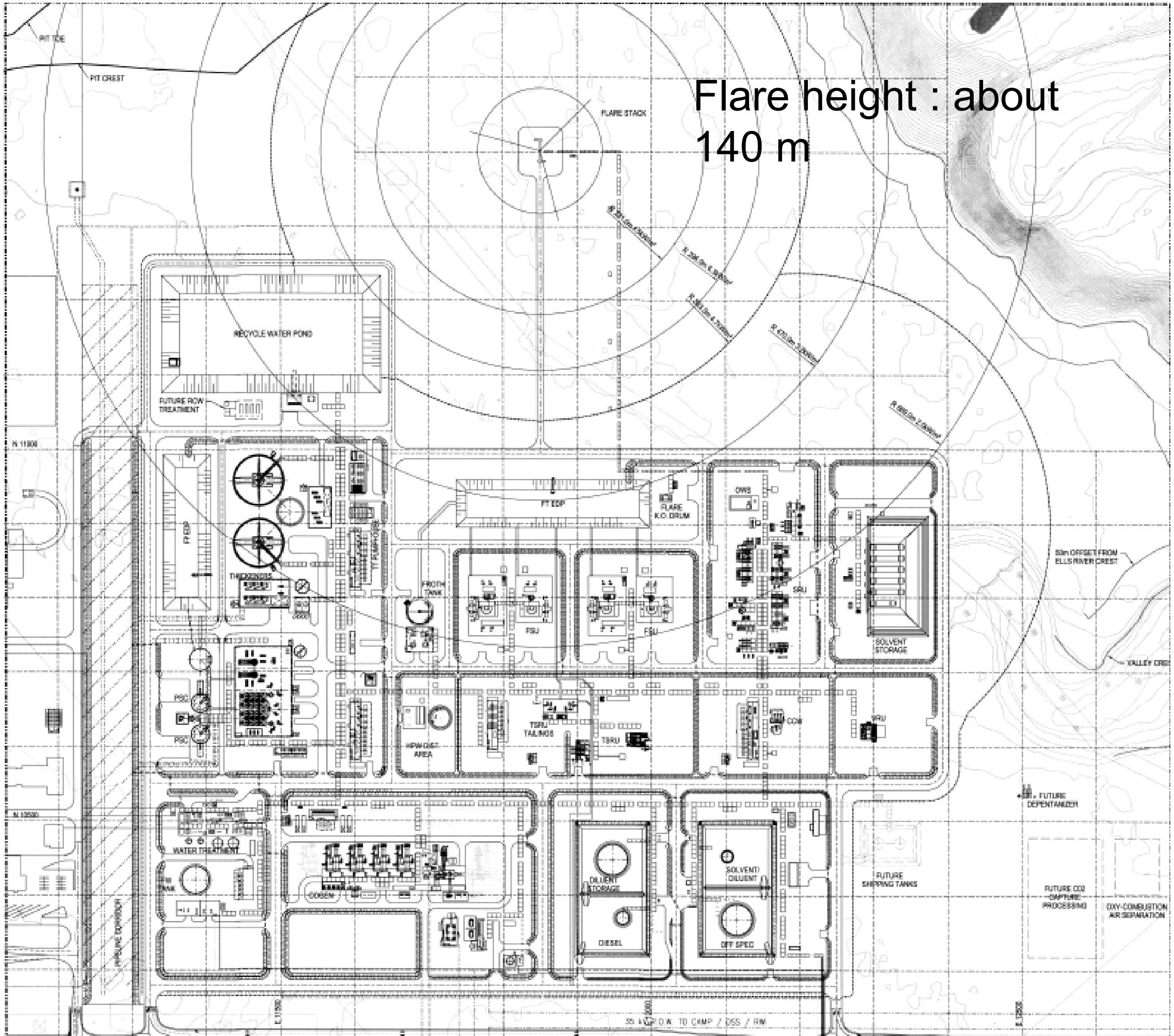
Vis de blocage de la soupape en cas de transport

Srew to be installed before PSV connected to the equipment

Vis à installer lors de la mise en place

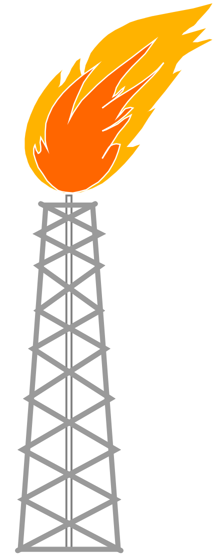
INFORMATION ABOUT FLARES

JOSLYN - CANADA



Flare height : about 140 m

Why are flares so tall?



Antwerp Refinery flare: 210 m
Major scenario : 600 t/hr (equivalent to 8000 MW)
Base load : 600 kg/hr
Turndown ratio : 1/1000

FINAL WORD

THANK YOU FOR YOUR ATTENTION

ANY QUESTION ?